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Retrospective Evaluation of Body Composition Parameters Measured by Bioimpedance Method According to Gender, Age, and BMI: The Case of Siirt Province

Biyoimpedans Yöntemi ile Ölçülen Vücut Kompozisyonu Parametrelerinin Cinsiyet, Yaş ve BKİ'ye Göre Retrospektif Değerlendirilmesi: Siirt İli Örneği

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ABSTRACT

Objective: To evaluate body composition parameters determined by bioelectrical impedance analysis (BIA) in adults aged 19-64 years in Siirt, Türkiye, across gender, age, and body mass index (BMI) categories.

Materials and Methods: This retrospective study analyzed single-measurement data from 1062 adults (286 males, 776 females) recorded at the Siirt Healthy Life Center between 2021 and 2024. Measurements were obtained using an InBody 270 device. Descriptive statistics, Welch's ANOVA, Games-Howell tests, and multiple linear regression were applied ($p<0.05$).

Results: Females exhibited significantly higher BMI, total fat mass, and visceral fat levels than males, whereas men showed greater fat-free mass, skeletal muscle mass, and bone mineral content. Regression analysis identified visceral fat level, skeletal muscle mass, and age as the factors most strongly associated with BMI ($R^2=0.822$).

Conclusions: Increased visceral adiposity in females and older age groups, along with the insufficiency of BMI alone, underscores the importance of gender-specific composition analyses in obesity management.

Keywords: Bioelectrical impedance, body composition, body mass index, obesity, visceral fat

ÖZ

Amaç: Bu çalışmanın amacı, Siirt ilinde yaşayan 19-64 yaş arası bireylerin biyoelektrik impedans analizi (BİA) ile belirlenen vücut kompozisyonu parametrelerini cinsiyet, yaş ve beden kütle indeksi (BKİ) gruplarına göre değerlendirmektir.

Materyal ve Metot: 2021-2024 yılları arasında Siirt Sağlıklı Hayat Merkezi arşivinden elde edilen, 1062 yetişkine (286 erkek, 776 kadın) ait tekil ölçüm verileri retrospektif olarak analiz edilmiştir. Ölçümler InBody 270 cihazı ile gerçekleştirilmiştir. Tanımlayıcı istatistikler, Welch ANOVA, Games-Howell testi ve çoklu doğrusal regresyon analizleri kullanılmıştır ($p<0,05$).

Bulgular: Kadınların BKİ, toplam yağ ve visseral yağ düzeyleri erkeklerden anlamlı düzeyde yüksek bulunmuştur. Erkeklerde ise yağsız vücut kütlesi, iskelet kası ve mineral miktarları daha fazladır. Çoklu regresyon analizine göre, visseral yağ düzeyi, iskelet kas kütlesi ve yaş, BKİ ile en güçlü ilişkili değişkenler olarak saptanmıştır ($R^2=0,822$).

Sonuç: Kadınlar ve ileri yaş grubunda visseral yağlanmanın arttığı, BKİ'nin tek başına yeterli olmadığı ve cinsiyete özgü kompozisyon analizlerinin obezite yönetiminde önem taşıdığı sonucuna varılmıştır.

Anahtar Kelimeler: Beden kütle indeksi, biyoelektrik impedans, obezite, visseral yağ, vücut kompozisyonu

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INTRODUCTION

The World Health Organization (WHO) defines obesity as "an abnormal or excessive fat accumulation that may impair health."[1] Because directly assessing body fat percentage is often impractical in clinical settings, the body mass index (BMI) is widely used to classify obesity. However, BMI disregards structural characteristics, such as body fat distribution and muscle mass. Consequently, individuals with identical BMI values can have different body compositions and health risk profiles.[2] This complicates the differentiation of conditions such as sarcopenic obesity and may obscure the fact that individuals within the normal BMI range can have elevated metabolic risk.[3]

