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Research Article

Analysis of Body Composition and Volleyball Performance in Athletes of the Italian Top League

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Abstract

Objectives: The assessment of body composition is crucial for identifying an individual's characteristics critical to performance, evaluating the effects of training programs, managing weight strategies, and monitoring athletic health. Bioimpedance vector analysis is spreading as a method to obtain a qualitative assessment of body composition. In the present study we investigated the relationship between body composition of top-level female volleyball players and their performing data during the matches of the Italian First League Championship.

Design: Observational. Method: Attackers from a volleyball team participating in the Italian 1st (Super Lega) division were monitored by bioelectric impedances performed before each match of the ON-season period and results were related to individual performance data provided for each match by the Italian Volleyball League.

Results: The height of the players was confirmed as a fundamental parameter, it was related to blocked attacks, to service errors, and to attack efficiency. The athletes' body mass showed a performance influence, too. It was correlated to blocked attacks and to the attack efficiency. The FM was correlated to the blocked attacks and with the invasion blocks. The total body water percentage was negatively related to blocks invasion. Conclusion: Any anthropometric and bioimpedance vector analysis data seems to influence the athlete's performance during competitive matches.

Keywords: Volleyball; BIVA; Performance; Body composition

Abbreviation

BC: Body Composition; BCM: Body Cellular Mass; MM: Muscular Mass; FM: Fat Mass; TBW: Total Body Water

ECW: Extracellular Mass Correlated to Extracellular Water; BIVA: BioImpedance Vector Analysis

Introduction

In sports science the assessment of Body Composition (BC) has different applications such as identifying individual's characteristics critical to performance, evaluating the effects of training programs, managing weight strategies, preventing injury risk, and monitoring athletic health [1].

Athletes of specific disciplines possess peculiar physical characteristics as regards the task they will have to perform, a centometrist will have a different body composition than a cross-country skier and a powerlifter will not have the muscle definition of a bodybuilder. The association between biophysical characteristics and performance could be questioned when discussing disciplines where different functional parameters come into play [2].

Volleyball is an activity where each member of the team plays a pre-established and synergistic role to obtain the maximum performance, the dynamism that must be created within the group must generate a complex balance where the peculiarities of the subjects make the difference. Volleyball is a very dynamic sport characterized by various sprints, jumps (blocking and spiking), and high-intensity court movements that occur repeatedly during competition [3]. The successful performance of these movement structures depends greatly on anthropometric and physical variables. Therefore, the analysis of body composition is a critical component in the field. Although densitometry and Dual-energy X-ray Absorptiometry (DXA) are the most accurate methods to evaluate BC, they are expensive and impractical for field use because they require large, specialized equipment [4].

In recent years, Bioimpedance Vector Analysis (BIVA) has received attention as a method to obtain a qualitative assessment of BC [5], even if recent studies conducted on athletes have highlighted the need for sport-specific BIVA references by establishing data from sets of sports such as soccer, volleyball, or cycling [6–9].

BIVA allows us to measure body cell mass (BCM) apart from simply assessing fat-free mass and fat mass [10]. BCM comprises protein-rich intracellular tissues responsible for nearly all of the metabolic processes in the body and also for strength. In a normal healthy individual, muscle tissue consists approximately of 60% of the body cell mass. The volume and function of the muscle portions of BCM further can be enhanced by physical activity and systematic exercise. Therefore, the evaluation of BCM in athletes is a stronger predictor of athletic performance and strength [11].

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BIVA measurements allows also to identify the phase angle (PhA), calculated as the arctangent of Xc/R × 180°/π [4]. It is a raw variable that has been gaining attention in recent years as it is supposed to be an index of the ratio between extracellular and intracellular water, body cell mass, and cellular integrity [2]. PhA is associated with muscle strength and physical activity [4,7,12], even if a recent review highlighted the need to assess to what extent PhA may be a reliable index for identifying an individual's characteristics critical to performance [2]. Generally, previous studies investigated the relationship between anthropometric data and performance tested by physical tests (sit-and-reach, grip strength, sit-up, push-ups, vertical jump, peak power performance, sprint). There is a lack of data relating to performance during the match. Therefore, the goal of the present study was to investigate the relationship between body composition of top-level female volleyball players and their performance data during the matches of the Italian First League Championship.

