# Differences in subcutaneous fat composition and skeletal muscle mass between female and male college students

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**Abstract.** Differences in body composition between men and women have been the subject of extensive research in physiology, anthropometry, and sports medicine. This study aims to analyze the differences in body composition between male and female students using Bioelectrical Impedance Analysis (BIA) data. Data were collected from 33 students, consisting of 24 males and 9 females, aged 20–24 years. The parameters analyzed included the percentage of subcutaneous fat, skeletal muscle mass, visceral fat, BMI, and basal metabolism. The results show that women have more subcutaneous fat and less skeletal muscle mass than men, with a more even fat distribution and better insulin sensitivity. Men tend to have more muscle mass and less subcutaneous fat, with fat distribution more concentrated in the abdominal area. Overall, these findings strengthen our understanding of physiological differences influenced by hormonal and metabolic factors, and how fat distribution and muscle mass can affect a person's metabolic health. This study provides an important basis for an individualized approach to nutrition and exercise, to optimize athlete health and performance based on each individual's body characteristics.

## 1 Introduction

Body composition is defined as the proportions of the various components that make up total body mass, including fat mass, fat-free mass, skeletal muscle mass, total body water, and bone mass [1]. Body composition analysis is a fundamental component in assessing nutritional status, evaluating health, and monitoring health intervention programs. A thorough understanding of body composition is not only crucial for clinical diagnosis but also for developing disease prevention and health promotion strategies. Differences in body composition between men and women have been the subject of extensive research in physiology, anthropometry, and sports medicine. Sexual dimorphism in body composition begins at puberty and is maintained throughout life, influenced by hormonal, genetic, and environmental factors [2]. Men generally have greater skeletal muscle mass, higher bone density, and a lower percentage of body fat than women. Conversely, women physiologically have a higher percentage of body fat, particularly subcutaneous fat, as a biological adaptation for reproductive and hormonal functions. A recent meta-analysis involving 12,847 subjects, showed that women have an 8-13% higher body fat percentage than men across all BMI categories and age groups. This difference is not limited to fat quantity but also its distribution. Men tend to accumulate fat in the abdominal area (android pattern), while women store more fat in the hips and thighs (gynoid pattern) [3]. This differential fat distribution has significant metabolic and

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health implications. Bioelectrical Impedance Analysis (BIA) has become one of the most popular methods for assessing body composition in clinical and research settings. This technology is based on the principle that different body tissues have different electrical conductivity. Water and electrolytes in the body, which are mostly found in fat-free mass, are good conductors, while fat has a high resistance to electrical flow [4]. The validity of BIA has been confirmed through various studies comparing it with standard reference methods such as DEXA (Dual-energy X-ray Absorptiometry) and underwater weighing. The advantages of BIA lie in its ease of use, non-invasiveness, relative affordability, and rapid results. However, BIA accuracy can be influenced by various factors such as hydration status, physical activity prior to measurement, food consumption, and individual characteristics of the subject. Therefore, standardizing measurement protocols is crucial to obtain accurate and reproducible results. The college student population is an interesting group to study because they are in the transition phase from adolescence to young adulthood. This period is marked by significant lifestyle changes, including dietary patterns, physical activity, and sleep habits. Epidemiological studies indicate that college is often associated with weight gain and unfavorable changes in body composition. 70% of college students experience weight gain during their first year of college, with an average gain of 1.75 kg [5]. Research on body composition in the Indonesian college student population is still relatively limited, although this data is crucial for developing targeted health promotion programs. Differences in anthropometric characteristics and body composition between ethnicities have been widely reported in the literature. Therefore, research in local populations is highly relevant to understanding specific body composition profiles. Understanding differences in body composition by sex in the college student population has broad practical implications. This information can be used to design gender-specific health intervention programs, optimize campus sports and fitness programs, and develop effective strategies for preventing obesity and metabolic diseases. Furthermore, body composition data can serve as an important baseline for monitoring health changes throughout the study period. Although BIA technology has been widely used in body composition research, more data on specific populations is needed to validate and accurately interpret measurement results. Previous studies have shown that ethnicity, age, and gender can influence the accuracy of body composition predictions using BIA [6]. Based on this background, this study aims to analyze differences in body composition between male and female college students using Bioelectrical Impedance Analysis technology. Specifically, this study will explore differences in body fat percentage, skeletal muscle mass, regional fat distribution, visceral fat, and metabolic parameters between the two genders. The results of this study are expected to contribute to the understanding of the body composition characteristics of Indonesian college students and serve as a basis for the development of more effective campus health programs.

