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Original Article

Comparison of Spike Techniques in College Beach and Classical Volleyball

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Abstract:

The purpose of the study was to identify differences between the spiking techniques in beach and classical volleyball providing athletes and coaches with timely feedback through identification of differences. Subjects were 18 (n=18) male volleyball players from a university team who regularly participated in classical and beach volleyball competitions. Ten successful phases of spiking were video captured for each subject both on classical and beach volleyball courts. Comparison of spiking techniques in beach and classical volleyball were broken down into four aspects: approach; high squat and detachment; flight; flight end. Significant differences ($p < 0.05$) in approach were found in mean length of the turn step (102±2.7 cm on court vs 89±3.9 cm on sand), knee and coxofemoral angles (112±2.2° vs 134±1.7° and 94±1.5° vs 103±2.1 Similar patterns of differences were found in high squat and detachment phase - knee and coxofemoral angles were respectively (94±1.5° vs 103±2.1°and 94±1.5° vs 89±3.8°). With the exception of the height, all other flight phase characteristics were similar. Video capture and analysis of spike movements proved to be viable, informative and sufficiently accurate for measurements. Feedback for players and coaches appeared to present a relatively simple and cost-effective method for creating a model of spike movements and a positive change in spiking biomechanics in beach volleyball. The proposed approach to assess spike efficiency was based on three selected parameters: initial ball velocity, hitting the court and hitting the assigned zone. The generalized value of spike efficiency was calculated as the parameters average.

Key words: beach volleyball, classical volleyball, volleyball spike, biomechanical analysis.

Introduction

Volleyball is dynamic and demanding game. Sport technique in volleyball consists of serving, passing, setting, hitting, blocking, and digging. The game requires fast movements around the court: running, sidestepping, bending, jumping and diving. There are two distinct variations of the game – classical volleyball, played by two teams of 6 players on a hard court 18 by 9 meters, and beach volleyball, played by teams of two on a sand court 16 by 8 meters. Due to these differences players are specialized in beach or classical volleyball, but less advanced athletes may combine both. The rules in both types of volleyball are quite similar, as are the techniques and tactics, however specialization requires focus on one or the other.

Previous studies have examined the spiking techniques in classical and beach volleyball (Borràs at al., 2011; Ciapponi at al., 1996; Cronin at al., 1996; Hedrick 2007, 2008; Reeser at al., 2010), but there exist no comparisons of spike techniques made on the same groups of athletes. This situation becomes magnified by beach volleyball coaches and players coming from classical volleyball and therefore have to apply classical techniques to beach volleyball which may not be the best approach for this purpose (Homberg at al., 1994; Buzhinskiy at al., 2014).

The purpose of the study was to identify differences between the spiking techniques in beach and classical volleyball and to provide athletes and coaches with objective models of spiking techniques. It was hypothesized that the findings of the key differences between the spike parameters in beach and classical volleyball will help to improve the efficiency of spike motor skills. The hypothesis was that quantitative and qualitative analysis of the movements could become the basis for management of technical training of beach volley players not only in terms of their spiking but also in overall tactical and technical actions.

Material & methods

A crossover design was employed so that comparisons could be made between beach and classical volleyball styles. The independent variables under assessment were divided into 3 groups:

- duration of the main phases of the attack (final phase of runup, detachment, the air phase with the spike itself, end of the flight phase: landing and touchdown);
- kinematic characteristics (horizontal and vertical velocities and positions of attacking hand, elbow, shoulder and body mass center (center of gravity), knee, ankle, elbow and shoulder angles, shoulder abduction/adduction, momentum and position of the body mass center);

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- dynamic characteristics of spike phases and the athlete's movements during the attack, i.e. duration of some phases, velocity, displacement, knee, ankle, elbow and shoulder angles as well as trunk twist, shoulder abduction/adduction, momentum and position of the body mass center.

Participants

Subjects under study were 18 (n=18) male (mean age 19.9±0.9 years, mean height 190.5±2.3 cm, mean weight 89.3±1.4 kg) volleyball players from a college team who regularly participated in classical and beach volleyball competitions. The mean length of training in classic volleyball of the subjects was 5.4±0.6 years, while their length of training in beach volleyball was 3.7±1.1 years.

