The Kinematics of Forearm Passing in Low Skilled and High Skilled Volleyball Players

M. E. Ridgway[1] and N. Hamilton[2]

1) Physical Education Department, University of Texas-Arlington, Arlington, Texas USA
2) Department of Physical Education, University of Illinois, Urbana, Illinois USA

INTRODUCTION

Passing may well be the least glamorous of all volleyball techniques. It is usually appreciated only by players and coaches who realize its importance. Since the advent of the forearm pass in the 1950's, many volleyball coaches at all levels of play, find themselves spending an inordinate amount of practice time in perfecting this skill. Some of the variables that make it difficult to successfully pass the ball are the varying ball speeds, angles, and unpredictable flight paths associated with float serves and block deflections.

Every offensive play begins with a pass. The flow of the match is very much influenced by the serve reception which mainly is done with a forearm pass. Bad receptions prevent quick combination attacks which many teams rely on in today's game. Today's quick paced game has created an even greater need for exact, consistent passing. The goal in today's game is to isolate hitters against only one blocker. Pinpoint passing accuracy is required so that the setter has a choice of several quick play-sets and is not forced to always go outside where a double block is waiting. In higher levels of play forearm passing is often executed with low passing angles and a quick delivery to the setter in order to speed up the offensive pace and decrease the defense's time to set up effectively against the attack.

Few studies (Koenh, 1978; Rauh, 1972; Plunket, 1969) have investigated the kinematics of the forearm pass and no published research has been identified that has studied passing in both high and low skilled passers. The purposes of this study were to produce a kinematic profile of low skilled and high skilled volleyball players on the forearm pass. The resulting profile will be a significant step in the development of sound coaching techniques.

METHODOLOGY

The forearm pass performance of seven junior high and junior varsity female players and seven NCAA Division I female volleyball players was recorded on high speed film. The junior high and junior varsity players were classified low skilled (LS) and the college players were classified high skilled (HS) on the forearm pass.

The performance records were filmed with a 16 mm Photosonics P-1 camera operating at a transport speed of 200 frames per second. Each subject was filmed for three trials of the forearm pass. Subjects were given unlimited practice before performing the trials used for filming. The camera was placed in a position perpendicular to the sagittal plane of the subjects. A volleyball training device, «Catch-It, Bask-It» was used to provide a vertical and horizontal passing target for the subjects.

Spatial coordinates were obtained through the utilization of a Sonic digitizer interfaced with an Apple Ile microcomputer. Segmental endpoints of the right side of the body from alternate frames were analyzed with software written by Richards and Wilkerson (1984). Digitizing of each trial began with the point of maximum flexion defining the conclusion of the preparation phase and continued through the follow through. The raw data were smoothed with a second order low pass digital filter set at 6 Hz. Data were then analyzed to produce measures of the elbow and knee angles as defined by lines drawn between the articulation of interest and the adjacent joints. Additional angles of inclination of body segments were analyzed. The angles of inclination of the head, trunk, upper arm, and thigh were measured relative to the vertical around their respective articulations.

Kinematic variables for the biomechanical analysis of the ball were derived from the geometric center of the ball as defined by Hudson (1982). Three ball spatial coordinates that shared no common X or Y coordinates were submitted to the triangulation method for X and Y

coordinate determination of the geometric center. Ball center coordinates were stored and futher analyzed. Temporal and ball variables studied were velocity of the ball at release, angle of ball projection at release, distance from the wrist to point of ball contact, and time of ball contact with the arms.

RESULTS

Temporal and Ball Variables

Temporal and ball kinematic data are included in Table 1. Distinctive passing patterns between the LS and HS groups were observable. The LS group had a mean contact time of .009s and the HS group had a mean value of .013s. Higher ball projection velocities were observed in the LS group (12.95 m/s) than in the HS group (10.27 m/s). Approximately an 8 degree difference in projection angle resulted with the LS group projecting at a mean angle of 71.94 degrees and the HS group at a lower mean angle of 63.74 degrees. The LS players tended to pass the ball from a position on the forearms closer to the wrists than the HS players. A mean distance from the wrist to point of ball contact was 4.36 cm (LS) and 7.28 (HS).

TABLE 1
Ball Kinematics

VARIABLE	LS Mean	SD	HS Mean	SD
Time of Contact(s)	.009	.004	.013	.005
Angle of Projection (deg)	71.94	3.39	63.74	3.42
Projection Velocity (m/s)	12.95	1.32	10.27	2.12
Ball Contact Distance from Wrist (cm)	4.36	.24	7.28	.32

To evaluate accuracy of the passes, records were kept of how many passes went in the «Catch-It, Bask-It» target. The HS group passed 17 of 21 balls into the basket and the LS group passed 7 of 21 into it.

Angular Variables

Table II presents mean positional data for the head, trunk, elbow, hip,

and knee at the start of the pass, instant of ball contact, and end of the follow through. Both the LS and HS groups started with the head almost vertical and during the pass the head extended several degrees. The LS group had a more upright trunk position at the start of the pass (15.15°) than the HS group who had a mean trunk flexion angle of 28.46°. Extension occurred in the trunk in both groups with the LS group positioned essentially upright (4.41°) when the follow through was completed while the HS group maintained 20.02° of flexion.