According to the WHO, 2.5 billion adults were overweight in 2022, of whom 890 million had obesity.[1] Current trends indicate that 3.8 billion adults worldwide will be overweight or obese by 2050, making obesity a global public health problem that threatens sustainable development goals.[4] A similar trend has been observed in Türkiye. According to the Türkiye Nutrition and Health Survey (TNSA) data, one in three adults is affected by this condition.[5] The WHO European Regional Obesity Report 2022 highlights Türkiye as the European nation with the highest adult obesity prevalence, at 32.1%.[6] Regional disparities within Türkiye are influenced by socioeconomic factors, and the confluence of these factors in socioeconomically disadvantaged regions, such as the Southeastern Anatolia Region, contributes to the escalating prevalence of obesity. Lower income and education levels, limited access to healthy foods and recreational spaces, and higher levels of occupational and environmental stress can shape dietary patterns and physical activity behaviors in ways that increase obesity risk in these regions.[7,8]

Given the limitations of BMI, a comprehensive evaluation of body composition is increasingly important.[2] Bioelectrical impedance analysis (BIA) is widely used in clinical and epidemiological studies because it is rapid, non-invasive, and relatively low-cost.[9] BIA provides multidimensional information on fat mass, fat-free mass, skeletal muscle mass, and visceral fat levels, thereby addressing BMI's inability to distinguish between lean and fat compartments or to capture fat distribution.[2,9] Although factors such as hydration status and recent exercise can influence BIA measurements, standardized protocols allow BIA to generate clinically useful data for large-scale and regional obesity assessment.[10]

To our knowledge, no study has investigated the body composition of adults in Siirt Province using BIA. This study aimed to retrospectively analyze the body composition parameters measured via BIA in individuals aged 19-64 residing in Siirt and to compare these parameters across gender and BMI groups.

MATERIALS AND METHODS

Ethics Committee Approval: This study adhered to the ethical principles of the Declaration of Helsinki and was approved by the Siirt University Non-Interventional Clinical Research Ethics Committee (date: 21/04/2025, decision no: 2025/01/04/1). All evaluated data were anonymized, with no information that could identify the individuals included in the analysis. Data security was maintained using a restrictive access protocol limited to authorized researchers.

Study Design and Sample: This retrospective study analyzed electronic archival data of body composition measurements from the Nutrition and Physical Activity Counseling Unit of the Healthy Life Center, operating under the Siirt Provincial Health Directorate, between 2021 and 2024. A criterion-based sampling method was employed, including all individuals aged 19-64 who visited the unit and met the inclusion criteria.

The primary inclusion criterion was the completeness and logical consistency of the records for age, gender, height, weight, and fundamental body composition parameters. In routine practice at the Healthy Life Center, individuals who are pregnant, have cardiac pacemakers or other implanted medical devices, a malignancy diagnosis, or are receiving dialysis or have advanced-stage chronic disease are not evaluated with BIA. Therefore, such cases were not present in the electronic database. In such conditions, fluid balance and tissue conductivity may be substantially altered, and the use of electrical impedance may raise safety concerns, which could bias BIA-based estimates of body composition.[11] We also excluded professional athletes or bodybuilders, as their body composition parameters differ significantly from those of the general population, which could affect the internal validity of the study. For individuals with multiple measurements, only the most recent record was included to ensure statistical independence and to reflect their current physiological state. In total, 1985 BIA measurements were initially retrieved from the Healthy Life Center database. After restricting the dataset to adults aged 19-64 years (excluding 133 measurements from individuals younger than 19 or older than 64 years) and removing 766 repeated measurements (retaining a single measurement per person), and further excluding 24 individuals identified as athletes, the final analytic sample consisted of 1062 adults (286 men and 776 women).

Data Collection: Body composition assessments were performed as part of routine clinical practice by dietitians at the Healthy Life Center. In accordance with the manufacturer's InBody 270 (InBody Co., Ltd., Seoul, Korea) guidelines and standard clinical protocols to minimize hydration-related fluctuations, participants were instructed to avoid strenuous exercise and alcohol for at least 24 hours before testing, to refrain from eating or drinking for at least 4 hours prior to the measurement, and to empty their bladder immediately beforehand. All assessments were conducted with participants barefoot, wearing light clothing, and with all metallic accessories removed.