Procedure/Test protocol/Skill test trial/Measure/Instruments

All subjects received an explanation of the study and testing which were in accordance with, and approved by the institutional ethics committee. Each subject read and signed the consent form before participation in the study. According to the standard testing procedure, all subjects completed a warm up protocol which consisted of 5-7 minutes of pass-set-hit drill in pairs. The subjects were given 3-5 warm up trials before being recorded with 2-3-minute rest between the trials and test spikes. Ten successful attempts of spike were filmed for each subject on both classical and beach volleyball courts. All spike movements were performed as power spikes. The procedure was repeated at the beginning and at the end of classic volleyball and beach volleyball seasons.

Video capture was performed by a high-speed Sony HDR-AS200V camera with the resolution of HD 720i (1280x720) at the speed of 120 f/s. The main camera was placed in a tripod 1.6 meters high 2 meters from the side of a court and 1.5 meters behind the net. To determine the ball flight velocity right after the spike itself, video capture was performed using an additional FujiFilm FinePix HS20EXR camera, which was placed on a tripod just above the net.

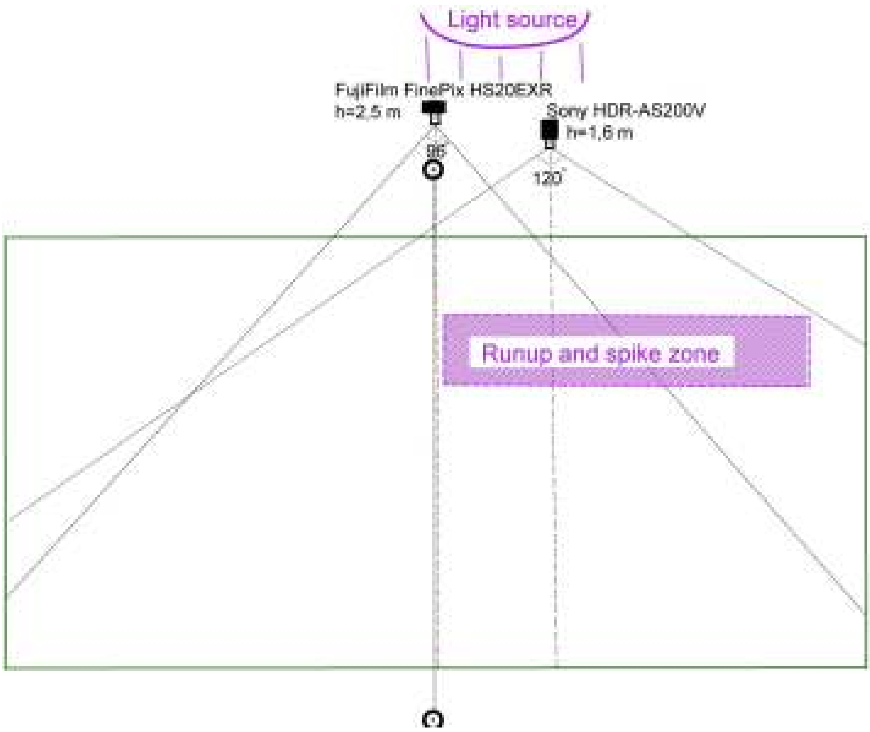

Fig. 1. Arrangements of the main and the axillary cameras for videocapture of spikes

For classical volleyball, the court had an additional 60 W (≈5500 lm) LED lights, whereas for beach volleyball, the procedure was conducted in the natural lighting at the outdoor sand court. In both cases videos were shot from the side of the spiking hand (16 out of 18 athletes under the study were right-handed).

To minimize optical aberrations, the cameras were placed in such a way that they could pick up spike instants and the first 4-5 meters of the trajectory of a ball (See Fig. 1). For this purpose, the main camera was placed at 1.6 m elevation and the additional camera was elevated at 2.5 m. The optimal viewfinder angles were selected empirically (120° and 96° respectively).

Initial analysis of kinetic characteristics, including the duration of the spike phases, knee, ankle angles of take-off foot when pushing and taking off, at key instants of the flight phase, trunk twist angle in typical positions, elbow and shoulder angles, and provided assessment of feet positions when pushing and landing was made using Kinovea Version 0.8.15 software.

