CORRELATIONS BETWEEN MUSCLE MASS AND ADIPOSE TISSUE: A BODY COMPOSITION ANALYSIS IN FEMALE STUDENTS

Holubiac Iulian Ştefan
Stefan cel Mare University of Suceava, Romania
holubiac.iulianstefan@usm.ro

Abstract
The aim of this study was to investigate the relationships between Body Mass Index (BMI), skeletal muscle mass, and adipose tissue in a sample of female university students aged 20 to 23. By employing bioelectrical impedance analysis (BIA), we sought to assess detailed body composition parameters and identify potential correlations between BMI and both lean and fat mass components. The study also aimed to highlight the importance of precise body composition evaluation in young adult populations, as a basis for early health interventions and lifestyle optimization.

Introduction
Body composition is a fundamental parameter in assessing both health status and physical performance. It is defined by the relative proportions of different body components, particularly skeletal muscle mass, adipose tissue, and bone mass. Skeletal muscle, a key component of metabolically active tissue, plays a crucial role in maintaining energy homeostasis, functional capacity, and basal metabolic rate. In contrast, adipose tissue, although an essential energy reserve, is strongly associated—when present in excess—with a range of metabolic disorders, cardiovascular diseases, and chronic low-grade inflammatory conditions. In the context of university students—a demographic group often characterized by a sedentary lifestyle and inconsistent dietary habits—body composition assessment becomes increasingly relevant. It provides critical insights for the prevention and management of obesity, sarcopenia, and other emerging metabolic dysfunctions during this pivotal stage of life. Recent studies have highlighted significant correlations between muscle mass and body fat percentage, emphasizing the interdependence of these components in maintaining physiological balance. Understanding their relationship is essential for developing targeted intervention strategies aimed at optimizing student health and physical performance. Skeletal muscles are vital not only for strength and mobility, but also for basal energy metabolism, glucose regulation, and insulin sensitivity. Loss

The Annals of the "Ştefan cel Mare" University of Suceava.
Physical Education and Sport Section. The Science and Art of Movement
eISSN 2601 - 341X, ISSN 1844-9131

of muscle mass (sarcopenia) is associated with reduced physical function and an increased risk of morbidity and mortality, particularly in older populations [1]. Muscle tissue can be infiltrated by intermuscular adipose tissue (IMAT), which compromises muscle quality and adversely affects both strength and metabolic function. A study conducted on obese adolescents revealed that IMAT proportion is negatively correlated with insulin sensitivity and overall metabolic performance [2]. Muscle mass is influenced by a variety of factors, including physical activity, dietary intake (especially protein consumption), sex, age, genetic predisposition, and overall health status. Adipose tissue is not merely an energy depot; it also functions as an endocrine organ, secreting adipokines that regulate inflammation, insulin sensitivity, lipid homeostasis, and energy metabolism [3]. There are significant physiological and functional differences between visceral and subcutaneous adipose tissue, as well as between white and brown adipose tissue. Visceral fat is more strongly associated with metabolic dysfunction, as it is closely linked to systemic inflammation, insulin resistance, and cardiovascular disease. In contrast, brown adipose tissue has gained increasing attention due to its role in lipid oxidation and energy expenditure through non-shivering thermogenesis, representing a potential target for obesity counter-regulation strategies [4], [5], [6]. Dysfunctional adipose tissue—particularly visceral and intermuscular fat depots—has been associated with insulin resistance, chronic low-grade inflammation, dyslipidemia, and an elevated risk of developing metabolic diseases [7], [8]. On the other hand, high and well-maintained skeletal muscle mass exerts a protective effect by reducing mortality risk, enhancing physical function, and supporting metabolic homeostasis [1], [9]. Moreover, muscle quality plays a critical role in metabolic health, beyond mere muscle quantity. Factors such as fat infiltration, muscle density, and oxidative vs. glycolytic fiber composition significantly impact muscular function and metabolic performance. Even when muscle mass is preserved, excessive fat infiltration or a shift toward a glycolytic fiber profile can compromise metabolic efficiency and physical performance [10].

