KINEMATICS OF THE HIGH OUTSIDE SET AND THE TWO-SET IN VOLLEYBALL

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Utilizing a variety of set placement and disguising the type of set that is being executed is essential in high levels of play in volleyball. Such deception is mandatory for a team to allow their hitter to spike against either no blockers or a single blocker which enhances the offense's chance for success. This study was undertaken to examine biomechanical differences and similarities in executing the high outside set (HOS) and the two-set (2-S). Several quantitative investigation have been conducted on overhead setting, but few have included the analysis of a fast, low set variation such as the 2-S.

METHODS

Subjects.

Ten female collegiate volleyball setters who were participants on NCAA Division I teams in 1983 were used as subjects in this study. Five major colleges were represented and included the following: Lamar University, University of Houston, Louisiana State University, Texas A & M University, and the University of Texas at Arlington.

Data Collection.

The athletes were filmed using a 16 mm Photosonics P-1 camera. The camera was positioned to film the sagittal view of the subjects, with a filming rate of 200 frames/sec. A timing light generator pulsed a light-emitting diode mounted inside the camera to mark the edges of the film at constant intervals of 0.1 s. A one-meter multiplier was filmed to allow for proper scaling during data reduction.

Each subject performed 3 trials of the HOS and 3 trials of the 2-S. Subjects were given unlimited practice trials before performing the trials used for filming. The accepted height of the HOS was 6 to 9 ft vertical projection with a 15 to 18 ft horizontal projection. The accepted height of the 2-S was 3 to 4 ft vertical projection with a horizontal displacement of no more than 3 ft. A volleyball training device, "Catch-It, Bask-It", was used to provide a vertical and horizontal setting target for the subjects. All data were collected outdoors on a tennis court.

Data Analysis.

A two-dimensional film analysis was conducted on a Numonics 1224 digitizer and Dec 20 mainframe computer. The best trial for analysis was chosed in accordance with specific height and distance requirements and from the individual subject's preference of the best trial.

Analysis consisted of digitizing the film data to obtain joint angles of the right and left knees, elbows, hips, and the left wrist at initial contact with the ball; joint angles of the right and left knees and elbows at the moment of release of the ball; distance the ball traveled during the absorption and projection phases; distance and angle of the ball to the forehead at initial contact; time of ball contact; hand velocity from initial contact to start of projection to release; and ball velocity from initial contact to start of projection to release. The Wilcoxon Signed-Ranks Test was used to treat the data. (The level of significance adopted in this study was $p<.01$).

FINDINGS

Results showed significant differences (Table I) between the two types of set with respect to the angle of the left wrist and the angle of the ball to the forehead at contact, and the distance of the ball to the forehead. Tables II through IV present the mean values of the performance variables under investigation. The angle of the left wrist (Table II) was 118.39° for the HOS and 128.23° for the 2-S which indicates a more extended position during the 2-S. The angle of the ball to the forehead (Table III) was lower for the HOS (55.34°) than for the 2-S (61.90°). The angle of ball projection (Table III) also was lower for the HOS (61.48°) than for the 2-S (77.94°) which may be attributable to the smaller horizontal and vertical distance requirement for the 2-S.

Right knee angles (Table II) varied from 140.70° at the lowest point of the body's cg to 163.72° at contact to 170.37° at release for the HOS. Similar extension of the knees occurred during execution of the 2-S and in left knees. While the knees begin their extension earlier than the elbows, it is apparent that knee and elbow extension (Table II) are important parts of the setting technique. Right elbow angles varied from 121.54° at the lowest point of the body's cg to 140.19° at contact to 150.72° for the HOS. Similar patterns of extension were noted during the 2-S and in left elbow angles.

Hips angles at contact (Table II) were approximately the same for the two types of set with right hip angles varying from 152.56° (HOS) to 152.79° (2-S). The left hip angle at contact for the HOS was 171.96° and 171.70° for the 2-S. The front-back stride position accounted for angle differences between right and left hips. Trunk lean angles (Table II) indicate a more extended position of the trunk during the 2-S than the HOS. An angle of 79.57° for the HOS and 85.54° for the 2-S was observed.

