A QUALITATIVE ANALYSIS OF THE HIGH RACQUET POSITION BACKHAND DRIVE OF AN ELITE RACQUETBALL PLAYER

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Since 1950, when Joe Sobek put strings on his paddleball paddle, the sport of racquetball has grown to the point where it has attained international status. Today, racquetball is played in 57 countries. It has been granted representation on the United States Olympic Committee (USOC) and is under consideration as a future Olympic sport, possible as early as the 1992 games. In spite of its rapid and international growth, racquetball remains a relatively new sport,on which very little research has been reported.

Some of the kinematics and kinetics involved in the various racquetball strokes appear similar to those of other sports that involve striking an object with an implement, i.e. tennis, squash, or baseball. Racquetball does, however, possess specific motion characteristics that are unique to the sport. Proficiency in racquetball is often determined to a large extent by the mechanics employed by the athlete in performing the various shot techniques. Since the backhand drive is an integral part of the successful player's shot repertoire, the mechanics used in performing this shot will play a major part in determining a player's proficiency and potential in competition. Thus, the purpose of this investigation was to perform a qualitative kinematic analysis of the high racquet position backhand drive shot of an elite (professional) racquetball player by comparing his technique with that of a sub-elite performer.

Procedures

Subjects

Subjects selected for this study were matched in terms of gender (male), age (35years), and height (183 cm). The elite player has been a professional racquetball player for eight years and has achieved national-level status (he has most recently won the U.S. national 35-and-over singles championship). The sub-elite player is a good all-around athlete who possesses average playing ability and racquetball experience reflective of the general population.

Instrumentation

A Quasar VK766YE high resolution (400 lines/inch) VHS video camera, equipped with a high speed shutter, was used to film both subjects in two planes, sagittal and transverse (overhead) as they performed several trials of the backhand drive. The video camera operated at a speed that approximated 30 frames per second and was used with a Quasar VP5750YE recorder and synthesized tuner. After filming, the video records were reviewed and analyzed using this one-half inch video cassette recorder, equipped with special effects for single frame and frame-by-frame advance. The recorder was connected to a Quasar Dyna-Tech high resolution monitor (400 lines/inch) for display and analysis.

Methods

Prior to filming, each subject's joint centers of rotation were marked for identification purposes and a scale factor was filmed in both fields of view. Subjects then each performed a number of trials of a backhand drive shot while being filmed, first in a sagittal plane and then in a transverse plane. Since only one camera was used for this study, it was not possible for these film records to be simultaneous, synchronized recordings. A commercial photography spotlight was used in both views to supplement available light sources.

Trials were performed with a self-initiated stroke both using a dropped ball and soft bounce toss by one of the investigators. In the latter case, the subjects directed the investigator as to optimum delivery of the bounce toss. Subjects were instructed to perform 8-10 trials each of their best backhand drive shot, concentrating more on power and velocity than accuracy.

After previewing all trials from both camera views, the single best trial from each plane was selected for the purposes of analysis. These trials were then played back on the video monitor so that transparent tracings could be made from each of several key frames selected form the trial. Key frames identified for purposes of analysis were: 1) full racquet preparation; 2) early swing phase; 3) late swing phase; 4) impact; and, 5) follow-through.

Figure 1.

