EFFECTS OF PLYOMETRIC TRAINING ON SPORT-SPECIFIC TESTS IN FEMALE VOLLEYBALL PLAYERS

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Abstract
Vertical jump height has been identified as a critical component in the sport of volleyball. Therefore, improving vertical jump in volleyball should be the main objective for all coaches. The main objective of this study was to determine the effects of plyometric training methods on jumping ability in female junior volleyball players. Sixty female volleyball players (mean ± SD age, 17 ± 6 months) participated in this study. The experimental group conducted six weeks of plyometric training method for developing explosive leg power. Players were tested for Attack and Block jump test with and without approach. There were significant interaction between the groups for right foot block jump and left foot block jump. Plyometric training induced significant improvements in RFBJ ($p<0.01$), LFBJ, COBJ, SSBJ ($p<0.05$). However, control group showed no significant improvements ($p>0.05$) in any Spike and Block jump test. In conclusion, completion of a 6 week plyometric training program improved selected Block jump tests in female junior players. However, there were no significant changes in Attack jumps following the plyometric training program.

Key words: *jump training, impact, female athletes, explosive strength*

Introduction

Volleyball is an intermittent sport that requires players to compete in frequent short bouts of high-intensity exercise, followed by periods of low intensity activity (Gabbett, and Georgieff, 2007). Elite male players have been reported to perform 250 to 300 high-power activities during a 5-game match, and the jumps constitute most of the power events (Hasegawa, et al., 2002).The countermovement jump is performed from different starting positions in different sports with ball. In volleyball, a countermovement jump is usually performed in a fast spike and in a static block jump. Volleyball players use two different Block jump techniques, starting from an upright position or starting from a squat position, with a countermovement being performed in both cases (Amasay, 2008). A number of studies have investigated the effects of different training methods at off-season (Gabbett, and Georgieff, 2007), preseason (Sheppard, et al., 2008), or during the competitive season in volleyball (Bloomfield, Polman, O'Donoghue, and McNaughton, 2007;Moir, Button, Glaister, and Stone, 2004; Stanganelli, Dourado, Oncken, Mancan, and da Costa, 2008). Plyometric exercises and their impact were investigated in numerous studies(Markovic, 2007). Newton, Kraemer, and Haekkinen (1999) reported an increase in vertical jump performances in elite volleyball players over an eight-week period. Results from Fatouros et al. (2000) also supported this finding concluding that plyometric training over twelve weeks significantly improved vertical jump performance. However, the combination of plyometrics and traditional weightlifting exercises produced significantly greater improvements than plyometrics alone (Fatouros et al., 2000). Furthermore, plyometric exercises may increase performance and decrease injury risk in competitive female athletes (Hewett, Lindenfeld, Riccobene, & Noyes, 1999; Hewett, Stroupe, Nance, & Noyes, 1996). However, despite the advantages of plyometric training, the principal issue of determining the optimal elements of a plyometric program remains inconclusive. With an understanding of how beneficial plyometric training can develop vertical jump, it is of great importance to female volleyball players to maximize results by conducting these exercises correctly. Vertical jump height has been identified as a critical component in the sport of volleyball (Sheppard et al., 2007), so the identification of possible ways to improve this characteristic is extremely important. Most research conducted on the vertical jump does not incorporate the horizontal movement prior to jumping that is used in blocking (Fukashiro & Komi, 1987; Harman, Rosenstein, Frykman, & Rosenstein, 1990; Hudson, 1986; Robertson & Fleming, 1987; Shetty&Etnyre, 1989). Therefore, improving spike and block jump in volleyball, as a specific field tests, should be the main objective for all coaches concerning the physical performance in volleyball. The main objective of this study was to determine the effects of plyometric training methods on jumping ability in female junior volleyball players.