Records included age, gender, height, and body weight, along with device-provided parameters such as total body fat mass, fat-free mass, skeletal muscle mass, body mineral mass, visceral fat level, and BMI (kg/m²). The device's "obesity degree (%)" parameter, which qualitatively assesses body composition by comparing the individual's current BMI with an ideal BMI, was also analyzed. BMI was categorized according to the WHO classification: normal weight (18.5-24.9 kg/m²), overweight (25.0-29.9 kg/m²), and obese (≥30.0 kg/m²).[1] Data extracted from the electronic archive were manually reviewed for logical integrity, and records with missing or inconsistent data were excluded.

***Data Analysis*:** All statistical analyses were performed using Python in a Google Colab environment with Pandas, NumPy, Matplotlib, Seaborn, and SciPy libraries. Continuous variables are expressed as mean and standard deviation (SD).

The distributional properties of the data were assessed by examining skewness and kurtosis values; as these were within the ±1 range, the assumption of normal distribution was met, further supported by the large sample size. Statistical analyses included independent samples t-tests, chi-square tests, and one-way analysis of variance (ANOVA). The homogeneity of variance was assessed using Levene's test; when this assumption was not met, Welch's ANOVA was used for comparisons among BMI and age groups.

For parameters with significant gender discrepancies, effect size was determined using Cohen's d, interpreted as: <0.20 (very small), 0.20-0.49 (small), 0.50–0.79 (medium), 0.80–1.19 (large), and ≥1.20 (very large).[12] A post-hoc power analysis conducted with G*Power 3.1.9.7 software confirmed that statistical power (1-β) was >95% for variables with significant gender-based differences.

Pearson correlation (r) coefficients are presented in a heatmap to facilitate the comparative interpretation of relationships between genders. Multiple linear regression analysis was used to identify the predictors of BMI (dependent variable). Gender, age, visceral fat level, body fat mass, and skeletal muscle mass were included as independent variables. Model significance was assessed using an F-test and explanatory power using the R^2 coefficient. The Variance Inflation Factor (VIF) was <5 for all variables, indicating no multicollinearity. The Games-Howell post-hoc test was applied to variables with significant intergroup differences. Two-tailed tests were used for all analyses, and statistical significance was set at p<0.05.

RESULTS

Table 1 presents the body composition by sex in 1062 adults (286 males, 776 females). Age did not differ between the genders (34.31±9.37 vs 35.07±9.66 years; p=0.246). Males had higher body weight, height, fat-free mass, skeletal muscle mass, and body mineral mass, whereas females had higher BMI, body fat mass, visceral fat level, and obesity degree (all p<0.001). Effect sizes were very large for height (d=-2.49), fat-free mass (d=-2.59), skeletal muscle mass (d=-2.67), and body mineral mass (d=-2.34); large for visceral fat level (d=0.86); medium for body fat mass (d=0.63); and small for obesity degree (d=0.48) and BMI (d=0.27). The BMI category distribution also differed by gender [$\chi^2(2)=15.313$, p=0.001; Cramér's V=0.12, small].

Analysis by age group showed statistically significant increases in body weight, BMI, body fat mass, visceral fat level, and obesity degree with advancing age (p<0.001) (Table 2). For example, BMI increased from 26.60±5.99 kg/m² in the 19-29 years group to 33.03±6.27 kg/m² in the 40-64 years group, visceral fat level from 10.78±5.58 to 16.09±4.12, and obesity degree from 125.09±28.67% to 155.73±30.15% (all p<0.001). Fat-free mass showed a small but significant difference, being higher in the 40-64 years group than in the younger groups (p=0.049). In contrast, no significant differences were observed among the age groups for skeletal muscle mass (p=0.071) or body mineral mass (p=0.209).