Similar ball absorption distances (Table III) occurred in both types of set. An absorption phase of 5.59 cm for the HOS and 6.07 cm for the 2-S was calculated. Distance of the ball projection phase (Table III) was over 10 cm greater in the HOS than the 2-S indicating the greater setting distance requirement for the HOS. The distance of the ball from the forehead at contact (Table III) was 33.02 cm for the HOS and 34.11 cm for the 2-S.

Table I

WILCOXON'S SIGNED-RANKS SUMMARY TABLE

	T	P
Angles		
Right Knee at Initial Contact	13	.140
Left Knee at Initial Contact	14	.142
Right Knee at Release	9	.030
Left Knee at Release	15	.147
Right Hip at Initial Contact	24	.959
Left Hip at Initial Contact	26	.918
Trunk Lean at Initial Contact	6	.025
Left Wrist at Initial Contact	3	.001*
Ball to the Forehead	1	.007*
Ball Projection	0	.001*
Distances		
Ball to Forehead	18	.332
Absorption Phase	12	.627
Projection Phase	10	.045
Time of Contact	17	.256

Note: Rejection Region: $T \leq 3$ for $\alpha = .01$

Table II

JOINT KINEMATICS

VARIABLE[a]		HOS	2-S
Knees-Lowest CG (deg)	Right	140.70	135.11
	Left	144.72	136.23
Knees-Contact (deg)	Right	163.72	155.13
	Left	162.69	153.69
Knees-Release (deg)	Right	170.37	168.24
	Left	171.45	167.89
Elbows-Lowest CG (deg)	Right	121.54	120.78
	Left	123.76	122.39
Elbows-Contact (deg)	Right	140.19	130.78
	Left	141.37	133.27
Elbows-Release (deg)	Right	160.72	152.73
	Left	163.19	150.27
Hips-Contact (deg)	Right	152.56	152.79
	Left	171.96	171.70
Wrist-Contact (deg)	Left	118.39	128.23
Trunk Lean-Contact (deg)		79.57	85.54

[a]Mean Values

Table III

BALL KINEMATICS

VARIABLE[a]	HOS	2-S
Angle of Ball to Forehead-Contact (deg)	55.34	61.90
Distance of Ball to Forehead (cm)	33.02	34.11
Angle of Ball Projection (deg)	61.48	77.94
Time of Ball Contact (sec)	.06	.07
Distance of Absorption Phase (cm)	5.59	6.07
Distance of Projection Phase (cm)	29.69	19.60

[a]Mean Values

Table IV

HAND-BALL VELOCITY

VARIABLE[a]	HOS	2-S
Hand Velocity (m/s)		
Contact	2.01	2.43
Start of Projection	3.47	2.56
Release	7.07	6.68
Ball Velocity (m/s)		
Contact	2.92	3.11
Start of Projection	2.85	2.47
Release	8.53	7.88

[a]Mean Values

A mean contact time (Table IV) of .06 s for the HOS and .07 s for the 2-S was noted. Hand velocity (Table IV) increased from 2.01 m/s at contact to 3.47 m/s at the start of the projection to 7.07 m/s at release. A slightly lower release velocity was calculated for the 2-S. A contact velocity of 2.43 m/s increased to a release velocity 6.68 m/s. Ball velocity (Table IV) variations during set execution indicate a slowing of the ball as it comes into the hands. At the time of release velocity had approximately tripled for the HOS. Ball velocity for the 2-S varied from 3.11 m/s at contact to 2.47 m/s at the start of projection to 7.88 m/s at release.

DISCUSSION

The limitations of planar analysis were recognized in obtaining quantitative data. While several investigators have analyzed overhead setting (Shierman, 1978; Wehrman, 1977), there are few other studies (Ishii, 1978; Ryan, 1979) with which to compare what we have observed in both the two-set and high outside set. The similarities in executing the two types of set exceed the differences which indicates that good setting performance is in part based upon the ability to deceive the defense with respect to the type of set being executed. It would indeed be difficult for the opponent to perceive the speed, trajectory, and placement of the set without observable differences in the body position of the setter. Setter training programs should include the teaching of similar body and ball position for setting the numberous types of set variations required in executing a multiple offense. The investigation offers practical interpretation for improvement of setter performance in addition to providing information useful to a defensive player in learning how to read and defend against a variety of offensive plays.

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