



## Description of Student Body Composition Based on Bioelectrical Impedance Analysis (BIA)

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### ABSTRACT

Modern lifestyle changes, particularly among university students, have led to decreased physical activity and increased health risks related to body composition. While Body Mass Index (BMI) is commonly used to assess nutritional status, it does not adequately reflect the distribution of body fat and muscle mass. Therefore, more comprehensive methods such as Bioelectrical Impedance Analysis (BIA) are needed to provide accurate health assessments. This study aimed to describe the body composition profile of university students using the OKOK application integrated with a Digipounds digital scale. A quantitative descriptive design was employed involving 24 students selected through total sampling. Body composition measurements included BMI, body fat percentage, muscle mass, and bone mass using BIA technology. Data were analyzed using descriptive statistics (mean, standard deviation, minimum–maximum) and categorical distribution. The results showed that the average BMI was 20.42, with 62.5% of participants classified as normal, 20.8% overweight, and 16.7% underweight. Most students had normal body fat levels (54.2%), while 20.8% were categorized as high. Muscle mass was generally normal (50.0%), with 29.2% high and 20.8% low. Cross-tabulation analysis revealed that some students with normal BMI had high body fat percentage, indicating the presence of normal weight obesity. In conclusion, BMI alone is insufficient to represent overall health status, whereas BIA-based digital assessment provides more comprehensive and accurate body composition data. These findings highlight the importance of regular body composition monitoring to support early health detection among university students.

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A. Conception and design of the study;  
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## INTRODUCTION

In recent decades, rapid modernization has significantly altered human lifestyles, particularly among university students. The increasing reliance on digital technologies, prolonged academic demands, and reduced engagement in physical activities have contributed to a predominantly sedentary lifestyle (Alamsyah & Akkase, 2025). This behavioral shift has raised serious concerns regarding health status, especially in



relation to body composition. Body composition, which refers to the proportion of fat mass, lean mass, and bone mass, serves as a critical indicator of physical fitness and overall health (World Health Organization, 2020).

Traditionally, Body Mass Index (BMI) has been widely used as a simple and practical tool to assess nutritional status and categorize individuals into underweight, normal weight, overweight, or obese groups. However, despite its widespread application, BMI has substantial limitations. It does not differentiate between fat mass and lean mass, resulting in potential misclassification of individuals with high muscle mass or varying body compositions (Nuttall, 2015). Consequently, individuals with identical BMI values may present significantly different physiological profiles, leading to inaccurate health assessments. This limitation highlights the need for more comprehensive and precise methods for evaluating body composition. Among the available techniques, Bioelectrical Impedance Analysis (BIA) has emerged as a practical, non-invasive, and efficient approach. BIA enables the estimation of multiple body composition components, including body fat percentage, muscle mass, and total body water, by measuring the resistance of body tissues to electrical currents (Heymsfield et al., 2016). With advancements in technology, BIA devices are now integrated into digital scales and mobile applications, allowing real-time monitoring and easier accessibility for users. Despite these technological advancements, many university students remain unaware of their body composition status. This lack of awareness is concerning, given that the student population is in a transitional phase characterized by significant physical, psychological, and behavioral changes (Pengpid et al., 2015). Poor lifestyle habits, such as irregular eating patterns, low physical activity levels, and insufficient health monitoring, can lead to unfavorable body composition profiles, increasing the risk of non-communicable diseases in the future. Therefore, there is a pressing need to conduct research that provides a detailed description of student body composition using more advanced and accurate methods such as BIA. Such studies are essential for promoting early detection, prevention strategies, and health awareness among students.

Recent developments in health technology have revolutionized the assessment and monitoring of body composition. Bioelectrical Impedance Analysis (BIA) has gained popularity due to its practicality, affordability, and ability to provide multi-component body composition data (Moon, 2013). Compared to traditional anthropometric measurements, BIA offers a more comprehensive evaluation by distinguishing between fat mass, fat-free mass, and hydration status. Furthermore, the integration of BIA devices with digital platforms and smartphone applications has enhanced user engagement and accessibility. These technologies allow individuals to track their health metrics over time, facilitating better self-awareness and health management (Bardus et al., 2016). Studies have shown that digital health applications can significantly improve health behaviors by providing personalized feedback and promoting self-monitoring practices. In addition, global research trends emphasize the importance of body composition assessment over BMI alone. Contemporary studies have demonstrated that body fat percentage and muscle mass are more accurate predictors of metabolic health, cardiovascular risk, and physical performance (Ng et al.,