Thigh positioning was similar for both groups in all phases of the forearm pass. At the start of the pass both groups had the thighs positioned at approximately 46° of flexion, and extension occurred throughout the passing action and follow through. The knees were flexed more in the LS group at the start of the pass (125.61°) than in the HS group (134.82°). The knees extended similarly in both groups through contact and follow through.

In analyzing the upper extremities the means for elbow position at the start of the pass were similar for both groups (151.34°-LS; 158.83°-HS). However, at contact with the ball, the LS group showed freater flexion (161.29°) than the HS group (172.44°). With respect to upper arm positioning both groups were very similar in mean angle positions at the start of the pass. At ball contact the LS group had a mean upper arm position of 58.03° flexion and the HS group had a mean value of 50.71°. A more noticeable difference occurred at the en of the follow through where the LS group had swung their upper arms up to a mean position of 95.85° while the HS completed the follow through with a mean position of 85.66° flexion. In other words the HS players did not swing (flex) their arms at the shoulder past the horizontal on the follow through.

Figure 1 presents ranges of motion in the elbow, shoulder, hip, and knee joints. The most observable difference between the two groups was the excursion of the upper arm at the shoulder joint. The LS group flexed the upper arms through approximately a 10° greater range of motion than the HS group (LS-85.71°; HS-76.71°).

TABLE 2

Joint Kinematics

Variable[a]	Level	Start		Contact		End	
Head	LS	3.87	(1.96)	−2.46	(3.67)	−10.12	(5.3)
	HS	7.23	(5.52)	2.19	(4.91)	−6.50	(10.03)
Trunk	LS	15.15	(4.26)	8.75	(4.66)	4.41	(6.28)
	HS	28.46	(6.91)	19.84	(10.19)	20.02	(11.31)
Upper	LS	10.21	(5.19)	58.03	(7.89)	95.86	(11.43)
Arm	HS	9.06	(6.15)	50.71	(6.13)	85.66	(10.82)
Elbow	LS	151.34	(7.76)	161.29	(7.46)	166.62	(9.25)
	HS	158.83	(11.59)	172.44	(5.08)	170.22	(6.39)
Thigh	LS	46.56	(4.55)	31.56	(4.23)	22.84	(7.03)
	HS	46.29	(6.42)	30.68	(9.28)	18.76	(7.19)
Knee	LS	125.61	(10.40)	143.18	(11.74)	154.31	(13.89)
	HS	134.82	(7.48)	147.38	(10.61)	158.91	(11.19)

[a] Mean values in degrees (standard deviation).

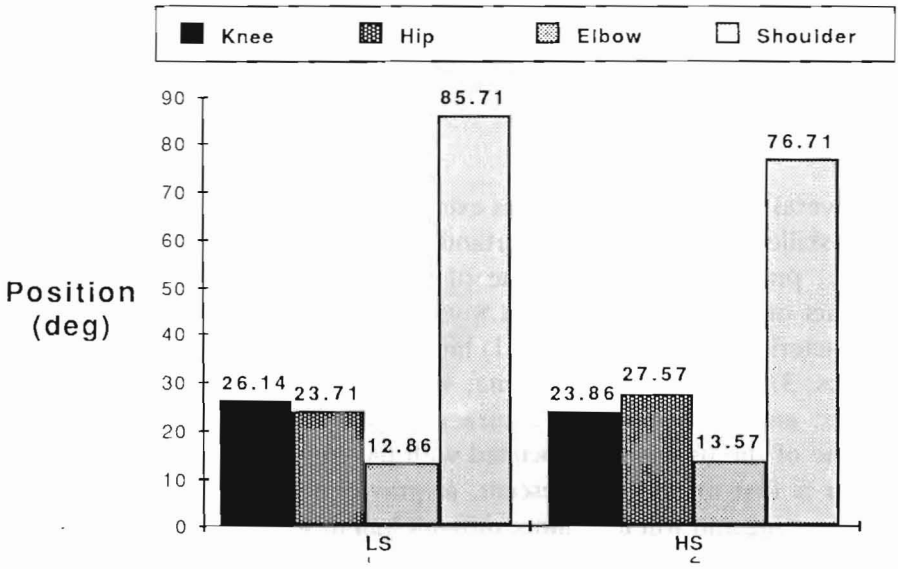

Fig. 1 Mean Joint Ranges of Motion.

Mean angular velocities at ball contact in the shoulder and knee joints are reported in Figure 2. The HS players had a much lower mean angular velocity in the shoulders (353.56°/s) than the LS players (718.22°/s). The opposite pattern occured in the knees with the LS players exhibiting a lower mean angular velocity at contact (65.54°/s) than the HS players (107.26°/s).

