13 (1) (2026) 534 - 542

Journal of Physical Education, Health and Sport

https://journal.unnes.ac.id/journals/jpehs

Body Composition, Characteristics, and Basal Metabolic Rate in Male Sports Students

Dewi Fa'iqotul Latifah[1]✉, Yetty Septiani Mustar[2], Mokhamad Nur Bawono[3]

Sports Science Study Program, Faculty of Sports Science and Health, State University of Surabaya, Indonesia[123]

History Article

Received March 2026
Approved April 2026
Published vol 13 no 1 2026

Keywords

Body Composition; Basal Metabolic Rate; Sports Students

Abstract

The digital lifestyle has led to an increase in sedentary behavior among sports students, which affects their body composition and metabolic status. An imbalance between physical activity and energy intake can alter the BMR (Basal Metabolic Rate). However, descriptive data on these variables among sports students remain limited. This study aims to describe body composition characteristics and Basal Metabolic Rate (BMR) in male sports students, and to illustrate the relationship between BMR and various body composition parameters. This study used a quantitative descriptive design with a cross-sectional approach. The study subjects consisted of 18 male sports students aged 18–23 years. Body composition measurements included Body Mass Index (BMI), Percent Body Fat (PBF), Body Fat Mass (BFM), Fat-Free Mass (FFM), Total Body Water (TBW), and Basal Metabolic Rate (BMR) using the InBody 370 device based on bioelectrical impedance analysis (BIA). The data were analyzed using descriptive statistics and presented as means, category percentages, and a correlation matrix. Results: 66.67% of sports students had a BMR in the normal range, 16.67% in the low range, and 16.67% in the high range. In general, most body composition parameters were within the normal range, with a predominance of fat- free mass. Correlation analysis showed that BMR had a very. strong relationship with FFM and TBW, a strong relationship with BMI, a moderate relationship with BFM, and a weak relationship with PBF. Most male sports students had relatively normal body composition profiles and BMR. BMR in this group was mainly influenced by active metabolic tissue components, particularly fat-free mass and total body water.

How to Cite

Latifah, D. F., Mustar, Y. S., & Bawono, M. N. (2026). Body Composition, Characteristics, and Basal Metabolic Rate in Male Sports Students. Journal of Physical Education, Health and Sport, 13 (1), 534-542.

✉ Correspondence Author:
E-mail: dewi22175@mhs.unesa.ac.id

p-ISSN 2354-7901
e-ISSN 2354-8231

INTRODUCTION

The development of lifestyle in the digital era has brought significant changes, even among sports students. Many students lead sedentary lifestyles, spending their leisure time on gadgets and social media (Tyas & Jannah, 2024). Research shows that a sedentary lifestyle poses a serious challenge to maintaining balance in body composition and metabolic status (Hanifah dkk., 2023). In addition, a sedentary lifestyle also poses a risk for metabolic syndrome and other health risk factors. An imbalance among energy intake, physical activity, and metabolism can increase body fat and decrease muscle mass (Chomiuk dkk., 2024). Therefore, understanding the relationship between body composition and basal metabolic rate (BMR) is important for objectively assessing students' physical condition. Assessing metabolic parameters and body composition is important as early indicators of health risks in the young adult population (Zigová dkk., 2023). This monitoring also helps prevent long-term metabolic disorders associated with a sedentary lifestyle (Kochman dkk., 2022).

Conceptually, body composition refers to the relative proportions of the components that make up the human body, particularly fat mass and fat-free mass, which are closely related to an individual's health status and physiological and metabolic functions (Roundtable on Obesity Solutions dkk., 2024) on Obesity Solutions dkk., 2024). Body composition components include percent body fat (PBF), total body water (TBW), and fat-free mass (FFM). FFM includes muscle, organs, bones, and body fluids, which are the main determinants of BMR because muscle tissue is metabolically active (Buscemi dkk., 2025). PBF influences BMR through the relationship between body fat and muscle mass (Gitsi dkk., 2024). Meanwhile, TBW (Rosenbaum dkk., 2025) not an active metabolic tissue, but it has a crucial relationship (Guan dkk., 2022).

Physical education students with low BMR tend to have higher body fat (Fields dkk., 2024). Body composition characteristics and BMR are influenced by age, gender, physical activity, diet, and genetics (Verma dkk., 2023). Research shows that variations in FFM are the dominant indicator of BMR differences among individuals. Therefore, body composition analysis is the primary approach in understanding the basal energy requirements and metabolic status of active individuals (Hasan, et al., 2021).

According to ((Tatsuta dkk., 2012) Differences in the proportion of active metabolic tissue influence the BMR-to-FFM ratio among athletes, so individuals with lower FFM tend to have higher basal energy requirements. The findings align with the study by (Gasperín-Rodríguez dkk., 2022), which used a cross-sectional design in a sample of prospective sports students and measured body mass index, body fat percentage, fat-free mass, and BMR. A similar study in Indonesia used a cross-sectional design to analyze the relationship between Body Mass Index (BMI) and Basal Metabolic Rate (BMR) in adolescents and found that BMR varied with body composition characteristics (Munawaroh, 2021). Previous studies have focused only on professional athletes with different training programs and metabolic conditions (Schranner dkk., 2021). Differences in physical characteristics and training loads mean that student athletes' metabolic responses differ from those of professional athletes. This reinforces the need for studies of the sports student population to obtain a more detailed picture of metabolism (Dehghani dkk., 2025).

