EFFECTS OF PLYOMETRIC TRAINING ON GRASS SURFACE AND CONCRETE SURFACE ON JUMPING PERFORMANCE AMONG VOLLEYBALL ATHLETES

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Abstract

The purpose of this study was to compare the effects of 4 weeks of plyometric training on grass surface group and concrete surface on jumping performance among volleyball athletes. The vertical jump was evaluated in two types of jump; squat jump (SJ) and countermovement jump (CMJ). The results of this study indicate that 4 weeks of intervention led to a significant improvement in post-tests of SJ and CMJ ($p < 0.05$) for both grass surface and concrete surface. However, in comparing the grass and concrete surfaces, there was no significant difference ($p > 0.05$). These findings suggest that plyometric training on different surfaces may be associated with similar training-induced effects on neuromuscular factors related to the efficiency of the stretch-shortening cycle.

Keywords: Plyometric, types of surface, volleyball athletes, jumping, performance

Introduction

Volleyball requires both offensive and defensive skills such as the attack, block, and serve, which place considerable demands for great jumping performance (Jastrzebski, Wnorowski, Mikolajewskia, Jaskulska, & Radziminski, 2014). Volleyball is played on different types of surface depending on whether it is conducted indoors or outdoors (Gortsila, Theos, Nesic & Maridaki, 2013). Plyometric training has been shown to be an effective method for the improvement of strength and explosiveness or power (Amrinder, Sakshi, & Singh, 2014). Plyometric training or jumping exercises are parts of resistance training which will enhance the jumping ability of athletes and they bridge the gap between speed and strength exercises to ease the accessing of motor units (Rezaimnesh, Amiri-Farsani & Saidian, 2011).

In volleyball, there are specific movement patterns associated with jumping, including the block jump and attack or spike jump. Thus, SJ and CMJ are important in those movements (Sattler, Sekulic, Hadzic, Uljevic & Dervisevic, 2012). As the level of competition becomes higher, these become more important, especially when playing in the front row. The ability to jump high vertically is always the main focus for coaches when they train their athletes.

Plyometric training uses the phenomenon of stretch-shortening cycle (SSC) as characterized by rapid eccentric phases and explosive muscular contractions potentiated by the stretch reflex (Bobbert, 1990). Neuromuscular factors are related to the efficiency of the stretch-shortening cycle and these induced different effects on the athletes' performance, if related to different training surfaces (Impellizzeri, Rampinini, Castagna, Martino, Fiorini, & Wisloff, 2007). The positive effect of plyometric training on jumping performance includes the function it plays in the stretch-shortening cycle phenomenon, in which type of surface plays an important role (Sozbir, 2016). The most common surface to train for plyometric training is on firm surface, such as wood or grass. However, most amateur volleyball athletes practice their volleyball skills on a concrete surface.

Different types of the surface might develop the different effect on athletics performance. Athletic performance is influenced by the amount of energy returned to the athlete from the different training surfaces depending on the stiffness of the surface (Zamparo, Perini, Orozio, Sacher & Ferretti, 1992; Martin & Priouz, 2016). In rules written by international sport federations, volleyball is played on a tartan surface (Hanlon, 2009). However, the athletes training surface might not happen on the competition surface as regulated. The most prominent training surface is either the concrete or grass as used as the subjects of this present study. Most studies have investigated the effects of different surfaces on jumping performance (Impellizzeri et al., 2007); however, to the best of our knowledge, no study has examined the effect of plyometric training in terms of grass and concrete surfaces. It is crucial to understand the differences between surface types in response to plyometric training on jumping performance of volleyball athletes. Some universities provide outdoor facilities for indoor sports such as futsal, netball, basketball and volleyball. In this study, most volleyball athletes regularly train on outdoor courts of concrete because they are durable for all types of weather. Grass surfaces are always accepted as the safest surface if the training involves jumping activities. The type of grass in the study is cowgrass, or *Paspalum conjugatum* and *Axonopus compressus*. This type of grass is synonymous with football fields in Malaysia and is easily maintained due to its durability. Therefore, the aim of this study was to compare the effect of plyometric training on jumping performance when performed on either a grass or concrete surface.

Methodology

Study design

A randomized pre and post-test design was used in this study. After the pre-test of vertical jump, the participants were randomly assigned to two groups; plyometric training on grass surface (cowgrass type) and plyometric training on concrete surface. Pre-test was completed a week before the intervention period, while post-test was conducted right after the end of the experimental training period ended.

