SPIKING TECHNIQUE OF ELITE AND RECREATIONAL FEMALE VOLLEYBALL PLAYERS

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Successful spiking performance may be linked to genetic factors, the training program, neuromuscular programming and technique. Technique determines how effectively the explosive strength of the spiker is used and impacts the efficacy of the jump. At present there is great interest in improving performance of volleyball players, yet few studies have identified technique differences between different skill levels. This study focuses on the jumping technique used by elite and recreational volleyball players during spiking performance. A major objective is to determine whether spikers differing in skill abilities display differences in the various phases of the spiking technique. In addition, it may be hypothesized that more skilled spikers may be more successful in part because they achieve faster approach velocities with a more effective transition to vertical velocity at takeoff (TO) through techniques employed in the approach (APP), setup (SU) and extension (EXT) phases.

According to Kovalev (1978). the spiker tries to execute a loading action during the last step of the approach, resulting in an eccentric lengthening of the quadriceps muscles and a more forceful contraction during TO. Relatively little leg flexion occurs during the braking action and is dependent on approach speed, leg strength, body mass and other factors. Jump height is dependent on not only correct technique and leg strength, but the ability to load during the SU phase.

The results of a study of U.S. National Team male volleyball players by Colvin, Beal & Zier (1984) indicate that elite spikers move through the SU phase with a minimum (approximately 20 degrees) of flexion at the knees and ankles. Extension is postponed until the EXT phase at which time there is extension of the hips, knees and ankles. APP times for the elite male spikers ranged from 0.07-0.17s. SU phase from 0.09-0.10s and EXT phase from 0.08-0.11s.

METHODOLOGY

Two dimensional high-speed photography was used to compare the spiking performances of six elite (EL) and three recreational (REC) female volleyball players.

The EL athletes were varsity players at the University of Illinois-UC. A LOCAM high-speed 16-mm camera operating at a nominal rate of 100 Hz and two video cameras were used to film the subjects performing a minimum of three successful spikes of a high, outside set in left front position. Kinematic data were obtained by digitizing 10 anatomical landmarks using procedures by Richards and Wilkerson (1984). The raw data were smoothed with a second order low pass digital filter set at 6 Hz. The thigh was measured as an absolute angle from the vertical and the relative knee and ankle angles were also computed. Significant spiking phases analyzed included the approach, setup (loading), extension (propulsion), flight, ball contact and landing. Analysis of variance was used to test the significance of the differences between biomechanical variables common to both levels of players. After processing, the three spike trials were used for detailed analysis.

RESULTS

Table 1 summarizes results of the observed trends for the kinematic variables under investigation. As expected, significant group main effects were prevalent among the dependent variables because of the differences in skill levels between the EL and REC groups. Results demonstrated that the EL group had significantly ($p<.05$) faster APP (horizontal velocity) and TO velocity (vertical velocity) than the REC group (EL-APP vel-2.63 m/s; TO vel-3.05 m/s; REC-APP vel-2.28 m/s; TO vel-2.48 m/s). The EL group spent a significantly greater time in the SU and EXT phases (SU-.06s; EXT-.18s) than the REC group (SU-.03s; EXT-.14s). As may be expected the EL group jumped higher (51.62 cm) than the REC group (38.14 cm) with a longer time of flight. It was interesting to note the quicker time of ball contact for the EL (0.02s vs 0.04s) than REC, possibly a result of a faster, more powerful arm swing. Joint kinematics were similar for the two groups with the exception of a faster angular velocity at the knee at TO for the EL group (350.77°/s) than the REC group (268.20°/s). Many similarities exist between the EL and REC groups such as time of approach, time of landing, lower extremity angular velocities at takeoff and joint positioning during the different phases of spiking.

Data were comparable to those reported by Colvin, Beal & Zier (1984). They reported a horizontal approach velocity of 3.95 m/s, an average hip velocity of 400°/s and knee velocity of 300°/s at time of takeoff for the elite male spikers in their study.

