EFFECTS OF SHORT HIGH IMPACT PLYOMETRIC TRAINING ON JUMPING PERFORMANCE IN FEMALE VOLLEYBALL PLAYERS

Tomislav Krističević, Ivan Krakan and Mario Baić

Faculty of Kinesiology, University of Zagreb, Zagreb, Croatia

Original scientific paper

Abstract

Fifty four female volleyball players participated in this study (15±1). The aim of this research is to determine the effects of 5 week plyometric training in female volleyball players. Standard anthropometry (height, standing-reach height, body mass, vertical jumps and specific volleyball jumps were the tests selected. 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. A five-week-long training program was applied in plyometric group. There was significant interaction between the groups for Squat jump. Plyometric training induced significant improvements in SJ and CMJ. However, control group showed no significant improvements in any vertical jump test. In conclusion, the completion of a 5 week plyometric training program improved selected vertical jump tests in young female volleyball players. However, there were no significant changes in spike and block jumps following the plyometric training program.

Key words: *jump training, impact, power, female athletes*

Introduction

Although previous methods have shown a significant impact on increasing vertical jump performance, coaches and most authors agree that the plyometrics as the method of choice is the best for increasing VJ and explosive leg strength (Markovic, 2007). In the meta-analysis (De Villarreal, Requena,& Newton, 2010) which examined the effects of plyometric training on the expression of power, the authors have come to the conclusion that an exercise program that lasts less than 10 weeks and includes up to 15 training sessions, as well as high intensive training with over 40 jumps, has the positive impact on the strength increase. It is also recommended to combine different plyometric programs with strength training, rather than to use only plyometric treatment. Another meta-analysis was performed, that analysed the role of various factors on the effects of plyometrics on vertical jump performance (de Villarreal, Kellis, Kraeme,&Izquierdo,2009). Subjects with more sports experience achieve better results in the vertical jump. The subjects with good or bad form make equal progress by using plyometric training, while man score better results in power than women. Athletes must be sufficiently mature not only physiologically but also psychologically in order to participate in the program. For the lower part of the body the proper technique of contact with the surface is crucial, especially for depth jumps (Zatsiorsky, & Kraemer, 2006).While plyometrics can successfully affect the increase of the speed, power, sport performance, it may also cause injure even more than it can be caused by less intensive exercise (Zatsiorsky, & Kraemer, 2006). Recently unexplored and very sensitive field today is showing a positive effects of plyometric exercise on motor skills within children and adolescents. There is a growing number of authors who speak on positive impact and safety performance within children (Diallo, Dore, Duche, and Van Praagh, 2001; Faigenbaum et al., 2007; Kotzamanidis, 2006; Matavulj, Kukolj, Ugarkovic, Tihanyi, &Jaric, 2001). However, all authors agree that this must be strictly controlled program with a certain load of intensity, volume and frequency of exercise. Much effort has been invested in research and promotion of plyometrics since it was mentioned for the first time in the USA. A large number of researches, review articles and meta-analyses have proven effectiveness and safety performance. However some parts are still not in fully explained and explored. The question of the ideal and shortest program that will contribute to a greater leap in motor skills is still not in fully resolved, because the safety performance of certain rules must be respect. Therefore, the aim of this research is to determine the effects of 5 week plyometric training in female volleyball players.

Methods

Participants

Fifty four female volleyball players 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 female national squad. General descriptive parameters are presented in Table 1. All the participants provided written consent after being informed of the test protocol. All volleyball players participated in 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 2-4 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	15.4±1.32	15.5±1.52
Body	170.76±4.81	169.11±5.88
Body	60.76±8.43	61.31±7.61

Procedures

Standard anthropometry (height, standing-reach height, body mass, vertical jumps and specific volleyball jumps were the tests selected. Players were instructed to refrain from strenuous exercise for at least 48 hours prior to the fitness testing session and consume their normal pre training diet prior to the testing session. The testing session began with anthropometric measurements. Players then underwent measurements of lower-body muscular power (vertical jump and spike jump), Subjects performed 2 trials muscular power tests, with a recovery of approximately 3 minutes between trials. Players were encouraged to perform low-intensity activities and stretches between trials.