Participants

A convenience sampling technique was employed in recruiting the participants. The sample involved university volleyball athletes who have actively trained and competed in volleyball games. Their range of age was from 18 to 24 years old. A total of $N = 12$ participants participated in this study (Age = 21.00 ± 2.089 years old, Height = 165.75 ± 6.943 cm, Weight = 60.75 ± 8.379 kg, Male = 6, Female = 6). Research and ethics approval was sought from the faculty before conducting the study. Written consent form and general health screening by using Physical Activity Readiness Questionnaire (PAR-Q) was also obtained from the participants. All participants underwent a familiarization session with all testing procedures and had experience in plyometric training.

Intervention

The four-week plyometric training regimen was adopted and revised from Jastrzebski, Wnorowski, Mikolajewski, Jaskulska and Radziminski (2014) that has shown to be effective in enhancing jumping performance (Table 1). The participants performed the same number of sets and repetitions with 2-minute rest intervals between sets and 15 to 20 second intervals between repetitions in order to maintain a high level of execution. The participants were trained for 4 weeks with 2 sessions of 48 hours recovery days per week. The participants also performed their regular training, which consisted of aerobic and technical-tactical training throughout the intervention period. The equipment for the intervention was a 20cm plyometric box and a 71cm hurdle. The total number of contact (volume) of the training session was 144 for the first two weeks and progressed to 160 in the last two weeks of plyometric training. This volume corresponds to guidelines by Beachle and Earle (2008), as the participants were considered intermediate athletes in plyometric training.

Table 1: Plyometric training program adopted from Jastrzebski et al., (2014)

Type of exercise	Week			
	1-2		3-4	
	Reps (Set)	No of contact	Reps (Set)	No of contact
Drop from the height of the platform to the squat position followed by single leg maximal vertical jump	12 (4)	48	12 (4)	48
Double leg jump over a hurdle	8 (6)	48	8 (7)	56
Double leg drop jump	8 (3)	24	7 (4)	28
Double leg drop jump over a hurdle	8 (3)	24	7 (4)	28
Total number of contact (volume)	144		160	

Measurement

Jumping performance consisting of SJ and CMJ was measured using VERTEC equipment. The Vertec was adjusted to match the height of the participant by having him or her stand with the dominant side to the base of the testing device. The dominant hand was raised and the Vertec was adjusted so that the hand was at the appropriate distance away from the marker based on the markings of the devise itself. For SJ, the subjects started from a standing position, bending knees to 90º, stopping for 3 seconds, and then jumped as high as possible trying to reach the maximal height with no countermovement. CMJs were performed starting from a standing position, after which the participants were asked to jump as high as possible with a rapid, preparatory downward eccentric action. The participants performed the proper jumping maneuver for three trials, with 20 seconds to 30 seconds of recovery between trials. The data collected to the closest 1.0 cm and the best trial was recorded. The testing has shown a high reliability (r = .87 - .93) (Gjinovi, Idrizovic, Uljevic & Sekulis, 2017).

Statistical analysis

The data collected were analyzed by using Statistical Package for Social Science (SPSS) version 22.0. A two-way repeated measure analysis of variance (ANOVA) was employed to compare the effects of two different surfaces of plyometric training on jumping performance among the volleyball athletes. The statistical significance level was set at .05 ($p < .05$).

Results

Table 2 shows the descriptive statistics for pre-test and post-test for the plyometric training on a grass surface and concrete surface for SJ and CMJ. Both jumps improved significantly in jumping distance in posttests ($p < .05$) in both types of surface. There was a significant main effect for repeated measures time (pre – post) in the types of surface, SJ (Wilks Lambda = .947, F = 15.901 df = 1, $p < .05$) and CMJ (Wilks' Lambda = .990, F = 45.00, df = 1, $p < .05$).

However, in comparing between grass surface and concrete surface on SJ performance, the results show that there was no significant different ($p > .05$). CMJ also indicates a similar result ($p > .05$).

Table 2: Descriptive statistics of variables

Types of jump	Group	Pre-test	Post-test
		M (± *SD*) cm	
SJ	Grass surface [w, ǂ]	38.83 (7.36)	42.00 (6.693)*
	Concrete Surface [w, ǂ]	39.33 (9.585)	41.50 (7.635)*
CMJ	Grass surface [¥, €]	36.83 (6.940)	40.17 (5.981)*
	Concrete surface [¥, €]	35.33 (6.976)	39.00 (6.899)*

[w] Wilks' lambda = .947, F = 15.901, df = 1, $p < .05$.
[¥] Wilks' Lamda = .990, F = 45.00, df = 1, $p < .05$.
*$p < .05$ (Significance within group, pre vs post)
ǂ $p > .05$ (Significance between group, SJ – grass surface vs concrete surface)
€ $p > .05$ (Significance between group, CMJ – grass surface vs concrete surface)

Discussion

Based on the findings of the current study, there were significant improvements in the post-tests of jumping performance in two training surfaces of grass and concrete. This indicates that the plyometric training was effective in improving the jumping performance of the athletes irrespective of the training surfaces. For SJ, the improvement was 8.16% in grass surface, while in the concrete surface was 5.52%. This indicates that SJ performance improves greater in grass surface of plyometric training. The result of the present study have contradicted a previous study which found that the CMJ improved more than SJ on a grass surface (Impellizzeri, Rampinini, Castagna, Martino, Fiorini & Wisloff, 2007).

