Body Composition and Segmental Bioimpedance Phase Angle in Elite Volleyball Players

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Abstract: Because of the great interest in the evaluation of body composition (BC) in athletes, this study aimed to estimate BC variables like fat-free mass (FFM) and fat mass (FM) of volleyball players compared to a group of healthy subjects. 12 female volleyball players (VP, age 23.8 ± 3.6 years; weight 63.0 ± 5.1 kg; stature 170 ± 4 cm; BMI 21.9 ± 1.3 kg/m²) and 22 healthy females as control group (CG, age 23.6 ± 2.0 years; weight 60.7 ± 4.8 kg; stature 167 ± 5 cm; BMI 21.9 ± 1.3 kg/m²), participated to the study. BC was evaluated by skinfold thickness and whole-body and segmental bioimpedance analysis (BIA) measurements were assessed. BC resulted significantly different in VP than CG (FM (kg) = 15.7 ± 2.7 vs. 18.0 ± 3.0, p<0.036; FM (%) = 24.8 ± 3.0 vs. 29.5 ± 3.8, p<0.001; FFM (kg) = 47.4 ± 3.5 vs. 42.8 ± 3.6, p<0.001). These data confirm previous observations on FM % in VP. Moreover, assessing segmental BIA-derived phase angle (PhA) appears to be sensible in these evaluations.

1 INTRODUCTION

Body composition (BC) assessment plays an important role in monitoring athletes’ nutritional status and the effects of training (Brocherie, 2014). Bioelectrical impedance analysis (BIA) and skinfold thickness measurement are field methods for assessing BC that are portable and easy to use. Raw BIA variables are widely used to evaluate cellular function and hydration status. Resistance (R) is the pure opposition of tissues to the flow of the electric current, while reactance (Xc) is related to the capacitance of cell membranes, tissue interfaces, etc. Phase angle (PhA) is the shift between current and voltage (Norman, 2012), is widely used in clinical practice to monitor nutritional status, the effectiveness of nutritional intervention and to predict mortality (Santarpia, 2009; Norman, 2015; Lukaski 2017; Mundstock 2018). There is increasing interest in the use of PhA in athletes as an index of muscle quality, especially with respect to body water distribution, but data are not yet consistent when different sport specialties are compared to each other, and its association with sport performance is still uncertain. In healthy subjects, the PhA ranges from 5 to 7 degrees (Barbosa-Silva, 2005), whereas in trained athletes it may reach 8.5 degrees (Marra, 2009). Several studies (Carrasco-Marginet, 2017; Mascherini, 2015) described that PhA increases after an athletic season, whereas a study by Marra (Marra, 2014) has shown in a team of elite endurance cyclists, during a three-week stage race, a significant and progressive reduction of PhA, especially for lower-limbs, probably due to a loss of intracellular water (ICW) because of continuous vigorous exercise during a long-lasting competition.

Several studies have evaluated the BC of volleyball players (VP) in comparison with other athletes practicing different sport games (Mala, 2015; Valente-Dos Santos, 2018; Fields, 2018; Fields, 2018); or among groups of VP (Mala, 2010; Maly, 2011) but none of them compared BC of VP to a control group with similar anthropometric characteristics.

The aim of this study was to evaluate BC and BIA-derived PhA (for the whole-body or limbs) in 12 elite female VP compared to a group of 22 healthy-controls.

2 METHODS

Twelve elite female volleyball players (VP, age 23.8±3.6 years; weight 63.0±5.1 kg; stature 170±4 cm...
cm; BMI 21.9±1.3 kg/m²) and 22 control young-women with similar characteristics (control non-athletic=C-NA, age 23.6±2.0 years; weight 60.7±4.8 kg; stature 167±5 cm; BMI 21.9±1.3 kg/m²) participated in the study. Data were collected during the regular season of the 2015/2016 Italian Women’s Volleyball Serie B League. Athletes trained to Monday to Saturday four hours/day. Control women did not follow regular exercise regimes.