Methods

The present study was carried out on players recruited from a volleyball team participating in the Italian 1st (Super Lega) division, which ended the championship in the 6th position. To make the sample homogeneous, only the six attackers were included, while setters and liberos were not, according to the standard classification of playing position in this sport [3,13]. Informed written consent was obtained from the study participants. The athletes had an average age of 28 (range 20-33) years at the beginning of the observational season. Bioelectric impedances were performed before each match of the ON-season period. Individual performance data were provided for each match, by the Italian Volleyball League.

The physical characteristics of the subjects including height (cm) and weight (kg) are measured by anthropometric rod and digital weighing machine respectively followed by standard procedure.

BC including Body Cell Mass (BCM), Body Mass Index (BMI), Fat-Free Mass (FFM), fat mass, total fat percent, total Muscle Mass (MM), Total Body Water (TBW) and Extra-Cellular Water (ECW) are measured using Bioelectrical Impedance Analysis (BIA 101 Anniversary, Akern, Florence, Italy), which applies an alternating current of 800 μA at a single frequency of 50 kHz. Measurements are made using four electrical conductors. The subjects are in a supine position taking rest for 5 minutes on a non-conducting surface, with the arms slightly abducted from the trunk and the legs slightly separated. Surface electrodes are placed on the right side of the body on the dorsal surface of the hands and feet. In the case of hand, electrodes are placed proximal to the metacarpal- phalangeal and medially between the distal prominences of the radius and ulna. In the case of feet, electrodes are placed proximal to the metatarsal-phalangeal joints, respectively, and also medially between the medial and lateral malleoli at the ankle [1,2].

Individual performance data, provided by the Italian Volleyball League includes data for service – ace, errors, ace per set, and efficiency, calculated as the aces minus errors, divided by total services; data for the reception - errors, negative/poor defense, perfect defense, percentage of perfect defense calculated on total defense, efficiency, calculated as perfect defense minus errors, divided by total defenses; data for the attack - errors, blocked attacks, winning attacks, percentage of winning attacks on total attacks, and efficiency, as winning attacks minus error attacks divided by total attacks; data for blocks-invasion blocks, block points per set (http://www.legavolleyfemminile.it).

Statistical analyses were performed using the SPSS package, version 25.0 (IBM Corp.). For the analysis of the data the athletes were subdivided into two groups concerning their play role, wing spikers and middle hitters, 4 and 2 respectively. Spearman's correlation was calculated to assess relationships between variables and the Wilcoxon test was used to compare means. The mean differences and correlations were considered significant if $p < 0.05$ and highly significant if $p<0.01$.

Results

The player's characteristics in terms of BC data are reported in Table 1. Analyzing the influence of the anthropometric variable on performance on the field (Spearman's rho correlation), the height of the players is negatively related to blocked attacks (-0.659, $p<0.05$), to service errors (-0.593 $p<0.05$); and positively related to attack efficiency (0.484, $p<0.05$). While the athlete's body mass is negatively related to blocked attacks (-0.717 $p<0.01$) and positively related to the attack efficiency (0.494 $p<0.05$).

FM in negatively related to blocked attacks (-0.565 $p<0.05$) and positively related to the invasion blocks (0.720 $p<0.05$). The total body water percentage is negatively related to blocks invasion (-0.739 $p<0.05$).

No other significant correlation between statistical performance data and the other anthropometric data was observed.

Discussion

The mean height of 187 cm of our players is higher than 181+-2 cm registered in volleyball hitters by Malousaris et al. [14], or than reviewed by Lindor et al. (between 164.3 +- 4.0 cm and 187 +- 5.4 cm) [15,16] or than (1.73 ± 0.07 m) more recently evaluated by Papadopoulou et al. [17]. The height of the players reduces the attacks blocked, the service errors and correlates with the efficiency of the attack, highlighting the parameter of height as fundamental physiological characteristic related to performance in volleyball as elsewhere pointed out for athletes involved in the same sport [14,16–20], or more in general in sports in which the high of the jump is

Table 1: Descriptive analysis of the main characteristics of the athletes during the observation period.

	Athletes	Measure number	Min	Max	Mean	St. Dev.
Height (cm)	6	22	185	189	187	1.5
Weight (Kg)	6	22	71	86	79.75	4.2
Age (years)	6	6	20	33	28	4
PhA	6	22	6.2	8.2	7.13	0.57
BCM (kg)	6	22	32.1	41.9	36.65	2.63
MM (Kg)	6	22	39.4	50.5	44.57	3.01
FM (Kg)	6	22	10.6	22.5	17.18	3,91
FM%	6	22	15	27	21.3	3.93
TBW %	6	21	53	62.5	57.5	3.09
ECW %	6	21	38	45	41.4	1.99
TBW (L)	6	21	37.6	53.75	45.8	2.46

fundamental for the performance [21,22].