More detailed quantitative 2D analysis was provided by SkillSpector version 1.3.2 software using 16-unit Simple Full Body model. After manual digitization of the processed video, it was possible to view and trace the displayed points and links. The most important variables for investigation were advanced leg, hitting hand and body mass center (BMC). The software calculated velocity, displacement, angles as well as angular momentum and moment. Therefore, the measurements obtained allowed to assess variables and make correlations between beach and classical volleyball spike parameters to identify favorable and unfavorable characteristics of spiking movements.

Data collection and analysis / Statistical analysis

The data obtained for beach and classical volleyball was analyzed in several steps. Data distributions were checked for normality. No abnormal patterns were found.

Significance was assessed for changes in spike techniques at the beginning and end of the relevant season. The validity of the variables was determined by t-test.

All statistical analyses used level of significance of $p \leq 0.05$ or greater, and were conducted using the standard application of MS Excel 2013.

An original method was proposed for quantitative assessment of technique parameters' effect on the spike efficiency. The selected assessment parameters were: initial ball velocity, hitting the court and hitting the assigned zone. The generalized value of the spike efficiency was calculated as the average of the three above parameters. The final step was to select the most informative technique parameters which can be determined between the attempts in training session and promptly communicated to the athlete.

Results

The results revealed similarities and differences between the techniques of spike in beach and classical volleyball.

The approach techniques demonstrated lower run-up velocity for the beach volley players (3.86±0.19 m/s sand vs. 4.22±0.22 m/s court). On sand players demonstrated more accentuated preparation for takeoff with last steps of 1.32±0.07 m to 1.26±0.06 on court together with more apparent arms back swing 77.2±0.6 degrees to 33.6±0.9 degrees "on court". The last stride on the sand by takeoff foot was accentuated on the heel with some delay in ankle extension almost prior to the beginning of detachment.

Table 1. Comparison of the vertical movements of BMC (height of BMC above/below the standard standing level), in classic volleyball and beach volleyball

Phases	Boundary moments	Height of BMC above/below the initial level, cm, x□±s x Classic volleyball x□±s x	Beach volleyball x□±s x	Statistical significance, P
Run-up	1-st step, low	-8±0.8	-7±1.9	p>0.05
	1-st step, high	-6±1.1	-3±0.7	p<0.05
	2-nd step, low	-10±0.4	-9±1.4	p>0.05
	2-nd step, high	-8±0.4	-5±1.1	p>0.05
	Turn step, low	-15±1.1	-17±2.8	p>0.05
	Turn step, high	-10±1.0	-11±2.9	p>0.05
Preparing for take-off	High squat	-13±1.1	-19±1.9	p<0.05
Take-off phase	Up-forward swing of arms and torso	5±0.3	0±2.2	p<0.05
	Take off	7±0.8	4±1.5	p<0.05
Backswing	Trunk twist – rise of the attacking arm	60±2.6	43±4.7	p<0.05
	Highest point	69±2.1	57±3.5	p<0.05
Spike	Contact phase	66±0.8	52±3.3	p<0.05
Landing	Contact of the homonymous leg	0±1.7	4±2.1	p<0.05
	Contact of the opposite leg	-2±0.6	-3±2.8	p>0.05
Cushioning	Lowest BMC level	-22±2.6	-16±4.1	p<0.05

In the detachment phase, the focus was set on the correlation between a considerable increase of swing leg amplitude on sand and a deeper squatter in the previous phase. (r=0.692). At the beginning of this phase, the projection of the body mass center tended to be more lagging behind the area of support than in classical volleyball. Furthermore, it was noted that the amplitude increase of front swing involving both hands and trunk resulted in up to 15% increase of the swing duration on sand.