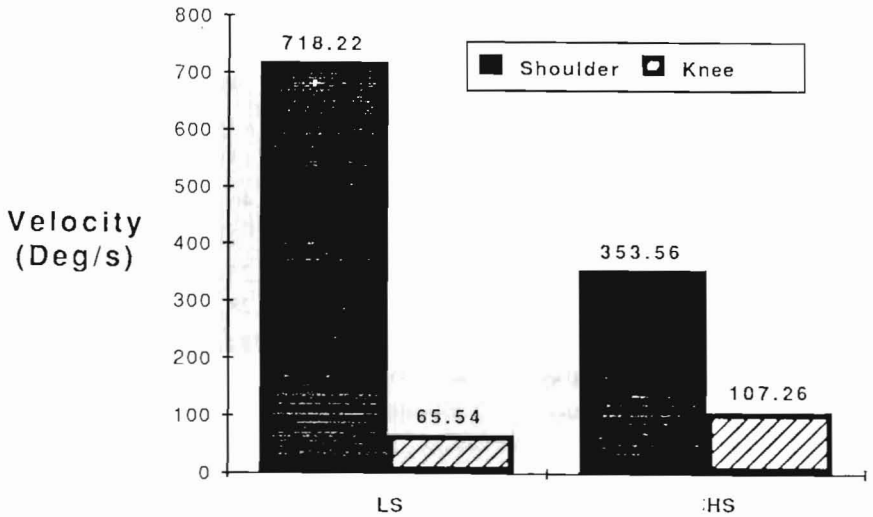

Fig. 2 Mean Angular Velocities at Ball Contact.

DISCUSSION

Several observable differences existed between the low skilled and the high skilled passers. Most importantly were the differences in projection angle, projection velocity, time of ball contact, and location of ball contact on the forearms. The LS group's passing performance may be characterized by the following: 1) high trajectory passes; 2) high velocity passes; 3) short ball contact time; 4) contact with the ball close to the wrists; and 5) inconsistent accuracy of forearm passes.

One of the problems associated with passing the ball too high to the setter is that on the ball descent, as gravity acts on the ball it will be accelerating and will be a more difficult ball to set. In addition the setter must look up to find the high pass and this action interferes with the setter's peripheral vision which is a crucial factor in the setter knowing where the hitters are positioned and how the defense is aligned prior to

the set. Another factor influenced by overly high passes is the time it takes to initiate the offensive play. If a team runs quick play-sets a high pass with a long flight time will break down fast paced offensive attacks and give the defense more time to position.

Figure 3 shows one of the high skilled passers executing the forearm pass and Figure 4 shows one of the low skilled passers. Several of the differences between the two levels of passers are depicted in the photos. The main factors causing the LS group to pass too high appears to be the more upright trunk position at time of ball contact. Also the large range of motion the upper arms go through and the high angular velocities in the shoulder joint at contact contribute to high passing angles and high projection velocities. In most passing situations the passer uses the arms and body to attentuate the force of the incoming ball because accuracy is the primary objective of the forearm pass. The LS passers appeared much more rigid and «stiff» in their passing actions and were unable to absorb the force of the ball and redirect it to the targer consistently.

Fig. 3 Subject #1 of HS Group.

Fig. 4 Subject #4 of LS Group.

The contact point on the forearms for the LS group was not as cushioned an area as a position farhter from the wrists would afford. Force absorption and passing accuracy are enhanced by contacting the ball on a fleshy part of the arms that cushions the ball in addition to providing a large, flat surface area for rebounding the ball. The HS group passed an inch or two higher up from the wrists and this seemed to provide a better contact area. Several LS passers could be observed passing off the wrists and thumbs.

Most experts suggest that a good pass does not go extremely high but makes a gentle arc, landing softly in the target area. Many coaching sources indicate that the passer should not swing the arms past the point of the shoulders. The LS group finished the follow through of the pass at a point above the shoulders and above the horizontal which indicates overswinging at the ball and perhaps inadequate use of the legs.

IMPLICATIONS

Implications for beginning passers

1. Emphasize good body position in relation to the ball and to the intended target.
2. Emphasize leg extension during the pass while minimizing arm swing.
3. Emphasize forward trunk lean for a better passing angle and for keeping the ball from coming in too close to the body.
4. Emphasize contacting the ball 2-6" above the wrists on a fleshy flat part of the forearms.
5. Emphasize that the arms should be extended well in front of the body during the pass.

Implications for advanced passers

1. Emphasize an arm dominated pattern with minimal use of the legs.
2. Emphasize good movement patterns to get in to position to pass with an arm controlled pattern.
3. Emphasize extended arms pointed more toward the ground which allows for lower, faster passes instead of the traditional 45 degrees.
4. Emphasize less forward trunk lean which will lower the passing angle.

The actions of the advanced passers are not always suitable for the beginner to emulate. The elite should not necessarily serve as a model for the beginner. The level of play will determine the type of passing style and type of pass desired. Advanced passers in volleyball may pass the ball from seemingly awkward positions and still be extremely accurate while the beginning passer is very much dependent on excellent positioning to the ball and the intended target area in order to achieve any degree of accuracy. While highly skilled passers performed the same technical actions, they differed individually among themselves in many performance aspects. Coaches should not try to make the athlete conform to any one model.

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