TENNIS GROUND STROKES FROM A BIRD'S EYE VIEW - A ESTIMATE OF ANGULAR MOMENTUM ABOUT THE LONGITUDINAL BODY AXIS

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In this paper, a simple 2D video method will be outlined to estimate the angular momentum about the longitudinal body axis in tennis ground strokes from the base line. From a bird's eye view, ground strokes of 19 young male experienced tennis players with two different skill levels were analyzed when returning balls released from a ball machine with three different ball frequencies. The angle between the shoulder axis and the base line was used as an estimate for the angular momentum about the longitudinal body axis. A validation procedure with a fully automated 3D motion capture system as adopted to evaluate the error involved in the 2D motion analysis. The results of this study show that for forehand and backhand strokes advanced young tennis players show consistently larger shoulder-baseline angles across all ball frequencies than players with a lower skill level.

KEY WORDS: skill analysis, 2D kinematics, tennis ground strokes

INTRODUCTION: The transfer of angular momentum about the longitudinal body axis has been suggested to be an important determinant of the tennis ball acceleration during baseline strokes in tennis (Knudson, 2001; Bahamonde & Knudson, 2003; Elliott, 2006). However, up to date, respective studies on the trunk rotation required costly and time-consuming 3D-film analyses while using the angular displacement between the shoulder alignment and the baseline as an estimate for the amount of angular momentum (e.g., Elliott et al., 1997). Here, we outline a simple 2D video analysis from a bird's eye view right above the player ready to be used as an online-information system. The angle between the shoulder axis (defined as a line joining the acromion processes of the right and left scapula) and the base line was used as an estimate for the angular momentum about the longitudinal body axis. The main goals of this study were to establish evidence on the reliability and the validity of the analysis system and to compare different skill levels to find differences in the shoulder angles towards the base line prior to the stroke. Mean values of alternating forehand and backstrokes were evaluated in two groups of players with different skill levels when returning balls from a ball machine at three different ball frequencies. We hypothesized that the angular displacement of the shoulder axis prior to the stroke should vary according the skill level and the ball frequency. Two assess the quality of the measurements Cronbach Alpha values were calculated for an estimate of internal consistency.

METHODS: Ten young male right-handed players (age: 12,4 ± 0,8 y, body height: 1,70 ± 0,09 m; body weight: 42,2 ± 6,7 kg; 4,5 ± 1,9 years of tennis playing; 234 ± 94 min tennis training per week) among the best of the regional county and nine young male players (eight right-handed and one lefthanded) from a lower level district training group (age: 13,4 ± 1,0 y, body height: 1,69 ± 0,13 m; body weight: 54,4 ± 15,7 kg; 4,6 ± 1,2 years of tennis playing; 110 ± 47 min tennis training per week) participated in the study. Measurements were conducted indoors with players returning balls released from a ball machine (Playmate 2000 from Metaltek, Morrisvielle, NC) cross court at 19,1 ± 0,28 m/s while alternating between forehand and double-handed backhand strokes on a carpet floor. Three blocks of 30 balls with different ball frequencies per block (ball-to-ball delay: freq 1: 2,65 ± 0,1 s; freq 2: 2,08 ± 0,04 s; freq3: 1,75 ± 0,04) were evaluated. A Canon Legria HV40 video camera located 4,5 m above the baseline was used for the 2D video analysis (shutter aperture 1/1000s operated

