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Elit Kadın Voleybolcularda Bölgesel Vücut Kompozisyonunun ve Uzuvlar Arası Asimetrilerin Değerlendirilmesi

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Özet

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Amaç: Bu çalışmanın amacı, elit kadın voleybolcularda yağ kütlesi (FM), kas kütlesi (MM) ve yağsız vücut kütlesi (FFM) için normatif verileri belirlemek ve vücut kompozisyonunda uzuvlar arası farklılıkları incelemektir.
Gereç ve Yöntem: Çalışmaya toplam 34 elit kadın voleybolcu katılmıştır. Vücut kompozisyonu, biyoelektrik empedans analizi (BIA) yöntemi kullanılarak değerlendirilmiştir. Tüm ölçümler sabah saatlerinde, 08.00 ile 10.00 arasında, kontrollü laboratuvar koşullarında (22–24 °C) gerçekleştirilmiştir. Sporculara ölçümden en az 12 saat önce herhangi bir gıda tüketmemeleri, ayrıca ölçümden 24 saat önce kafein, alkol ve yoğun fiziksel egzersizden kaçınmaları talimatı verilmiştir.
Bulgular: Yağ kütlesi, yağsız vücut kütlesi ve toplam vücut suyu için ortalama değerler sırasıyla 13.26 ± 4.62 kg, 53.81 ± 7.95 kg ve 30.80 ± 12.09 L olarak bulunmuştur. FM, FFM ve MM'nin uzuvlar arasındaki karşılaştırmalarında istatistiksel olarak anlamlı bir fark tespit edilmemiştir ($p > 0.05$). Dominant ve nondominant bacaklar arasındaki karşılaştırmada, yağ kütlesi, FFM ve MM için p-değerleri sırasıyla 0.058, 0.066 ve 0.071 iken; kollarda bu değerler sırasıyla 0.070, 0.384 ve 0.281 olarak bulunmuştur.
Sonuç: Uzuvlar arasında anlamlı morfolojik farklılıklar tespit edilmemesine rağmen, fonksiyonel düzeyde küçük asimetriler mevcut olabilir. Bu bulgular, elit kadın voleybolcuların dengeli bir vücut kompozisyon profiline sahip olduğunu göstermektedir. Morfolojik ve fonksiyonel asimetriler arasındaki ilişkiyi daha iyi anlamak için gelecekteki araştırmalarda kas tonusu ve sertliği ölçümlerinin entegre edilmesi önerilmektedir.

Assessment of Regional Body Composition and Interlimb Asymmetries in Elite Female Volleyball Players

Abstract

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Keywords:
Body composition, Interlimb asymmetry, volleyball.

Aim: The aim of this study was to determine normative data for fat mass (FM), muscle mass (MM), and fat-free mass (FFM) in elite female volleyball players and to examine interlimb differences in body composition.
Method: A total of 34 elite volleyball players participated in the study. Body composition was assessed using the bioelectrical impedance analysis (BIA) method. All measurements were performed in the morning, between 08:00 and 10:00 a.m., under controlled laboratory conditions (22–24 °C). Athletes were instructed to avoid food intake for at least 12 hours, and to refrain from caffeine, alcohol, and strenuous exercise 24 hours prior to testing.
Results: The mean values for fat mass, lean body mass, and total body water were 13.26 ± 4.62 kg, 53.81 ± 7.95 kg, and 30.80 ± 12.09 L, respectively. Comparisons of FM, FFM, and MM between limbs revealed no statistically significant differences ($p > 0.05$). In the comparison between dominant and non-dominant legs, the p-values for fat mass, FFM, and MM were 0.058, 0.066, and 0.071, respectively, whereas the corresponding values for the arms were 0.070, 0.384, and 0.281.
Conclusion: Although no significant morphological differences were detected between limbs, minor asymmetries may exist at the functional level. These findings indicate that elite female volleyball players exhibit a well-balanced body composition profile. Future research is recommended to integrate muscle tone and stiffness measurements to better understand the relationship between morphological and functional asymmetries.

