The effects of ball impact location on wrist flexion for one-handed tennis backhand groundstrokes

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A torque-driven, 3D computer simulation model of an arm-racket system was used to investigate the effects of ball impact location (nine locations on the stringbed) on wrist flexion for one-handed tennis backhand groundstrokes. The model consists of nine segments with three rotational degrees of freedom at the shoulder, two at the elbow, two at the wrist, three at the grip and two between the racket handle and racket head. Seven pairs of torque generators were used to control joint angle changes with each pair of torque generators representing the torque exerted by the corresponding agonist-antagonist muscles across a joint. The torque exerted during a simulation was determined by multiplying maximum voluntary torque and the corresponding torque activation level which was specified as a function of time using flexor and extensor torque activation profiles. The stringbed was represented by nine point masses connected to each other and the racket frame with elastic springs and three torsional spring-dampers between the hand and the racket were used to represent grip tightness. The model was designed so that the ball could contact the racket at any of the nine point mass locations and therefore allow simulations for different ball impact locations. The starting point of all simulations was a matched centre impact trial with all parameters in the model kept at the values used in the matching simulation apart from ball impact location. For each perturbation of ball impact location, simulations were run for a 50 ms period starting with ball-racket impact. The effect of ball impact location on the movement of the racket and wrist could be clearly grouped into three impact locations; above the longitudinal axis of the racket, on the longitudinal axis of the racket and below the longitudinal axis of the racket. Simulations showed that during off-centre impacts below the longitudinal axis of the racket, the wrist was forced to flex up to 16° more than comparison with a matched centre impact simulation. As a consequence off-centre impacts below the longitudinal axis of the racket may be a substantial contributing factor for tennis elbow injuries due to forced wrist flexion and eccentric contraction of the wrist extensors.

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Keywords: Tennis; back-hand; Wrist-flexion