DISCUSSION

Film observation of the TO phase indicated that all of the lesser skilled players were slowing at the end of their approaches and began extending prematurely during the SU phase, possibly resulting in a slower TO velocity and a lower jump. The slower APP and shorter SU phase may be partially influenced by the leg strength of the athlete. The strongest jumpers were generally those with the largest vertical velocity at takeoff. A certain amount of flexion of the hips and knees is important in the loading phase (storage of elastic energy) to facilitate the active lengthening of the quadriceps muscle group prior

Table 1

Body Segment Position, Joint Angles, Angular Velocity, Temporal and Linear Kinematics During Approach, Setup, Extension, Touch Down and End of Landing

	REC M	REC SD	ELITE M	ELITE SD	SIG (p<.05)
Angular Factors					
Angle (deg)					
Thigh-End of Approach	123.78	4.45	123.15	11.88	NS
Take-Off	177.02	3.13	158.19	4.07	NS
Touch Down	151.67	3.53	158.19	4.07	NS
End of Landing	145.17	7.11	143.38	6.94	NS
Knee-End of Approach	112.60	11.54	109.67	9.55	NS
Flexion During Setup	28.35	2.27	15.26	1.83	SIG
Take-Off	173.83	4.58	171.47	5.71	NS
Touch Down	161.59	5.76	161.53	5.01	NS
End of Landing	113.88	9.59	123.09	14.38	NS
Ankle-End of Approach	102.26	15.97	95.77	15.46	NS
Take-Off	150.26	4.54	151.78	4.53	NS
Touch Down	143.60	3.24	142.29	8.88	NS
End of Landing	96.01	14.07	100.92	7.94	NS
Angular Velocity **(deg/s)**					
Thigh-AvgVel-Takeoff	325.12	40.66	306.67	52.92	NS
Peak Velocity	688.54	61.46	609.61	78.66	NS
Knee-Avg Vel-Takeoff	268.20	31.38	350.77	47.84	SIG
Peak Velocity	857.33	56.44	905.86	69.98	SIG
Ankle-Avg Vel-Takeoff	328.03	45.65	313.92	52.66	NS
Peak Velocity	745.01	97.20	858.70	93.31	NS
Temporal Factors **(sec)**					
Time of Approach	0.12	0.03	0.13	0.01	NS
Time of Setup	0.03	0.01	0.06	0.01	SIG
Time of Extension	0.14	0.02	0.18	0.02	SIG
Time of Flight	0.56	0.02	0.63	0.02	SIG
Time of Ball Contact	0.04	0.01	0.02	0.01	SIG
Time of Landing	0.11	0.03	0.12	0.03	SIG
Linear Factors					
Approach Vel (m/s)	2.28	.44	2.63	.32	SIG
Takeoff Vel (m/s)	2.48	.12	3.05	.21	SIG
Height Jumped (cm)	38.14	3.46	51.61	5.81	SIG

to extension. Too much bending results in the dissipation of forces leading to a lower vertical velocity at takeoff. There was less "buckling" (knee flexion) in the EL players during loading than in the REC players. Skilled spiking technique is characterized by knee extension preceding plantar flexion of the ankles. Two of the lesser skilled group initiated plantar flexion before knee extension and actually began extending during the loading phase, while the better players began knee extension prior to ankle plantar flexion and delayed knee extension until after the loading phase.

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CONCLUSIONS

The results of this study indicate that for an effective spike jump spikers should:

1 - Develop a large horizontal velocity in the approach.
2 - Convert this velocity to a large change of vertical velocity at time of takeoff.
3 - Develop maximum tension during loading (the legs must withstand or not allow much knee flexion during the setup phase.)
4 - Do not begin extension during the setup phase.

The better spikers delayed premature extension during the loading phases, kept increasing their horizontal velocity throughout their approach, and generated higher angular velocities at the knee at time of takeoff. These factors resulted in higher jumps and a longer time of flight which allowed the spiker more latitude in adjusting to the set and successfully spiking the ball.

Further study is needed to determine the biomechanical techniques employed by different skill levels of players. Three dimensional film analysis of the upper body and extremities is necessary to study in greater depth the kinematic factors influencing success in spiking a volleyball. Knowledge of spiking technique is a fundamental prerequisite for understanding spiking biomechanics.

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