Mitchell, S.R., Jones, R., King, M.A. and Kotze, J., "The Influence of Racket Inertia Properties on the Tennis Serve: A 3-Dimensional Analysis",*Medicine & Science in Tennis (Joint Newsletter of the STMS, ITF, ATP and Sanex WTA Tour)*, 6(1), March 2001, p 7.

Abstract:

Several factors influence ball speed in tennis, including the player's skill and athleticism, the court properties and the ball itself. A number of researchers have also noted the racket's importance, including its inertia properties, in generating ball speed [e.g. Brody (1979, 1987, 1997), Elliot (1982), Liu (1983), Hatze (1993), Cross (1997)]. A heavier racket with a higher moment of inertia is harder to swing and should result in lower head speeds or greater effort to achieve the same speed. Conversely a lighter racket should result in higher head speeds or less effort. Since ball service speed is dependent on head speed, and less so on mass, increased head speed should result in faster serves.

The ITF is currently funding an investigation into the degree to which racket characteristics magnify a player's ability to generate ball speed in the tennis serve. This article is specifically concerned with results from an initial study of how racket inertia properties affect head speed generation.

Racket motion during impact with the ball was studied for 6 University team players attempting to serve as fast as they were able. Several trial rackets were employed with mass and moment of inertia characteristics adjusted to represent the range of 'playable' characteristics from the lightest commercial racket to an earlier wooden design. A dual *cartesian optoelectronic dynamic anthropometer* (CODA) real time 3D-motion capture system, manufactured by Charnwood Dynamics Ltd., was used to measure the position of 4 infrared LED active markers attached to the racket during the shot. The CODA system was used to burst sample the markers at a sampling rate between bursts of 400 Hz. The position of each marker was recorded at a resolution of ± 0.1 mm in the horizontal and vertical directions perpendicular to the sensor array viewing direction, and a depth measurement resolution of ± 0.6 mm.

As predicted the results indicate a statistically significant ($p<0.01$) racket head speed increase with reduction in mass and moment of inertia, despite the small population studied. Further, when normalised with respect to the individual player's performance with his or her own racket, the results suggest a consistent relationship between the head speed generated and the racket's moment of inertia for all the players tested. The mean head speed results for all players tested indicate a 10% increase in head speed for the 12% decrease in racket inertia simulated. The results also indicate that the instantaneous centre of rotation for the racket at impact is surprisingly consistent for most of the subjects despite changes in the racket characteristics. The mean result for 4 of the players with the trial rackets was 12.6± 3.0 cm behind and 18.0± 3.1cm below the racket butt, indicating that the players adapted to the different rackets remarkably quickly.

The study is based on a limited population and a wider study is required to confirm these findings, especially within other player groups.