Comparative analysis by BMI classification revealed significant differences in all measured parameters (all p<0.001; Table 3). For example, body fat mass increased from 16.07±4.86 kg in the normal BMI group to 41.28±9.36 kg in the obese group, while visceral fat level rose from 6.68±2.69 to 18.05±2.47 and obesity degree from 103.92±10.31% to 167.65±24.01% across the same categories. Consistent with these patterns, higher BMI categories were associated with higher age, body weight, body fat mass, visceral fat level, and obesity degree. Notably, fat-free mass and skeletal muscle mass also showed a concurrent and significant increase with higher BMI categories, whereas body mineral mass was higher in the overweight and obese groups than in the normal group but did not differ between those two categories.

Table 1. Comparative descriptive statistics of body composition variables by gender, with p-values and effect sizes.

Variables		Male (n=286)	Female (n=776)	Total (n=1062)	p value$^{\alpha}$	Cohen's d	95% CI	Effect Size$^{\#}$
Age (years), Mean±SD		34.31±9.37	35.07±9.66	34.87±9.59	0.246	0.08	[-0.06-0.22]	Very small
Body Weight (kg), Mean±SD		85.88±16.46	76.10±16.84	78.73±17.28	**0.001**	-0.58	[-0.72-0.45]	Medium
Height (cm), Mean±SD		175.40±6.30	160.33±5.96	164.39±9.02	**0.001**	-2.49	[-2.66-2.32]	Very large
BMI (kg/m²), Mean±SD		27.92±5.23	29.69±6.82	29.21±6.48	**0.001**	0.27	[0.14, 0.41]	Small
Body Mineral Mass (kg), Mean±SD		4.20±0.58	3.13±0.41	3.42±0.66	**0.001**	-2.34	[-2.50-2.17]	Very large
Body Fat Mass (kg)		23.76±11.35	31.29±12.29	29.27±12.49	**0.001**	0.63	[0.49-0.76]	Medium
Fat-Free Mass (kg), Mean±SD		62.12±8.15	44.80±6.05	49.47±10.18	**0.001**	-2.59	[-2.77-2.42]	Very large
Skeletal Muscle Mass (kg), Mean±SD		35.21±4.87	24.55±3.63	27.42±6.19	**0.001**	-2.67	[-2.84-2.49]	Very large
Visceral Fat Level, Mean±SD		9.82±5.06	14.10±4.96	12.94±5.33	**0.001**	0.86	[0.72-1.00]	Large
Obesity Degree (%), Mean±SD		126.92±23.75	141.37±32.49	137.48±31.04	**0.001**	0.48	[0.34-0.61]	Small
Variables		**Male** (n=286)	**Female** (n=776)	**Total**	**p value**$^{\beta}$		**Cramér's V**	**Effect Size**
BMI Classification n (%)	**Normal**	87 (30.4)	195 (25.1)	282 (26.6)	χ^2=15.313			
	Overweight	113 (39.5)	245 (31.6)	358 (33.7)	df=2		0.12	Small
	Obese	86 (30.1)	336 (43.3)	422 (39.7)	p=**0.001**			

$^{\alpha}$: Independent samples t-test; $^{\beta}$: Pearson's chi-square test; SD: Standard deviation; $^{\#}$: Negative d values indicate situations in which males have a higher average than females; Note: Effect size was expressed as Cohen's d for continuous variables and Cramér's V for the BMI classification.

Table 2. Comparative descriptive statistics of body composition variables by age group (n=1062).