Material-method

This study was conducted on a sample of 30 female participants, all undergraduate students enrolled in the first, second, or third year of university, aged between 20 and 23 years. To assess body composition, the TANITA MC-780 bioelectrical impedance analyzer was used. This device is scientifically validated and allows for accurate, non-invasive measurement of various anthropometric parameters. The variables measured

The Annals of the "Ştefan cel Mare" University of Suceava.
Physical Education and Sport Section. The Science and Art of Movement
eISSN 2601 - 341X, ISSN 1844-9131

included the Body Mass Index (BMI), skeletal muscle mass, total body fat percentage, and its distribution. Measurements were performed under standardized conditions, following strict pre-assessment protocols: participants were instructed to abstain from food or fluid intake for at least three hours prior to testing and to avoid intense physical activity the day before the evaluation. The primary objective of the study was to investigate the correlations between BMI and body composition parameters. Statistical analysis included the computation of Pearson correlation coefficients to evaluate the strength and direction of the relationships between the variables. This methodological approach enables a comprehensive assessment of the interrelationships between body components, offering a detailed perspective on the factors that may influence health status and body composition among university students.

Results and discussions
Body fat percentage was found to be strongly and positively correlated with BMI ($r = .867$, $p < .001$). This strong association indicates that increases in BMI are proportionally associated with higher body fat percentages, reaffirming BMI's utility as an indirect indicator of body composition—albeit with notable limitations.

Table 1. Characteristics and results of the body composition measurements of the subjects

Age	19.5±1.1
Body Fat (%)	16.6±7.1
Body Fat (kg)	13.1±7.6
BMI	22.9±3.8
Free Fat Mass (kg)	62.1±8.0
Muscle Mass (kg)	59±7.8

BMI also showed significant positive correlations with fat mass (kg) ($r = .917$, $p < .001$), free fat mass ($r = .604$, $p < .001$), and muscle mass ($r = .603$, $p < .001$). These findings suggest that BMI reflects not only adiposity but also lean body mass, highlighting its limited capacity to differentiate between distinct tissue types. Although BMI is commonly used as a general indicator of overweight or obesity, the data from this study indicate that a considerable portion of BMI variability can be attributed to muscle mass or lean body mass, not just fat accumulation.

Table 2. Pearson correlations between variables

The Annals of the "Ştefan cel Mare" University of Suceava.
Physical Education and Sport Section. The Science and Art of Movement
eISSN 2601 - 341X, ISSN 1844-9131

		Body Fat (%)	Body Fat (kg)	BMI	Free Fat Mass (kg)	Muscle Mass (kg)
Body Fat (%)	Pearson Correlation	1	.963**	.867**	.281	.280
	Sig. (2-tailed)		< .001	< .001	.132	.133
Body Fat (kg)	Pearson Correlation	.963**	1	.917**	.481**	.481**
	Sig. (2-tailed)	< .001		< .001	.007	.007
BMI	Pearson Correlation	.867**	.917**	1	.604**	.603**
	Sig. (2-tailed)	< .001	< .001		< .001	< .001
Free Fat Mass (kg)	Pearson Correlation	.281	.481**	.604**	1	1.000**
	Sig. (2-tailed)	.132	.007	< .001		< .001
Muscle Mass (kg)	Pearson Correlation	.280	.481**	.603**	1.000**	
	Sig. (2-tailed)	.133	.007	< .001	< .001	

Muscle mass (kg) was perfectly correlated with free fat mass ($r = 1.000$, $p < .001$), and showed moderate positive correlations with fat mass (kg) ($r = .481$, $p = .007$) and BMI ($r = .603$, $p < .001$). The perfect correlation between muscle mass and free fat mass suggests that, within this sample, muscle mass is the predominant component of lean body mass. This may reflect either the method of measurement (e.g., overlapping definitions in bioelectrical impedance analysis) or the physiological characteristics of the participants. Overall, the results reveal strong and statistically significant correlations between BMI, fat mass, and lean body mass components. While BMI remains a widely used index for general weight status classification, these findings

