nutrición clínica y Dietética Hospitalaria

Artículo Original

Nutr Clín Diet Hosp. 2025; 45(2):434-442
DOI: 10.12873/452rahmawati

# Early screening for overweight and obesity in Maros Regency: body fat percentage, visceral fat, cell age, and BMR with BMI in adult women

RAHMAWATI[1,2], Evy DAMAYANTHI[1], Budi SETIAWAN[1], Eny PALUPI1, NURMASITA[2], Sri WAHYUNINGSIH[2], MASYITA[2], Reni WULANDARI[2]

*1 Department of Community Nutrition, Faculty of Human Ecology, IPB University, Bogor, Indonesia.*
*2 Nursing Academy Yapenas 21 Maros, Maros, Indonesia.*

Recibido: 25/abril/2025. Aceptado: 24/junio/2025.

## ABSTRACT

**Introduction**: Women are more likely to be overweight and obese, which can affect reproductive health and pregnancy. Many are unaware of this condition, often because of busy lifestyles that limit exercise, rest, and healthy eating.

**Objectives**: This study aimed to explore the relationship between body fat percentage, visceral fat, cell age, and basal metabolic rate (BMR) with body mass index (BMI) as an initial screening tool for overweight and obesity.

**Methods**: This study used a cross-sectional design and a sampling technique with consecutive sampling. The study was conducted on adult women with an age range 19-27 years which is the period between early adulthood and productive age. The subject measurement location was centred on the Yapenas 21 Maros Nursing Academy, Adatongeng, Turikale District, Maros Regency. South Sulawesi, Indonesia. The total final sample obtained was 105 subjects.

**Results**: The data collected in this study consisted of anthropometric and body composition measurements. Body Mass Index (BMI) was manually calculated using the standard formula, whereas body composition parameters including body fat percentage, visceral fat, cellular age, and basal metabolic rate (BMR were obtained using a bioelectrical impedance analysis (BIA) device. The BIA method estimates these values based on the body's electrical conductivity in combination with demographic factors such as age, sex, height, and weight. Spearman Rho correlation tests showed significant correlations ($p<0.05$), with strong positive correlations for body fat ($r=0.724$), visceral fat ($r=0.941$), cell age ($r=0.949$), and BMR ($r=0.898$) with BMI.

**Conclusion**: Higher values of body fat percentage, visceral fat, cell age, and BMR corresponded to a higher BMI. Therefore, BMI is thus a relevant predictor of metabolic health. Positive lifestyle changes such as regular exercise and a healthy diet can prevent metabolic-related diseases.

## KEYWORDS

Weight status, metabolic health, adiposity, body composition.

## ABBREVIATIONS

BMR : Basal Metabolic Rate.

BMI : Body Mass index.

BIA : Bioelectrical Impedance Analysis.

NEAT : Non-exercise activity thermogenesis.

## INTRODUCTION

Overweight and obesity are significant nutritional problems in adult women. This is because women are more likely than men to be overweight and obese, which has far-reaching implications for reproductive health and particularly in pregnancy. In theory, adulthood begins around at >18 years of age and the period of reproductive age. This period represents a physiologically mature population in a transitional lifestyle stage and aexperiencing an increased risk of early

**Correspondencia:**
Evy Damayanthi
edamayanthi@apps.ipb.ac.id

onset of body composition-related health issues. Targeting this age group allows for early identification of risk factors associated with overweight, obesity, and metabolic health[1].

Many factors affect the nutritional status of adults, one of which is their daily food consumption habits. Eating habits were not influenced by the nutrients in the food. The environment is one of the many factors that influence eating habits. Adults usually tend not to pay attention to what they eat. Generally, adults prefer to eat oily, savory, and sweet foods. Fibre-rich foods such as vegetables and fruits are ignored. Consequently, the intake of energy (calories) in the body is excessive[2].

Being overweight and obese are significant risk factors for various cardiometabolic diseases, including metabolic syndrome, type 2 diabetes mellitus, hypertension, dyslipidemia, cardiovascular disease, and non-alcoholic fatty liver disease. Being overweight as an adult increases susceptibility to metabolic complications as one ages. In women, obesity is also associated with a higher risk of unfavorable pregnancy outcomes such as gestational diabetes, preeclampsia, operative delivery, fetal macrosomia, and neonatal morbidity. The prevalence of metabolic syndrome is especially high among overweight and obese women, and this risk increases further with advancing age and degree of obesity[3,4].

World Health Organization (WHO) data from 2016 show that more than 1.9 billion adults aged >18 years are overweight. Of these, more than 650 million adults are obese. The overall prevalence of overweight and obesity was higher in women (44.4%) than that in men (26.6%). The majority of these incidences occur in developing countries[5,6]. The prevalence of overweight ini Indonesian women was 15.1%, and that of obesity was 29.2% in 2018. South Sulawesi had the 6th highest obesity rate, while Makassar exceeded the prevalence of South Sulawesi (19.1%) and National (21.8%) at 24.05%. In the Maros District, overweight and obesity in adult females were 15.61% and 23.75%, respectively, compared to males[6,7]. The prevalence of central obesity at the age of >15 years in Indonesia is also mostly experienced by women (42.1%) and men (11.3%) men[8]. In 2030-2040, Indonesia is projected to have a population of 297 thousand people and 64% of them are of productive age[9], so this is a challenge so that productive age can be optimised with good health status.