2014). This shift reflects a broader movement toward precision health, where individualized data plays a central role in health evaluation and intervention. Among student populations, several studies have explored the relationship between lifestyle behaviors and body composition. Findings consistently indicate that low physical activity levels and unhealthy dietary habits are associated with increased body fat percentage and reduced muscle mass. However, many of these studies still rely heavily on BMI as the primary measurement tool, limiting the depth of analysis. Moreover, technological advancements in wearable devices and smart health systems have opened new opportunities for continuous health monitoring. These innovations align with the growing emphasis on preventive healthcare, particularly among young adults. Nevertheless, the application of such technologies in academic research, especially within developing countries, remains relatively limited.

Despite the increasing recognition of the importance of body composition analysis, several critical gaps remain in the existing literature. First, most studies conducted in Indonesia and similar contexts still predominantly utilize BMI as the main indicator of health status. This reliance on BMI fails to capture the complexity of body composition and may lead to incomplete or misleading conclusions. Second, although BIA technology is widely available and increasingly affordable, its utilization in academic research involving university students is still limited. Few studies have comprehensively described student body composition using BIA-based measurements integrated with digital applications. This gap indicates a lack of empirical data that reflects the true physiological condition of students. Third, there is insufficient research focusing on the descriptive profiling of body composition among students using modern technological approaches. Existing studies often emphasize correlations or interventions rather than providing a detailed baseline description of body composition characteristics. Such descriptive data are crucial for developing targeted health programs and interventions. Additionally, the potential of digital health technologies in enhancing awareness and promoting healthy behaviors among students has not been fully explored. While digital tools offer significant advantages in terms of accessibility and real-time monitoring, their effectiveness in academic and research settings requires further investigation. Finally, factors affecting the accuracy of BIA measurements, such as hydration status, time of measurement, and individual variability, are often overlooked. This limitation underscores the need for careful interpretation and standardized measurement procedures in research applications.

Based on the identified problems and research gaps, this study aims to describe and analyze the body composition of university students using Bioelectrical Impedance Analysis (BIA) integrated with digital applications. Specifically, the study seeks to provide a comprehensive overview of body fat percentage, muscle mass, and other body composition components among students. The novelty of this research lies in several key aspects. First, it adopts a technology-based approach by utilizing BIA devices integrated with digital applications, enabling more accurate and comprehensive measurements compared to traditional methods. Second, this study focuses on a descriptive analysis, providing a detailed baseline profile of student body composition,

which is often lacking in previous research. Third, it emphasizes the integration of health technology and behavioral awareness, highlighting the role of digital tools in promoting self-monitoring and preventive health practices. Furthermore, this research contributes to the advancement of knowledge in sports science and health by bridging the gap between traditional anthropometric assessments and modern technological approaches. The findings are expected to serve as a reference for developing evidence-based interventions aimed at improving student health and fitness.

In conclusion, the shift toward sedentary lifestyles among university students necessitates more accurate and comprehensive methods for assessing health status, particularly body composition. While BMI remains widely used, its limitations underscore the importance of adopting advanced techniques such as BIA. The integration of digital technology further enhances the potential for effective health monitoring and awareness. However, the limited application of BIA-based assessments in student populations, particularly within the Indonesian context, highlights a significant research gap. Therefore, this study provides a timely and relevant contribution by offering a detailed description of student body composition using modern technological tools. Ultimately, the findings are expected to support the development of preventive strategies and promote healthier lifestyles among students.

## **METHODS**

This study employed a quantitative descriptive research design aimed at providing an objective profile of student body composition based on measurements obtained through Bioelectrical Impedance Analysis (BIA). A descriptive approach was selected because the study did not seek to test causal relationships or hypotheses, but rather to systematically describe the physiological characteristics of the participants in a measurable and statistically interpretable manner (Weyant, 2022). Descriptive quantitative designs are widely used in health and sports science research to establish baseline data that can inform future interventions and comparative studies.

The population of this study consisted of students enrolled in the Sports Science program. A total sampling technique was applied, meaning that all individuals who met the inclusion criteria were selected as participants. This approach ensures comprehensive representation of the population and minimizes sampling bias, particularly in studies with relatively small populations (Etikan et al., 2016). A total of 24 students participated in this study. Inclusion criteria included: (1) active student status, (2) willingness to participate voluntarily, and (3) absence of medical conditions that could significantly influence body composition measurements, such as metabolic disorders or acute illness. These criteria are consistent with standard procedures in body composition research to ensure measurement validity (Kyle et al., 2016).