Although the relationship between body composition and basal metabolic rate has been widely reported, most prior studies have focused on professional athletes or the general population with varying exercise characteristics and metabolic conditions. Descriptive data on the characteristics of BMR and body composition in male sports students, particularly using a BMR classification approach based on the upper and lower limits of measurement tools, remain limited. This condition indicates the need for research that provides an objective, contextually descriptive account of the metabolic status of the sports student population, an active group with varying activity patterns and lifestyles. Sports students are in a transitional phase between the general population and athletes, thus having unique and heterogeneous physiological characteristics. Limited data on this group could create an information gap in developing evidence-based health and fitness programs.

Therefore, this study aims to describe the characteristics of body composition, including weight, body mass index (BMI), percent body fat (PBF), free fat mass (FFM), total body water (TBW), and basal metabolic rate (BMR) in male sports students. This study also presents BMR classification based on the upper and lower limit guidelines for BMR from Inbody 370 as an initial interpretation of metabolic health status. The results of this study are expected to serve as the basis for future research on sports physiology, nutrition, and energy metabolism. Practically, the results can be used by coaches, lecturers, and students to design appropriate training programs and nutritional intake patterns. The novelty of this research lies in the interpretation of metabolic health and BMR classification among sports students, so the results are expected to serve as an initial reference for further studies on energy metabolism and physical performance in active populations. This descriptive approach is expected to provide an initial overview of the metabolic condition of sports students based on objective data. The research findings also have the potential to support the development of promotional and preventive policies in higher education sports environments.

METHOD

This study used a quantitative, descriptive design with a cross-sectional approach, in which all data were collected at a single time point without any specific treatment. The descriptive design was chosen to describe the characteristics of body composition and Basal Metabolic Rate (BMR) in male sports students based on measurement results. The cross-sectional approach was used to obtain an overview of participants' physiological condition at a specific point in time, aligning with the study's mapping and descriptive objectives rather than to analyze cause-and-effect relationships.

The research subjects consisted of 18 active male sports students from the Faculty of Sports Science and Health. Subject selection was conducted using purposive sampling, selecting participants based on criteria aligned with the research objectives. This research was used to obtain subjects with relatively uniform characteristics, especially in terms of gender and age range specific criteria. There were inclusion criteria: 1) Subjects were male sports students, 2) Subjects were aged 19–23 years. 3) Subjects were in good physical condition when taking the test. The exclusion criteria include 1) Subjects who, at the time of data collection, experience certain physical conditions that may hinder the measurement process, 2) Subjects who are under 19 years of age or over 23 years of age, and 3) Subjects who have incomplete measurement data.

Body composition and Basal Metabolic Rate (BMR) measurements were performed using an InBody 370 (JMZL570; Biospace Co., Ltd., Seoul, Korea), which operates on the principle of multifrequency bioelectrical impedance analysis (BIA). This method was used because it is non-invasive and commonly used for body composition measurements. Before measurement, participants were instructed to fast for at least 2 hours and avoid strenuous physical activity. At the time of measurement, participants were asked to remove their shoes, any metal objects that could affect the results, and electronic devices that could interfere with the process. Basic data such as weight, height, age, and gender were entered into the device. Next, participants stood on the device, held the electrodes as instructed, and maintained a relaxed posture during the measurement. The parameters obtained included body weight and body fat percentage. (PBF), body mass index (BMI), fat-free mass (FFM), total body water (TBW), and BMR, which included lower and upper limits.

The measurement data were processed in Microsoft Excel and analyzed using the latest version of JASP. Descriptive statistics were used to characterize the respondent data, including the mean and standard deviation (SD). The Shapiro-Wilk test was used to assess the distribution of the data, and Pearson correlation was used to examine the relationship between Basal Metabolic Rate (BMR) and body composition indicators in normally distributed data. The significance level was set at $P < 0.05$. BMR values were compared with the lower and upper limits of the reference tool (lower limit and upper limit) to describe the distribution of basal metabolic values in sports students. The data were presented in tables and matrices to facilitate interpretation.

RESULTS AND DISCUSSION

Table 1 presents the participants' characteristics as mean values ± standard deviation, along with the results of the Shapiro–Wilk normality test for each variable.

Table 1. Description of the table

Characteristics of participants	N = 18	
	Mean ± SD	p (sig)
Height (cm)	167.5 ± 4.5	0.929
Age (years)	20.7 ± 1.3	0.026
Weight (kg)	60 ± 8.1	0.839
PBF (%)	15.9 ± 4	0.398
BFM (kg)	9.7 ± 3.3	0.654
FFM (kg)	50.2 ± 5.7	0.419
BMI (kg/m²)	21.3 ± 2.3	0.883
TBW (l)	36.9 ± 4.2	0.362
BMR (kcal/day)	1,455.6±125.1	0.416

Note: PBF = percent body fat, BFM = body fat mass, BMI = body mass index, TBW = total body water, BMR = basal metabolic rate