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Introduction

Body composition is a critical parameter in athletes that indicates how total body mass is distributed across components such as fat mass (FM), which represents the amount of adipose tissue in the whole body or a specific region; muscle mass (MM), which refers to the total weight of skeletal muscle tissue; and **fat-**free mass (FFM), which accounts for all body components excluding fat, such as muscle, bone, and water (Ackland et al., 2012). Especially in team sports such as volleyball, a high FM can negatively affect key performance parameters, including quickness, agility, and vertical jump ability (Nikolaidis & Ingebrigtsen, 2013). However, excess fat tissue can impair movement speed, prolong reaction time, and limit athletic performance by creating additional and non-functional load (Silva et al., 2010). In addition, asymmetries between limbs in terms of muscle mass (MM), (FFM), or strength can negatively influence performance and increase the risk of injury (Lockie et al., 2014). In this context, determining body composition values of volleyball players at both whole-body and regional levels and establishing reference norms are of great importance (Malousaris et al., 2008).

Studies investigating the body composition of volleyball players, systematic reviews using traditional methods show that different measurement techniques generate significant variability in results (Ackland et al., 2012; Malousaris et al., 2008). It has been reported that the percentage of body fat in female volleyball players varies considerably depending on the measurement method, with average values of approximately 18% using the skinfold thickness method, 18.4% using bioelectrical impedance analysis (BIA), and 24.2% using dual-energy X-ray absorptiometry (DXA) (Matłosz et al., 2023). Although the study by Matłosz et al. significantly advanced the comparison of different body composition assessment methods, it failed to establish practical reference norms that could be directly applied by coaches and sport scientists in real-world contexts. The measurement system employed was cost-prohibitive and limited in accessibility, reducing its applicability in field environments. Similarly, in a study conducted by Bisch et al. (2020) using the DXA method on U.S. collegiate female volleyball players, total and regional muscle–fat distributions were examined. The authors reported that regional muscle mass and bone mineral density were significantly higher in front-line players (middle blockers and spikers/outside hitters–setter cross) compared to those in other positions (Bisch et al., 2020). These findings indicate that different evaluation norms should be determined for athletes playing in different positions. Sieroń et al. (2023) examined changes in body composition among young female volleyball players over a one-year training cycle and observed increases in lean mass and body cell mass, as well as a decrease in FM between the pre-season and post-season measurements (Sieroń et al., 2023). This study emphasizes that body composition values obtained according to the season period should be evaluated differently. Although these studies clearly demonstrate the importance of body composition in volleyball players in terms of performance and training planning, most have focused only on whole-body values or have not conducted a systematic analysis at the regional level (Campa et al., 2021; Ziv & Lidor, 2010). While previous studies have clearly demonstrated the importance of body composition in volleyball players for performance and training planning, most have focused solely on whole-body values or have not conducted systematic analyses at the regional level. Moreover, the findings related to reference normative values describing interlimb asymmetries in MM, FM, and FFM among elite female volleyball players remain

quite limited. Therefore, the present study aims to address this gap by analyzing differences in body composition between the dominant (DOM) and non-dominant (NDOM) legs and arms of elite female volleyball players.

In conclusion, this study aims to determine the FM, MM, and FFM values of female volleyball players at both the whole-body and regional levels (trunk, DOM and NDOM leg, DOM and NDOM arm). The purpose of this research is to identify differences in muscle and fat mass between limbs in elite female volleyball players and to establish reference normative values in this regard. Accordingly, it was hypothesized that there would be significant compositional differences between limbs, with the DOM limb exhibiting greater muscle mass than the NDOM limb. The findings of this study are expected to provide valuable reference data for maintaining performance, monitoring asymmetries, and individualizing training planning in female volleyball players.

Material and Methods

Research Group

In this study, data were collected from 1st and 2nd Division Volleyball Clubs affiliated with the Turkish Volleyball Federation. A total of 34 elite female volleyball players who were actively competing in the leagues voluntarily participated in the study. All participants were free from any musculoskeletal injuries or health problems that could affect their performance during the testing process. Athletes who had sustained injuries within the previous six months were excluded from participation. The mean and standard deviation values for age, height, body weight, and body mass index (BMI) of the participants were 20.44 ± 4.59 years, 180.06 ± 9.85 cm, 67.44 ± 11.28 kg, and 20.65 ± 1.76 kg/m², respectively.

Measurement Protocol

Body composition measurements were performed using the Tanita BC-418 Segmental Body Composition Analyzer (Tanita Corporation, Tokyo, Japan). This device estimates body components-FM, FFM, and total body water-based on electrical impedance differences, according to the principle of bioelectrical impedance analysis (BIA). To ensure measurement accuracy, all procedures were conducted under standardized BIA conditions, as described in previous studies (Kelly & Metcalfe, 2012; Völgyi et al., 2008).Measurements were performed in the morning (between 08:00 and 10:00) in a laboratory setting maintained at 22–24 °C. Participants were instructed to fast for at least 12 hours prior to testing, to void their bladder on the morning of measurement, to refrain from strenuous physical activity for 24 hours beforehand, and to avoid alcohol, caffeine, and smoking the day before testing (Kelly & Metcalfe, 2012). All metal accessories were removed before assessment, and measurements were not performed during menstruation to prevent fluctuations in body fluid balance. Data collection took place only under conditions where proper hydration status was achieved.