Essentially, overweight and obese conditions occur because of the continuous accumulation of triglycerides in adipose tissue. Initially, adipocytes undergo hypertrophy and eventually develop into hyperplasia. This causes white adipose tissue (WAT) to produce leptin, which regulate fat tissue mass and controls lipid reserves. Leptin levels increase as triglyceride levels in adipose tissue increase. As a result, leptin resistance increases appetite (unsatiety)[10].

Leptin is characterised by an increase in body fat percentage, which reflects the size of hypertrophied subcutaneous adipocytes[10]. The results of research by Sumadewi et al. (2017) showed that serum leptin levels are positively and significantly correlated with body mass index (BMI)[11]. Meanwhile, excess visceral fat can be detected by measuring the waist circumference. An increase in visceral fat is associated an increase release of free fatty acids into the portal circulation, which in turn contributes to the development of insulin resistance and other components of metabolic syndrome[12]. However, recently, visceral fat has also been detected through bioelectrical impedance analysis (BIA)[13]. The use of modern imaging technologies such as BIA can provide more precise results[14].

Some studies using BIA have been conducted by Gotera et al. (2014), which showed a positive correlation between visceral fat levels and triglycerides and LDL and a negative correlation between visceral fat levels and HDL levels[13]. Agustiyawan et al. (2025) showed a significant positive relationship between body fat percentage, visceral fat levels, and the risk of cardiovascular disease[14]. Susantini et al. (2021) also reported an association between BMI, body fat percentage, and visceral fat levels[15]. Munawaroh et al. (2021) showed an association between BMI and obesity status with increasing cellular age, but no association with basal metabolic rate (BMR)[16].

On the other hand, monitoring of nutritional status such as body fat percentage, visceral fat composition, basal metabolic rate (BMR), and cell age of early adult women through the Bioelectrical Impedance Analyzer (BIA) in Maros Regency is still very limited which relates to Body Mass Index (BMI). In fact, early adult women are productive ages that will produce the forerunners of the nation's next generation. The nutritional status of early adults is also very interesting because it is difficult for this group to have a healthy lifestyle, given the busyness in the world of careers and education, so that less rest, less exercise, and the difficulty of consuming healthy foods are due to limited time. Therefore, this study aimed to determine the relationship between body fat percentage, visceral fat composition, basal metabolic rate (BMR), and cell age with body mass index (BMI) of adult women as an initial screening for monitoring overweight and obesity.

## METHOD

### *Study Design, Place, and Time*

This study had a cross-sectional design. The variables studied were body mass index (BMI), percent body fat, visceral fat content, basal metabolic rate (BMR), and cell age, all measured at a single point in time. The study was conducted from February to April 2025. The location of the subject measurements was centered on the Yapenas 21 Maros Nursing Academy Campus, Adatongeng, Turikale District, Maros Regency.

### *Data Collection*

Subjects in this study were obtained based on consecutive sampling, non-probability technique, which is a sampling technique in which all subjects who come and meet the selection criteria were included in the study until the required number of subjects is met. The inclusion criteria are as follows: (1) adult women aged 19-29 years which is the period between early adulthood and productive age. Focusing on this age group allows for the early identification and potential prevention of these risk factors before they progress into chronic conditions[1]; (4) Students or alumni from universities located in the Maros regency; (3) Ability to understand and follow the research; and (4) Willingness to become research subjects. The exclusion criteria are as follows: (1) Pregnancy; (2) Smoking; and (3) Alcohol consumption. The sampling process concludes when either the required number of participants is reached (sample saturation) or the predetermined time frame has ended (time saturation). The total final sample obtained was 105 subjects.

BMI value was obtained from weight divided by square height. BMI (body mass index) categories using standard measurement criteria for Asian populations[17], namely underweight (<18.5 kg/m$^2$), normal (18.5-22.9 kg/m$^2$), overweight (>22.9-27.5 kg/m$^2$), and obesity (>27.5 kg/m$^2$). Measurements were performed using the Omron Bioelectrical Impedance Analyzer (BIA) for weight and body composition measurements including body fat percentage, visceral fat level, basal metabolic rate (BMR), and cell age (accuracy ±400 g for 40.0–135.0 kg; ±1%), as well as an Onemed-brand manual height meter with an accuracy of 0.1 cm. Participants were instructed to refrain from engaging in strenuous physical activity and from consuming heavy meals for at least three hours prior to the measurement. As the measurements were conducted at different times for each subject, participants were asked beforehand whether they had eaten and how long ago, to ensure consistency. All participants were adequately hydrated at the time of assessment. Prior to measurement, participants removed all jewelry and watches, wore light clothing, and removed their shoes to minimize measurement variability.