Figure 1, continued.
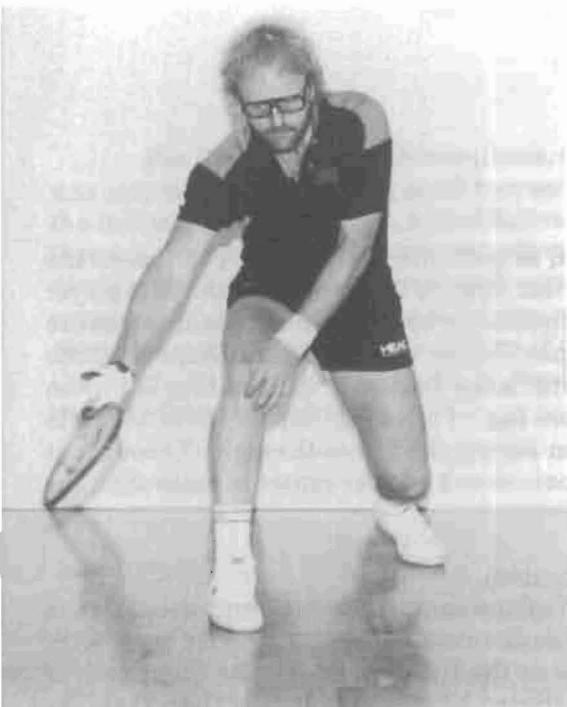
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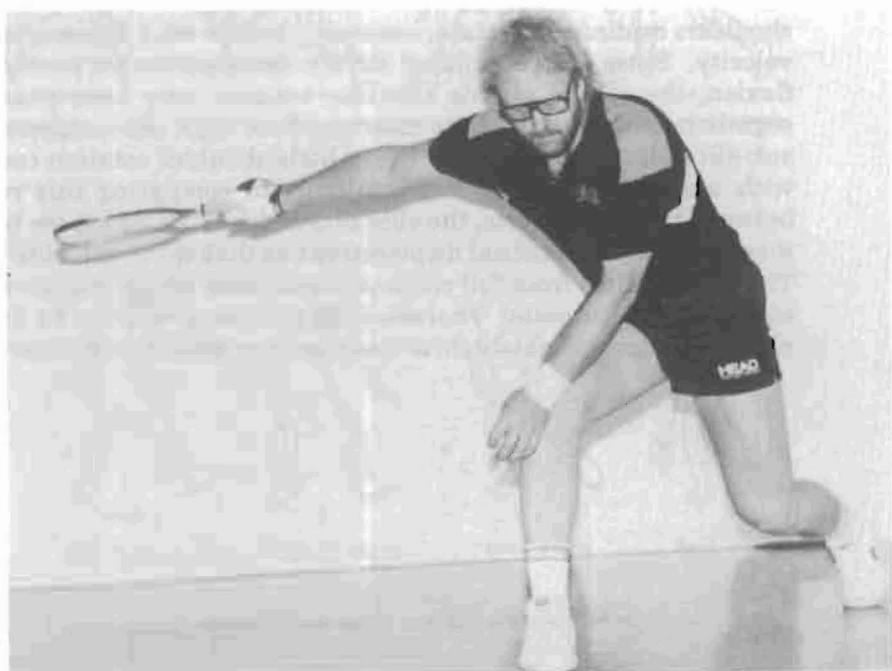
Results

Lower Leg Motion

Both subjects started in a slightly flexed knee position at the point of full racquet preparation. (Figure 2) Thereafter, the elite player demonstrated greater knee flexion for both legs throughout the entire stroke, with the greatest knee flexion evident at ball impact. Both subjects demonstrated greater knee flexion of the trailing leg when compared to that of the lead leg. Following impact, both subjects demonstrated knee extension during the follow-through. Throughout the stroke, the elite player maintained a lower center of mass than the sub-elite player.

Hip and Shoulder Rotation

The total angular displacement of the hips and shoulders is illustrated in Figure 3. The assessment of this motion was made with reference to a stationary line on the floor, parallel to the flight path of the ball. The elite player initiated hip rotation earlier than shoulder rotation during the swing phase. As his hip rotation began to slow, the shoulders continued to rotate, increasing both in total displacement and velocity. Since the elite player did not demonstrate noticeable trunk flexion, the effects of this shoulder rotation may have provided a segmental summation to the rotation of the hips. In comparison, the sub-elite player demonstrated very little shoulder rotation combined with a small amount of hip rotation. In comparing this rotation between the two subjects, the elite player demonstrated three times as much combined rotational displacement as that of the sub-elite player. The elapsed time from full racquet preparation to ball impact was the same for both subjects. Therefore the rotational velocity for the elite player was approximately three times greater than the sub-elite player.