The primary instrument used in this study was a Digipounds digital scale integrated with the OKOK smartphone application, which utilizes Bioelectrical Impedance Analysis (BIA) technology. BIA is a non-invasive and widely validated method for estimating body

composition by measuring the resistance of body tissues to a low-level electrical current (Moon, 2013; Sergi et al., 2015). This method allows for the estimation of multiple variables, including Body Mass Index (BMI), body fat percentage, muscle mass, and bone mass, which are considered key indicators of physical health and fitness (Heymsfield et al., 2016). The integration with a mobile application enhances data accessibility, storage, and monitoring, reflecting current trends in digital health technology (Bardus et al., 2016).

Data collection was conducted in a single measurement session following standardized procedures to ensure reliability. Prior to measurement, participants were provided with a clear explanation of the study objectives and measurement protocols, and informed consent was obtained. Participants' height was measured using a conventional stadiometer, after which body composition was assessed using the BIA device. During measurement, participants were instructed to stand barefoot on the digital scale in a relaxed and upright position. Standardization of measurement conditions is crucial in BIA assessments, as factors such as hydration status, recent physical activity, and posture can influence impedance readings (Ling et al., 2011; Lukaski, 2017).

All measurement results were automatically recorded and displayed via the OKOK application, ensuring accuracy and minimizing manual recording errors. The collected data were then compiled into a structured dataset for analysis. Data analysis was performed using descriptive statistical techniques with the assistance of statistical software. The results were presented in terms of mean, standard deviation, minimum, and maximum values to provide a comprehensive overview of the distribution of each variable (Field, 2018). Additionally, categorical classifications were applied, particularly for BMI, based on established international standards to enhance interpretability and contextual relevance (World Health Organization, 2020). Descriptive statistical analysis is essential in identifying patterns and variations within the data, thereby supporting a clearer understanding of the body composition profile of the participants (Creswell & Creswell, 2018).

## RESULTS AND DISCUSSION

### Result

This study involved 24 university students whose body composition was measured using the OKOK application integrated with a Digipounds digital scale based on Bioelectrical Impedance Analysis (BIA). The variables analyzed included age, height, Body Mass Index (BMI), body fat percentage, muscle mass, and bone mass.

### Descriptive Statistics of Body Composition

**Table 1.**  
Descriptive Statistics of Student Body Composition

Variable	Mean	SD	Min	Max
Age (years)	18.4	0.5	18	19
Height (cm)	164.16	6.21	152	178
BMI	20.42	2.63	16.4	26.7
Body Fat (%)	13.72	5.81	5.0	28.3
Muscle Mass (%)	80.74	8.92	53.4	93.0
Bone Mass (kg)	2.21	0.39	1.00	2.79

Based on Table 1, the average age of respondents was 18.4 years, indicating that all participants were in the late adolescent stage. The mean height was 164.16 cm, showing moderate variation among individuals.

The average BMI of 20.42 suggests that, in general, the respondents were within the normal weight category. However, the minimum (16.4) and maximum (26.7) BMI values indicate variability, with some participants classified as underweight and others as overweight.

The mean body fat percentage was 13.72%, with a wide range (5.0%–28.3%), indicating substantial variation in fat distribution among participants. Meanwhile, muscle mass averaged 80.74%, with considerable variability, reflecting differences in physical fitness levels.

In contrast, bone mass showed a relatively stable pattern, with a mean of 2.21 kg and a narrower range, suggesting that bone composition is less variable compared to other body components.

### BMI Category Distribution

**Table 2.**  
Distribution of BMI Categories

BMI Category	Frequency	Percentage
Underweight	4	16.7%
Normal	15	62.5%
Overweight	5	20.8%
Obese	0	0%

Table 2 shows that the majority of students (62.5%) were in the normal BMI category. However, 16.7% were underweight and 20.8% were overweight, indicating that not all students had an ideal nutritional status. This distribution highlights the heterogeneity of body weight conditions within the sample.

### Body Fat Percentage Distribution

**Table 3.**  
Distribution of Body Fat Percentage

Category	Frequency	Percentage
Low (<10%)	6	25.0%
Normal (10–20%)	13	54.2%
High (>20%)	5	20.8%

As shown in Table 3, the majority of respondents (54.2%) had normal body fat levels. However, 25.0% had low body fat, and 20.8% had high body fat, indicating potential health risks for a subset of participants. This variation suggests that BMI alone may not fully represent body composition status.

