INFLUENCE OF RACKET LENGTH ON TENNIS STROKE

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INTRODUCTION: The contact phase during the very complex and short tennis stroke is the most important event in tennis playing. Many factors influence the rebound velocity of the ball. In consideration of the extremely short duration of the tennis stroke of only a few milliseconds, a computer-assisted simulation as already required by Groppel (1986), Brannigan and Adali (1981) was performed. The computer-simulation allows a 100% reproducibility at an almost arbitrary time resolution and an independent variation of all input parameters. Another advantage is the availability of all forces in all segments of the model.
A frequently discussed problem is the influence of racket length on the rebound velocity of the ball. The current design of tennis rackets tends to so-called long body rackets, expected to produce a higher rebound velocity because of the more distally situated hitting point. This study was done to give critical consideration to the common claim, advertised by leading manufacturers of tennis equipment, that a longer racket inevitably produces better performance.
The theoretical investigations of earlier studies served as a basis for the developed computer-model. A complex substitution model for arm and racket was presented by Casolo and Ruggieri 1991, while the visco-elastic properties of frame, strings and ball were analyzed by Leigh and Lu (1992).

METHODS: The computer model used in this study was based on a two-dimensional multiple pendulum consisting of upper and lower arm, hand and racket as described in Figure 1. The mass distribution was determined using Zatziorsky's (1986) anthropometric model. The arm segments were linked by hinge joints. The pre-impact angular velocity of the arm was set to a constant value for all investigated rackets. The trajectory of the ball was adjusted to hit the racket perpendicular to the string surface at its center with a velocity of 20m/s. The visco-elastic properties of the racket, strings and ball were combined in an overall spring-damper system according to Leigh and Lu (1992).

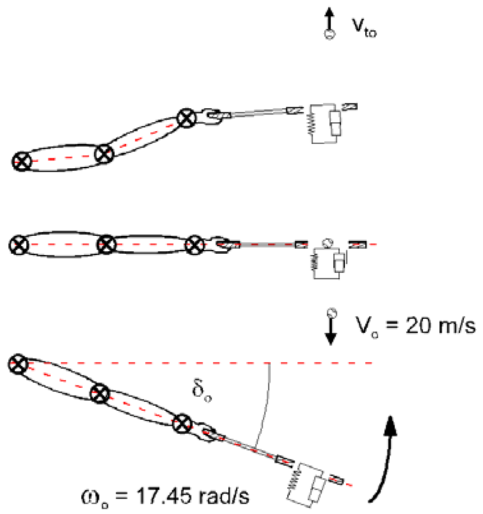

Figure 1 - Standardized computer-simulated tennis stroke

The experimentally determined geometries and mass distributions of three existing rackets, as shown in Table 1, served as input variables for this model. The selection consists of one normal sized racket (N1) and two long body versions (L1 and L2) selected from a pool of about sixty investigated rackets.
Table 1 -
The interesting results are the rebound velocity of the ball as a performance parameter and the joint forces of grip, wrist and elbow as parameter for loads.

Table 1 – Mass Distributions of the Investigated Rackets

	mass/kg	length/m	Balance/%	Inertia/kgm²
N1	0.319	0.685	48.6	0.01590
L1	0.340	0.710	48.6	0.01660
L2	0.273	0.705	55.5	0.01272

Note. head heavy rackets have a balance more than 50%

An analysis tool which fulfills all requirements concerning model setup and calculations of impact kinetics is the DADS (Dynamic Analysis and Design System) software package (CADSI, IA). DADS supports the analysis of multi-body systems and provides a complete set of data of all kinematic and dynamic variables for each body and each joint.

RESULTS: The investigation indicates that the shape of the longer rackets is either obtained by a pure elongation of the grip, keeping the design of the short version (L1 and N1), or by creating a complete new design concerning the mass geometry. As we can see from Figures 2 and 3 the gain of a 2% higher rebound velocity increases the loads in the wrist (16%), ellbow (17%) and particularly the grip joint (212%), which results in no acceptable advantages for the amateur player.

On the other hand, more sophisticated designed long body rackets (L2) increase ball velocity without producing higher impact loads on the arm.
So, only rackets that are especially designed for a long version yield advantages in tennis performance. The increase in length alone is not a significant feature for the performance of a racket.

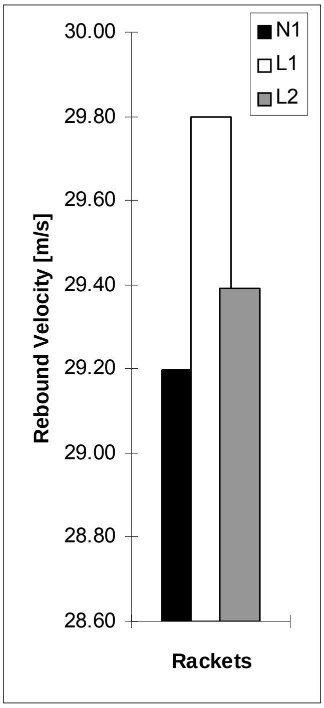

Fig. 2 - Rebound Velocity

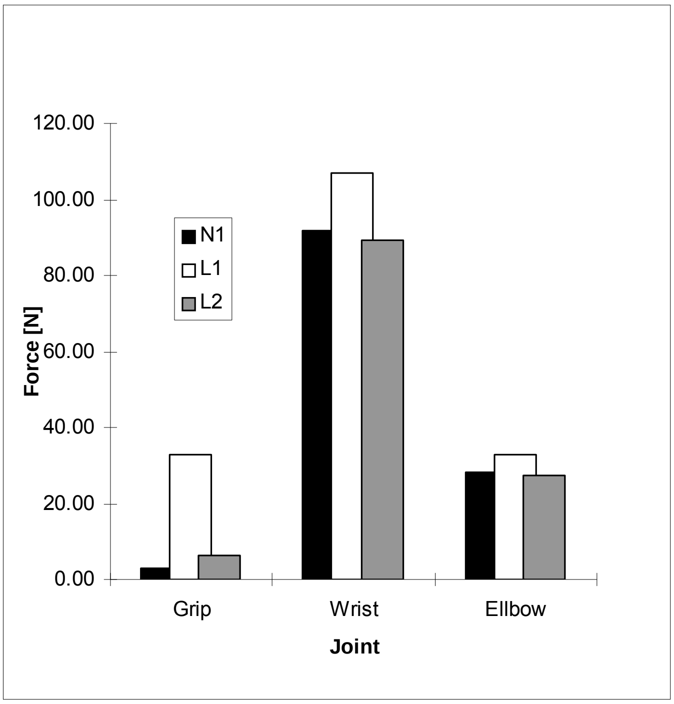

Fig. 3 - Maximal Impact Forces

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