Variables	19-29 Years (n=350) Mean±SD	30-39 Years (n=401) Mean±SD	40-64 Years (n=311) Mean±SD	p value
Body Weight (kg)	73.15±17.54^{a}	77.67±15.53^{b}	86.39±16.41^{c}	**0.001**
Height (cm)	165.71±9.31^{a}	165.15±9.03^{a}	161.91±8.16^{b}	**0.001**
BMI (kg/m²)	26.60±5.99^{a}	28.53±5.64^{b}	33.03±6.27^{c}	**0.001**
Body Mineral Mass (kg)	3.39±0.72^{a}	3.45±0.66^{a}	3.41±0.59^{a}	0.209
Body Fat Mass (kg)	24.60±12.17^{a}	27.87±10.91^{b}	36.31±11.71^{c}	**0.001**
Fat-Free Mass (kg)	48.54±10.95^{a}	49.80±10.27^{a}	50.08±9.06^{b}	**0.049**
Skeletal Muscle Mass (kg)	26.89±6.69^{a}	27.65±6.26^{a}	27.74±5.46^{a}	0.071
Visceral Fat Level	10.78±5.58^{a}	12.39±4.79^{b}	16.09±4.12^{c}	**0.001**
Obesity Degree (%)	125.09±28.67^{a}	134.13±27.03^{b}	155.73±30.15^{c}	**0.001**

SD: Standard deviation; ^{a,b,c}: Within each row, different superscript letters indicate significant differences; identical letters indicate no difference; Note: Welch's ANOVA with Games–Howell post-hoc tests.

Table 3. Comparative descriptive statistics of body composition variables according to BMI level (n=1062).

Variables	Normal (n=282) Mean±SD	Overweight (n=358) Mean±SD	Obese (n=422) Mean±SD	p value
Age	29.39±6.69^{a}	34.43±8.20^{b}	38.90±10.41^{c}	**0.001**
Body Weight (kg)	61.24±9.02^{a}	75.19±8.78^{b}	93.43±14.18^{c}	**0.001**
Height (cm)	166.05±8.58^{a}	165.62±9.07^{a}	162.23±8.84^{b}	**0.001**
BMI (kg/m²)	22.14±2.21^{a}	27.35±1.37^{b}	35.53±4.95^{c}	**0.001**
Body Mineral Mass (kg)	3.15±0.57^{a}	3.47±0.66^{b}	3.55±0.67^{b}	**0.001**
Body Fat Mass (kg)	16.07±4.86^{a}	25.49±4.42^{b}	41.28±9.36^{c}	**0.001**
Fat-Free Mass (kg)	45.17±9.22^{a}	49.69±10.17^{b}	52.15±9.86^{c}	**0.001**
Skeletal Muscle Mass (kg)	24.85±5.68^{a}	27.56±6.21^{b}	29.03±5.95^{c}	**0.001**
Visceral Fat Level	6.68±2.69^{a}	11.86±2.95^{b}	18.05±2.47^{c}	**0.001**
Obesity Degree (%)	103.92±10.31^{a}	128.35±7.19^{b}	167.65±24.01^{c}	**0.001**

SD: Standard deviation; ^{a,b,c}: Within each row, different superscript letters indicate significant differences; identical letters indicate no difference; Note: Welch's ANOVA with Games–Howell post-hoc tests.

The Pearson correlation matrix (Figure 1) revealed robust positive correlations among body weight, BMI, body fat mass, fat-free mass, skeletal muscle mass, and visceral fat level for both genders ($p<0.001$). In females, age demonstrated a stronger positive correlation with adiposity markers such as BMI ($r=0.43$) and visceral fat level ($r=0.42$) compared to males. For both genders, the strongest correlation was between BMI and body fat mass, followed by BMI and visceral fat level.

The multiple linear regression model was statistically significant, explaining 82.2% of the variance in BMI [$F(4, 1057)=1221.421$, $p<0.001$; $R^2=0.822$] (Table 4). According to the standardized beta coefficients (β), the strongest statistical association with BMI was observed for visceral fat level ($\beta=0.774$, $p<0.001$), followed by skeletal muscle mass ($\beta=0.380$, $p<0.001$) and age ($\beta=0.075$, $p<0.001$). When other variables were held constant, female gender ($\beta=-0.133$, $p<0.001$) was negatively associated with BMI.