### Muscle Mass Distribution

**Table 4.**  
Distribution of Muscle Mass

Category	Frequency	Percentage
Low (<70%)	5	20.8%
Normal (70–85%)	12	50.0%
High (>85%)	7	29.2%

Table 4 indicates that 50.0% of respondents had normal muscle mass, while 29.2% were categorized as high and 20.8% as low. This distribution reflects differences in physical activity levels and fitness conditions among students. Higher muscle mass may indicate better engagement in physical training, while lower levels may reflect insufficient physical activity.

### Crosstab Analysis: BMI and Body Fat Percentage

**Table 5.**  
 Crosstabulation of BMI and Body Fat Percentage

BMI Category	Low Fat	Normal Fat	High Fat	Total
Underweight	3	1	0	4
Normal	3	9	3	15
Overweight	0	3	2	5
<b>Total</b>	<b>6</b>	<b>13</b>	<b>5</b>	<b>24</b>

The most notable finding is presented in Table 5, which illustrates the relationship between BMI and body fat percentage. Among participants classified as having normal BMI, there were still three individuals with high body fat levels.

This phenomenon indicates the presence of normal weight obesity, a condition where individuals have a normal body weight but an excessive body fat percentage. This condition is often undetected when BMI is used as the sole indicator of health status.

Overall, the findings reveal that although the majority of students fall within the normal BMI category, there is considerable variability in body composition components, particularly in body fat and muscle mass. The presence of individuals with high body fat despite normal BMI underscores the limitations of BMI as a standalone measure and highlights the importance of using more comprehensive methods such as BIA.

These results emphasize the need for increased awareness of body composition monitoring among students, as well as the integration of modern digital health technologies in assessing physical health more accurately.

### Discussion

The findings of this study provide important insights into the body composition profile of university students measured using Bioelectrical Impedance Analysis (BIA). Although the majority of respondents were categorized within the normal Body Mass Index (BMI) range (62.5%), further analysis revealed substantial variability in body fat percentage and muscle mass. This result reinforces the growing consensus in contemporary health research that BMI alone is insufficient to comprehensively represent an individual's physiological condition (Nuttall, 2015; Heymsfield et al., 2016).

The presence of individuals with normal BMI but elevated body fat percentage indicates the phenomenon known as normal weight obesity (NWO) or "skinny fat." This condition has been increasingly reported in recent studies and is associated with higher risks of metabolic syndrome, insulin resistance, and cardiovascular diseases despite a normal body weight (De Lorenzo et al., 2016; Oliveros et al., 2014). This finding is particularly relevant in young populations, as early detection of unfavorable body composition can contribute to preventive health strategies (Kim et al., 2019). As

demonstrated in this study, three respondents with normal BMI exhibited high body fat levels, confirming that BMI fails to differentiate between fat mass and lean body mass.

Conversely, the study also found that some individuals categorized as overweight did not necessarily exhibit high body fat percentages. This suggests that increased BMI values may be influenced by higher muscle mass rather than excessive fat accumulation. Similar findings have been reported by Ortega et al. (2016), who emphasized that physically active individuals may present higher BMI values due to increased muscle mass. This highlights the importance of using multi-component body composition analysis rather than relying solely on BMI classifications.

Muscle mass variation among respondents further supports the heterogeneity of physical fitness levels. Approximately 29.2% of participants were categorized as having high muscle mass, which may reflect higher engagement in physical activity or resistance training. Muscle mass plays a critical role in metabolic health, as it is directly associated with resting metabolic rate, glucose regulation, and functional capacity (Srikanthan & Karlamangla, 2011; Wolfe, 2017). Conversely, respondents with low muscle mass (20.8%) may be at risk of reduced metabolic efficiency and lower physical performance, which are often linked to sedentary lifestyles (Pedersen & Saltin, 2015).

The variation in body fat percentage observed in this study also reflects differences in lifestyle behaviors, particularly physical activity levels and dietary patterns. Students with normal or low body fat percentages are likely to maintain more active lifestyles and balanced nutritional intake. In contrast, those with higher body fat levels may be influenced by sedentary behavior, irregular eating patterns, and increased consumption of high-calorie foods (Pengpid et al., 2015; Keating et al., 2017). This aligns with global trends indicating that university students are increasingly exposed to lifestyle risk factors that negatively affect body composition (Guthold et al., 2018).