The Annals of the "Ştefan cel Mare" University of Suceava.
Physical Education and Sport Section. The Science and Art of Movement
eISSN 2601 - 341X, ISSN 1844-9131

underscore the importance of conducting detailed body composition assessments to accurately distinguish between fat and lean tissue. This analysis emphasizes the need for direct and differentiated methods of body composition evaluation in health, nutrition, and exercise science research. Relying solely on BMI may obscure important distinctions between adiposity and muscularity, potentially leading to misclassification in clinical or athletic contex Our study identified significant correlations between Body Mass Index (BMI) and various body composition parameters, including skeletal muscle mass and body fat percentage, among university students aged 20 to 23 years. These findings are consistent with existing literature, which emphasizes the importance of detailed body composition assessment to better understand the health status of young populations. A study conducted among Malaysian university students reported a weak positive correlation between physical activity and muscle mass, and a weak negative correlation between physical activity and fat mass [11]. These findings suggest that increased levels of physical activity may contribute to gains in skeletal muscle and reductions in fat mass—key factors in maintaining a healthy body composition. Regarding the relationship between BMI and body composition, numerous studies have shown that BMI does not always accurately reflect the proportions of lean mass and adipose tissue. For instance, a study from Italy found significant anthropometric differences between males and females, along with weak correlations between BMI and body fat percentage [12]. Such evidence reinforces the need for more precise and direct methods of assessment—such as bioelectrical impedance analysis (BIA)—to obtain reliable data on individuals' health and composition profiles. Another relevant factor to consider is the influence of body image perception on skeletal muscle mass. A study involving female university students found that body perception and the desire to alter body shape were associated with skeletal muscle mass index, suggesting that psychosocial factors can influence muscle development [13]. These findings imply that interventions aimed at improving body image may have a meaningful impact on body composition and health behaviors. A study conducted among medical students at the Wroclaw Medical University demonstrated that both moderate and vigorous physical activity are significantly correlated with basal metabolic rate (BMR), muscle mass, bone mass, and total body water content, indicating that higher levels of physical activity may contribute to increased muscle mass and reduced fat mass [14]. Another relevant investigation aimed at understanding the relationship between physical activity and body composition was carried out on a group of 75 students (33 males and 42 females) from the same university. The primary objective was to identify

The Annals of the "Ştefan cel Mare" University of Suceava.
Physical Education and Sport Section. The Science and Art of Movement
eISSN 2601 - 341X, ISSN 1844-9131

which body composition components most strongly correlate with the physical activity levels of young participants, particularly medical students. Assessments included the use of accelerometers to quantify physical activity, alongside standardized anthropometric and body composition analyses. Results showed that the volume of vigorous physical activity (high intensity) was moderately correlated with several physiological parameters, including BMR, body fat percentage, total body water, muscle mass, fat-free mass (FFM), bone mass, the extracellular-to-intracellular water ratio (ECW/ICW), and phase angle (PA). Correlation coefficients ranged between ±0.2 and 0.4, indicating statistically significant but moderate relationships. In contrast, moderate-intensity physical activity was positively correlated with total body mass, BMI, BMR, fat-free mass, and bone mass, with correlation coefficients between 0.3 and 0.5. Regarding the relationship between BMI and body composition, studies have consistently shown that BMI does not always accurately reflect the proportions of muscle mass and adipose tissue. For example, one study highlighted significant anthropometric differences between males and females, as well as weak correlations between BMI and body fat percentage [15]. Another important aspect concerns the influence of body image perception on muscle mass. A study conducted on female university students revealed that body perception and the desire to modify body shape were associated with the skeletal muscle mass index, suggesting that psychosocial factors may influence muscle development [13]. A recent study [16] conducted on a cohort of German university students investigated the influence of physical activity, anthropometric parameters, body composition, and dietary factors on bone stiffness, an important indicator of bone health and a predictor of future osteoporosis risk. The study aimed to elucidate the relationships between various lifestyle factors and bone parameters in young adults—a critical period for bone density accumulation that affects long-term musculoskeletal health. The study included 285 participants, comprising 233 females and 52 males, with mean ages of 22.7 and 24.0 years respectively, and average body mass indices within normal ranges. Bone stiffness was assessed by measuring the stiffness index at the heel using quantitative ultrasound, while body composition was determined through bioelectrical impedance analysis. Additionally, current and past physical activity levels were quantified using a standardized questionnaire, and dietary intake was monitored via detailed three-day food records [16]. Results revealed that a small but significant proportion of participants exhibited osteopenia, defined by a T-score between -2.5 and -1. Among females, significant positive correlations were found between bone stiffness and BMI, total fat mass, lean body mass, current physical

