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JUMPING ABILITIES IN ELITE FEMALE VOLLEYBALL PLAYERS: COMPARATIVE ANALYSIS AMONG AGE CATEGORIES

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ABSTRACT: The aim of the study was to examine age-related differences in the maximal power and height of rise of the body's centre of mass, measured in the counter-movement jump (CMJ) and the spike jump (SPJ), between elite cadet, junior and senior female volleyball players. The study was conducted on elite cadet (n=39), junior (n=8) and senior (n=23) female volleyball players. The maximal power and height of jumps were measured for CMJ and SPJ. Cadets had a significantly smaller maximal relative power output (40.92±8.10 $W \cdot kg^{-1}$) than junior (49.47±6.47 $W \cdot kg^{-1}$) and senior (46.70±8.95 $W \cdot kg^{-1}$) volleyball players during SPJ. The height of rise of the centre of mass measured in CMJ and SPJ were similar between groups. Our research has shown that age-related differences were observed only in power output of SPJ. The differences between elite cadet, junior and senior female volleyball players were not statistically significant in relation to height of jumps (both CMJ and SPJ), and maximal power in CMJ.

KEY WORDS: power output, volleyball, spike jump (SPJ), counter-movement jump (CMJ), female

INTRODUCTION

Volleyball puts emphasis on explosive movements such as jumping, hitting, and blocking [3,13,17]. In addition to technical and tactical skills, it has been argued that muscular strength and power are the most important factors that give a clear advantage for successful participation in elite competitions [13]. Jumping ability is also critical to success in volleyball, allowing for a competitive advantage in attack and in defence (higher blocking position). The measurement of height of jump and leg power in the countermovement jump (CMJ) and the spike jump (SPJ) is a fundamental tool in biomechanical performance diagnostics in volleyball players. Despite the increase of professionalization in this discipline, there is a paucity of research on performance characteristics of female volleyball players [15]. The professional literature includes a number of works about comparisons of volleyball players with untrained individuals, elite with none-elite athletes, or male players with female players [1,7,10,19,21]. However, only a few works present comparisons that regard players of different performance level [1,21]. Franchini et. al. [9] pointed out that there is a need to increase the number of works which include comparisons of age categories among sport disciplines.

The aim of the study was to examine age-related differences in the maximal power and height of rise of the centre of mass measured in the counter-movement jump (CMJ) and the spike jump (SPJ) between elite cadet, junior and senior female volleyball players.

MATERIALS AND METHODS

The study was granted approval of the Research Ethics Committee. The subjects were informed about the scope and protocol of the study, and of the possibility to withdraw from the study at any moment. All subjects submitted their written consent to participate. The study was conducted on Polish elite cadet, junior and senior female volleyball players. Their basic characteristics are presented in Table 1. Significant differences were found only between cadet and junior and senior female volleyball players for age and training experience.

The power output of lower extremities and the height of rise of the centre of mass during vertical jumps were measured on a force plate with a Kistler amplifier Type 9281A (Switzerland) for the counter-movement jump (CMJ) and the spike jump (SPJ). The amplifier

TABLE 1. MEAN VALUES (±SD) OF BASIC CHARACTERISTICS

Variables	Cadet, n = 39	Junior, n = 8	Senior, n = 23
Age [years]	15.8 ± 0.7	18.0 ± 0.6[a]	22.5 ± 3.2[a]
Body mass [kg]	69.6 ± 7.1	70.7 ± 8.7	72.5 ± 6.9
Body height [cm]	182.4 ± 1.4	182.9 ± 7.1	184.8 ± 8.0
Training experience [years]	4.5 ± 1.4	6.8 ± 1.4[a]	10.4 ± 3.1[a]

Note: Cadet significantly different from Junior and Senior ([a] - $p<0.05$).

was connected to a PC via an A/D converter. The MVJ v. 3.4 software package ("JBA" Zb. Staniak, Poland) was used for measurements. In the applied physical model, the subject's body mass bouncing on the force plate was reduced to a particle affected by the vertical components of external forces: the body's gravity force and the vertical component of the platform's reactive force. The maximal power (P_{max} [W]), relative maximal power ($P_{max} \cdot mass^{-1}$ [$W \cdot kg^{-1}$]) and maximal height (h [m]) of rise of the body's centre of mass (COM) were calculated from the registered reactive force of the force plate [2,4,5]. Each subject performed six vertical jumps with maximal force on the force plate: three counter-movement jumps (CMJ) and three spike jumps (SPJ). There were 5-s breaks between the CMJ, and 1-min breaks between the SPJ. The jump with the highest elevation of the body's COM was chosen for statistical analysis.