Interestingly, bone mass demonstrated relatively low variability compared to other body composition components. This stability is consistent with existing literature, which suggests that bone mass is largely influenced by long-term factors such as genetics, calcium intake, and sustained physical activity rather than short-term behavioral changes (Weaver et al., 2016; NIH, 2020). Weight-bearing exercises and adequate nutrient intake are known to play significant roles in maintaining bone health, particularly during early adulthood when peak bone mass is achieved (Bonjour et al., 2016).

The use of BIA-based digital technology, specifically the Digipounds scale integrated with the OKOK application, proved to be effective in providing a comprehensive assessment of body composition. This aligns with recent studies highlighting the growing role of digital health technologies in improving health monitoring and awareness (Piwek et al., 2019; Bardus et al., 2016). The integration of mobile applications allows users to track changes over time, facilitating self-monitoring and promoting behavioral changes toward healthier lifestyles (Patel et al., 2015).

However, despite its practicality, BIA technology has certain limitations that must be acknowledged. Measurement accuracy can be influenced by factors such as hydration status, recent physical activity, food intake, and time of measurement (Moon, 2013;

Lukaski, 2017). Therefore, while BIA provides valuable estimates of body composition, it should be interpreted cautiously and, when possible, complemented with other assessment methods such as dual-energy X-ray absorptiometry (DEXA) for higher precision (Kyle et al., 2017).

The findings of this study also highlight the importance of adopting a holistic approach to health assessment. The discrepancy between BMI and body fat percentage underscores the need for multi-dimensional evaluation tools. Modern health frameworks increasingly emphasize the integration of anthropometric, physiological, and behavioral indicators to provide a more accurate representation of individual health status (WHO, 2020; Ng et al., 2014).

From a practical perspective, the results of this study have significant implications for health promotion among university students. The identification of students with unfavorable body composition, despite normal BMI, suggests the need for targeted interventions focusing on physical activity enhancement, nutritional education, and lifestyle modification. Universities can play a strategic role in implementing structured health programs, including fitness assessments, exercise training, and digital health monitoring initiatives (Plotnikoff et al., 2015).

Furthermore, the accessibility and ease of use of BIA-based devices make them suitable for large-scale health screening in educational settings. This aligns with the increasing emphasis on preventive healthcare, where early identification of risk factors is crucial for reducing the burden of non-communicable diseases (Kohl et al., 2012; Lee et al., 2012).

In conclusion, this study demonstrates that body composition assessment using BIA provides a more comprehensive understanding of student health compared to BMI alone. The presence of normal weight obesity, variations in muscle mass, and differences in fat distribution highlight the complexity of body composition and the need for advanced assessment tools. The integration of digital health technologies offers a promising approach to improving health awareness and monitoring, particularly among young adults.

These findings reinforce the importance of promoting balanced physical activity, proper nutrition, and regular health monitoring among students. Future research is recommended to explore longitudinal changes in body composition and the effectiveness of intervention programs in improving student health outcomes.

## CONCLUSION

This study concludes that, in general, university students demonstrate a normal Body Mass Index (BMI) profile, with an average BMI of 20.42 and 62.5% of participants categorized within the normal range. However, a deeper analysis using Bioelectrical Impedance Analysis (BIA) through the OKOK application and Digipounds digital scale reveals substantial variability in body composition components, particularly in body fat percentage and muscle mass. The mean body fat percentage of 13.72% (ranging from

5.0% to 28.3%) and muscle mass average of 80.74% (ranging from 53.4% to 93.0%) highlight significant individual differences that are not captured by BMI alone.

Importantly, the study identifies the presence of normal weight obesity (NWO), where several students with normal BMI exhibit elevated body fat levels. Conversely, some overweight individuals do not necessarily have high body fat, indicating that increased BMI values may be influenced by higher muscle mass rather than fat accumulation. These findings confirm that BMI, as a single indicator, is insufficient to comprehensively represent an individual's health status.

The use of BIA-based digital technology provides a more detailed and practical approach to assessing body composition, enabling the measurement of multiple physiological components simultaneously. Despite its advantages, the results must be interpreted cautiously due to potential influences such as hydration status and measurement conditions.

Overall, this study emphasizes that technology-based body composition assessment offers a more comprehensive and accurate evaluation of health compared to BMI alone. Therefore, routine monitoring of body composition is strongly recommended, particularly among university students, as part of preventive health strategies. Promoting awareness of body composition not merely body weight can support healthier lifestyle behaviors and contribute to long-term physical well-being.

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