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CHANGES OF POWER–VELOCITY RELATIONSHIP IN VOLLEYBALL PLAYERS DURING AN ANNUAL TRAINING CYCLE

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ABSTRACT

Purpose. The aim of the study was to follow the changes of maximal power output and power–velocity relationship in male volleyball players during an annual training cycle. Basic procedures. The study was conducted on six first-league volleyball players: age 25.0 ± 5.3 years, body height 195.2 ± 7.2 cm and body mass 91.2 ± 14.7 kg. Force–velocity and power–velocity relations were determined from five maximal cycle ergometer exercise tests, 10 s each, with increasing external loads amounting to 2.5, 5.0, 7.5, 10.0 and 12.5% of body weight, respectively. There were 2-min breaks between the tests. Maximal power output was computed from power–velocity curves. Maximal power output and power–velocity relationships were determined before the preparatory period (I), after the first competitive season (II) and after the second competitive season (III). Main findings. Significant increases occurred in the maximal power output from 12.80 ± 0.79 (preparatory period) to 13.11 ± 0.94 (after the first competitive season) and 13.44 ± 0.62 W·kg⁻¹ (after the second competitive season). The mean optimal velocity (vₒ) increased non-significantly from 122.2 ± 16.1 rpm (I) to 129.2 ± 14.9 rpm (II), and decreased non-significantly during the second competitive season (119.5 ± 18.5 rpm). Conclusions. In the annual training cycle under study a statistically significant increase of the power output with the external load of 7.5% of body weight was noted. The relative maximal power output increased significantly after the second competitive season as compared with the measurement before the preparatory period. The optimal velocity changed insignificantly in the entire annual training cycle.

Key words: power–velocity relationship, maximal power output, volleyball

Introduction

Volleyball is a sport involving short and intensive physical efforts during training and competition [1, 2]. Volleyball players’ fitness relies on their force, power output and jumping ability [3, 4]. Although the players’ power output is measured on a cycloergometer, its value depends, however, on the amount of external loading [2]. Different authors have examined the force-velocity (F–v) and power-velocity (P–v) relationships, measured during cycloergometer exercises in different groups of athletes [5, 6] and discussed the effects of specific training exercises on the force–velocity relationship [7–9]. Their results suggest that sport training can influence the correlation mentioned [5–7]. With the exception of Häkkinen’s work [10] discussing changes of force and jumping ability in female volleyball players during the competitive season, there have been no studies, however, examining changes in the force–velocity and power–velocity relationships in volleyball players during an annual training cycle. The aim of the present study was to follow changes of the maximal power output and power–velocity relationship in male volleyball players during an annual training cycle.

Material and methods

The study was granted approval of the Research Ethics Committee. The sample consisted of six male volleyball players from the Polish Volleyball League aged 25.0 ± 5.3 years, with body height of 195.2 ± 7.2 cm and body weight of 91.2 ± 14.7 kg. The measurements were performed before the preparatory period (I), after the first competitive season (II) and after the second competitive season (III).

The force–velocity (F–v) and power–velocity (P–v) relationships were determined on the basis of results of exercises performed on a Monark 874 E cycloergometer connected to a PC, using the MCE 4.0 software package. After adjusting the ergometer saddle and handlebars each subject performed the tests in a stationary position, without lifting off the saddle, with his feet strapped onto the pedals. Each player performed five 10-second maximal cycloergometer tests with increas-
K. Buśko, Changes of power–velocity relationship

Table 1. Absolute (P) and relative (P/mass) power outputs recorded for an external force–velocity relationship (mean values ± SD) in volleyball players during the competitive season