The Annals of the "Ştefan cel Mare" University of Suceava.
Physical Education and Sport Section. The Science and Art of Movement
eISSN 2601 - 341X, ISSN 1844-9131

activity level, as well as physical activity during adolescence—associations that were not observed in males. Surprisingly, dietary and nutritional parameters showed no significant association with bone health, suggesting that in young adults, factors related to physical activity exert a stronger influence on bone stiffness than diet. A detailed analysis demonstrated that physical activity during adolescence, current physical activity levels, and body mass index together explain approximately 8% of the variance in bone stiffness, emphasizing the critical importance of maintaining an active lifestyle from early developmental stages. These findings support the notion that promoting high levels of physical activity throughout childhood, adolescence, and early adulthood is essential for optimizing bone health and reducing the risk of musculoskeletal disorders later in life. In the context of our own study, these conclusions are particularly relevant as they highlight the role of regular physical activity in shaping body composition, especially regarding muscle mass and adipose tissue—key factors for overall health maintenance. Moreover, the results indicate that while nutrition plays an important role, its impact on bone stiffness within this age group may be less pronounced compared to the influence of consistent physical activity. Consequently, encouraging an active lifestyle among university students represents a vital strategy for preventing bone-related problems and imbalances in body composition, ultimately contributing to improved long-term quality of life. These findings reinforce the concept that regular physical activity, particularly of moderate to vigorous intensity, positively affects not only muscle mass and body composition but also basal metabolic rate and overall cellular health status. Our results complement previous research, confirming that physical activity level is a significant predictive factor for favorable changes in the body composition of students. Thus, promoting an active lifestyle among young adults can substantially aid in optimizing lean body mass, reducing adipose tissue, enhancing hydration status, and maintaining healthy bone mass, with long-term implications for general health.

Conclusion
In conclusion, our study confirms the importance of detailed body composition assessment among university students, considering the identified correlations between BMI, muscle mass, and adipose tissue. These insights can inform the development of personalized intervention strategies aimed at fostering healthy lifestyles within young populations.

References:

[1]   Adam J Santanasto, Bret H Goodpaster, Stephen B Kritchevsky, Iva Miljkovic, Suzanne Satterfield, Ann V Schwartz, Steven R Cummings, Robert M Boudreau, Tamara B Harris and Anne B Newman , "Body Composition Remodeling and Mortality: The Health Aging and Body Composition Study," *J Gerontol A Biol Sci Med Sci,* vol. 72, no. 4, pp. 513-519, 2017.

[2]   S Lee, Y Kim, D A White, J L Kuk and S Arslanian, "Relationships between insulin sensitivity, skeletal muscle mass and muscle quality in obese adolescent boys," *Eur J Clin Nutr,* vol. 66, no. 12, pp. 1366-1368, 2012.

[3]   Liping Luo and Meilian Liu, "Adipose tissue in control of metabolism," *J Endocrinol,* vol. 231, no. 3, pp. R77-R99, 2016.