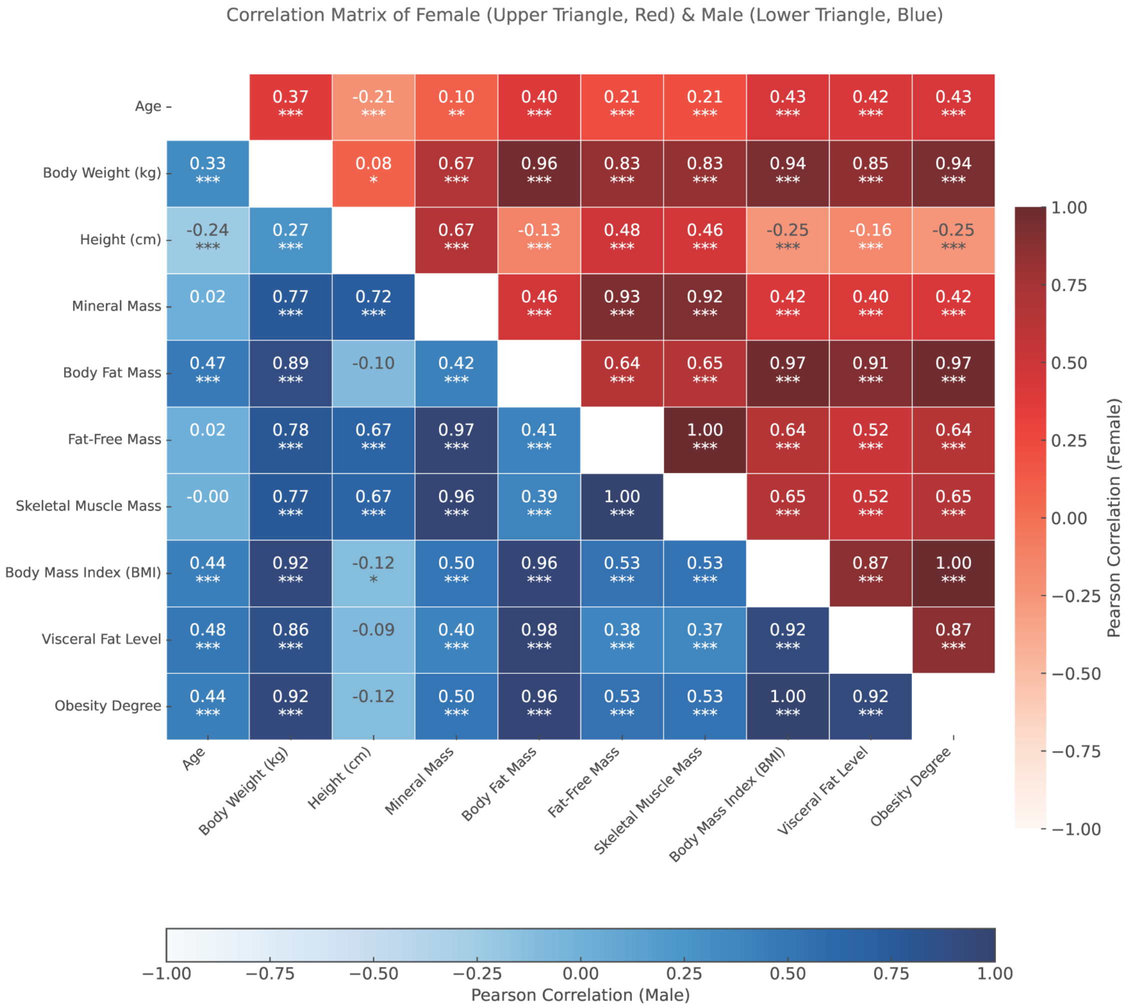

Figure 1. Pearson correlations between body composition variables in male and female individuals. Blue tones: Pearson correlation coefficients for males are shown in the lower triangle; Red tones: Pearson correlation coefficients for females are shown in the upper triangle; Asterisks indicate statistical significance (*p<0.05; **p<0.01; ***p<0.001).