For the purposes of this analysis, the speed of the video system was assumed to be operating at 30 frames/second. The tracings allowed the investigators to perform a qualitative analysis of the performance through the use of basic kinematic parameters, i.e. angular and linear displacement, temporal features, and approximated velocities. For the purposes of this qualitative analysis, the following three motion phenomena were analyzed: 1) motion of the lower legs with respect to the thigh; 2) rotational motion of the hips and shoulders; and, 3) motion of the racquet arm.
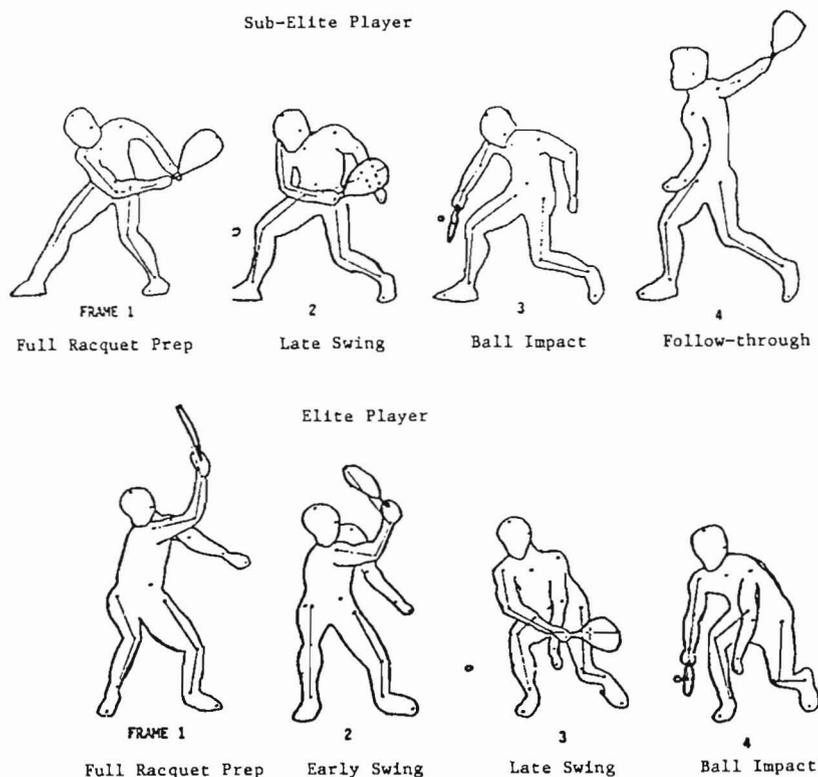

Figure 2. Sagittal Views of Sub-elite and Elite Player Swing Phases

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A. Full Racquet Prep   B. Early Swing   C. Late Swing