During the measurements, participants stood barefoot on the analyzer platform and firmly grasped the hand-held electrodes with both hands. The device performed the analysis through an eight-electrode system, assessing five body segments: right arm, left arm, right leg, left leg, and trunk. For the whole-body assessment, FM, FFM, and total body water (TBW) parameters were analyzed. For the regional analyses of the lower limbs (DOM and NDOM legs), upper limbs (DOM and NDOM arms), and trunk, FM, FFM, and

MM values were measured. In addition, whole-body averages of these variables were included in the overall analysis. Upper limb dominance was determined by the question, 'Which hand do you use for spiking?', while lower limb dominance was identified by the question, 'Which leg do you use for kicking a ball?'(van Melick et al., 2017).

The inter-limb asymmetry index (AI%) for fat mass (FM), fat-free mass (FFM), and muscle mass (MM) was calculated using the following formula:

AI% = [(|Dominant - Non-dominant|) / Dominant] × 100 (Bishop et al., 2018)

This formula provides a normalized percentage to quantify the magnitude of differences between the preferred and non-preferred limbs.

Statistics

Statistical analyses were performed using IBM SPSS Statistics 24.0 software (IBM Corp., Armonk, NY, USA). The normality of the measurement parameters was assessed using the Shapiro–Wilk test, and the homogeneity of variances was evaluated with Levene's test. After confirming that all data followed a normal distribution and that variances were homogeneous, paired-sample t-tests were conducted to examine differences between the DOM and NDOM limbs. In addition to the statistical significance, the inter-limb asymmetry index (AI%) was evaluated. An AI% value of >10% was determined as the threshold for identifying a significant morphological asymmetry between limbs, in accordance with the established sports science literature(Bishop et al., 2018; Read et al., 2021). The results are presented as mean ± standard deviation (mean ± SD). Statistical significance was set at $p < 0.05$ (significant) and $p < 0.01$ (highly significant).

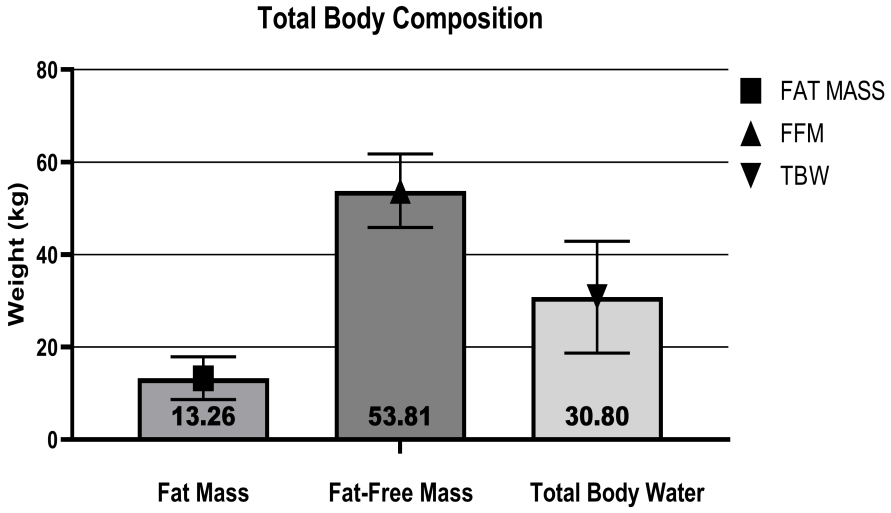
The statistical power of the study was evaluated using G*Power software (v3.1.9.4, Heinrich Heine University, Düsseldorf, Germany). For the comparison of regional body composition of between parameters between dominant and non-dominant limbs, a post-hoc power analysiswas performed using the "Difference between two dependent means (matched pairs)" design. Based on the sample size of 34 participants, an alpha level (α) of 0.05, and the observed effect size ($dz = 0.58$), the actual power (1-β) of the study was calculated as 0.95 (Cohen, 2013).

All participants were informed about the purpose and procedure of the research and signed a written voluntary consent form. The study was approved by the Istanbul University-Cerrahpaşa Ethics Committee (Decision No: 2024/252).