This study involved 18 male sports students. The measurement data were presented to illustrate body composition and basal metabolic rate. The average age of the participants was 20.7 ± 1.3 years. The Shapiro-Wilk normality test indicated that the age data were not normally distributed (p = 0.026), whereas the other variables were normally distributed (P > 0.05). Meanwhile, the participants' height (167.5 ± 4.5 cm; p = 0.929), weight (60.0 ± 8.1 kg; p = 0.839), and body mass index (21.3 ± 2.3 kg/m²; p = 0.883) were normally distributed. Body composition analysis showed that participants' average percent body fat (PBF) was 15.9 ± 4.0% (p = 0.398). The average body fat mass (BFM) was recorded at 9.7 ± 3.3 kg (p = 0.654). The average Fat Free Mass (FFM) of participants was 50.2 ± 5.7 kg (p = 0.419). The average Total Body Water (TBW) was 36.9 ± 4.2 L, and the distribution was normal (p = 0.362).

Table 2. Distribution of Basal Metabolic Rate (BMR) Categories Among Participants

Category BMR	N = 18		
	kkcal/day	n	%
Low	< 1.361,4	3	16.67
Normal	1.361,4-1.581,8	12	66.67
High	> 1.581,8	3	16.67

Note. BMR = basal metabolic rate

Table 2. Shows the distribution of Basal Metabolic Rate (BMR) categories among study participants (n = 18). The participants' BMR values had a mean of 1,361.4 ± 134 kcal. Based on the classification used, the upper limit of BMR was 1,581.8 ± 163.9 kcal/day. BMR classification in this study was divided into three categories, namely low (< 1,361.4 kcal/day), normal (1,361.4–1,581.8 kcal/day), and high (> 1,581.8 kcal/day). Based on the frequency distribution, 12 participants (66.67%) were in the normal BMR category. Meanwhile, 3 participants (16.67%) were in each of the low-BMR and high-BMR categories.

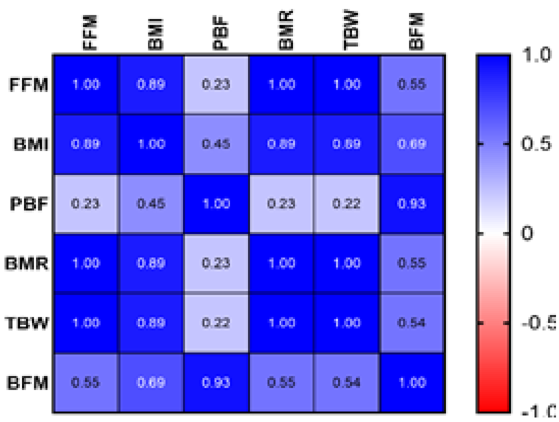

Figure 1. Correlation Matrix of BMR and Body Composition

Figure 1. Shows the correlation matrix between Basal Metabolic Rate (BMR) and body composition indicators, including Fat-Free Mass (FFM), Total Body Water (TBW), Body Mass Index (BMI), Body Fat Mass (BFM), and Percent Body Fat (PBF) in male sports students (n = 18). The correlation matrix provides a visual representation of the direction and strength of relationships between variables, facilitating the identification of patterns of association between BMR and body composition components. Results of the correlation analysis between basal metabolic rate (BMR) and body composition indicators in participants (n = 18). BMR had a very strong correlation with FFM and TBW (r = 1.000). These findings indicate that increases in fat-free mass and total body water were followed by increases in BMR in all participants. This very high correlation illustrates a consistent linear relationship between BMR and metabolically active body components. In addition, BMR showed a strong positive correlation with BMI (r = 0.893), indicating that participants with higher BMI tended to have higher BMR. However, because BMI is a general indicator of body size, this correlation represents the Influence of total body size on BMR without distinguishing its constituent components. The correlation between BMR and Body Fat Mass (BFM) was moderate (r = 0.548). This result indicates that body fat mass remains positively associated with BMR, although the strength of this association is lower than that between BMR and Percent Body Fat (PBF) is weak (r = 0.230), indicating that body fat percentage does not correlate strongly with variation in BMR among participants in this study. Overall, the correlation matrix shows that variation in BMR among male sports students is more closely associated with absolute body mass components and fat-free mass than with body fat proportion.

The results of this study show that some male sports students have body composition and basal metabolic rate (BMR) values consistent with those of an active population. The average body fat percentage, fat mass, fat-free mass, and body fluid are within the normal range according to the measurement standards used. In addition, the respondents' BMR values are generally within the normal range for their age group. These findings provide initial evidence that sports students, even though not all undergo structured training programs like professional athletes, still exhibit relatively well-maintained physiological profiles.

The body composition of sports students is academically and practically exposed to higher levels of physical activity than that of non-sports students. Physical activity, through practical lectures and daily activities, helps maintain body composition and basal metabolism. The results of this study show that the physiological characteristics of sports students lie between those of the general population and those of athletes. In sports science, sports students are often positioned as a transitional group between the general population and athletes. This group has higher exposure to physical activity than non-athletic students, but does not always undergo strict periodization of training and physiological monitoring as elite athletes (Morais dkk., 2025). Therefore, the body composition and basal metabolic profile of athletic students serve as a model for understanding the impact of moderate physical activity on metabolic health (Antoni dkk., 2025).