Methods

Subjects
Sixty female volleyball players (mean ± SD age, 17 ± 6 months) participated in this study. Players were members of youth and junior squads from several Serbian volleyball clubs. A few were candidates for youth and junior national squad. All the participants provided written consent after

being informed of the test protocol. All volleyball players were subjected to medical examination, to determine their health state, because in the research can participate only healthy athletes and those whose parents agreed that their children can take part in the research. The protocol of the study was approved by the Ethical Committee of the Faculty of sport and physical education, University of Nis and according to the revised Declaration of Helsinki. Each player had 3-5 years of training experience, corresponding to 2-hour training sessions, and at least 1 competition per week.

Table 1.General descriptive parameters of participants (Mean ± SD).

	Plyometric	Control
Age	17.18±1.32	17.30±1.52
Body	175.76±4.81	179.11±5.88
Body	64.76±8.43	65.21±7.61

Procedures

Attack and block jump performances

For the standing reach, while wearing their normal volleyball footwear, the players were requested to stand with their feet flat on the ground, extend their arm and hand, and mark the standing reach height while standing 90° to a wall. The players were encouraged to fully extend their dominant arm to displace the highest vane possible to determine their maximum standing reach height. The measurement of the standing reach height allowed for a calculation of the relative jump heights on each of the jumping tasks i.e. absolute jump height – standing reach height = relative jump height (Sheppard et al., 2009). The attack jump (ATJ) and block jump (BLJ) performances for volleyball players depend heavily on the height at which these skills are performed above the net and are determined by not only the ability of the athlete to vertically raise his center of gravity, but also his stature and standing reach.

In this particular case, specific tests would provide a further understanding of the training-induced adaptation. For the ATJ, the standing reach was determined as the maximal distance between the fingertip of the attack hand and the ground, while standing laterally next to the wall. The ATJ was measured from a running start (2- or 3-step approach) by using a basketball backboard marked with lines 1 cm apart with a 1-minute rest interval between them. For the BLJ, the standing reach was determined as the maximal distance between the fingertips of the block hands and the ground, while facing the wall. The BLJ jumps started from a standing position with the hands at shoulder level and arms raised from the start position without an extra swing. All of the tests used the same observer who was situated on a volleyball referee stand placed 2 m from the backboard. Both jumps were recorded as the best of 3 attempts (Stanganelli, Dourado, Oncken, Mançan, da Costa, 2008). The Left foot take-off attack jump (LFAJ) and Right foot take-off attack jump (RFAJ) tests used the same protocol as the Attack jump test. The difference is in the last step and jump which are conducted with the left or right foot, while in the Attack jump the jump is with both feet. The Left foot take-off block jump (LFBJ) and Right foot take-off block jump (RFBJ) tests used the same protocol as the Block jump test. The difference is in the take-off phase which is conducted with the right or left foot. The Slide step block jump (SSBJ) test involves moving the lead foot laterally and closing the trailing foot to within 15 cm of the lead foot. The movement is repeated until the desired jumping position is reached. In the Crossover step block jump (COBJ) test the player crosses one foot in front of the other and begins to move parallel (with running steps, if necessary) in the direction that the initial step was taken. If moving to the left, the player starts with the right foot.

From a stationary position, the right foot is crossed over the left; the next step is made with the left foot parallel to and in the same direction as the right. All of the tests used the same observer who was situated on a volleyball referee stand placed 2 m from the backboard. For all the jumps, the best of 3 attempts was recorded and used for analysis. The reliability and validity of the RFBJ, LFBJ, RFAJ and LFAJ tests was proven by Milić (2007). The reliability and validity of the SSBJ and COBJ tests was proven by Pajić (2011).

Training program

Before the study, the pre-season mesocycle for three weeks was carried out. Each week there will be five training sessions lasting 90 to 120 minutes. The main objective of this period will be to improve the aerobic endurance and strength. In the micro cycle of seven days, three sessions will be designed to develop endurance, and two sessions in the gym. After completing the preparatory phase the initial measurement will be carried out and the final measurement will be implemented within three days after the end of the experimental program. The experimental group (EG) conducted six weeks of plyometric training method for developing explosive leg power. The number of training sessions will be 12. Set model for developing of explosive leg power consisted of five exercises, and exercises will be done in the first part of the training, after a 30-minute warm up. The control group did not apply the plyometric training method at the same time. They were involved only in regular moderate intensity volleyball training.