Table 4. Results of multiple linear regression analysis of variables affecting BMI.

Variables	B	SE	β	t	VIF	p value
Constant	6.836	0.484	-	14.134	-	**0.001**
Gender (Female=1)	-1.936	0.359	-0.133	-5.397	3.589	**0.001**
Age	0.051	0.010	0.075	5.189	1.246	**0.001**
Visceral Fat Level	0.941	0.021	0.774	44.655	1.787	**0.001**
Skeletal Muscle Mass (kg)	0.397	0.024	0.380	16.643	3.090	**0.001**
			Model Summary			
Model Parameters	**R**	**R^2**	**Adjusted R^2**	**SE**	**ANOVA (F, df)**	**p value**
	0.907	0.822	0.821	2.737	F(4, 1057)=1221.421	**0.001**

B: Coefficient; SE: Standard error; β: Standardized beta; VIF: Variance inflation factor.

DISCUSSION AND CONCLUSION

This study utilized BIA, a widely used and accessible clinical instrument, to evaluate the body composition of 1062 adults in Siirt Province. Given that body composition parameters are known to vary significantly according to age, gender, and BMI in healthy adult populations,[13,14] our research addresses a substantial local data deficit, providing a foundational dataset for future public health initiatives in Southeastern Türkiye.

The results indicated a high prevalence of overweight (33.7%) and obesity (39.7%) in our sample (Table 1). These rates exceed Türkiye's national obesity prevalence of 20.2%, as reported by the Turkish Statistical Institute (TURKSTAT) for 2022.[15] While our findings align more closely with the nationally representative, measurement-based TNSA 2019 study,[5] the high obesity rate documented among females (43.3%) suggests distinct regional patterns or the influence of sample selection bias, as our data were derived from individuals seeking care at a health center. This discrepancy underscores the critical need for direct measurement methods in population health surveillance to capture a more accurate epidemiological picture than that provided by survey-based estimates alone.

Our gender-stratified analyses revealed pronounced sexual dimorphism in the body composition. While males exhibited significantly higher fat-free mass and skeletal muscle mass, females presented with greater body fat mass, visceral fat levels, and BMI (Table 1). The large effect size for the difference in visceral fat level (Cohen's d=0.86) highlights a clinically significant disparity that aligns with obesity from a gender-specific disease perspective.[16] The literature supports these fundamental differences in adipose tissue distribution. Males typically accumulate metabolically riskier abdominal/visceral (android) fat, whereas premenopausal females tend to store fat predominantly in subcutaneous lower-body (gynoid) depots, which are comparatively metabolically benign.[16] Although men typically accumulate more abdominal/visceral fat, in our sample, women had higher visceral fat levels. This pattern may reflect region-specific lifestyle and sociocultural factors (e.g. lower physical activity and different dietary patterns among women in Siirt), as well as the care-seeking nature of our sample. The detrimental impact of excess visceral (android) adiposity on cardiometabolic health is well documented; a recent systematic review and meta-analysis reported that higher visceral adiposity index values are associated with increased risks of cardiovascular disease, stroke, coronary heart disease, and cardiovascular mortality.[17] Although males possess greater absolute muscle mass, recent meta-analytic evidence indicates that relative gains in muscle hypertrophy following resistance training are comparable between the genders.[18] This finding suggests that, despite differing baseline values, the physiological capacity for muscle development is similar, reinforcing the necessity for gender-specific reference standards in clinical contexts.