D. Ball Impact   E. Follow-through
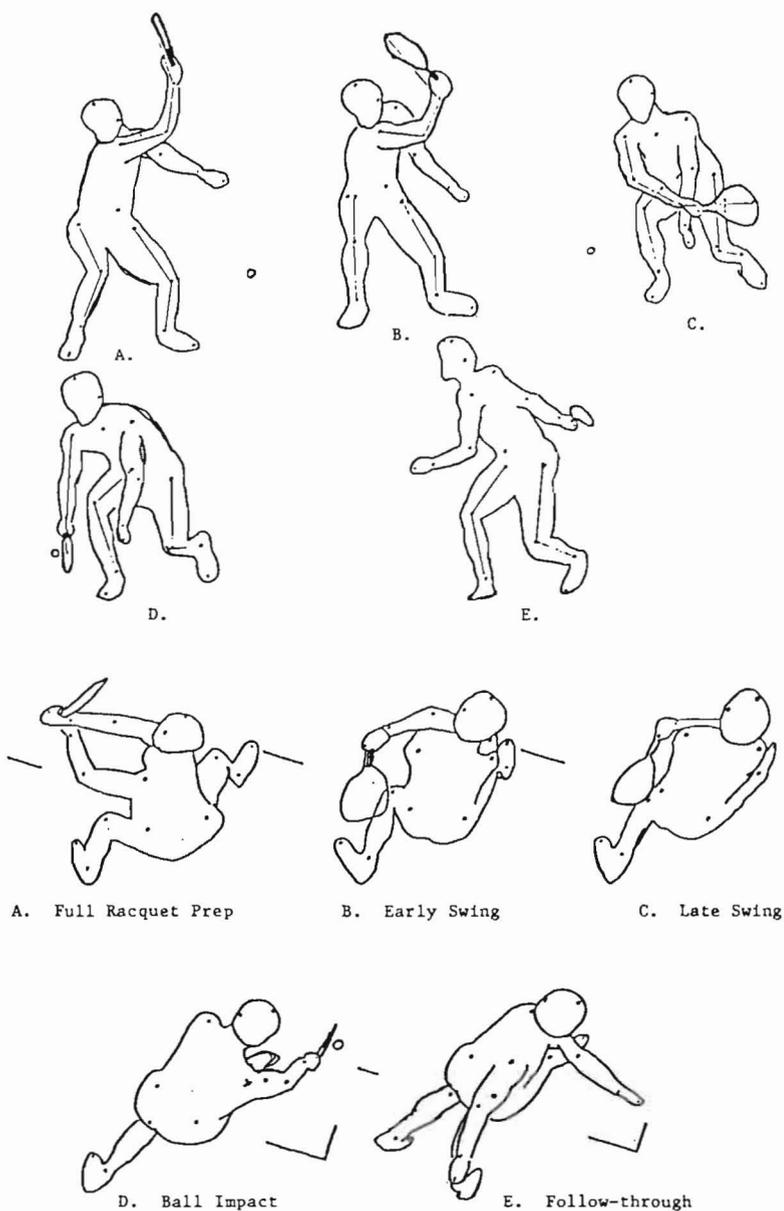
Figure 3. Concurrent Sagittal and Transverse Views of Elite Player's Stroke

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who increases the rate of spin by drawing in the limbs closer towards the center of mass. Thus, as demonstrated by the elite player, greater knee flexion coupled with less trunk flexion results in higher rotational velocity of the most proximal arm segment during the stroke.

The motion of the racquet arm during the execution of the high racquet position backhand drive raises interesting possibilities regarding the application of the 'kinetic link principle' to racquetball. In racquetball, more than tennis or golf (sports motions in which the arm is relatively straight throughout the swing phase), the racquet arm can be analyzed as a three-segment system. In such a system, the proximal segment accelerates to its maximum velocity, then decelerates as the next distal segment accelerates. This pattern continues distally along the segments of the racquet arm to the moment of ball impact where the summation of rotational velocities has, hopefully, reached its peak. Any factor, either internal or external, that minimizes the rotational velocity of any segment during the swing may result in less than maximal racquet head velocity before impact. This sequential timing of segmental contributions has been suggested by Kreighbaum and Barthels (1985) and Milburn (1982) in related work as an explanation for the kinematics of rotational velocity and its role in striking motions. Whether this timing is under voluntary control, or is caused by centrifugal force acting on the distal segments, cannot be fully addressed in this analysis.

If a true kinetic link system were acting during the performance of the high racquet position backhand drive, then the wrist should have attained a higher rotational velocity than that observed. In our opinion, a modified link system exists in which the most distal segment is prevented from acting as a true 'free hinge' by muscle action prior to ball impact. This mechanism may exist in order to prevent tissue injury caused by too rapid a deceleration of the hand and racquet following, or prior to, ball impact.

Applications

Use of a qualitative analysis in the teaching and coaching of racquetball holds many benefits. First, the video methods used in this study were inexpensive, relatively light in terms of time demand, and could be learned and mastered in a short period of time by individuals knowledgeable in racquetball. Thus, coaches and teachers could easily incorporate this methodology in their instructional techniques, thereby better illustrating the mechanical principles involved. Second, the use

of comparisons of proficient performances with less proficient ones can demonstrate: 1) use of improper techniques; 2) the contributions of specific motions (including the magnitude of such motions); 3) the effects of beneficial timing and positioning; and, 4) general motion characteristics. Lastly, the ability to view one's own performance objectively through video can clarify misperceptions regarding motion techniques used in a sports skill.

References

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