Countermovement and Squat Jump Performance

For the purpose of the explosive strength assessing, a device "Myotest" was used. Subjects performed two vertical jumps, Countermovement Jump (CMJ) and Squat jump (SJ). The sample of the variables, processed and mistreated by the device "Myotest" consisted of the: Height (expressed in cm); Power (expressed in W/kg); Force (expressed in N/kg) and Velocity (expressed in cm/s). Subjects carried a belt around their lower trunk, on which was positioned a wireless device "Myotest" (safely attached to a belt). All subjects performed three vertical jumps (CMJ), in the following way: from the initial position, i.e., normal standing position and the hands placed on the hips, through the flexion in the articulations of the knee up to 90º, after the audio signal of the device, the subjects performed the maximum vertical take-off, and landed with affable flexion (up to 110º) in the articulations of the knee and finally, went back into a starting standing position, while waiting for the new sound signal, when the specified jump technique was repeated.

In the case, when the CMJ was not well performed, double audio signal, informed the subject, to repeat properly specified jumping technique. At the end of the protocol, software of the device "Myotest", automatically processed and mistreated the mean values of analyzed variables. The squat jump (SJ) allows measurement of "non-plyometric" displacement and the ability to develop a great deal of strength within a very short space of time (explosiveness). This test consisted of the person jumping as high as possible with their hands on their hips from a half-squat position (i.e. 90° bending of the knees). This position was maintained for about 1s. The subjects were then instructed to extend the lower limbs as explosively as possible with the aim of performing a squat jump. Three attempts were made at this exercise. The best result was retained for analysis.

Spike and block jump performances

For the standing reach, while wearing their normal volleyball footwear, 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. 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 (absolute jump height (cm) – standing reach height (cm) = relative jump height) (Sheppard, Gabbett, & Stanganelli, 2009). Spike and Block jump 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 capacity of the athlete to raise vertically 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 spike jump, the standing reach was determined as the maximal distance between the fingertip of the attack hand and the ground, while standing 90° to a wall. The spike jump was measured from a running lead (2- or 3-step approach) by using a basketball backboard marked with lines 1 cm apart. For the Block, the standing reach was determined as the maximal distance between fingertips of the block hands and the ground, while facing the wall. The block jumps started from a standing position with the hands at shoulder level and arms raised from the start position without extra swing. All 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 the 3 attempts (Stanganelli, Dourado, Oncken, Mançan, da Costa, 2008).

Plyometric training

Before the study, the pre-season mesocycle for two 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 for strength. In addition, concerning the fact that players were young female athletes, they were involved in familiarisation sessions with aim for learning proper technique of the tests. After completing the preparatory phase the initial measurement will be carried out and the final measurement will be implemented within two days after the end of the experimental program. Specific details of the Plyometric program are presented in Table 1. A five-week-long training program was applied in plyometric group.

The first two weeks were a preparatory phase, followed by two more weeks with increased volume, and one week with decreased volume to taper.

Training sessions were performed twice a week (Tuesdays and Thursdays). Plyometric training group was also involved in regular volleyball training.

Table 2. Plyometric training program

		Week 1	Week 2	Week 3	Week 4	Week 5
Hurdle jumps	Sets x repetitions	2 x 6	2x6	4x6	4x6	3x6
	Box height	30 cm	30 cm	40 cm	40 cm	30 cm
	Intensity	moderate	moderate	high	high	moderate
Depth jumps	Sets x repetitions	2x10	3x10	3x10	3x10	2x10
	Box height	20 cm	20 cm	30 cm	30 cm	20 cm
	Intensity	moderate	moderate	high	high	moderate
Lateral jumps over box	Number of jumps	2x30 sec	3x30 sec	3x60 sec	3x60 sec	3x40 sec
	Box height	20 cm	20 cm	30 cm	30 cm	20 cm
	Intensity	moderate	moderate	high	high	moderate
Lunge jumps	Sets x repetitions	2x9	2x10	3x10	3x10	2x10
	Intensity	moderate	moderate	high	high	moderate
Vertical jumps	Sets x repetitions	2x8	2x10	3x10	3x12	2x10
	Intensity	moderate	moderate	high	high	moderate

Unlike in other plyometric training routines the specificity of the present program was that beside double-leg jumps, high intensity single-leg exercises into both sagittal and lateral directions were also included. Participants were instructed to minimize ground contact and to maximize jumping height for greater the release of stored energy.