Bulgular

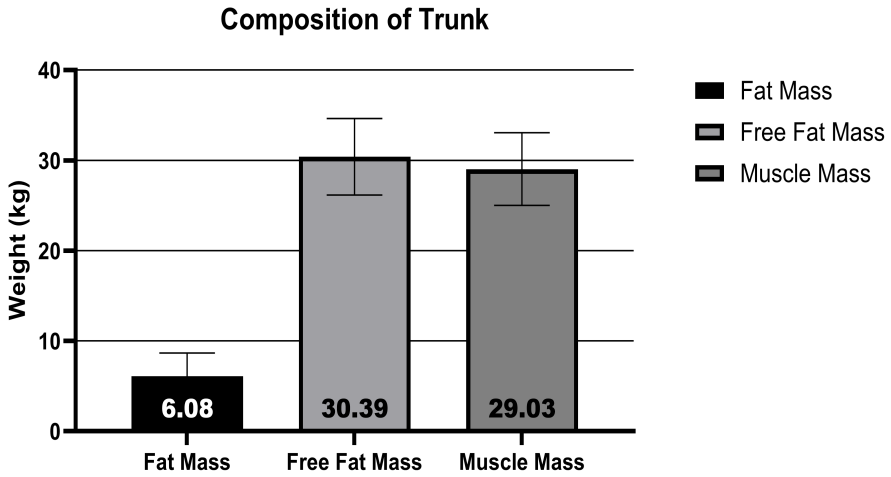
The whole-body composition values of the female volleyball players are presented in Figure 1. Examination of the mean FM, FFM, and TBW values indicates that elite-level athletes generally exhibit a low fat ratio and a high proportion of lean mass.

Figure 1. The values of whole-body composition parameters, including FM, lean mass, and total body water, are presented for the female volleyball players.



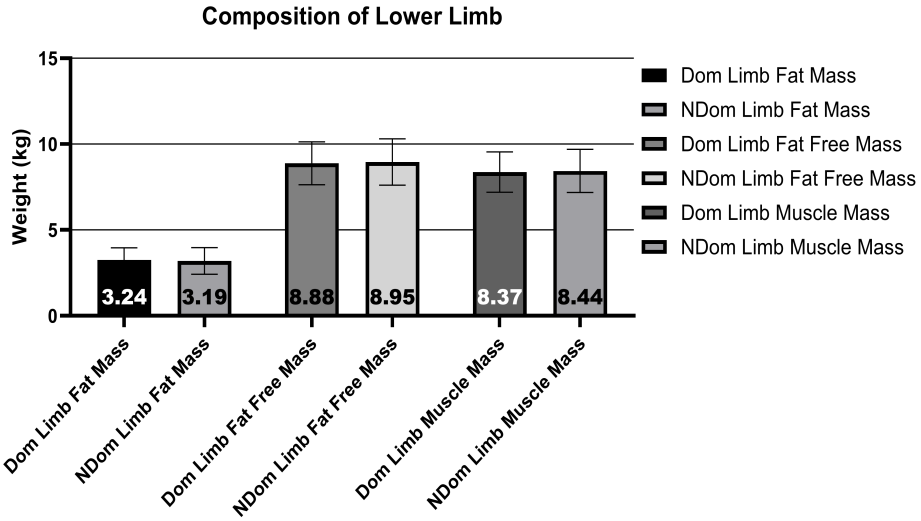
The body composition values of the trunk region of female volleyball players are presented in Figure 2. The average values of FM, lean body mass (Fat-Free Mass) and TBW obtained from the measurements are shown.

Figure 2. Body composition values of the trunk region in female volleyball players. The graph shows the average fat mass, lean body mass(FFM) and total body water (TBW) values of the trunk area.



