BIOMECHANICAL STUDIES OF BADMINTON UNDERARM. POWER STROKES, COURT MOVEMENT, AND FLEXIBILITY -- A REVIEW

B. A. Gowitzke
McMaster University, Hamilton, Ontario, **CANADA**
D. B. **Waddell**
Ancaster, Ontario, **CANADA**

A companion paper, "**Biomechanical Studies** of Badminton **Overhead** Power Strokes -- A Review", is included in the present symposium, and should be consulted for a description of the background work leading up to the content included here.

UNDERARM POWER STROKES

Biomechanical studies of underarm power strokes have been extremely limited. Of the few studies found, they appear to be unpublished theses which focus only on the serve (Hale. 1970; Tefreault. 1964). In 1985. the present authors conducted a study of international players performing underarm power strokes (Gowitzke & **Waddell,** 1986).

Eight world class badminton players competing in the World Badminton Championships in Calgary, Canada participated in the research project. They performed underarm forehand and backhand clears and the high (singles) serve. Performances were recorded on 16 mm film using two LOCAM cameras operating at a film speed of 350 frames per second. Subsequent qualitative analysis revealed that world class players gain a major proportion of power for the underarm forehand clear and the high serve by pronating the forearm and **medially** rotating the upper **arm.** Backhand clears are performed using supination of the forearm and lateral rotation of the upper **arm. These** results were consistent with some of the badminton literature. although many **references** side-stepped the movement description or chose to ignore the stroke.

An interesting spin-off from the analysis of the high serve was revealed as a **result** of the cinematographic analysis. According to the Laws of Badminton, during **the serve,** the racquet head, once started forward, must not stop or move backward but **must** continue to move forward. The spirit of the Law is to keep players from "tricky" **serves** in which they deceive the opponent by feinting a movement similar to making **contact** with the shuttle on the **first** forward movement of the racquet However, the **best** badminton players in the world appear to commit a fault every time they **serve. The** elite badminton player starts the raquet forward by a combination of hip and trunk rotation combined with a bit of shoulder flexion; when the racquet is approximately opposite the side of the player, the player 'lays the raquet head back' by laterally rotating the arm at the shoulder pint and supinating the forearm at the radio-ulnar joints while still driving the hand forward. In fact, the racquet head backs up while the racquet hand moves forward! The visual impression is that the racquet is moving forward because the action is too fast for the human eye to *set.* The fact that this raquet action of players is too fast to see is borne out by the fact that these players are not being called f a rule infractions on their serves in competitions. Indeed, the racquet head movement is so fast that it is impossible f a service judges to see.

Biomechanically, the action is recommended because the player is placing on stretch, muscles which are about to be importantly involved in the next, force-producing phase of the serve, namely, medial rotators of the shoulder and pronators of the radioulnar pints. This is a good example of employing a technique which is biomechanically sound, but which tests the Laws of Badminton, the abilities of umpires, and the interpretation of the rules by the International Badminton Federation.

The authors also conducted a force platform study of the high serve at the same time that they studied overhead power strokes (Gowitzke & Waddell, 1980). Since it was not possible for the subject to place both feet on the platform without compromising his or her normal stance for the high serve, recordings of ground reaction forces were made with each foot placed on the platform individually. Results showed that players employed an unweighting. weighting, unweighting sequence similar to that seen in the overhead power strokes, while transferring the weight from the back to the front foot. However, results also suggested that some players remove the back foot from the platform an instant before contact with the shuttle, and thereby come dangerously close to committing a 'foot fault' according to the Laws of Badminton.

COURT MOVEMENT

No biomechanical studies have been carried out on speed of locomotion on court until a study was carried out by the present authors during 1988 (Gowitzke, et al, 1989). During a game, a badminton player is required to move backward quickly while watching a shuttlecock overhead, which forces the "neck" into a dorsi-flexed position. Yet, in "shadow" drills for training badminton players to increase their speed, coaches generally do not require players to look up.

It was hypothesized that the speed of movement for a player moving backward with the "neck" dorsi-flexed was slower than that with the head in a normal position and that neck or labyrinthine righting reflexes may play an inhibiting role. The purpose of the study was to determine the effect of two head positions on the speed of moving backward on a badminton court.

Eight female and eight male experienced players, the majority of whom were provincially-ranked or university team players, comprised the subjects. Reaction times and movement times were monitored as subjects moved backward over a three-meter distance while looking straight ahead and while looking upward. In addition, the motion of the players over the three-meter distance was recorded cinematographically.

Results showed that reaction times did not differ in the two head positions, but movement times were significantly affected. Average horizontal velocities of the center of gravity of the sixteen subjects varied from 1.97 to 3.07 m/s. Mean movement times for running backward with the head up vs head normal were 1.287 s and 1.274 s, respectively. The hypothesis was confirmed. It took subjects longer to run backward with the head facing upward than facing straight ahead.