On the other hand, in evaluating the CMJ, the grass surface improved 9.07%, while the improvement on the concrete surface was 10.39%. This shows that the concrete surface gave a greater improvement in CMJ following the plyometric training. As agreed by Rubley, Haase, Holcomb, Girouard, and Tandy (2011), plyometric training improved lower-body performance, especially in the areas of jump height and power. Plyometric training creates high stretch loads that will store elastic energy, increase the pre-contraction activation state and greatly activate the stretch-reflex to produce explosive concentric muscle contractions (Bobbert, 1990). These characteristics have been suggested to induce neuromuscular adaptations which leading to improvement in performance (Rimmer & Sleivert, 2000), which in this study refers to jumping ability. The increasing of the jumping ability may be influenced by electromyography activities. Plyometric training induced significant increases in the electromyography activity of lower extremity, which could result from an increased sensitivity of the muscle spindle via enhanced α-γ co-activation to enhance the stretch reflexes (Sozbir, 2016). The Achilles tendon might be elongated due to the adaptation by plyometric training, which resulted in the increased amount of stored elastic energy (Kubo, Morimoto, Komuro, Yata, Tsunoda, Kanehisa & Fukunaga, 2007). Thus, this contributed to better jumping performance in the athletes.

In comparing the SJ and CMJ on both surfaces, there were no significant differences in jumping performance between the grass surface group and concrete surface group ($p > .05$). Slight differences in percentages were discussed. Even though in SJ of grass surface was 2.32% greater than the concrete surface, the CMJ of concrete surface, however, was greater by 1.32% than the grass surface. This may suggest that jumping on grass requires more intense concentric push-off phase, which might compensate for the degradation of the elastic energy potentials caused by grass absorption and the difficulty of the ankle to push along the vertical axis. Therefore, the SJ was superior on grass surface. This finding is consistent with studies comparing grass and sand surfaces (Impellizzeri et al., 2007; Giatsis, Kollias, & Panoutsakopoulus, 2004) where the softer surface which was the sand exhibited the similar finding as the present study. On the other hand, the performance of CMJ in concrete surface was enhanced by the effects of pre-stretch augmentation (Kubo, Kawakami & Fukunaga, 1999). The lower CMJ of grass surface might be associated with a lesser reuse of the stored elastic energy as well as energy loss, due to the feet which slightly slipped during the push-off phase. This also happened in studies examining the plyometric training on sand surface (Impellizzeri et al., 2007; Miyama & Nosaka, 2004, Giatsis, Kollias & Panoutsakopoulus, 2004; Lejeune, Willems & Heglund, 1998). Even though there was no statistically significant difference between the two groups, the discussed phenomena should be taken under consideration, as this study has compared two surfaces which are very prominent in athletics.

Conclusion

Based on these results, there was no significant difference between the grass surface group and concrete surface group in terms of SJ and CMJ on the vertical jump test. Both surfaces brought improvements in jumping ability after four weeks of plyometric training with SJ was greater in grass surface and, CMJ was greater in concrete surface training. This leads to the conclusion that plyometric training does enhance and improves jumping ability, especially on jump height, with the consideration of the types of jump and types of surface.

Practical applications

It is recommended that coaches and strength and conditioning professionals use grass surfaces for plyometric training to improve jumping ability as the present study exhibited significant improvements. As noted, most recreational and amateur volleyball players train outdoors. Thus, practicing plyometric on grass surface could improve jumping ability and also safe for the joints. Future studies should consider adding duration in comparing the types of surface, using elite volleyball athletes as participants and including other explosive performance as the outcome variable such as sprint performance. However, they must be aware that training on a firm surface might be more stressful than a softer surface, thus might lead to musculoskeletal injuries (Hamid, Eston, Abbas, Behnam & Alireza, 2016), as the current study volume of training program was very short at two sessions per week for four weeks.

Limitation and Future Direction

The current study focused on actively trained volleyball athletes who represent the university in competition. Using elite volleyball athletes is recommended for future studies. The finding might be different as compared to the current one. The responses of amateur and elite athletes are different; thus, high-performance coaches could benefit from the findings by using elite volleyball athletes as a sample.

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