[4]   Maria-Zinaida Dobre, Bogdana Virgolici and Olivia Timnea, "Key Roles of Brown, Subcutaneous, and Visceral Adipose Tissues in Obesity and Insulin Resistance," *Curr. Issues Mol. Biol.,* vol. 47, no. 5, p. 343, 2025.

[5]   Almudena Gómez-Hernández, Nuria Beneit, Sabela Díaz-Castroverde and Óscar Escribano, "Differential Role of Adipose Tissues in Obesity and Related Metabolic and Vascular Complications," *Int J Endocrinol,* 2016.

[6]   Sung-Min An, Seung-Hee Cho and John C Yoon, "Adipose Tissue and Metabolic Health," *Diabetes Metab J,* vol. 47, no. 5, pp. 595-611, 2023.

[7]   Almudena Gómez-Hernández, Nuria Beneit, Sabela Díaz-Castroverde and Óscar Escribano, "Differential Role of Adipose Tissues in Obesity and Related Metabolic and Vascular Complications," *Int J Endocrinol,* 2016.

[8]   Michele Longo, Federica Zatterale, Jamal Naderi , Luca Parrillo , Pietro Formisano, Gregory Alexander Raciti, Francesco Beguinot and Claudia Miele , "Adipose Tissue Dysfunction as Determinant of Obesity-Associated Metabolic Complications," *International journal of molecular sciences,* vol. 20, no. 9, 2019.

[9]   Masoud Isanejad , Lyn M Steffen, James G Terry , James M Shikany, Xia Zhou , So-YunYi, David R Jacobs Jr and John Jeffrey Carr , "Diet quality is associated with adipose tissue and muscle mass: the Coronary Artery Risk Development in Young Adults (CARDIA) study," *J Cachexia Sarcopenia Muscle,* vol. 15, no. 1, pp. 425-433, 2024.

[10] David A. Reiter, Moriah P. Bellissimo,, Lei Zhou,, Scott Boebinger, Greg D. Wells, Dean P. Jones, Thomas R. Ziegler and Jessica A. Alvarez, "Increased adiposity is associated with altered skeletal muscle energetics," *Journal of applied physiology,* 2023.

[11] You HW, Tan PL and Mat Ludin AF, "The Relationship between Physical Activity, Body Mass Index and Body Composition among Students at a Pre-

The Annals of the "Ştefan cel Mare" University of Suceava.
Physical Education and Sport Section. The Science and Art of Movement
eISSN 2601 - 341X, ISSN 1844-9131

University Centre in Malaysia," *IIUM Medical Journal Malaysia,* vol. 19, no. 2, 2020.

[12] Luciana Zaccagni , Davide Barbieri and Emanuela Gualdi-Russo, "Body composition and physical activity in Italian university students," *J Transl Med,* 2014.

[13] Tomoki Mase, Kumiko Ohara, Katsumasa Momoi and Harunobu Nakamura, "Association between the recognition of muscle mass and exercise habits or eating behaviors in female college students," *Sci Rep,* vol. 12, no. 1, 2022.

[14] Aleksandra Jaremków, Iwona Markiewicz-Górka, Wojciech Hajdusianek, Karolina Czerwińska and Paweł Gać, "The Relationship between Body Composition and Physical Activity Level in Students of Medical Faculties," *J Clin Med,* vol. 13, no. 1, p. 50, 2023.

[15] A Morabia, A Ross, F Curtin, C Pichard and D O Slosman, "Relation of BMI to a dual-energy X-ray absorptiometry measure of fatness," *Br J Nutr,* vol. 82, no. 1, pp. 49-55, 1999.

[16] Juliane Heydenreich, Antje Schweter and Petra Lührmann, "Impact of physical activity, anthropometric, body composition, and dietary factors on bone stiffness in German university students," *J Sports Med Phys Fitness,* vol. 61, no. 4, pp. 571-581, 2021.