Consistent with previous work, our cross-sectional data showed that older age was associated with progressively higher BMI, body fat mass, and visceral fat levels after the fourth decade of life (Table 2). This trend is critically linked, especially in females, to the menopausal transition, a period characterized by hormonal changes that accelerate visceral fat accumulation.[19,20] As an active endocrine organ, this visceral fat depot is directly implicated in the pathogenesis of insulin resistance, systemic inflammation, and several cardiometabolic diseases.[21,22] The combination of age-related visceral fat gain and declines in muscle mass and strength has been described as a "sarcopenic obesity" phenotype, which is associated with increased all-cause mortality.[23,24] Our finding of a statistically stable skeletal muscle mass across age groups (p=0.071) may mask underlying declines in muscle quality or strength, demonstrating how this perilous condition can be missed by BIA or BMI alone.[3,23,25]

The analysis demonstrated the profound limitations of BMI as a standalone diagnostic tool and the heterogeneity of obesity in adults. As shown in our BMI-stratified data (Table 3), increases in BMI were paralleled by significant increases in both deleterious fat mass and metabolically protective skeletal muscle mass. This paradox, in which BMI is influenced by both tissues, is shown in our correlation matrix (Figure 1). This confirms that BMI is a blunt instrument that can misclassify muscular individuals while failing to identify high-risk phenotypes such as "normal weight obesity," a condition in which individuals with a normal BMI harbor excess body fat.[26] The danger of normal weight obesity is significant; it has been shown to elevate the risk of developing sarcopenia by up to 25-fold in females.[3] Furthermore, a large-scale cohort study in individuals with overweight/obesity has challenged the "obesity paradox", showing that higher fat mass is associated with increased mortality, whereas greater lean mass is associated with lower mortality.[27] Our multiple linear regression analysis encapsulates this issue. The model, which explained a significant proportion of the variance in BMI (R^2=0.822, p<0.001), showed that visceral fat level had the strongest statistical association with BMI (β=0.774), followed by skeletal muscle mass (β=0.380) (Table 4). The negative beta coefficient for gender suggests that when other factors are held constant, females tend to have a lower BMI, likely reflecting biological differences in body structure. Taken together, these associations support the interpretation of BMI as a composite measure influenced by both metabolically unfavorable (fat mass, visceral adiposity) and more beneficial (skeletal muscle) components, which may limit its utility as a standalone indicator of individual metabolic risk.

These findings should be interpreted in the context of several methodological limitations. The retrospective, single-center, non-probabilistic sampling design carries an inherent risk of selection bias and limits the generalizability of our findings to other populations. The BIA method has documented vulnerabilities; its accuracy is contingent on hydration status,[11] and it systematically underestimates bone mineral content compared to the gold standard, Dual -Energy X-ray Absorptiometry (DXA).[28] This instrumental bias may partly explain the large mineral deficit observed in females and underscores the need for caution. While modern high-frequency BIA devices show a better correlation with DXA for lean mass, their accuracy can be diminished in obese populations.[29,30] Finally, the lack of control over confounders such as physical activity and the absence of socioeconomic data narrow the scope of our study.

In conclusion, this cross-sectional study of 1062 adults from Siirt Province showed a high prevalence of overweight and obesity and unfavorable patterns of visceral adiposity, particularly among women and older adults. Visceral fat level demonstrated the strongest statistical association with BMI, while skeletal muscle mass showed a weaker but positive association, highlighting the composite nature of BMI and its limitations as a standalone indicator of metabolic risk. These findings underline the importance of incorporating bioelectrical impedance-based body composition assessment into routine clinical practice, especially in socioeconomically disadvantaged regions, to improve risk stratification and counseling. Future multicenter, prospective studies using gold-standard methods, such as DXA, and including detailed lifestyle and socioeconomic data, are needed to confirm and extend these observations.

Ethics Committee Approval: The study was conducted in accordance with the ethical principles of the Declaration of Helsinki and was approved by the Siirt University Non-Interventional Clinical Research Ethics Committee (date: 21/04/2025, decision no: 2025/01/04/1).

Conflict of Interest: No conflict of interest was declared by the authors.

Author Contributions: Concept – ED, RZA; Supervision – ED, RZA; Materials – ED, RZA; Data Collection and/or Processing – ED, RZA; Analysis and/or Interpretation – ED, RZA; Writing – ED, RZA.

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