Body fat percentage categories were obtained from Omron's Karada Scan Body Composition Monitor (model HBF-375, Japan) and further refined based on studies using similar BIA devices by Molz et al. (2023)[18], to ensure relevance to the population studied, which was differentiated by sex for women: low: 5-19.9%, normal: 20-29.9%, and high, ≥30%. The reference value of visceral fat content was normal: <10, high: ≥10. Classified the cell age into two groups: those with cell age ≤ chronological age and those with cell age > chronological age based on the results obtained from the Omron BIA device. Omron describes the cell age feature as an estimate derived from body weight, body fat percentage, and skeletal muscle mass. This feature does not directly measure cellular age at the biomolecular level, but rather reflects an index of overall body composition and physical health. Cell age is expressed in years and reflects an estimate of biological aging based on body composition metrics, rather than chronological time alone. This categorization was also applied in the study by Munawaroh et al. (2020)[16].

Basal Metabolic Rate (BMR) values were obtained using the Omron BIA device, which estimates BMR via a proprietary algorithm incorporating demographic variables (age, sex, height, weight) and body composition data derived from bioelectrical impedance analysis (BIA). The BMR values were subsequently categorized into three groups: <1200 kcal/day, 1200–1300 kcal/day, and >1300 kcal/day, based on the observed distribution among participants. This classification is supported by the physiological principle that BMR increases with greater body mass, especially in individuals with higher lean body mass. These groupings also reflect commonly cited BMR ranges for healthy adult women, as estimated by the Mifflin-St Jeor equation[19].

Body weight and body composition were taken twice for each subject to ensure the accuracy and reliability of the BIA device. The average of the two readings was calculated and used as the final recorded value for each parameter. These averaged results are presented in the data collection table.

### *Statistical Analysis*

The data analysis was performed using a correlation test. Before the statistical tests, the Kolmogorov-Smirnov normality test was performed. Normally distributed data were subjected to statistical analysis using the Pearson's correlation test; otherwise, Sperman's rho was used. This statistical test was used to determine whether there was a correlation between body fat percentage, visceral fat composition, cell age, BMR, and BMI. The test results were considered significant if the p-value wass less then 0.05. Then the r value from the correlation test was interpreted as 0 (nil), +/-0.1-0.3 (weak), +/-0.4-0.6 (moderate), +/-0.7-0.9 (strong), +/-1 (perfect)[20]. The data were processed using microsoft excel and continued with statistical tests were performed using statistical product and service solutions (SPSS) IBM version 26. This study also added a graph in the form of a simple scatter plot to observe the increase in the correlation of each variable using a linear regression equation.

### *Ethical Approval*

This study was approved by the Ethics Committee for Research Involving Human Subjects, Faculty of Public Health, Hasanuddin University (number: 663/UN4.14.1/TP.01.02/2024). This study complied with the principles of the Declaration of Helsinki since 1964 (last revised in Finland 2024) regarding research on human subjects[21].

## RESULT

This study was conducted on early adult female subjects aged 19-27 years, which is the reproductive age period. As many as 105 have patients met the inclusion criteria. As shown in Table 1, the majority of participants fell into the underweight BMI category (28.6%). Interestingly, as much as 45.7% had excess BMI status when accumulated from the total overweight (27.6%) and obesity (18.1%). This indicates that there is a double burden of malnutrition, in which undernutrition occurs simultaneously with overnutrition and obesity.

Table 1 also shows that the majority of the subjects had excess fat (44.8%), although visceral fat was still largely within normal conditions (83.8%). However, considering the wide range between the values, there were still some subjects with high visceral fat levels. In addition, the cellular age of the subjects showed that most fell into the category that did not correspond to their chronological age (58.1%) and most subjects have a BMR of less than 1200 calories (58.1%). This may indicate that almost most of the subjects did not have a healthy body.

Table 2 shows the results of the bivariate correlation analysis conducted on each variable. Based on the normality test, most of the data did not follow a normal distribution in the Kolmogorov-Smirnov test, only the body fat percentage data followed a normal distribution with a p-value of 0.200 ($p > 0.05$) (Table 1); therefore, the data were analyzed using the spearman rho correlation test. The test results show that all the variables are significant ($p < 0.05$), which means that all the variables are correlated. The r values showed a strong positive correlation in succession for body fat at r=0.724, visceral fat at r=0.941, cell age at r=0.949, and BMR at r=0.898 with BMI. Graphical explanations are shown in Figure 1 in the form of scatter plots for each variable.

For all variables in figure 1 part (a), (b), (c), and (d), the coefficient of determination ($R^2$) was calculated based on the correlation coefficient. The $R^2$ values indicate the extent to which BMI, as the independent variable, explains the variation

**Tabel 1.** Distribution of subjects based on Body Mass Index (BMI), Body Fat, Visceral Fat, Cell Age, and Basal Metabolic Rate (BMR) (n=105)