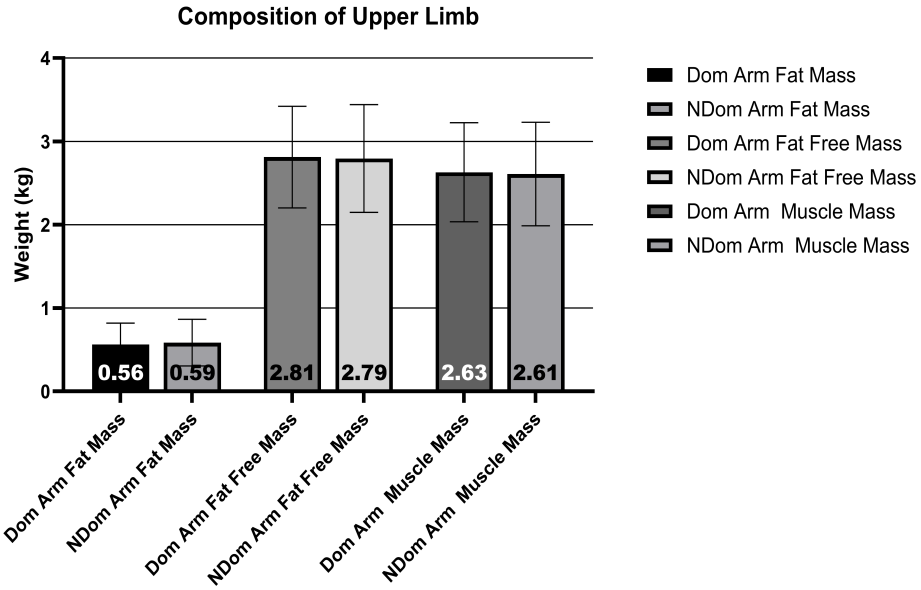
The body composition values of the DOM and NDOM legs of the female volleyball players are presented. The mean values of FM, FFM, and MM for both legs were compared.

Figure 3. Comparison of mean and standard deviation FM, FFM, and MM between DOM and NDOM legs in female volleyball players.



The body composition values of the DOM and NDOM arms of the female volleyball players are presented. The mean values of FM, FFM, and MM for both arms were compared.

Figure 4. Mean values of FM, FFM, and MM for the DOM and NDOM arms in female volleyball players.



The differences between the FM, FFM and MM values of the DOM and NDOM limbs in female volleyball players were analyzed with the Paired Sample t-Test. No statistically significant difference was found in comparisons made in both leg and arm regions ($p > 0.05$).

Table 1. Pared Saple t Test Results of DOM and NDOM limbs.

Body Part	Variables	*t*	*p* (2-tailed)	Asymmetry Index(%AI)	Cohen's d
Lower Limb	Fat Mass	1.963	0.058	3.45±3.35	0.34
	Fat-Free Mass	-1.898	0.066	2.21±1.48	0.32
	Muscle Mass	-1.866	0.071	2.05±1.59	0.32
Upper Limb	Fat Mass	-1.873	0.070	7.2±11.94	0.32
	Fat-Free Mass	0.882	0.384	2.89±2.64	0.15
	Muscle Mass	1.096	0.281	2.77±2.67	0.19

The comparison of body composition parameters between dominant (DOM) and non-dominant (NDOM) limbs revealed no statistically significant differences ($p > 0.05$) in either the lower or upper extremities (Table 1). While the p-values for FM (p=0.058), FFM (p=0.066), and MM (p=0.071) in the lower limbs approached the significance threshold, the corresponding Cohen's d effect sizes (ranging from 0.32 to 0.34) indicated only a 'small' magnitude of difference. Furthermore, the mean inter-limb asymmetry index (AI%) values for all analyzed parameters remained well below the 10% threshold. The highest asymmetry was observed in upper limb FM (7.20±11.94), while the lowest was found in lower limb MM (2.05 ±1.59). These findings demonstrate that elite female volleyball players exhibit a highly symmetrical morphological profile, with no practically meaningful asymmetries in regional body composition.

Table 2. Normative Percentile Values for Body Composition in Elite Female Volleyball Players (n=34)

Variables	25th Percentile	50th Percentile (Median)	75th Percentile
Total Fat Mass (kg)	10.00	12.60	16.20
Total Fat-Free Mass (kg)	48.60	53.00	59.10
Total Muscle Mass (kg)	46.10	50.90	56.60
Lower Limb MM (kg)	8.10	8.40	9.10
Upper Limb MM (kg)	2.10	2.60	2.90

To establish a reference framework for elite female volleyball players, normative percentile values were calculated (Table 2). The median (50th percentile) values for FM and MM were 12.60 kg and 50.90 kg, respectively. These percentile ranges provide coaches and sports scientists with practical benchmarks for evaluating individual athletic profiles and monitoring body composition changes throughout the competitive season.