MANOVA procedures were employed for data processing with post-hoc Scheffé test. StatisticaTM v. 10.0 software (StatSoft, USA) was used in data analysis.

RESULTS

Table 2 presents values (mean ±SD) of the maximal power and height of rise of the centre of mass measured for CMJ and SPJ jumps performed on a force plate. The height of rise of the centre of mass and maximal power measured in the counter-movement jump (CMJ) were similar in all the groups. The height of rise of the centre of mass measured in the spike jump (SPJ) were similar in all the groups too. An age-related difference was only observed in power output of the SPJ jump.

DISCUSSION

So far in the literature, the authors have described significant differences between trained and untrained subjects [20], non-elite and elite athletes [8], subjects of different ages [17,18], or cadets, juniors and seniors [1,9]. The results of our study do not support the thesis that cadets, juniors and seniors differ from each other. In our study elite cadet, junior and senior volleyball players generated similar height of rise of the centre of mass , as well as absolute and relative power in CMJ and SPJ, with the exception of the absolute and relative maximal power measured during SPJ. The cadets developed less power output in SPJ than junior and senior females. This is in agreement with the study of Gerodimos et al. [11]. They did not observe differences in absolute jump height between three groups (children, adolescents, and adults) of basketball players during countermovement jumps. Jumping is an integral part of volleyball, so considerable training time is allocated to developing this component [16]. CMJ and SPJ are performed differently. During the CMJ the jumping height and power output are assessed with the body's centre of mass (which lowers before the jump) and the leg muscles working in the stretch–shortening cycle. Also during the SPJ the body's centre of mass is used, as well as the horizontal velocity of the centre of mass during the take-off phase. A comparison of the body height during CMJ and BCMJ also allows assessment of coordination of the run-up and take-off phase of the jump. In our study in cadet, junior and senior females the difference in the height of the body's centre of mass between CMJ and SPJ was about 0.077 m, 0.087 m and 0.089 m, respectively, and in power output 11.82 $W \cdot kg^{-1}$, 18.14 $W \cdot kg^{-1}$ and 17.49 $W \cdot kg^{-1}$, respectively. Perhaps the significantly lower development of power output in the cadet group in SPJ is the result of generating lower strength of lower extremities. This is particularly important during the braking phase (eccentric work) before the take-off phase. On the other hand, the height in CMJ of Portuguese and Spanish professional female volleyball players (seniors) were 34.22±5.90 cm and 34.29±3.57 cm, respectively [12,14]. In comparison to the Polish elite cadet, junior and senior volleyball players, the jumping ability of the Portuguese and Spanish professional female volleyball players was considerably lower.

TABLE 2. MEAN VALUES (±SD) OF THE HEIGHT OF RISE OF THE CENTRE OF MASS (h), MAXIMAL POWER OUTPUT (P_{max}), RELATIVE MAXIMAL POWER OUTPUT ($P_{max} \cdot mass^{-1}$) DURING COUNTER-MOVEMENT JUMPS (CMJ) AND SPIKE JUMPS (SPJ) ON A FORCE PLATFORM

Variables	Cadet n = 39	Junior n = 8	Senior n = 23
P_{maxCMJ} [W]	2022.3 ± 390.7	2195.3 ± 278.2	2112.8 ± 407.2
$P_{max}CMJ \cdot mass^{-1}$ [$W \cdot kg^{-1}$]	29.10 ± 5.12	31.33 ± 4.80	29.21 ± 5.40
h_{CMJ} [m]	0.388 ± 0.044	0.407 ± 0.050	0.390 ± 0.045
P_{maxSPJ} [W]	2852.5 ± 634.4	3489.0 ± 513.4[a]	3316.2 ± 667.2[a]
$P_{maxSPJ} \cdot mass^{-1}$ [$W \cdot kg^{-1}$]	40.92 ± 8.10	49.47 ± 6.47[a]	46.70 ± 8.95[a]
H_{SPJ} [m]	0.465 ± 0.054	0.494 ± 0.052	0.479 ± 0.055

Note: Cadet significantly different from Junior and Senior ([a] - $p<0.05$).

CONCLUSIONS

The results of these studies have not confirmed the hypothesis that cadet, junior and senior groups differ from each other in jumping abilities. Our research has shown that age-related differences were observed between cadet, junior and senior female volleyball players only in power output of SPJ. The differences between elite cadet, junior and senior female volleyball players were not statistically significant either in height of CMJ and SPJ, or in maximal power output in CMJ.

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