Statistical analysis

The statistical Package for Social Sciences SPSS (v18.0, SPSS Inc., Chicago, IL) was used for the statistical analysis. Descriptive statistics were calculated for all experimental data. Kolmogorov-Smirnov test was calculated for all variables before analysis to prove the normality of distribution. Differences in jumping performance of the plyometric and control training groups before and after training were analyzed by using a 2-way (group x time) repeated-measures analysis of variance. The statistical significance was set at $p<0.05$.

Table 2. Plyometric training program

		Week 1	Week 2	Week 3	Week 4	Week 5	Week 6
Hurdle jumps	Sets x repetitions	2 x 6	3x6	4x6	3x6	3x6	4x6
	Box height	50 cm	50 cm	60 cm	50 cm	60 cm	50 cm
	Intensity	moderate	moderate	high	moderate	high	high
Depth jumps	Sets x repetitions	2x10	3x10	3x10	3x10	3x10	3x10
	Box height	40 cm	50 cm	60 cm	50 cm	60 cm	50 cm
	Intensity	moderate	moderate	high	moderate	high	high
Lateral jumps over box	Number of jumps	2x30 sec	3x30 sec	3x60 sec	3x60 sec	3x90 sec	3x90 sec
	Box height	20 cm	30 cm	30 cm	30 cm	30 cm	20 cm
	Intensity	moderate	moderate	high	moderate	high	high
Lunge jumps	Sets x repetitions	2x9	3x10	3x12	3x10	3x12	3x11
	Intensity	moderate	moderate	high	moderate	high	high
Vertical jumps	Sets x repetitions	2x8	3x9	3x11	3x9	3x11	3x12
	Intensity	moderate	moderate	high	moderate	high	high

Results

The Kolmogorov-Smirnov tests showed that data were normally distributed and no violation of homogeneity of variance found using Levene's test. The experimental and control groups were well matched on the pre-training tests with no significant differences found for any variable between the two groups. The jumping characteristics of the plyometric training group and control group are shown in Table 3. There were significant interaction between the groups for right foot block jump and left foot block jump. Plyometric training induced significant improvements in RFBJ ($p<0.01$), LFBJ, COBJ, SSBJ ($p<0.05$). However, control group showed no significant improvements ($p>0.05$) in any spike and block jump test (Table 3).

Table3. Differences between experimental and control group for Attack and Block jumps

	Plyometric group		Control group	
	Initial	Final	Initial	final
BLJ	31.96±4.59	33.04±3.72	32.96±5.32	32.24±3.78
RFBJ	21.48±2.98	23.84±3.18*†	24.72±4.02	25.92±4.77
LFBJ	21.80±4.22	24.28±3.48*†	24.32±4.10	24.80±4.09
COBJ	32.08±4.83	34.72±3.74*	33.04±6.18	33.32±5.62
SSBJ	31.72±4.62	35.08±4.06*	33.44±5.63	33.72±4.68
ATJ	37.52±5.93	37.34±4.39	34.12±6.86	34.68±6.02
RFAJ	28.32±5.57	29.78±4.26	28.76±5.47	28.76±4.43
LFAJ	28.96±5.78	30.54±4.21	28.84±5.63	28.12±3.61

*Different from before training. †Different from control group. Data are reported as mean ± SD. BLJ – block jump, RFBJ – right foot block jump, LFBJ – left foot block jump, COBJ – crossover block jump, SSBJ – sidestep block jump, ATJ – attack jump, RFAJ – right foot attack jump, LFAJ – left foot attack jump,