Apparently, time-phase relationships of motor patterns were changed even though foot patterns for moving backward were not altered. For example, cinematographical analysis revealed changes of up to 5 cm in the vertical location of the trajectories of the center of gravity for some subjects, but no trends were observed. Similarly, some subjects increased extension at knee and hip joints by as much as 10 degrees when the "neck" was dorsi-flexed.

It was concluded that head position affected movement time, and that this effect might be attributed to tonic labyrinthine reflex involvement The implication for badminton training is that players should always look up when moving backward in "shadow" drills; otherwise, the drills do not relate to the game situation and have little effect on decreasing movement time.

FLEXIBILITY

A group of young elite badminton players were tested for physiological parameters of strength and power, aerobic and anaerobic conditioning and biomechanical flexibility (Gowitzke et al, in press). The results of the biomechanical parameters are reported here.

Measures of range of motion at 18 different joints were accomplished by using the Leighton flexometer and following the procedures outlined by Leighton (1966). The following joints were selected for measurement: for the upper extremity, flexion/extension, abduction/adduction, and rotation at the shoulder joint, flexion/extension at the elbow joint; supination/pronation at the radio-ulnar joints and flexiodextension, and ulnar and radial flexion (abduction/adduction) at the wrist; for the lower extremity, flexiodextension at the hip joint, flexiodextension at both right and left knees, dorsi-/plantar flexion at the right and left ankles, and inversion/eversion at the right and left ankles; and for the axial skeleton, flexiodextension at the "neck", flexion/extension, lateral flexion, and rotation of the the "trunk".

There is no record of flexibility tests being administered to badminton players, but results were compared with some of the norms available from other populations. It was found that the flexibility measures of these young players compared favorably with those of other young people in other sports. However, no unusual ranges of motion or trends unique to a badminton population were found.

STRENGTH

Attempts were made to establish some base-line data on strength measures of badminton players (Gowitzke, et al, in press). Maximal single leg press strength for each leg was measured on a Cybex dynamometer at 15 and 75°/s. Strength was measured as peak torque and expressed absolutely in Nm. Maximal shoulder rotation strength was measured as peak torque at 30°/s and as impact torque at 300°/s. Maximal pronation and supination strength was also measured at low and high velocities. These were the first attempts to record strength measures of pronation and supination. There were no norms available for comparison with other populations. It was interesting that the means for the right leg were higher than those for the left leg. Since 15 of the subjects were right-handed players and therefore go to the net and play most strokes with the right leg forward, it seemed logical that the right leg was stronger than the left

SUMMARY

It would appear that there is a dearth of biomechanical information about badminton. Since badminton is now an official competitive sport in the Olympics, it is possible that considerably more interest and research in the sport will ensue. In the meantime, it is important that the information, which has been generated, should be made available to the teachers and coaches of the sport. Close attention should be given to dispensing to information in easily understood. "digestible" form so that the implications of the research for the player are correctly and effortlessly applied.

REFERENCES

Gowitzke. B.A. and D.B. Waddell (1980). A Force Platform Study of Overhead Power Strokes in Badminton, Proceedings: *International Symposium on The Effective Teaching of Racquet Sports,* ed. *JL.* Groppel. Urbana-Champaign: The University of Illinois. 37-47.

Gowitzke, B.A. and D.B. Waddell (1986). The Biomechanics of Underarm Power Strokes in Badminton. *Sports Science, (Proceedings of the VIII Commonwealth and International Conference on Sports, Physical Education, Dance, Recreation and Health),* ed. J. Watkins. London: E. & FN. Spon, 137-142.

Gowitzke, B.A., D.B. Waddell, T.D. Lee, and J.R. Poole (1989). Effect of Head Position on Badminton Players' Reaction Times, Movement Times and Kinematic Elements of Running Backward (abstract). *Journal of Biomechanics.* (Also, two-page paper in Proceedings: International Society of Biomechanics. UCLA, 1989).

Gowitzke, B.A., D.B. Waddell and J.D. MacDougall (in press). Biomechanical and Physiological Measures of Teen-Aged Badminton Players. Proceedings: *Biomechanics in Sports VI*, ed. E. Kreighbaum.

Hale, P.A. (1970). Construction of a Badminton Long Serve Test for Beginning Players (singles). Unpublished M.S. thesis, University of Wisconsin, Madison, Wisconsin, U.S.A.

Leighton, J.R., The Leighton Flexometer and Flexibility Test. *J. Asso. for Phys. and Mental Rehab. (1966) 20*:No. 3:86.