The findings of this study are consistent with previous research, which shows that the physiological condition of sports students is well maintained due to higher overall physical activity levels than in the general population (Kljajević dkk., 2021). The development of a sedentary lifestyle in the digital age not only contributes to a decline in physical fitness but can also increase the risk of health problems such as obesity and a weakened immune system (Chim dkk., 2020; Rivera-Carranza dkk., 2025). This indicates that physical activity is crucial for students in maintaining their metabolic function (Morgan dkk., 2024). Students have shown that structured physical activity and sports practices play a protective role against the negative effects of a sedentary lifestyle (Zhang dkk., 2025). Several recent studies show that students with a sports background have more stable body composition and metabolic profiles despite low physical activity (Mudarra-García dkk., 2025). Although students in sports have greater exposure to physical activity, the risk of sedentary behavior remains relevant in modern academic life (Junger dkk., 2025). Long periods of sitting during theoretical lectures and independent study are reported to reduce the benefits of physical activity on metabolism when not balanced by daily physical activity (Li dkk., 2025).

Meanwhile, participants' basal metabolic rates showed that male sports students were within the normal range. This indicates that metabolic function is optimal when energy intake, energy use, and body composition are balanced (Kurosaka dkk., 2023). These metabolic characteristics align with those of individuals with dominant muscle mass, who engage in regular physical activity and maintain an active lifestyle. A stable basal metabolic rate in young adulthood is an important indicator for maintaining long-term energy balance and preventing premature metabolic dysfunction (Oshita dkk., 2024). Researchers emphasize that BMR is influenced not only by age and body size but also by the distribution of active metabolic tissue, particularly skeletal muscle mass (Hasan, at al., 2021).

These findings are supported by international research showing that physical activity levels in young adults are significantly associated with Basal Metabolic Rate (BMR) and body composition parameters, particularly fat-free mass, the primary active metabolic tissue (Jaremków dkk., 2023). Other studies also report that the balance between energy intake and expenditure is a key factor in regulating basal metabolism and maintaining optimal metabolic function in physically active individuals (Kurosaka dkk., 2023). Additionally, research on athletic populations shows that individuals with regular physical activity and good body composition tend to have a more stable metabolic profile, which contributes to long-term health maintenance and physical readiness (Jagim dkk., 2023). A stable metabolic profile not only supports physical performance but also has implications for recovery, injury prevention, and the sustainability of physical activity (Reddy dkk., 2025). This makes BMR and body composition important parameters for monitoring the health of athletic students (Stampoulis dkk., 2025). These findings are reinforced by research (Kumaat dkk., 2025), which shows that Structured physical activities, such as aerobic exercise and yoga, contribute to physiological adaptations that support endurance and the stability of physiological responses, thereby helping maintain physical readiness and the sustainability of long-term physical activity.

The results of this study's analysis indicate that fat-free mass is the primary determinant of basal metabolic rate. Sports students with higher FFM generally have a higher BMR, as fat-free tissue, particularly skeletal muscle and organs, is the most metabolically active tissue. Fat-free tissue (muscle and organs) and skeletal muscle contribute the largest proportion to oxygen consumption and high energy turnover in muscles during rest. Physiologically, these are the most metabolically active components of the body and require more energy at rest than fat tissue (Gitsi dkk., 2024). The strong relationship between FFM and BMR reflects the central role of muscle mass as a determinant of resting energy expenditure (Zhou dkk., 2024).

Conversely, body fat mass and body fat

percentage have a much smaller effect on BMR than FFM (Van Dessel dkk., 2024). An increase in BFM or PBF does not automatically increase BMR, because fat tissue is much more metabolically passive than muscle. Adipose tissue is called metabolically passive tissue because its main function is to serve as an energy reserve rather than to use energy (Kazak, 2023). Fat cells (adipocytes) have fewer mitochondria than muscle and other metabolically active organs (Zhu dkk., 2022), so the contribution of adipose tissue to BMR is very small. The role of FFM in metabolism is also evident in the increase in Total Body Water (TBW), which serves as an indicator of active metabolic mass and hydration status in athletic students (Tseng dkk., 2024). The dominance of FFM and the stability of TBW in this study indicate that the participants have relatively good physiological conditions, reflecting their ability to maintain fitness despite not undergoing an intensive training program. Total body water is directly related to fat-free mass because most of the body's water is distributed in muscle tissue and organs (Zaplatosch dkk., 2025). Therefore, TBW is often used as a proxy for FFM in analyses of energy metabolism (Liu dkk., 2022). Evidence from the correlation test results between Basal Metabolic Rate (BMR) and body composition shows that this study shares a similar pattern with previous research: Body Fat Mass (BFM) has a moderate positive correlation with BMR, although not as strong as the relationship with fat-free mass, because fat tissue has low metabolic activity (Karagun & Baklaci, 2024).

Body Mass Index (BMI) shows a strong correlation because it reflects overall body size, which is associated with more active metabolic tissue. Research supports these results (Kfir dkk., 2023), which emphasizes the crucial role of body composition, particularly Fat-Free Mass, as the main determinant of BMR. The correlation between BMI and BMR must be interpreted cautiously because BMI does not distinguish between muscle and fat mass (Mainous dkk., 2025). Among sports students, a high BMI often reflects greater muscle mass rather than body fat accumulation (Pescari dkk., 2024).