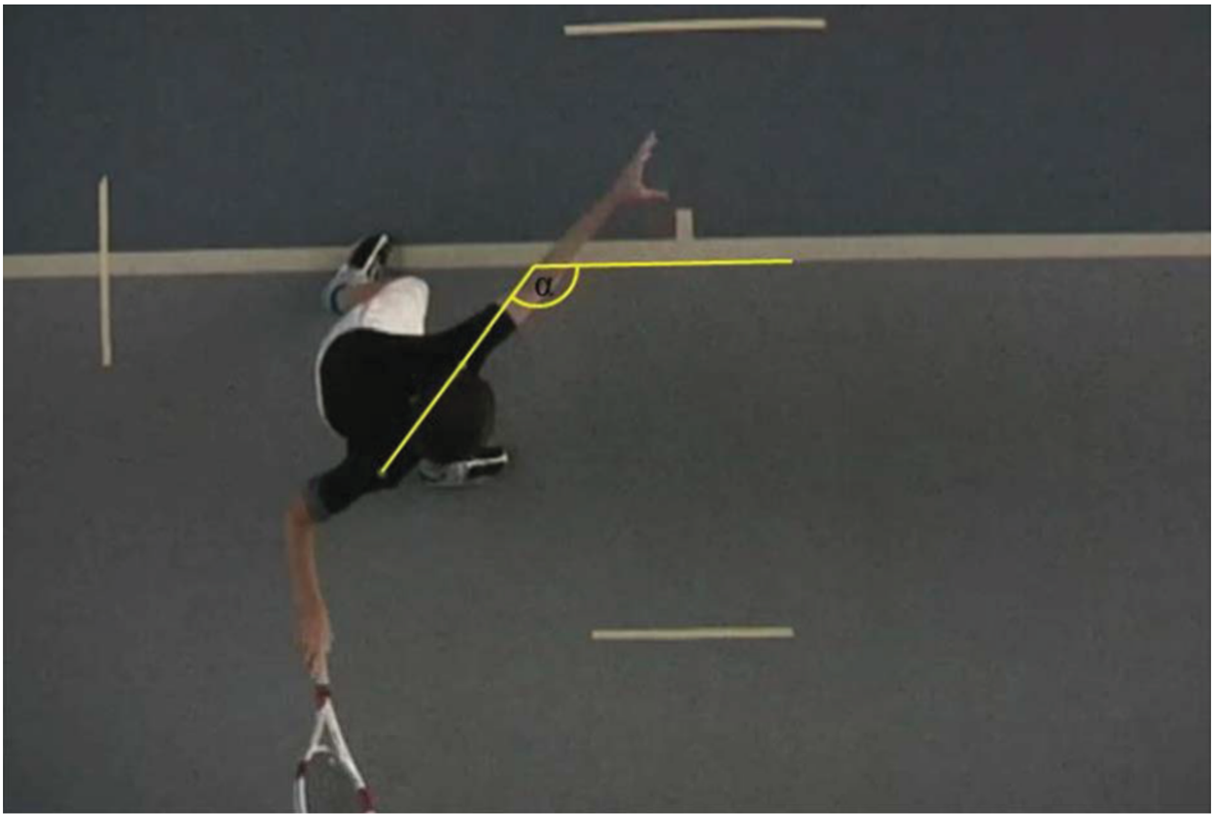

Figure 1 Forehand stroke with shoulder alignment towards the baseline from a bird's eye view

at 50 Hz) from the bird's eye view (see Figure 1). To establish external validity, a six-camera 3D Qualisys system (Oqus 3+, Qualisys AB, Gothenburg operated at 250 Hz) was used to reconstruct the 2D coordinates of the shoulder markers positioned above the acromion processes of the right and left scapula when projected onto the transverse plane. Data from four players were used for the validity analysis.

The acromion markers were also used to evaluate the 2D alignment of the shoulders through the 2D Simi Motion system (Version 8.0). Quarters of circular discs (radius 2 m) were used as target zones in the left and right corners of the opposite court side. For the statistical data analysis, mean values and standard deviations were calculated for the maximal angular displacement across the five most precise forehand and backhand strokes per block in each participant. Ball velocities from the ball machine and return velocities were evaluated through a video analysis above the net.

RESULTS: For the reliability analysis, consistently large Cronbach Alpha values were detected rangig for the forehand and backhand strokes across the three ball freqiencies between 0,91 und 0,97. Comparing the shoulder aligment between the 3D cordinates projected in the transverse plane and the 2D data, only small deviations of approximately 2 to 3 degrees were detected with somewhat larger differences towards the end of the stroke. The maximal angular displacements of the shoulder axis towards the base line are shown for both skill levels and across the three ball frequencies in Table. 1.

Table 1
Maximal angular displacement of the shoulder axis towards the baseline in forehand and backhand strokes in the two subgroups across the threeball frequencies (ball-to-ball delay: freq 1: 2,65 ± 0,1 s; freq 2: 2,08 ± 0,04 s; freq3: 1,75 ± 0,04 s)

	Skill Level A (N=10)	Skill Level B (N=9)	t-value
forehand freq 1	109,3 ± 12,0	90,4 ± 13,9	3,2**
forehand freq 2	104,7 ± 12,0	84,0 ± 18,3	2,9**
forehand freq 3	98,0 ± 14,8	81,5 ± 18,3	2,2*
backhand freq 1	126,9 ±7,8	100,8 ± 15,5	5,0**
backhand freq 2	119,7 ± 6,4	97,3 ±17,6	3,8**
backhand freq 3	113,2 ± 8,1	91,6 ± 14,0	4,2**

Across both subgroups, larger angular displacements of approximately 15 degrees were detected in the backhand strokes as compared to forehand strokes. Consistent angular differences of approximately 20 degrees were found between the two skill levels across the three ball frequencies. Larger return ball velocities were found in the backhand strokes as compared to forehand strokes.

DISCUSSION: This study shows that a simple 2D analysis from a bird's eye view may be easily used for an online-information on the shoulder alignment in the tennis grund strokes from the baseline. In turn, this measure has been suggested as an estimate for the angular momentum about the longitudinal body axis. Reliability and validity appear to be sufficient for diagnostic purposes when using this 2D analysis system. As consistent differences in the shoulder alignment were found between players of two skill levels in forehand and in backhand strokes, the bird's eye view appears to be a suitable tool for a technical analysis of groundstrokes in tennis.

CONCLUSION: Coaches and tennis clubs are encouraged to utilize the bird's eye view method to analyze the technical skills in young tennis players.

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