Table 2. Comparison of the main joint angles in the key moments of the attack spike. Classic volleyball (beginning and the end of the season)

Phases	Joints	Joint angles, °, x□+□s x October 2016	May 2017	Statistical significance, P
Turn step	Left Ankle-joint	101±2.9	102±3.5	p<0.05
	Left Knee	112±10.4	115±12.2	p<0.05
	Left Coxofemoral	95±5.9	91±4.7	P>0.05
High squat	Right Knee	99±7.1	103±2.6	P>0.05
	Right Coxofemoral	89±3.1	86±2.2	p<0.05
Backswing	Right Radiocarpal	151±5.6	153±6.9	p<0.05
	Right Shoulder-joint	32±2.9	29±3.4	p<0.05
Elbow Abduction	Right Radiocarpal	122±3.2	120±1.7	p<0.05
	Right Elbow	49±4.2	56±1.9	P>0.05
Spike	Right Shoulder-joint	162±5.7	164±2.4	p<0.05
	Right Elbow	179±0.3	180±0.4	p>0.05
	Right Coxofemoral	152±6.4	149±3.3	p>0.05
Landing	Right Coxofemoral	172±3.3	174±2.1	p<0.05
	Right Knee	165±3.3	149±2.6	P>0.05
Cushioning	Right Coxofemoral	149±3.2	153±1.9	p>0.05
	Right Knee	117±4.0	121±3.3	P<0.05

The spiking phase indicated no valid distinctions between the joint's angle parameters of attacking hand "on sand" vs. "court" (shoulder angles 164.9±3.3 sand vs 163.2±4.5 court; elbow angles 179.9±0.43 sand vs 180.1±0.25 court). Spike jump height measured as vertical movements of the body mass center (BMC) was lower on sand (52±3.3 cm sand vs 66±0.8 cm court, the difference was significant at $p<0.05$). At the same time, the spiking phase displayed very strong variability of the vertical movement of BMC; sand jump variability exceeded court jump by more than 3 times.

Table 3. Comparison of the main joint angles in the key moments of the attack spike. Beach volleyball (beginning and the end of the season)

Phases	Joints	Joint angles, °, x□±s x May 2017	September 2017	Statistical significance, P
Turn step	Left ankle-joint	104±6.5	105±8.2	p<0.05
	Left Knee	124±17.2	137±14.3	P>0.05
	Left Coxofemoral	96±5.2	103±8.9	P>0.05
High squat	Right Knee	97±2.9	84±4.9	P>0.05
	Right Coxofemoral	85±4.1	81±3.5	P>0.05
Backswing	Right Radiocarpal	150±7.2	148±10.2	p<0.05
	Right Shoulder-joint	44±5.9	87±9.6	P>0.05
Elbow Abduction	Right Radiocarpal	108±9.1	81±0.9	P>0.05
	Right Elbow	45±5.3	35±7.4	P>0.05
Spike	Right Shoulder-joint	162±4.2	170+□3.2	P>0.05
	Right Elbow	179±0.8	180±0.5	p>0.05
	Right	140±3.1	132+□2.8	P>0.05
Landing	Right Coxofemoral	146±3.3	131±2.4	p>0.05
	Right Knee	139±4.7	133±2.6	P>0.05
Cushioning	Right Coxofemoral	119±3.1	110±1.9	p>0.05
	Right Knee	101±4.4	97±2.5	P<0.05

At the end of the flight phase, the monitored parameters were preparation for landing and touch-down. On sand players showed stronger bending in hips (mean angles 139±3.0° in comparison to 173±2.8° at landing and 151±2.4° in comparison to 116±1.7° at cushioning), knees (mean angles 136±2.1° in comparison to 157±3.1° at landing and 116±3.8° in comparison to 120±3.6° at cushioning) and in trunk position (trunk front twist did not exceed 7-9±0.9º on the floor whereas on sand it reached up to 26±1.2º). The longitudinal displacements in the flight phase on sand also proved to be longer (127±3.1 cm in comparison to 121±1.9 cm).

Dicussion

The study was targeted to compare spiking in beach and classical volleyball through the use of video capture technologies. The results of this study demonstrate that there are several important similarities between spiking characteristics in beach and classical volleyball that can be useful for beach volleyball pedagogy.