Fat-Free Mass (FFM) is the strongest predictor of BMR because muscle and organ tissues have the highest energy requirements (Yildirim dkk., 2020). Body Fat Percentage (BFP) shows only a weak relationship with BMR because fat tissue has low metabolic activity. This pattern aligns with research (Hasheem dkk., 2025), which shows that, after accounting for muscle mass, fat mass does not significantly affect basal metabolic rate. This finding reinforces the theoretical framework that individual variations in BMR are more determined by the quantity and quality of active metabolic tissue than by total body weight.

Total Body Water (TBW) also shows a very strong correlation with BMR, consistent with its role as an indicator of FFM, as most fat-free mass is composed of water (blue, at al., 2023). Overall, these findings confirm that the amount of active metabolic tissue mass in the body primarily influences variation in BMR. The strong correlation between TBW and BMR in this study can be understood as a mathematical and physiological consequence of the TBW-FFM relationship. High correlation values do not indicate measurement bias; rather, they reflect a biologically meaningful relationship.

Physiologically, this indicates that students in sports with low fat-free mass tend to have lower BMR, putting them at risk of energy deficit if their training load is not balanced with adequate nutritional intake. This condition requires increased energy needs and muscle mass through weight training. An intervention approach focused on increasing muscle mass is an important strategy in increasing BMR and preventing chronic energy deficits in athletic students.

Meanwhile, male sports students with high body fat percentages should regulate their diet and perform exercises such as HIIT, which is highly effective at reducing body fat percentage and fat mass while increasing fat-free mass (Khodadadi dkk., 2023), along with resistance training, which plays a crucial role in building and maintaining muscle mass, improving strength, insulin sensitivity, and glucose oxidation to help reduce body fat and enhance physical condition (Moro dkk., 2020). The combination of high-intensity exercise. Resistance training has been shown to elicit more optimal metabolic adaptations than a single exercise modality (Wang dkk., 2024).

However, this study also has limitations, as it only involved 18 sports students. This very limited sample size may affect the representation of the study results and reduce the statistical strength of the findings. The study only involved male participants, so the findings cannot be generalized to female students. To address these limitations, future studies should include a broader population.

But for this kind of qualitative approach where necessary written description more detail, for example the approach '-logy study, history, analysis of discourse, writers can still write research methode..

CONCLUSION

This study concludes that male sports students have body composition and basal metabolic rate profiles within the normal range, indicating relatively well-maintained basal metabolic conditions and physiological balance. The findings indicate that variations in basal metabolism are primarily related to the dominance of active metabolic tissue, particularly fat-free mass and total body fluid. In contrast, fat mass and body fat percentage play a more limited role. These results meet the study's objective of providing a descriptive overview of the relationship between body composition and basal metabolism in male physical education students and confirm that a normal metabolic status can be maintained even when not all individuals undergo intensive structured training. Scientifically, this study strengthens the understanding of fat-free mass as the primary determinant of basal metabolism among sports students and providesan empirical basis for developing health-monitoring and physical activity planning based on body composition in sports education environments. Further research is recommended to include a larger sample size and female participants to enable broader generalization. Additionally, using a longitudinal design and including variables such as physical activity levels, energy intake, and exercise type are expected to provide a more comprehensive picture of changes in body composition and basal metabolism among students.

REFERENCES

Antoni, M. F., Damayanti, E. D. R., Suyoko, A., Eka, F., Andriana, L. M., & Yudhistira, D. (2025). Relative Leg Press Strength Related to Basal Metabolic Rate (BMR), Body Mass, And Body Fat in Female University Students: Implications for The Prescription of Exercise.

blue, malia N. M. (t.t.). Validity of total body water measured by multi-frequency bioelectrical impedance devices in a multi-ethnic sample. 2023, 54, 187–193. https://doi.org/https://doi.org/10.1016/j.clnesp.2023.01.026

Buscemi, S., Buscemi, C., Colombrita, P., Randazzo, C., Barile, A. M., & Arnaldi, G. (2025). Obesity: A disease of the ponderostat and the regulation of energy balance. Eating and Weight Disorders - Studies on Anorexia, Bulimia and Obesity, 30(1), 80. https://doi.org/10.1007/s40519-025-01790-9

Chim, H. Q., Oude Egbrink, M. G. A., Van Gerven, P. W. M., De Groot, R. H. M., Winkens, B., & Savelberg, H. H. C. M. (2020). Academic Schedule and Day-to-Day Variations in Sedentary Behavior and Physical Activity of University Students. International Journal of Environmental Research and Public Health, 17(8), 2810. https://doi.org/10.3390/ijerph17082810

Chomiuk, T., Niezgoda, N., Mamcarz, A., & Śliż, D. (2024). Physical activity in metabolic syndrome. Frontiers in Physiology, 15, 1365761. https://doi.org/10.3389/fphys.2024.1365761