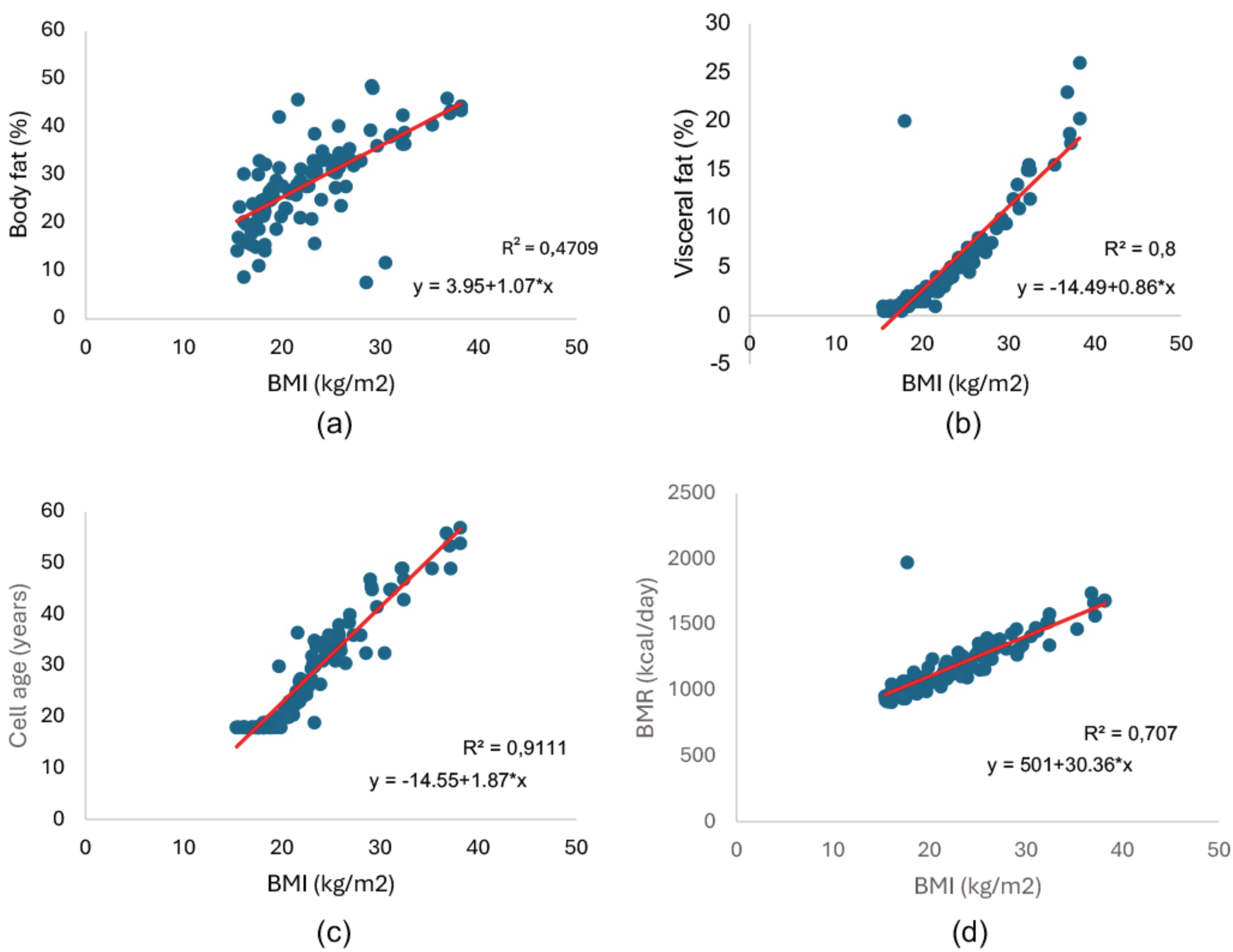
| Variable of Category | n | % | Mean± SD | Interval | Kolmogorov-Smirnov Test |
|---|---|---|---|---|---|
| BMI | | | 22.96±5.64 | 15.4-38.20 | 0,011 |
| *Underweight* | 30 | 28.6 | | | |
| Normal | 27 | 25.7 | | | |
| *Overweight* | 29 | 27.6 | | | |
| Obese | 19 | 18.1 | | | |
| Body fat | | | 28.48±8.83 | 7.7-48.65 | 0.200* |
| Low | 20 | 19.0 | | | |
| Normal | 38 | 36.2 | | | |
| High | 47 | 44.8 | | | |
| Visceral Fat | | | 5.08±5.39 | 0.50-26.00 | <0.001 |
| Normal | 88 | 83.8 | | | |
| High | 17 | 16.2 | | | |
| Cell age | | | 28.28±11.01 | 18-57 | <0.001 |
| ≤ chronological age | 44 | 41.9 | | | |
| > chronological age | 61 | 58.1 | | | |
| BMR | | | 1198.07±203.46 | 913.5-1976 | 0.001 |
| <1200 kkal/day | 61 | 58.1 | | | |
| 1200-1300 kkal/day | 17 | 16.2 | | | |
| >1300 kkal/day | 27 | 25.7 | | | |

Based on: Primary data, 2025, * Data has a normal distribution.

**Tabel 2.** Results of the Correlation Test Between Total Fat Percentage, Visceral Fat Percentage, Cell Age, and Basal Metabolic Rate (BMR) with Body Mass Index (BMI)

| Variabel | BMI | | Explanation |
|---|---|---|---|
| | ***p-value*** | ***r*** | |
| Body Fat (%) | <0.001* | 0.724 | Strong positive statistical corellation |
| Visceral Fat (%) | <0.001* | 0.941 | Strong positive statistical corellation |
| Cell Age (years) | <0.001* | 0.949 | Strong positive statistical corellation |
| BMR (kcal/day) | <0.001* | 0.898 | Strong positive statistical corellation |

* Spearman rho test, significant if the p <0.05.




A positive correlation coefficient indicates a direct relationship, meaning that higher BMI values are associated with increases in these body composition parameters.