A conditioning specialist supervised every training session to maximize safety by instructing proper technique and to motivate participants for maximal effort. The control group did not apply the plyometric training method at the same time. They were involved only in moderate continuous training and regular 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 $p<0.05$.

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 was significant interaction between the groups for Squat jump. Plyometric training induced significant improvements in SJ and CMJ ($p<0.05$). However, control group showed no significant improvements ($p>0.05$) in any vertical jump test (Table 3).

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

	Plyometric group		Control group	
	Initial	Final	Initial	Final
Block jump	31.96±4.59	33.04±3.72	32.96±5.32	32.24±3.78
Spike jump	37.52±5.93	37.34±4.39	34.12±6.86	34.68±6.02
SJ	21.80±4.22	24.28±3.48*†	24.32±4.10	24.80±4.09
CMJ	28.08±4.83	30.72±3.74*	33.04±6.18	33.32±5.62

*Different from before training. †Different from control group. Data are reported as mean ± SD.
SJ- squat jump, CMJ- countermovement jump

Discussion

This study has shown that 5 weeks of high impact plyometric training had positive effects on SJ and CMJ in young female volleyball players, but has no significant effects on spike and block jumps. Control group showed no significant improvement in both, Block jump test and Spike jump test. Moreover, results for SJ and CMJ in control group showed there were no significant differences between pre and post testing. 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 SJ and CMJ ($p<0.05$). However, there were no significant difference pre to post-training for spike and 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 SJ and CMJ, neither group showed significant improvement in Spike and Block jump tests. These results lead to the assumption that the technique of spike and block 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 players in our study already had 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 5 week plyometric training may not present a sufficient time to induce an additional physical performance benefits.

Conclusion

Completion of a 5 week plyometric training program improved selected vertical jump tests in young female volleyball players. However, there were no significant changes in spike and block jumps following the plyometric training program. Therefore, the results of our study could partially support our hypothesis. Vertical jump is especially relevant for 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.

References

Amasay, T. (2008). Static block jump techniques in volleyball: Upright versus squat starting positions. *The Journal of Strength & Conditioning Research*, 22(4), 1242-1248.

De Villarreal, E. S. S., Requena, B., & Newton, R. U. (2010). Does plyometric training improve strength performance? A meta-analysis. *Journal of Science and Medicine in Sport*, *13*(5), 513-522.

De Villarreal, E. S. S., Kellis, E., Kraemer, W. J., & Izquierdo, M. (2009).Determining variables of plyometric training for improving vertical jump height performance: a meta-analysis. *The Journal of Strength & Conditioning Research*, *23*(2), 495-506.

Diallo, O., Dore, E., Duche, P., & Van Praagh, E. (2001). Effects of plyometric training followed by a reduced training programme on physical performance in prepubescent soccer players. *The Journal of sports medicine and physical fitness*, *41*(3), 342-348.

Faigenbaum, A. D., Kraemer, W. J., Blimkie, C. J., Jeffreys, I., Micheli, L. J., Nitka, M., & Rowland, T. W. (2009). Youth resistance training: updated position statement paper from the national strength and conditioning association. *The Journal of Strength & Conditioning Research*, *23*, S60-S79.

Faigenbaum, A. D., McFarland, J. E., Keiper, F.B., Tevlin, W., Ratamess, N. A., Kang, J., & Hoffman, J. R. (2007). Effects of a short-term plyometric and resistance training program on fitness performance in boys age 12 to 15 years. *J Sports Sci Med*, *6*(4), 519-25.

Ingle, L., Sleap, M., & Tolfrey, K. (2006).The effect of a complex training and detraining programme on selected strength and power variables in early pubertal boys. *Journal of sports sciences*, *24*(9), 987-997.

Kotzamanidis, C. (2006). Effect of plyometric training on running performance and vertical jumping in prepubertal boys. *The Journal of Strength & Conditioning Research*, *20*(2), 441-445.