The approach is designed to gain horizontal velocity on the ground prior to spike jump where a horizontal force is converted into a vertical force. According to Dusault (Dusault at al., 1986), greater height in the jump is predicated on greater horizontal approach velocity. As biomechanical research shows, ideally the hitter will use the approach to achieve a high jump with minimal horizontal motion (Hu at al., 2002; Raiola at al., 2013) maximizing horizontal velocity at touch-down and minimizing it at takeoff. It is important to keep precise body position in relation to the trajectory of the ball to be able to make the run more effective (Tilp at al., 2008). According to the practice and research, Braking Force (BF), Base of Support BoS, and Line of Gravity (LoG) are the main factors which improve the approach and lead to a more powerful jump and attack spike (Raiola at al., 2013). A good accelerated runup for the jump is only possible if "start" and "jump" take place at the right instant giving maximal horizontal and then vertical velocity to the body. The lower runup velocity for the beach volley players under the study and their more accentuated preparation for takeoff were evidently due to the sand surface. In real sporting environment, beach attackers must be “light on their feet” to avoid sinking in the sand when approaching to spike. This is usually the major difference between the approach on the sand and the approach on the firm surface. The evidence of reduced horizontal velocity and more extended last steps of the beach players under the study caused less expressed arm back swing and delay in the ankle extension prior to takeoff.

At the beginning of this phase in our study, the projection of the body mass center on the sand tended to be more lagging behind the area of support than on the firm surface though one of the basic rules is to keep body line of gravity straight. It had a negative impact on step 2 as the most important for acceleration, which should be explosive and powerful. Furthermore, it was noted that the amplitude increase of front swing involving both hands and trunk resulted in up to 15% increase of the swing duration on sand. Therefore “the spring“ for beach players turned out to be not so “tight” and the horizontal force not as powerful as in the case of classical players, thus stressing the importance to improve the detachment techniques in terms of LoG and front swing duration.

As for the flight /air/ spike phase, the research findings indicate that the range of motion of the hitting hand is relative to the power of spike. The range usually consists of three sub-phases: a backswing action of the arms, a turn swing involving hip and trunk rotation and a forward swing with shoulder and elbow rotation. With a reduced jump in the sand it is crucial that an attacker in beach volleyball have a good arm extension (straight arm) and a high contact point when executing a spike. The flight phase under the present study indicated no valid distinctions between the motion parameters of hitting and non-hitting hand.

There were no correlations observed between spike jump height for beach and classical courts. The jump height was measured as the highest calculated coordinate of the body mass center. However, on sand jump height displayed very strong variability: the height variability of BMC in jump on sand exceeded that on the classical court by more than 3 times. It may attribute for the faster movements of the athletes on sand and the impact of the sand.

The last phase of the spike is relapse on the ground which consists of the preparation to landing and touch-down. This should be done on both foots at the same time. The cushioning is done by a slight knee bend.

In the study, the major correlations were noted in hip angles (2.5-3 times more on sand with 25-27% higher variability) and in trunk position (trunk front twist did not exceed 7-9º on the floor whereas on sand it reached up to 26º). The longitudinal displacements in the flight phase on sand also proved to be longer in duration. In general, proper landing biomechanics shortens readiness time for next action and prevents traumas; therefore, it needs consistent prompting feedback and integration into the athletes’ movement patterns requiring more practice to achieve the desired levels of trunk, hip, and knee flexion.

The findings of some studies (Hughes at al., 2010) underscore the importance of repetition of feedback for proper landing biomechanics. They suggest that only multiple feedback sessions may become sufficient to effect long-term change in a game specific situation, when the athlete must rely on subconscious thought to accomplish the landing movement correctly and safely.

The most prominent distinctions after seasonal testing both for beach and classical volleyball were significantly more variables changing at the end of the season compared to the season beginning. Only 4 out of 11 angle variables in classical volleyball had significant difference, whereas for beach volleyball this value was 9 out of 11 by the end of the season. In our understanding it shows that the subjects had more significant reserves in power spike technique improvement in beach volleyball in comparison to classical volleyball.

The results obtained allowed to conclude that the technical difference of the attack actions in beach and classical volleyball proved to be quite decisive. Seasonal changes in spike technique were less pronounced but still significant.

Conclusions

From a practical perspective, the study proved that on intercollegiate level players, who play beach and classical volleyball, have different spike techniques for each variation of the game. Moreover, spike efficiency showed sufficient improvement through a particular season. The study helped give immediate and consequent cues to the athlete as well as the coach in terms of the whole progression of spike. The similarities and distinctions between performance techniques of power spike in beach and classical volleyball could help to focus on the aspects, which make the difference for the particular season.

At the same time, beach volleyball coaches can use the findings of this study to assess individual progress of each player in mastering the spike using objective parameters, providing feedback to the players and developing training progress. .

Conflicts of interest - the authors have no conflicts of interest.

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