**Figure 1.** Scatter plots were used to illustrate the strong positive correlations between BMI and (a) body fat percentage, (b) visceral fat, (c) cell age, and (d) BMR

in the dependent variables, namely total body fat, visceral fat, cell age, and BMR. In addition, regression analysis was performed using the equation Y = a + bX to predict the values of the dependent variables based on BMI.

In Figure 1 part (a), a constant value of 3.95 and an IMT regression coefficient of 1.07 were obtained, which means that every 1 IMT increase will increase the body fat percentage by (3.95+1.07*1). A positive coefficient indicated a positive relationship between the percentage of body fat and BMI. The higher the body fat percentage, the higher is the BMI. The coefficient of determination ($R^2 = 0.471$) indicates that 47.1% of the variation in body fat percentage can be explained by BMI, while the remaining 52.9% may be attributed to other factors not included in the model. The moderate strength of this correlation highlights the influence of BMI as a predictor, though not the sole determinant, of body fat percentage. This condition was also the same for visceral fat (b), cell age (c), and BMR (d) with BMI.

## DISCUSSION

This study found that BMI had a strong positive correlation with body fat percentage, visceral fat composition, cell age, and BMR in 105 participants. BMI is the easiest way to estimate a person's nutritional status; therefore, it can be used as a control for a person's lifestyle. Measurement using this method is very simple and can be used in large-scale population studies. However, excess body mass indeks (BMI) is not always associated with excess body and visceral fat. This is evidenced by the initial screening results showing that there are several subjects with excess BMI, but body and visceral fat tend to be normal or even low. This phenomenon occurs because of the non-exercise activity thermogenesis (NEAT) factor.

NEAT is an important component of daily energy expenditure. It represents common daily activities, such as fidgeting, walking, and standing, cooking, cleaning, gardening, typing, and checking social media. Even high-effort NEAT movements result in an expenditure of up to 2000 extra kcal per day beyond the basal metabolic rate, depending on the body weight and activity level[22].

Therefore, this study provides a basis for screening for overweight and obesity in addition to the inclusion criteria for long-term interventions that need to check total and visceral fat, in addition to using BMI to obtain more accurate information. The results of study Kurniawan et al. (2018) even showed that body fat and visceral fat measurements were stronger predictors of insulin resistance in obesity than BMI and waist circumference[23]. Likewise, a study by Agustiyawan et al. (2025) showed that there was a significant positive association between body fat and visceral fat with the risk of heart disease[14].

Table 1 shows that 44.8% of the subjects had high body fat, but visceral fat was relatively normal (83.8%). This is because the subjects in this study were early adults and post-productive women with an age range of 19-27 years. In this age range, there is a tendency to store more fat in the subcutaneous area than in the visceral area, mainly due to differences in fat distribution influenced by estrogen, compared with men. Therefore, although the overall body fat increased, visceral fat was maintained at a lower level, indicating that health risks related to visceral fat may remain low in some cases.

Fats in the body are lipoproteins that contain triglycerides, phospholipids and cholesterol combined with proteins. The types of lipids that exist in the body are high-density lipoprotein (HDL), low-density liproprotein (LDL), veri low-density lipoprotein (VLDL), and glycolipids. Excess fat in the body will interfere with the control of the hypothalamic-pituitary axis, affects visceral fat and circulating fat, interferes with the activity of various regulators such as enzymes and hormones, and affects various intermediate mediators such as increased proinflammatory cytokines. These conditions cause chronic inflammation and will cumulatively reduce organ function[15].

This study showed that there was a strong positive correlation between body fat ($r = 0.724$) ($p <0.001$) and visceral ($r = 0.941$) ($p <0.001$) fat (Table 2 and Figure 1) with BMI. Subjects with visceral fat in this study were more obese than those with overweight. Individuals with obesity tend to have excess visceral fat. Visceral fat can also affect the size of the abdominal circumference, such that a higher percentage of visceral fat will increases the risk of developing central obesity.

Several studies have shown that in adult women after the age of 30 years, factors such as decreased metabolism, hormonal changes (such as decreased estrogen and testosterone), decreased physical activity, as well as stress factors and unhealthy diet, all contribute to increased visceral fat. Visceral fat is more risky than subcutaneous fat due to its association with various metabolic syndrome health problems such as diabetes, cardiovascular disease, hyperlipidemia, and hypertension. Visceral fat tends to increase with age until menopause[24]. Research Gotera et al. (2024) in the age range of 26-48 years showed that visceral fat was positively correlated with fasting blood glucose ($r = 0.326$) ($p <0.001$), LDL ($r = 0.251$) ($p = 0.007$), triglyseride ($r = 0.47$) ($p <0.001$), and negatively correlated with HDL ($r = -0.446$) ($p <0.001$)[15]. Research Muhdar et al. (2025) showed that 42.20% of late adult female subjects with an age range 60-69 years were obese with an increase in visceral fat (>10%) as much as 37% [25]. Thus, visceral fat increases with age and triggers an increase in various metabolic syndrome health problems.