## 2 Research Method

This research method used a quantitative approach with a descriptive-comparative cross-sectional design. The study subjects consisted of 33 university students aged 20 to 24 years, consisting of 24 men and 9 women, who were purposively selected to represent the young adult population. Data collection was carried out through direct measurements using a Bioelectrical Impedance Analysis (BIA) device, which is a non-invasive method and has been proven valid and reliable in assessing body composition. Parameters measured included subcutaneous fat percentage (whole body, trunk, arms, and legs) and skeletal muscle mass (whole body and its segments). All measurements were conducted following standard BIA protocols, such as measurements at rest, before meals, and not in a dehydrated state or after strenuous activity, to minimize data variability. The obtained data were analyzed descriptively to determine the mean, standard deviation, and range of values for each parameter. Next, a comparative analysis between the male and female groups was conducted to identify significant differences in body composition. Inferential statistical tests, such as the independent sample t-test, were used to determine the significance of differences between groups. The results of this analysis were then used as the basis for developing recommendations for gender-based intervention programs to improve student health and fitness.

Primary data from direct measurements using Bioelectrical Impedance Analysis (BIA) on 36 university students. The research methodology is comprehensively explained, with clear research subjects, specific measurement procedures, and systematic data analysis. In the context of body composition research, several fundamental formulas relevant to this study include:

$$\text{BMI} = \text{Body Weight (kg)} / [\text{Height (m)}]^2$$

$$\text{FFM (kg)} = \sqrt{[(\text{Height}^2/R) \times (0.401 + 3.825 \times (\text{Male}=1, \text{Female}=0) + 0.071 \times \text{Age})]}$$

$$\text{FM (kg)} = \text{Total Body Weight} - \text{FFM}$$

$$\%\ \text{Body Fat} = (\text{FM} / \text{Total Body Weight}) \times 100\%$$

$$\text{RMR} = 88{,}362 + (13{,}397 \times \text{BW}) + (4{,}799 \times \text{HB}) - (5{,}677 \times \text{Age})$$

Where FFM is Fat Free Mass, FM is Fat Mass, R is bioelectrical resistance, BB is body weight in kg, and TB is height in cm. The results of the study are presented in the form of quantitative data with in-depth discussions, comparing the findings with relevant literature, and providing a logical interpretation of the differences in body composition between male and female students.

## 3 Results

This study aimed to compare subcutaneous fat distribution and skeletal muscle mass between female (n = 9) and male (n = 24) students across different body regions, including whole body, trunk, arms, and legs. The results are presented as mean values for each group, along with the differences between males and females (M–F).

| Variable | Female (n=9) | Male (n=24) | Difference (M–F) |
|---|---|---|---|
| Subcutaneous Wholebody | **25.43** | 13.40 | **-12.03** |
| Subcutaneous Trunk | **21.10** | 11.95 | **-9.15** |
| Subcutaneous Arm | **40.68** | 19.41 | **-21.27** |
| Subcutaneous Legs | **37.47** | 18.70 | **-18.77** |
| Skeletal Wholebody | 26.64 | **34.62** | **+7.98** |
| Skeletal Trunk | 21.67 | **29.62** | **+7.95** |
| Skeletal Arm | 28.79 | **39.96** | **+11.17** |
| Skeletal Legs | 39.23 | **52.15** | **+12.92** |

**Fig. 1.** Mean Differences in Subcutaneous Fat and Skeletal Muscle Mass

## 3.1 Subcutaneous Fat Distribution

The results demonstrated that female students exhibited higher levels of subcutaneous fat than male students across all measured body regions (Fig 1). For whole-body subcutaneous fat, females recorded a mean value of 25.43, whereas males showed a lower mean value of 13.40, resulting in a negative difference of −12.03 (M–F). This indicates a substantially greater accumulation of subcutaneous fat among female participants at the whole-body level. A similar pattern was observed in the trunk region, where females had a mean subcutaneous fat value of 21.10 compared to 11.95 in males, yielding a difference of −9.15. In the arm region, the disparity between sexes was even more pronounced. Female students demonstrated a mean subcutaneous fat value of 40.68, more than double that of male students (19.41), corresponding to the largest observed difference (−21.27). In the legs, females also showed significantly higher subcutaneous fat levels (37.47) compared to males (18.70), with a difference of −18.77.

Overall, these findings indicate a consistent sex-based pattern in subcutaneous fat distribution, with females showing greater fat deposition across both central (trunk) and peripheral (arms and legs) regions. The arm region, in particular, emerged as the site with the greatest sex-related difference in subcutaneous fat.