<table>
<thead>
<tr>
<th>Load (% BW)</th>
<th>I</th>
<th>II</th>
<th>D (%)</th>
<th>III</th>
<th>D (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>P (W)</td>
<td>2.5 421.5 ± 93.5</td>
<td>429.5 ± 61.6</td>
<td>4.2</td>
<td>442.8 ± 50.1</td>
<td>7.9</td>
</tr>
<tr>
<td></td>
<td>5.0 796.5 ± 133.3</td>
<td>815.3 ± 119.8</td>
<td>2.7</td>
<td>817.1 ± 112.6</td>
<td>2.4</td>
</tr>
<tr>
<td></td>
<td>7.5 1021.0 ± 153.4</td>
<td>1064.8 ± 143.4</td>
<td>4.6</td>
<td>1049.7 ± 110.9</td>
<td>3.5</td>
</tr>
<tr>
<td></td>
<td>10.0 1144.2 ± 181.9</td>
<td>1183.5 ± 165.1</td>
<td>3.8</td>
<td>1170.2 ± 136.9</td>
<td>2.9</td>
</tr>
<tr>
<td></td>
<td>12.5 1110.8 ± 113.1</td>
<td>1135.5 ± 170.5</td>
<td>0.2</td>
<td>1189.8 ± 160.4</td>
<td>6.8</td>
</tr>
<tr>
<td>P_{max} (W)</td>
<td>1162.7 ± 164.1</td>
<td>1191.2 ± 163.2</td>
<td>2.6</td>
<td>1202.0 ± 145.3</td>
<td>3.7</td>
</tr>
<tr>
<td>P_{max}/mass</td>
<td>2.5 4.60 ± 0.55</td>
<td>4.72 ± 0.28</td>
<td>3.8</td>
<td>4.95 ± 0.19</td>
<td>9.2</td>
</tr>
<tr>
<td></td>
<td>5.0 8.74 ± 0.54</td>
<td>8.96 ± 0.70</td>
<td>2.5</td>
<td>9.06 ± 0.54a</td>
<td>3.9a</td>
</tr>
<tr>
<td></td>
<td>7.5 11.24 ± 0.96</td>
<td>11.72 ± 0.84a</td>
<td>4.4a</td>
<td>11.75 ± 0.51a</td>
<td>4.9a</td>
</tr>
<tr>
<td></td>
<td>10.0 12.59 ± 0.96</td>
<td>13.02 ± 0.98</td>
<td>3.6</td>
<td>13.11 ± 0.87</td>
<td>4.3</td>
</tr>
<tr>
<td></td>
<td>12.5 12.29 ± 0.82</td>
<td>12.29 ± 1.47</td>
<td>0</td>
<td>13.28 ± 0.64</td>
<td>8.5</td>
</tr>
<tr>
<td>P_{max}/mass (W/kg)</td>
<td>12.80 ± 0.79</td>
<td>13.11 ± 0.94</td>
<td>2.4</td>
<td>13.44 ± 0.62a</td>
<td>5.1a</td>
</tr>
</tbody>
</table>

*a* mean values differ significantly (*p* < 0.05) between the I (before the preparatory period), II (after the first competitive season) and III (after the second competitive season) measurements; D – percent differences in relation to the values recorded before the preparatory period (I) and successive measurements during the first (II) and second (III) competitive seasons.

The results were statistically processed using analysis of variance (ANOVA) with repeated measures. The statistical significance of the mean values was analysed using post-hoc Fisher’s least significant difference test (LSD). The level of statistical significance was set at *p* < 0.05. All statistical calculations were made with the use of Statistica (v. 8.0, StatSoft) software package.

**Results**

Table 1 presents the results obtained. The changes of the absolute values of maximal power and the highest velocity at a given load were statistically non-significant. In terms of relative values a significant increase of the maximal power output at the load of 7.5% of body weight was observed from 11.24 ± 0.96 W·kg⁻¹ before the preparatory period (I) to 11.72 ± 0.84 W·kg⁻¹ after the first competitive season (II) and 11.75 ± 0.51 W·kg⁻¹ after the second competitive season (III). The relative maximal power output increased from 12.80 ± 0.79 W·kg⁻¹ (I) to 13.44 ± 0.62 W·kg⁻¹ (III). Furthermore, a non-significant increase of optimal velocity was noted from 122.2 ± 16.1 rpm (I) to 129.2 ± 14.9 rpm (II), and non-significant decrease after the second competitive season (III) (119.5 ± 18.5 rpm).
Discussion

Volleyball is commonly classified as an “interval” sport, which uses both anaerobic and aerobic metabolism [3, 4, 12–14]; whereas volleyball players can be categorized as “power athletes” [15]. Thus volleyball training should develop the power of legs and improve players’ strength and/or velocity. The preparatory training period is usually devoted to the training of motor skills; while the competitive period focuses primarily on the improvement of volleyball technique and tactics [10].

A number of studies indicate that strength training consisting of exercises with high external loads and low velocity enhances the final course of the F–v curve (high power, low velocity), unlike the high velocity [8, 9, 16]. Training with low loads and high velocity improves the results in the entire course of the F–v curve [8, 16], or increases the force and power of movements performed with a high velocity [9, 16].

The present study showed that the volleyball training improved the players’ power–velocity relationship at a high force and low velocity between the preparatory period and the first competitive season. After the second competitive season a parallel shift of the power–velocity curve was noted (Fig. 1). During the entire season the values of relative maximal power increased. The changes in the P–v relationship and maximal power output were accompanied by a non-significant increase of the optimal velocity between the I and II measurements and a non-significant decrease after the second competitive season (III). Buśko [17] reported a significant training-related increase of the optimal velocity after the first competitive season as compared with the measurement results from before the preparatory period. The present study revealed non-significant changes of the optimal velocity. Considering the fact that volleyball training aimed at the improvement of players’ force also enhances their power and jumping ability [18, 19], the results obtained are satisfactory. It must, however, be kept in mind that a study of female volleyball players by Häkkinen [10] revealed an increase in all measured parameters only until the completion of the first competitive period, after which a decrease was noted.

Conclusions

1. In the annual training cycle under study a statistically significant increase of the power output with the external load of 7.5% of body weight was noted.

2. The relative maximal power output increased significantly after the second competitive season as compared with the measurement before the preparatory period.

3. The optimal velocity changed non-significantly in the entire annual training cycle.

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References


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