Visceral fat in the abdominal region is a predominant risk factor for metabolic syndrome and can lead to future health costs if not prevented early. Visceral fat deposits are associated with the formation of enlarged and dysfunctional adipose tissue. This dysfunctional adipose tissue secretes proinflammatory biomarkers such as prostaglandins, C-reactive protein (CRP), and cytokines such as interleukin-interleukin (interleukin-6), tumor necrosis factor alpha (TNF-α) and leptin. These inflammatory mediators contribute to the development of type 2 diabetes, hyperlipidemia, and cardiovascular diseases later in life[15].

In addition to body and visceral fat, this study also tested the correlation between cell age and BMI. Cell age is part of the body composition results obtained through the Bioelectrical Impedance Analyzer (BIA). This feature reflects overall body composition and physical health, not direct cellular age. This study involved subjects who did not engage in regular physical activity, which may have influenced the relationship between BMI and cellular aging. Nonetheless, the results offer a foundation for further research on the aging process in individuals who develop fat-related disorders later in life, particularly with the support of appropriate analytical tools. Table 1 shows that most participants at cell age were older than their chronological age (58.1%). The results of the correlation test of cell age with BMI also showed that there was a strong correlation (r = 0.949) (p <0.001) (Table 2 and Figure 1); incicating that high body fat, including visceral fat, contributes positively to increased oxidative stress, chronic inflammation, and metabolic disorders, all of which accelerate cellular aging. These processes exacerbate damage to body cells, shorten telomeres and impair the function of vital organs. The higher the excess body fat, the more likely the body is to experience faster biological aging and an increased risk of various age-related diseases such as diabetes, heart disease, and other metabolic disorders. This is also in accordance with research Munawaroh et al. (2021), who found a significant relationship between cell age and BMI[16].

The results of a meta-analysis Lin et al. (2021) showed that overweight or obese children have shorter telomere length than normal weight children (SMD: -0.85; 95% CI: -1.42 to -0.28; p <0.01)[26]. Thus, cellular responses triggered by excessive consumption are thus responsible for the increasing the rate of aging. Foods high in macronutrients such as carbohydrates and fats are likely to be the toxic effects of excess consumption. Consequently, obesity is a side effect of excessive food consumption status and the fulcrum is the cellular nutrient-sensing pathway. Numerous studies have shown that dietary components have the potential to reverse epigenetic changes associated with aging and influence cellular age. These findings open promising opportunities for the development of future anti-aging therapies[27]. In addition to dietary improvements, managing physical activity levels is essential. However, the interplay between caloric intake and physical activity is complex and warrants further research to fully understand its impact on overall health[28].

In this study, the subjects' BMR was tested which is also obtained from the BIA results. BMR values were empirically categorized into three groups (<1200, 1200–1300, and >1300 kcal/day) based on the observed distribution of BMR among the participants. This categorization aimed to estimate the body's energy expenditure at complete rest. It was not based on standardized clinical cutoffs but was developed as a data-driven approach. Interestingly, these groupings also reflect commonly cited BMR ranges in healthy adult women as estimated by the Mifflin-St Jeor equation, which supports their physiological plausibility[19]. The results showed that most subjects had a BMR <1200 kcal/day (58.1%), which is in line with the underweight results found in BMI (28.9%) (Table 1). Interestingly, the spearman rho test showed a strong correlation between BMR and BMI (r = 0.898) (p <0.001) (Table 2 and Figure 1), indicating that the higher the BMI, the higher the BMR, especially in people who are larger and have more body tissue. To the best of our knowledge, this stratification approach has not been widely used in previous studies. The observed association between higher BMR categories and increased BMI may reflect the known physiological relationship between lean body mass and basal energy expenditure. Given that BMR is primarily determined by fat-free mass, this classification may serve as a novel framework for interpreting variations in metabolic health within a population.

In obese people, a higher amount of body fat requires more energy to maintain, which can lead to a higher BMR compared to that in leaner individuals. This means that the body works harder to maintain body balance in individuals with more body fat. In addition, in larger people, even though body weight is mostly composed of fat, a larger amount of body tissue overall requires more energy to support daily body functions. However, despite a higher BMR, other factors such as lack of physical activity and body composition (fat vs. muscle), can affect total energy expenditure. Explained that the comparison of energy expenditure between non-obese and obese individuals, the results showed different behaviors in obese individuals. However, the specific energy expenditure component (rest, activity or food thermogenesis) that plays a major role in creating this difference is yet to be identified. Thus, more complex energy-related studies are required[29].

This suggests that health monitoring from early adulthood is essential to prevent further increases in metabolic risk later in life. Positive lifestyle changes such as regular aerobic and resistance exercise programs and/or a healthy diet with calorie restriction, can positively affect endocrine and metabolic function and act as preventative measures against various age-related diseases[30].

### *Limitations*

This study has several limitations. The total number of participants was determined using consecutive sampling rather than probability-based sampling methods, meaning the subjects were not selected to represent the broader population. Data collection was conducted at a single time point, involving only individuals who met the inclusion criteria and were present at the research site, thus eliminating the risk of participant attrition during the study period. As this study served as an initial screening for future clinical research, consecutive sampling was chosen to facilitate subject selection for subsequent phases. To ensure data homogeneity, participants were recruited from a similar academic and geographical background specifically, students and recent alumni from a university located in Maros Regency. BMI measurements were obtained using the same device, the Omron Karada Scan Body Composition Monitor. To ensure measurement validity, manual calculations were also performed to cross-verify the BMI values automatically generated by the BIA tool. This procedure was intended to distinguish between the anthropometric variables namely BMI and body composition and also to minimize redundancy and potential overlap in the data analysis process.