Discussion

This study has shown that 6 weeks of plyometric training had positive effects on Block jumps in female volleyball players, but has no significant effects on spike jumps. Players in the experimental group improved in almost all of Block jump test significantly. Control group showed no significant improvement in both, Block jump tests and Attack jump tests. The results in control group can be explained by the fact that players were involved in skill training with numerous repetitions of volleyball technique which is in contrast to the plyometric group that was involved in plyometric training and skill training. Accordingly, experimental group simulated the physiological demands of national-level female junior volleyball players. Importantly, plyometric training successfully simulated the high-intensity physiological demands of competition, concerning the great number of jumps during volleyball match. Plyometric training induced significant improvements in RFBJ ($p<0.01$), LFBJ, COBJ, SSBJ ($p<0.05$). However, there were no significant difference pre to post-training for standing block jump. Possible reason could be found in different jump technique used by players which led to great intra-individual variation. Some players, when performing a maximum vertical jump, use different arm swing to increase the jump height. An arm swing together with counter movement increases jump height (Walsh, Bohm, Butterfield, & Santhosam, 2007). In addition, volleyball players use two different Block jump techniques, starting from an upright position or starting from a squat position. This may influence the force generation during a game.

If the muscles are already loaded, the quick jump may be faster and the athlete may perform a faster BJ because it is submaximal effort. However, from the upright position, the player can load her muscles more and may achieve a higher jump (Amasay, 2008). Compared to Block jump tests, neither group showed significant improvement in Spike jump tests. These results lead to the assumption that the technique of spike jumps seems to be highly individual in volleyball players (Singh & Rathore, 2013) but especially in female players. In addition, the spike jump is technically more challenging than the vertical jump (Osborne, 2002).Another reason could be that female volleyball players already have a high level of jumping abilities and the potential for improving was small. In addition, jumps in female volleyball and testing are very similar. More research is needed to determine whether instructing players to use specific spike jump approach and landing techniques may help to improve jumping technique and reduce landing stress. The current study has some limitations. Firstly, control group did not match the intensity with plyometric group due to skill training in volleyball. Secondly, the 6 week plyometric training may not have sufficient time to induce an additional physical performance benefits.

Conclusion

Completion of a 6 week plyometric training program improved selected Block jump tests in female junior players. However, there were no significant changes in Attack jumps following the plyometric training program. Therefore, the results of our study could partially support our hypothesis. Vertical jump is especially relevant to performance in volleyball. Therefore, this kind of information could help coaches to improve performance and use movements that are safer. The use of this plyometric training program could potentially modify volleyball player's motion strategies, improve performance, and lower the athlete's risk for injury.

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UTJECAJ PLIOMETRIJSKOG TRENINGA NA SPECIFIČNE TESTOVE SKOČNOSTI KOD ODBOJKAŠICA

Sažetak

Vertikalna visina skoka je identificirana kao ključni sastojak u sportu na pijesku. Dakle, poboljšanje skoka u odbojci bi trebao biti glavni cilj svih trenera. Glavni cilj ovog istraživanja bio je odrediti efekte pliometrijskog treninga sa specifičnim testovima skočnosti kod odbojkašica juniorki. Šezdeset odbojkašica sudjelovalo je u ovom istraživanju. Igračice su bile članice odjeljenja za mlađe igrače i juniore iz nekoliko srpskih odbojkaških klubova. Igračice su testirane u osam različitih specifičnih skokova. Eksperimentalna grupa je sprovela šestotjedni pliometrijski trening. Pliometrijska grupa je proizvela značajan napredak u testovima za blok RFBJ ($p<0.01$), LFBJ, COBJ, SSBJ ($p<0.05$). Kontrolna grupa nije ostvarila napredak ni kod jedne varijable. Značajna interakcija između grupa je ostvarena kod varijabli bloka RFBJ, LFBJ. U zaključku, korištenje pliometrijskog programa treninga potencijalno može poboljšati specifične skokove u bloku kod odbojkašica.

Ključne riječi: *skok trening, utjecaj, sportašice, eksplozivna snaga*

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