Lephart, S. M., Abt, J. P., Ferris, C. M., Sell, T. C., Nagai, T., Myers, J. B., & Irrgang, J. J. (2005). Neuromuscular and biomechanical characteristic changes in high school athletes: a plyometric versus basic resistance program. *British journal of sports medicine*, *39*(12), 932-938.

Markovic, G. (2007). Does plyometric training improve vertical jump height? A meta-analytical review.*British journal of sports medicine*, *41*(6), 349-355.

Matavulj, D., Kukolj, M., Ugarkovic, D., Tihanyi, J., & Jaric, S. (2001). Effects of plyometric training on jumping performance in junior basketball players. *The Journal of sports medicine and physical fitness*, *41*(2), 159-164.

Osborne, M. (2002). Protocols for the physiological assessment of beach volleyball players. In: Queensland Academy of Sport Laboratory Manual, 1–21.

Santos, E. J., & Janeira, M. A. (2008). Effects of complex training on explosive strength in adolescent male basketball players.*The Journal of Strength & Conditioning Research*, *22*(3), 903-909.

Sheppard, J.M., Gabbett, T.J., &Stanganelli, L.C.R. (2009). An analysis of playing positions in elite men's volleyball: considerations for competition demands and physiologic qualities. *Journal of Strength and Conditioning Research*, *23*(6), 1858–1866.

Singh, A. B., & Rathore, V. S. (2013). Kinematic factors of off-speed and power spike techniques in volleyball. *Journal of Education and Practice*, *4*(7), 112-117.

Stanganelli, L.C.R, Dourado, A.C., Oncken, P., Mançan, S., & da Costa S. C. (2008). Adaptations on jump capacity in Brazilian volleyball players prior to the under-19 World Championship. *Journal of Strength and Conditioning Research*, *22*(3), 741-749.

Walsh, M. S., Bohm, H., Butterfield, M. M., & Santhosam, J. (2007). Gender bias in the effects of arm and countermovement on jumping performance. *Journal of Strength & Conditioning Research*, *21*(2), 362-366.

Zatsiorsky, V. M., & Kraemer, W. J. (2006). *Science and practice of strength training*. Human Kinetics.

UČINCI KRATKOG VISOKO-INTENZIVNOG PLIOMETRIJSKOG TRENINGA NA VERTIKALNI SKOK KOD MLAĐIH ODBOJKAŠICA

Sažetak

Pedeset i četiri mlađe igračice su sudjelovale u ovom istraživanju (15 ± 1).Cilj ovog istraživanja bio je da utvrdi učinke 5 tjedana pliometrijskog treninga kod odbojkašica. Standardna antropometrija (visina, visina stojnog dosega, tjelesna masa), vertikalni skokovi i specifični odbojkaški skokovi su odabrani testovi. Eksperimentalne i kontrolne skupine su dobro usklađene na testovima prije treninga bez značajnih razlika pronađenih za bilo koje varijable između dvije grupe. Program od pet tjedana se izvodi u grupi koja izvodi pliometrijski trening. Pronađene su značajne interakcije između skupina za skok iz čučnja. Grupa koja izvodi pliometrijski trening izazvala je značajna poboljšanja u testovima SJ i CMJ. Međutim, kontrolna skupina nije pokazala značajna poboljšanja u svim testovima skočnosti. Može se zaključiti, petotjedni visokointenzivni pliometrijski program doveo je do poboljšanja u izabranim testovima vertikalnog skoka kod mlađih odbojkašica. Međutim, nije bilo značajnijih promjena u specifičnim odbojkaškim skokovima nakon pliometrijskog programa.

Ključne riječi: *trening skočnosti, utjecaj, snaga, ženski sportaši*

Received: July 18, 2016
Accepted: September 5, 2016
Correspondence to:
Assist. Prof. Tomislav Krističević, PhD.
University of Zagreb
Faculty of Kinesiology
Zagreb, Croatia 10 000, Horvaćanski zavoj 15
Tel: +385 (1) 3658 666
E-mail: tomislav.kristicevic@kif.hr