## CONCLUSION

This study shows that there is a strong correlation between body fat percentage, visceral fat composition, cell age, and BMR, and BMI. Interestingly, the screening results showed a complicated situation, in that underweight and overweight subjects were almost comparable. This suggests that there is a double burden of malnutrition, with undernutrition occurring at the same time as overnutrition and obesity, and that health monitoring from early adulthood is essential to prevent further increases in metabolic risk later in life. Positive lifestyle changes such as regular aerobic and resistance exercise programs and/or a healthy diet with calorie restriction can positively affect endocrine and metabolic function and act as preventative measures against many age-related diseases.

## ACKNOWLEDGMENTS

The authors extend their gratitude to the Indonesian Education Scholarship (*Beasiswa Pendidikan Indonesia*), Center for Higher Education Funding and Assessment the Indonesia (*Pusat Pelayanan Pembiayaan dan Asesmen Pendidkan Tinggi*), and Endowment Fund for Education (*Lembaga Pengelola Dana Pendidikan*), Ministry of Finance of Republic Indonesia for awarding the scholarship [ID Number 202101130755].

## REFERENCES

1. Poobalan A, Aucott L. Obesity Among Young Adults in Developing Countries: A Systematic Overview. Curr Obes Rep. 2016;5(1):2–13. https://doi.org/10.1007/s13679-016-0187-x

2. Almoraie NM, Saqaan R, Alharthi R, Alamoudi A, Badh L, Shatwan IM. Snacking patterns throughout the life span: potential implications on health. Nutr Res. 2021;91:81–94. https://doi.org/10.1016/j.nutres.2021.05.001

3. Jéssika Maria Silva VDLM, Silva VM dos S, Martins IC de V, Augusto De Andrade ES, Borba MJ de O. Clinical and nutritional aspects in high-risk pregnant women interned in a reference center in Recife, Pernambuco. Nutr Clínica Dietética Hosp. 2022; 42(3):122–30. https://doi.org/10.12873/423maria

4. Marielle Priscila De Paula Silva Lalucci, Déborah Cristina De Souza Marques, Isabella Caroline Santos, Jéssica Zirondi Caitano, Bruno Ferrari Silva, Pablo Valdés-Badilla, et al. Interrelationship among body mass index, body composition, and biochemical profiles of overweight adolescents in south of Brazil: A cross-sectional study. Nutr Clínica Dietética Hosp. 2023;43(1):31–8. https://doi.org/10.12873/431silva

5. [WHO] World Health Organization. Obesity and overweight. WHO [Internet]. 2021; Available from: https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight

6. [UNICEF] United Nations Children's Fund. Analisis Lanskap Kelebihan Berat Badan dan Obesitas di Indonesia. UNICEF [Internet]. 2022; Available from: https://www.unicef.org/indonesia/id/gizi/laporan/analisis-lanskap-kelebihan-berat-badan-dan-obesitas-di-indonesia

7. [Balitbangkes] Badan Penelitian dan Pengembangan Kesehatan. Laporan Nasional Riskesdas 2018. Jakarta: Kemenkes RI [Internet]. 2019. https://repository.badankebijakan.kemkes.go.id/id/eprint/3514/

8. [Balitbangkes] Badan Penelitian dan Pengembangan Kesehatan. Laporan Hasil Riset Kesehatan Dasar 2013. Jakarta: Kemenkes RI [Internet]. 2013; Available from: https://repository.badankebijakan.kemkes.go.id/id/eprint/4428/

9. [DSF] Decentralization Support Facility. Indonesia's Intergovernmental Transfer: Response on Future Demographic and Urbanization Shift. Jakarta: The Minister of Finance, Republic of Indonesia [Internet]. 2011; Available from: https://documents1.worldbank.org/curated/en/548511468260133592/pdf/684550ESW0P11900Urbanization0shifts.pdf

10. Obradovic M, Sudar-Milovanovic E, Soskic S, Essack M, Arya S, Stewart AJ, et al. Leptin and Obesity: Role and Clinical Implication. Front Endocrinol. 2021;12:585887. https://doi.org/10.3389/fendo.2021.585887

11. Sumadewi KT. Korelasi Antara Kadar Leptin dengan IMT, Lingkar Pinggang dan RLPP pada Orang Dewasa Obesitas Usia 19-25 Tahun di Universitas Warmadewa. WMJ Warmadewa Med J. 2017;1(2):71. https://doi.org/10.22225/wmj.1.2.30.71-82

12. Gadekar T, Dudeja P, Basu I, Vashisht S, Mukherji S. Correlation of visceral body fat with waist–hip ratio, waist circumference and body mass index in healthy adults: A cross sectional study. Med J Armed Forces India. 2017;76(1):41–6. https://doi.org/10.1016/j.mjafi.2017.12.001

13. Gotera W, Aristian O, Nugraha IBA, Suastika K, Budhiarta AAG, Saraswati MR, et al. Korelasi lemak viseral sebagai penanda obesitas sentral pada pemeriksaan body impendance analysis dengan serum profil lipid dan kadar gula puasa. J Penyakit Dalam Udayana. 2024;8(1):1–6. Available from: https://www.jpdunud.org/index.php/JPD/article/view/214