Dehghani, E., Gohari Dezfuli, Z., Shab Bidar, S., Torki, F., Seif Barghi, T., & Djafarian, K. (2025). Comparison of athlete diet index and body composition between professional and non-professional athletes: A comparative cross-sectional study. Journal of the International Society of Sports Nutrition, 22(1), 2533497. https://doi.org/10.1080/15502783.2025.2533497

Fields, J. B., Askow, A. T., Jones, M. T., & Jagim, A. R. (2024). Differences in Body Fat in Athletes Categorized by Resting Metabolic Rate. Applied Sciences, 14(21), 9949. https://doi.org/10.3390/app14219949

Gasperín-Rodríguez, E. I., Gómez-Figueroa, J. A., Gómez-Miranda, L. M., Ríos-Gallardo, P. T., Palmeros-Exsome, C., Hernández-Lepe, M. A., Moncada-Jiménez, J., & Bonilla, D. A. (2022). Body Composition Profiles of Applicants to a Physical Education and Sports Major in Southeastern Mexico. International Journal of Environmental Research and Public Health, 19(23), 15685. https://doi.org/10.3390/ijerph192315685

Gitsi, E., Kokkinos, A., Konstantinidou, S. K., Livadas, S., & Argyrakopoulou, G. (2024). The Relationship between Resting Metabolic Rate and Body Composition in People Living with Overweight and Obesity. Journal of Clinical Medicine, 13(19), 5862. https://doi.org/10.3390/jcm13195862

Guan, L., Li, T., Wang, X., Yu, K., Xiao, R., & Xi, Y. (2022). Predictive Roles of Basal Metabolic Rate and Body Water Distribution in Sarcopenia and Sarcopenic Obesity: The link to Carbohydrates. Nutrients, 14(19), 3911. https://doi.org/10.3390/nu14193911

Hanifah, L., Nasrulloh, N., & Sufyan, D. L. (2023). Sedentary Behavior and Lack of Physical Activity among Children in Indonesia. Children, 10(8), 1283. https://doi.org/10.3390/children10081283

Hasan, M. (at al.,2021). Identification of nutritional status and body composition in weightlifting athlete. Journal of Physical Education and Sport, 21(4).

Hasheem, Z. O., Naji, A. A., & Al-Rudaini, R. S. (2025). Association between basal metabolic rate and body composition in patients attending Baghdad nutrition clinic, 2025. International Journal of Advanced Academic Studies, 7(8), 195–201. https://doi.org/10.33545/27068919.2025.v7.i8c.1647

Jagim, A. R., Jones, M. T., Askow, A. T., Luedke, J., Erickson, J. L., Fields, J. B., & Kerksick, C. M. (2023). Sex Differences in Resting Metabolic Rate among Athletes and Association with

Body Composition Parameters: A Follow-Up Investigation. Journal of Functional Morphology and Kinesiology, 8(3), 109. https://doi.org/10.3390/jfmk8030109

Jaremków, A., Markiewicz-Górka, I., Hajdusianek, W., Czerwińska, K., & Gać, P. (2023). The Relationship between Body Composition and Physical Activity Level in Students of Medical Faculties. Journal of Clinical Medicine, 13(1), 50. https://doi.org/10.3390/jcm13010050

Junger, J., Hrobacz, A., Melichar, R., & Salonna, F. (2025). Physical Activity And Sedentary Behavior In The Lifestyle Of University Students. Health Problems of Civilization, 19(4), 427–439. https://doi.org/10.5114/hpc.2025.146804

Karagun, B., & Baklaci, N. (2024). Comparative analysis of basal metabolic rate measurement methods in overweight and obese individuals: A retrospective study. Medicine, 103(35), e39542. https://doi.org/10.1097/MD.0000000000039542

Kazak, L. (2023). Promoting metabolic inefficiency for metabolic disease. iScience, 26(10), 107843. https://doi.org/10.1016/j.isci.2023.107843

Kfir, A., Lahav, Y., & Gepner, Y. (2023). Cross-Validation of a New General Population Resting Metabolic Rate Prediction Equation Based on Body Composition. Nutrients, 15(4), 805. https://doi.org/10.3390/nu15040805

Khodadadi, F., Bagheri, R., Negaresh, R., Moradi, S., Nordvall, M., Camera, D. M., Wong, A., & Suzuki, K. (2023). The Effect of High-Intensity Interval Training Type on Body Fat Percentage, Fat and Fat-Free Mass: A Systematic Review and Meta-Analysis of Randomized Clinical Trials. Journal of Clinical Medicine, 12(6), 2291. https://doi.org/10.3390/jcm12062291

Kljajević, V., Stanković, M., Đorđević, D., Trkulja-Petković, D., Jovanović, R., Plazibat, K., Oršolić, M., Čurić, M., & Sporiš, G. (2021). Physical Activity and Physical Fitness among University Students—A Systematic Review. International Journal of Environmental Research and Public Health, 19(1), 158. https://doi.org/10.3390/ijerph19010158

Kochman, M., Kasperek, W., Guzik, A., & Drużbicki, M. (2022). Body Composition and Physical Fitness: Does This Relationship Change in 4 Years in Young Adults? International Journal of Environmental Research and Public Health, 19(3), 1579. https://doi.org/10.3390/ijerph19031579