In the involved players, body mass value of 79.7 kg is higher than the range between 62.5 ± 8.0 kg and 75.1 ± 7.4 kg reviewed by Lindor et al. [16,20] or than 66.1 ± 9.1 more recently evaluated by Papadopoulou et al. [17]. Body mass is positively associated with the attack efficiency, and negatively related to blocked attacks, confirming that players with a higher skill level are taller and somewhat heavier [16].

The fat mass percentage mean value of 21.3 is in line with 23.4 ± 2.8 monitored by Bayios et al. [19] or with 22.2 by Ferris et al. [23] or superior to 11.7 ± 3.7% and 18.3 ± 3.4% monitored by Fleck et al [24]. The relationship between body fat and performance in volleyball has been identified for many decades [25,26] and again recently [27,28], highlighted that women of high-performance level had low BF. In the present study we recognize a positive relation between BF and invasion blocks, as athletes with more fat are more prone to invasion, classified body fat as a performance-damaging variable, but on the other hand, body fat is also negatively related to blocked attacks, emphasizing that athletes with more fat mass presented an additional efficiency in the reducing the opponent's wall.

The mean PA value of 7.1 of the athletes is higher than in a recent analysis evaluated for team sports female athletes, reporting 6.8 +- 0.8 [4]. But even if elsewhere PhA it is significantly associated with muscle strength and physical activity [4,7,12], in this study no relationship has been outlined with performance data, confirming the need emphasized by Di Vincenzo et al. that for or a given sport much more data should be collected in a systematic way and for some time appropriate to determine changes and trends [3]. The average age of 28 years of the players is greater than elsewhere recorded [14,16,18,19].

The mean age of 28 y in our sample (Table 1) is higher than elsewhere evaluated in top-lev performance, as than 26.9 ± 6.6 y by Campa et al. [4], or than 24.8 ± 5.3 years by Papadopoulou et al [17]. In our study we did not record differences in performance related to age, in line what Kitamura et al pointed out on top-level volleyball players, suggesting that aging per se is not capable of substantially improving loaded and unloaded vertical jump performances across different age categories [29].

Mean pre-match athletes' hydration status is 56%, below 60-65%, referred by the instrument algorithms as normal hydration. In a recent analysis the mean value for team sports female athletes was TBW 39.8 ± 4.8 L [4], lower than 45.8 L registered in the hitters involved in our study.

The marked negative relations observed between total body water percentage and blocks invasion doesn't find a plausible explanation. The maximum percentage of total water recorded is however within the limits of adequate hydration and does not encroach on values of hyper-hydration, so it finds no rational evidence with a higher incidence of wall invasions.

As per BCM, the only study that provided BCM data for athletes is Andreaoli et al [11]. But data were for male soccer athletes. Therefore, it is not possible to compare. Anyway, the trend they observed between lower BCM and lower athletic performance, evaluating the body cell mass as a stronger predictor of athletic performance and strength [11], was not observed in our study.

Conclusion

In conclusion, based on our study, the height confirmed its role in determining advantage characteristics for players of a higher skill level, especially for its role in attack efficiency and the service. Concerning body fat, published data are not consistent if it is an advantageous feature in volleyball. On the other hand, in the present study, a greater weight influenced the attack, the ability to overcome the opposing walls, and the possibility for greater strength of the attacks.

A limitation of our study is the low numbers of players involved and the small size of the data-set. This has probably influenced the opportunity to observe significant relations among BC data and sportive performance during the matches. For further study, in addition to expanding the number of players, the physical performance text inclusion is auspicial. Further studies are needed to deep analyze and discuss the influence of the anthropometric variables and athletic performance also during the competitive performance.

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Author's Contribution

Felicina Biorci: coordinate the work.

Felicina Biorci: design the work.

Felicina Biorci: subject inclusion.

Martina Scandola: body composition analysis and data collection.

Felicina Biorci: sports performance data extraction.

Giorgio Gilli and Raffaella Degan: collaboration on the coordination and revision of the work.

Marcello Lucchese: write the draft work.

Deborah Traversi: statistical analysis and bioinformatics, revision of the draft work.

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