Participants were studied in the morning (9.00 a.m.) by the same operator, following standard procedures, at the BC and energy expenditure laboratory, Clinical Nutrition Unit, Department of Clinical Medicine and Surgery, “Federico II” University Hospital of Naples. Weight was measured to the nearest 0.1 kg using a platform beam scale and stature to the nearest 0.5 cm using a stadiometer (Seca 709; Seca, Hamburg, Germany). BMI was then calculated as weight (kg)/stature² (m²).

BC was estimated by skinfold thickness (biceps, triceps, subscapular and suprailiac sites), measured on the left side of the body, in triplicate to the nearest 0.2 mm, using an appropriately calibrated Harpenden calibre by the same operator (MM). Body density was estimated from the sum of these four subcutaneous skinfolds values by Durnin and Womersley equation (Brozek, 1963; Durnin, 1974). Bioimpedance analysis (BIA) was performed at 50 kHz on the non-dominant side of the body (Human Im Plus II, DS Medica S.r.l., Milan, Italy) to collect data on R and PhA.

Fat-Free Mass (FFM) and Fat Mass (FM) was determined using the Siri Equation (Siri, 1961).

Statistical Analysis

Results are expressed as mean±standard deviation. The independent samples t-test was used to assess the association between variables (SPSS. 19.0 vers., Chicago, USA). Statistical significance was pre-determined as p<0.05.

3 RESULTS

Anthropometric characteristics of the participants are described in Table 1. Age, weight, stature and BMI were similar between the two groups. FM both in absolute and percentage values resulted significantly lower and FFM resulted higher in VP than in control group.

BIA-derived PhA values resulted significantly higher in VP, both for the whole body (p=0.001) and limbs, and especially for lower limbs (p<0.001) (Table 1).

### Table 1: Anthropometric characteristics, body composition and phase angle of volleyball players and controls.

<table>
<thead>
<tr>
<th></th>
<th>Volleyball Players (n = 12)</th>
<th>Control Group (n = 22)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>23.8±3.6</td>
<td>23.6± 2.0</td>
<td>NS</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>63.0±5.1</td>
<td>60.7±4.8</td>
<td>NS</td>
</tr>
<tr>
<td>Stature (cm)</td>
<td>170±4</td>
<td>167±5</td>
<td>NS</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>21.9±1.3</td>
<td>21.9±1.3</td>
<td>NS</td>
</tr>
<tr>
<td>Fat mass (kg)</td>
<td>15.7±2.7</td>
<td>18.0±3.0</td>
<td>0.036</td>
</tr>
<tr>
<td>Fat mass (%)</td>
<td>24.8±3.0</td>
<td>29.5±3.8</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Fat-free mass (kg)</td>
<td>47.4±3.5</td>
<td>42.8±3.6</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Phase angle (degrees)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Whole-body</td>
<td>6.8±0.43</td>
<td>6.0±0.66</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Upper-limb</td>
<td>5.1±0.53</td>
<td>4.7±0.72</td>
<td>0.080</td>
</tr>
<tr>
<td>Lower limb</td>
<td>8.6±0.86</td>
<td>6.3±0.98</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

SD= standard deviation; BMI= Body Mass Index; NS=not significant;

4 DISCUSSION

Several studies agree that appropriate BC is of crucial importance for volleyball performance because of the characteristics of this sport specialty. Usually, high ratios of FFM to FM and low FM% are auspicious for training and competitive athletes. In the present study, BC of VP has been compared to that of a group of healthy control subjects, matched for anthropometric characteristics (weight, stature, BMI). Our results underline that VP presented different BC than a healthy non-athletic population. Specifically, VP showed a lower FM both in absolute values and in percentage as well as a higher FFM than C-NA females. Additionally, this study compared PhA of VP group (whole-body and limbs) to that of the C-NA group clearly showing that both whole-body and lower-limb values were significantly higher in VP.

In conclusion, this study confirms previous observations on lower FM in VP. Moreover, highlights that BIA (especially with regard to segmental assessment) appears to be helpful in qualitative evaluations of muscle mass and possibly in assessing changes due to training.

REFERENCES