Kumaat, N. A., Caturia Sasti Sulistyana, & Yudi Dwi Saputra. (2025). Pengaruh senam aerobik low impact dan yoga terhadap aerobic endurance dan tingkat stres wanita usia 30-40 tahun. Bravo's: Journal of Physical Education and Sport Science, 13(2), 418–424. https://doi.org/10.32682/bravos.v13i2/96

Kurosaka, Y., Nagasawa, T., Minato, K., Hasegawa-Tanaka, T., Naito, H., Wakui, S., & Machida, S. (2023). Blood biomarkers for estimating energy intake in Japanese male collegiate athletes: A pilot study. BMC Sports Science, Medicine and Rehabilitation, 15(1), 150. https://doi.org/10.1186/s13102-023-00765-6

Li, J., Lin, Z., Zou, M., Feng, X., & Liu, Y. (2025). Association between daily movement behaviors and optimal physical fitness of university students: A compositional data analysis. BMC Public Health, 25(1), 877. https://doi.org/10.1186/s12889-025-22151-2

Liu, S., Yang, Y., Song, J., Ma, L., Wang, Y., Mei, Q., & Jiang, W. (2022). Total body water/fat-free mass ratio as a valuable predictive parameter for mortality in maintenance hemodialysis patients. Medicine, 101(31), e29904. https://doi.org/10.1097/MD.0000000000029904

Mainous, A. G., Yin, L., Wu, V., Sharma, P., Jenkins, B. M., Saguil, A. A., Nelson, D. S., & Orlando, F. A. (2025). Body Mass Index vs Body Fat Percentage as a Predictor of Mortality in Adults Aged 20-49 Years. The Annals of Family Medicine, 23(4), 337–343. https://doi.org/10.1370/afm.240330

Morais, J. F. E., Larrière, O., Bragada, J. A. A., Bartolomeu, R. F. B., Magalhães, P. M., Schnegg, A., Houndekon, M., Garnier, Y. M., & Mourot, L. (2025). Comparative analysis of physical fitness and body composition in first-year bachelor sports sciences students from France and Portugal. BMC Sports Science, Medicine and Rehabilitation, 17(1), 315. https://doi.org/10.1186/s13102-025-01359-0

Moro, T., Marcolin, G., Bianco, A., Bolzetta, F., Berton, L., Sergi, G., & Paoli, A. (2020). Effects of 6 Weeks of Traditional Resistance Training or High Intensity Interval Resistance Training on Body Composition, Aerobic Power and Strength in Healthy Young Subjects: A Randomized Parallel Trial. International Journal of Environmental Research and Public Health, 17(11), 4093. https://doi.org/10.3390/ijerph17114093

Mudarra-García, N., Pérez-Mudarra, M., Ortuño-Soriano, I., Badía-Iborra, R., Vicente-Galán, M. J., Zaragoza-García, I., Roque-Rojas, F., & García-Sánchez, F. J. (2025). Impact of Exams on Diet, Physical Activity, and Body Composition in University Students. Nutrients, 17(11), 1929. https://doi.org/10.3390/nu17111929

Munawaroh, M. M. (2021). Komposisi Lemak Viseral, Basal Metabolic Rate (BMR), Dan Usia Sel Terhadap Indeks Masa Tubuh (IMT) Pada Remaja. Jurnal Untuk Masyarakat Sehat (JUKMAS), 5(1), 110–119. https://doi.org/10.52643/jukmas.v5i1.1120

Oshita, K., Ishihara, Y., Seike, K., & Myotsuzono, R. (2024). Associations of body composition with physical activity, nutritional intake status, and chronotype among female university students in Japan. Journal of Physiological Anthropology, 43(1), 13. https://doi.org/10.1186/s40101-024-00360-9

Pescari, D., Mihuta, M. S., Bena, A., & Stoian, D. (2024). Comparative Analysis of Dietary Habits and Obesity Prediction: Body Mass

Index versus Body Fat Percentage Classification using Bioelectrical Impedance Analysis. Public Health and Healthcare. https://doi.org/10.20944/preprints202408.1236.v1

Reddy, K. V., Putluri, V. L., L B, L. R., Bavoge, H. R., & Bavoge, H. R. (2025). Metabolic Efficiency Paradox: Compensatory Role of Basal Metabolic Rate (BMR) in Mitigating Visceral Fat-Driven Anaerobic Speed Deficits Across BMI Categories in Young Adults. Social Sciences. https://doi.org/10.20944/preprints202503.1906.v1

Rivera-Carranza, T., León-Téllez-Girón, A., González-Vázquez, R., Vázquez-Cárdenas, P., Esquivel-Campos, A. L., Mendoza-Pérez, F., Rojano-Rodríguez, M. E., Mimiaga-Hernández, C., Cifuentes-Goches, J. C., Peralta-Valle, O. E., Zúñiga-León, E., & Bojalil-Parra, R. (2025). Cellular Immunity in Obesity: Pathophysiological Insights and the Impact of Bariatric Surgery. International Journal of Molecular Sciences, 26(20), 9867. https://doi.org/10.3390/ijms26209867

Roundtable on Obesity Solutions, Food and Nutrition Board, Health and Medicine Division, & National Academies of Sciences, Engineering, and Medicine. (2024). Exploring the Science on Measures of Body Composition, Body Fat Distribution, and Obesity: Proceedings of a Workshop Series (A. Berhaupt, Ed.; hlm. 27461). National Academies Press. https://doi.org/10.17226/27461