Discussion

Body composition and its effects on performance parameters have been extensively studied in female volleyball players. The present study aimed to characterize body composition components both at the whole-body and regional levels and to clearly identify potential differences between limbs. As one of the key determinants of performance in team sports, body composition can vary considerably among female athletes depending on factors such as playing position, training experience, competitive level, and strength profile. However, most existing studies in the literature have examined this variability only at the whole-body level, without systematically addressing interlimb differences in muscle, fat, and fat-free mass. By addressing this gap, the present study provides detailed normative data for trunk, arm, and leg segments in elite female

volleyball players, offering a valuable reference framework for both scientific research and applied performance assessment.

Body composition is one of the important determinants affecting performance in volleyball players, and especially low fat content and high FFM ratio have a direct effect on agility, jumping and strength production. In the present study, the mean body fat percentage of female volleyball players was 19.2%, fat-free mass (FFM) was 49.8 ± 5.7 kg, and muscle mass (MM) was 47.2 ± 5.1 kg (Figure 1). These values are largely consistent with the normative ranges reported in previous studies. Matłosz et al. (2023) reported that in female volleyball players, the body fat percentage was approximately 18.3% using the skinfold method, 18.4% using BIA, and 24.2% using DXA (Matłosz et al., 2023). Similarly, Cereda et al. (2025) found that elite female volleyball players assessed by the BIA method had an average body weight of 72.6 ± 6.2 kg and a height of 182.7 ± 5.4 cm, with a body fat percentage consistent with a highly competitive athletic profile (Cereda, 2025). In this context, the fact that the fat percentage observed in our study falls within the normative ranges recommended in the literature, together with the high FFM values, indicates that our participants exhibit an optimal body composition profile characteristic of elite female volleyball players.

Analysis of the DOM and NDOM limb results revealed no statistically significant differences in FM, FFM, or MM (Table 1). These findings are largely consistent with the normative data reported in previous studies. For instance, Joksimovic et al. (2024) reported that the difference in DOM and NDOM leg muscle mass among elite female volleyball players was less than 3%, which was not considered clinically relevant for performance(Joksimovic et al., 2023). Similarly, Carrasco-Fernández et al. (2023) noted that while no significant morphological asymmetry was observed in handball players in terms of muscle distribution, minor functional differences in force production (e.g., jump height or single-leg thrust) could vary depending on playing position(Carrasco-Fernández et al., 2023). The 'small' effect sizes (Cohen’s d: 0.32–0.34) and AI% values well below the 10% threshold indicate that the observed differences are not clinically relevant or performance-limiting. While volleyball involves unilateral movements like spiking, the bilateral nature of jumping and landing tasks in elite training appears to maintain morphological symmetry. These findings suggest that elite female volleyball players possess a well-balanced structural profile, and any potential performance asymmetries are likely functional or neuromuscular rather than morphological in origin.

In the literature, asymmetries related to playing position have been reported in force platform assessments, isokinetic strength tests, and various field-based performance tests (Bishop et al., 2023; Nicholson et al., 2022). However, because many of these asymmetries are associated with neuromuscular control and force production dynamics, the distribution of fat, muscle, or lean mass measured at the body composition level may not directly reflect these functional differences. Consistent with this, no morphological differences were observed between the DOM and NDOM limbs in the present study, suggesting that compositional balance is maintained in elite athletes. Therefore, although performance-based asymmetry indicators are evident among volleyball players, the absence of morphological asymmetry in terms of muscle and fat ratios implies that these differences are likely functional rather than structural in origin.

In conclusion, the findings of this study indicate that the body composition of female volleyball players is well balanced, with no significant morphological differences between limbs, and that any potential performance-related asymmetries are largely functional in nature. These results suggest that systematic training programs implemented at the elite level contribute to maintaining structural symmetry by promoting a balanced distribution of muscle and FM. Consequently, body composition should be considered not only as an indicator of physical fitness but also as a valuable assessment tool for reducing injury risk and ensuring performance continuity. The normative, segmental-level body composition values obtained in this study provide an important reference database for future research in performance monitoring, rehabilitation, and training program design for female volleyball players.

Future Directions

In future research, it is recommended that morphological findings related to body composition be evaluated in conjunction with functional parameters. Specifically, assessing interlimb asymmetries not only at the mass or proportion level but also through physiological indicators such as muscle tone, muscle stiffness, and muscle activation patterns would enhance the interpretive power of the findings. In this context, the use of measurement systems capable of directly assessing muscle properties, such as tensiomyography (TMG) or myotonometry, could provide a more comprehensive understanding of the relationship between compositional differences, performance, and injury risk. Moreover, longitudinal assessments conducted throughout the training period would be valuable for determining how changes in body composition are reflected in performance indicators over time.

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