## 3.2 Skeletal Muscle Mass

In contrast to subcutaneous fat distribution, male students exhibited higher skeletal muscle mass across all analyzed body regions (Table X, Figure X). For whole-body skeletal muscle mass, males demonstrated a mean value of 34.62, whereas females showed a lower mean value of 26.64, resulting in a positive difference of +7.98 (M–F).

Similar trends were observed in regional skeletal muscle mass. In the trunk, male students had a mean value of 29.62 compared to 21.67 in females, corresponding to a difference of +7.95. In the arm region, males exhibited a substantially higher skeletal muscle mass (39.96) than females (28.79), with a difference of +11.17. The greatest difference was observed in the legs, where males recorded a mean skeletal muscle mass of 52.15 compared to 39.23 in females, yielding a difference of +12.92.

These results clearly indicate that male students possess greater skeletal muscle mass both globally and regionally, with the most pronounced differences observed in the lower extremities.

## 4 Discussion

The present study revealed clear sex-based differences in body composition, particularly in subcutaneous fat distribution and skeletal muscle mass. Female students consistently demonstrated higher subcutaneous fat levels across all measured body regions, whereas male students exhibited greater skeletal muscle mass. These findings are consistent with previous literature and can be explained by physiological, hormonal, and behavioral differences between sexes.

### 4.1 Sex Differences in Subcutaneous Fat Distribution

The higher subcutaneous fat levels observed among female students align with extensive evidence indicating that females naturally store a greater proportion of body fat compared to males [7]. Estrogen plays a central role in regulating adipose tissue distribution, particularly promoting fat accumulation in subcutaneous depots rather than visceral regions [8]. This physiological adaptation is closely linked to reproductive function and long-term energy storage.

The pronounced differences observed in the arm and leg regions support the concept of a gynoid fat distribution pattern, which is commonly reported in women. Peripheral fat storage has been shown to be metabolically protective compared to central fat accumulation, which may partly explain sex-specific differences in cardiometabolic risk profiles [9]. Additionally, sex differences in adipocyte size, lipolytic activity, and insulin sensitivity may further contribute to the greater subcutaneous fat deposition observed in females [10].

Behavioral factors such as physical activity levels and resistance training participation may also influence regional fat distribution. Males generally engage in higher levels of vigorous physical activity, which may contribute to lower subcutaneous fat accumulation, particularly in the upper limbs [11].

### 4.2 Sex Differences in Skeletal Muscle Mass

In contrast to fat distribution, male students exhibited significantly higher skeletal muscle mass across all body regions, with the largest differences observed in the legs. These findings are consistent with previous research demonstrating that males possess greater absolute and relative muscle mass than females. Testosterone plays a critical role in stimulating muscle protein synthesis, increasing muscle fiber cross-sectional area, and promoting hypertrophy, particularly in large muscle groups [12].The substantial difference in lower-limb muscle mass observed in this study is particularly noteworthy, as the legs contain the largest skeletal muscle groups and are highly responsive to mechanical loading and hormonal influences. Greater engagement in weight-bearing activities and higher absolute force production in males may further enhance muscle development in this region [13]. These sex-based differences in skeletal muscle mass have important functional implications, as muscle mass is strongly associated with strength, power, metabolic rate, and physical performance.

### 4.3 Implications for Health and Exercise Programming

The observed differences in body composition highlight the importance of sex-specific considerations in health assessment, exercise prescription, and nutritional interventions. Higher subcutaneous fat levels in females should not be interpreted solely as a negative health indicator, as subcutaneous fat—particularly in peripheral regions—has been associated with lower cardiometabolic risk compared to visceral fat [14]. Conversely, the greater skeletal muscle mass observed in males suggests a higher capacity for strength and power-oriented activities. However, females may benefit significantly from resistance training interventions aimed at increasing lean mass and improving functional capacity [15]. Recognizing inherent physiological differences between sexes is essential for optimizing training outcomes, preventing injury, and promoting long-term health.

# 5 Conclusion

There are significant differences in body composition between men and women. Women tend to have higher levels of subcutaneous fat, with a more even distribution throughout the body. Conversely, men have greater skeletal muscle mass, which is distributed more predominantly in the trunk, arms, and legs. Furthermore, research shows that subcutaneous and visceral fat influence insulin sensitivity, but there is no significant difference in insulin suppression effects between the sexes. Women have better glucose tolerance and insulin sensitivity, despite having lower muscle mass than men.
Overall, these findings strengthen our understanding of physiological differences influenced by hormonal and metabolic factors, and how the distribution of fat and muscle mass can influence an individual's metabolic health. This study provides important foundations for individualized approaches to nutrition and exercise, optimizing athlete health and performance based on each individual's body characteristics.

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