Schranner, D., Schönfelder, M., Römisch-Margl, W., Scherr, J., Schlegel, J., Zelger, O., Riermeier, A., Kaps, S., Prehn, C., Adamski, J., Söhnlein, Q., Stöcker, F., Kreuzpointner, F., Halle, M., Kastenmüller, G., & Wackerhage, H. (2021). Physiological extremes of the human blood metabolome: A metabolomics analysis of highly glycolytic, oxidative, and anabolic athletes. Physiological Reports, 9(12). https://doi.org/10.14814/phy2.14885

Stampoulis, T., Avloniti, A., Draganidis, D., Balampanos, D., Chalastra, P. E., Gkachtsou, A., Pantazis, D., Retzepis, N.-O., Protopapa, M., Poulios, A., Zaras, N., Michalopoulou, M., Fatouros, I. G., & Chatzinikolaou, A. (2025). New Bioelectrical Impedance-Based Equations to Estimate Resting Metabolic Rate in Young Athletes. Methods and Protocols, 8(3), 53. https://doi.org/10.3390/mps8030053

Tatsuta W., Yokota Y., Kamei A., Tawara N., Kawahara T., Taguchi M., & Higuchi M. (2012). High basal metabolic rate/fat-free mass ratio in Japanese elite male athletes can be attributed to body composition. Japanese Journal of Physical Fitness and Sports Medicine, 61(4), 427–433. https://doi.org/10.7600/jspfsm.61.427

Tseng, C.-C., Hung, K.-Y., Chang, H.-C., Huang, K.-T., Wang, C.-C., Chen, Y.-M., Lin, C.-Y., Lin, M.-C., & Fang, W.-F. (2024). The importance of high total body water/fat free mass ratio and serial changes in body composition for predicting hospital mortality in patients with severe pneumonia: A prospective cohort study. BMC Pulmonary Medicine, 24(1), 470. https://doi.org/10.1186/s12890-024-03302-4

Tyas, A. P., & Jannah, M. (2024). Analisis Deskriptif Aktivitas Olahraga pada Generasi Z. 11.

Van Dessel, K., Verrijken, A., De Block, C., Verhaegen, A., Peiffer, F., Van Gaal, L., De Wachter, C., & Dirinck, E. (2024). Basal metabolic rate using indirect calorimetry among individuals living with overweight or obesity: The accuracy of predictive equations for basal metabolic rate. Clinical Nutrition ESPEN, 59, 422–435. https://doi.org/10.1016/j.clnesp.2023.12.024

Verma, N., Kumar, S. S., & Suresh, A. (2023). An evaluation of basal metabolic rate among healthy individuals—A cross-sectional study. Bulletin of Faculty of Physical Therapy, 28(1), 26. https://doi.org/10.1186/s43161-023-00139-6

Wang, Y., Yang, X., Deng, J., Wang, Z., Yang, D., Han, Y., & Wang, H. (2024). Combined high-intensity interval and resistance training improves cardiorespiratory fitness more than high-intensity interval training in young women with overweight/obesity: A randomized controlled trial. Frontiers in Endocrinology, 15, 1450944. https://doi.org/10.3389/fendo.2024.1450944

Yildirim, I., Dogan, I., Isik, O., Yildirim, Y., & Karagoz, S. (2020). Investigation of the relationship between basal metabolic rate and body composition in young adults using CHAID analysis. Progress in Nutrition, 22(1-S), 5–10. https://doi.org/10.23751/pn.v22i1-S.9761

Zaplatosch, M. E., Meireles, J. F., Amason, J. S., Dabeer, S., Kliszczewicz, B. M., Mangine, G. T., Barry, V. G., Gower, B. A., & Ingram, K. H. (2025). Validity of Body Composition Estimates in Women Assessed by a Multifrequency Bioelectrical Impedance Device. Sensors, 25(16), 5037. https://doi.org/10.3390/s25165037

Zhang, L., Zhong, T., & Dong, K. (2025). University-based physical education as a structured temporal and spatial opportunity for shaping health-oriented lifestyles. Frontiers in Public Health, 13, 1597480. https://doi.org/10.3389/fpubh.2025.1597480

Zhou, W., Su, H., Tong, J., Du, W., Wang, B., Chen, P., Wan, H., & Zhou, M. (2024). Multiple factor assessment for determining resting metabolic rate in young adults. Scientific Reports, 14(1), 11821. https://doi.org/10.1038/s41598-024-62639-2

Zhu, Q., An, Y. A., & Scherer, P. E. (2022). Mitochondrial regulation and white adipose tissue homeostasis. Trends in Cell Biology, 32(4), 351–364. https://doi.org/10.1016/j.tcb.2021.10.008

Zigová, M., Petrejčíková, E., Mydlárová Blaščáková, M., Gaľová, J., Hedviga Vašková, Kalafutová, S., & Šlebodová, M. (2023). Cardiometabolic risk assessment in Eastern Slovak young adults using anthropometric indicators. Anthropological Review, 86(4), 81–97. https://doi.org/10.18778/1898-6773.86.4.07.