14. Agustiyawan A, Wibisono H, Azahra RM, Siregar HJ, Ghani G, Rifanty AP. Pemanfaatan Bioelectrical Impedance Analysis (BIA)

untuk Pengukuran Body Fat dan Visceral Fat yang Terasosiasi pada Resiko Penyakit Jantung. Malahayati Nurs J. 2025;7(3): 1123–30. https://doi.org/10.33024/mnj.v7i3.18378

15. Susantini P. Hubungan Indeks Masa Tubuh (IMT) dengan Persen Lemak Tubuh, dan Lemak Viscelar di Kota Semarang. J Gizi. 2021;10(1):51. https://doi.org/10.26714/jg.10.1.2021.51-59
16. Munawaroh MM, Wijayanti W, Fatimah OZS. Komposisi Lemak Viseral, Basal Metabolic Rate (BMR), Dan Usia Sel Terhadap Indeks Masa Tubuh (IMT) Pada Remaja. J Untuk Masy Sehat JUKMAS. 2021;5(1):110–9. https://doi.org/10.52643/jukmas.v5i1.1120
17. Nishida C. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. The Lancet. 2004;363(9403):157–63. https://doi.org/10.1016/S0140-6736(03)15268-3
18. Molz P, Da Silva TG, Schlickmann DDS, Steffens JP, Colombelli RAW, Franke SIR. Influence of different categories of supplements on the body composition of resistance-training practitioners. Nutrition. 2023;105:111816. https://doi.org/10.1016/j.nut.2022.111816
19. Mifflin M, St Jeor S, Hill L, Scott B, Daugherty S, Koh Y. A new predictive equation for resting energy expenditure in healthy individuals. Am J Clin Nutr. 1990;51(2):241–7. https://doi.org/10.1093/ajcn/51.2.241
20. Dancey CP, Reidy J. Statistics without maths for psychology. Seventh Edition. Harlow, England London New York Boston San Fancisco Toronto Sydney Dubai Singapore Hong Kong Tokyo Seoul Taipei New Delhi Cape Town São Paulo Mexico City Madrid Amsterdam Munich Paris Milan: Pearson; 2017;609 p.
21. World Medical Association (WMA). WMA Declaration of Helsinki - Ethical Principles for Medical Research Involving Human Participants. 2024; Available from: https://jamanetwork.com/journals/jama/fullarticle/1760318
22. Villablanca PA, Alegria JR, Mookadam F, Holmes DR, Wright RS, Levine JA. Nonexercise Activity Thermogenesis in Obesity Management. Mayo Clin Proc. 2015;90(4):509–19; Available from: https://www.mayoclinicproceedings.org/article/S0025-6196(15)00123-8/fulltext
23. Kurniawan L, Bahrun U, Hatta M, Arif M. Body Mass, Total Body Fat Percentage, and Visceral Fat Level Predict Insulin Resistance Better Than Waist Circumference and Body Mass Index in Healthy Young Male Adults in Indonesia. J Clin Med. 2018;7(5):96. https://doi.org/10.3390/jcm7050096
24. Mazza E, Troiano E, Ferro Y, Lisso F, Tosi M, Turco E, et al. Obesity, Dietary Patterns, and Hormonal Balance Modulation: Gender-Specific Impacts. Nutrients. 2024;16(11):1629. https://doi.org/10.3390/nu16111629
25. Muhdar IN, Riyadi H, Khomsan A, Jauhari M. Physical activity, percent body fat, visceral fat, ASMI, and blood pressure with obesity in indonesian older women: a cross-sectional study. Nutr Clínica Dietética Hosp. 2025;45(1):346–53. https://doi.org/10.12873/451muhdar
26. Lin L, Qin K, Chen D, Lu C, Chen W, Guo VY. Systematic review and meta-analysis of the association between paediatric obesity and telomere length. Acta Paediatr. 2021;110(10):2695–703. https://doi.org/10.1111/apa.15971
27. Salvestrini V, Sell C, Lorenzini A. Obesity May Accelerate the Aging Process. Front Endocrinol. 2019;10:266. https://doi.org/10.3389/fendo.2019.00266
28. Said I, Dodik Briawan, Meti Dwiriani C, Annisa Utami Seminar. Factors Associated to Body Mass Index (BMI) in adolescent in south Jakarta: Cross Sectional Study. Nutr Clínica Dietética Hosp. 2025 May 14;45(2):215–20. https://doi.org/10.12873/452briawan
29. Fonseca DC, Sala P, De Azevedo Muner Ferreira B, Reis J, Torrinhas RS, Bendavid I, et al. Body weight control and energy expenditure. Clin Nutr Exp. 2018;20:55–9. Available from: https://www.clinicalnutritionopenscience.com/article/S2352-9393(18)30008-3/fulltext
30. Pataky MW, Young WF, Nair KS. Hormonal and Metabolic Changes of Aging and the Influence of Lifestyle Modifications. Mayo Clin Proc. 2021;96(3):788–814. Available from: https://www.mayoclinicproceedings.org/article/S0025-6196(20)30922-8/fulltext