THE IMPACT COMPARISON OF TOP-SPIN BALL OF TENNIS ON CLAY COURT AND HARD COURT

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The purpose of this study was to compare the experiment parameters resulting from different incident angles, respectively 20, 30, 40,50,60,and 70 degrees, and top-spin ball of tennis, after the impact of the ball on the clay court and the hard court. Ten top-spin tennis(v=21m/sec,w=-142 rad/s) were filmed with High-Speed camera which impact on two different types of surface. The conclusion was as follows□Under the different angles of top-spin, the horizontal velocity, the vertical velocity, and the angular velocity change n the hard court are greater than those in the clay court. The rebound angle in the clay court are greater than those in the hard court. The value of the above –mentioned parameters, except the rebound angle and the vertical velocity, will decrease as the incident angle increased.

KEY WORDS: experiment parameters, clay court, hard court

INTRODUCTION: A tennis court's dimensions are specified exactly to the centimeter by the rules of the game, but nowhere do those rules mention the composition of the surface material that the game is to be played on. This leads to a variety of types of bounce because tennis is played on clay, wood, synthetic and rubber carpets and tiles, concrete and even grass. Some of these surfaces are characterized as being “fast” some are called ”slow”- but this is quite subjective (Brody,1984). The motion or path or trajectory of a tennis ball through the air is completely determined by the laws of physics. The height to which the ball bounces and the "speed “ of the court are also subject to the same laws. But you do not need to be a physicist in order to use physics to play better tennis, for you have learned from experience to take the first few feet of a ball’s trajectory and anticipate exactly where that ball will be at some later time. From years of watching tennis balls, you know instinctively to start to move in or back up, how high the ball will bounce or how fast it is coming at you. You do not have to think about it- and you certainly do not calculate the trajectory in your head by applying Newton’s laws of motion. You do a pattern recognition to match the pattern of a ball’s trajectory. Knowing the physical laws behind the trajectory and the bounce of a tennis ball, however, can be of use in a number of situations and can make you a better player. This research is an attempt to quantify the interaction of a tennis ball and the court surface on clay court and hard court, and show how, by making a few measurements, one court surface can be compared to another court surface.

METHODS: The primary instruments used were to measure angles (Acuangle), which function to set the incident angle of a JUGS ball thrower and a high-speed film camera. The former was used, to examine the R.P.S of a JUGS ball thrower in pilot study, respectively upper wheel and lower wheel (r=0.2302m). After that, to calculate R.P.M and peripheral speed from the first 10 scale of ball thrower (0~100 scale). By means of 2 orders (upper wheel) and 3 orders (lower wheel) a polynomial regression predicted the acquired result from the first 1 scale of ball thrower(0~100 scale). Final, were predicted the speed of wheel which was conformed by equation (V= r□2□f),and the value of Stand Estimate Error is 0.4. Ten top-spin tennis balls(v=21m/sec,w=-142 radian/sec) which impacted on clay court and hard court were filmed with a high-speed camera (Type Ektpro 1000-500 HZ). The 2D(two-dimension) coordinates and digital data were used, in combination with the data of designed software of Lab Biomechanics of Sport, NTNU, to calculate the positions of the mass center of tennis and experiment parameters.

Analysis methods:

$$\frac{\Delta X_{in}}{\Delta T} = \dot{X}_{TD} = \frac{X_{m+1} - Y_m}{\Delta T}$$

$$\frac{\Delta Y_{in}}{\Delta T} = \dot{Y}_{TD} = \frac{Y_{m+1} - Y_m}{\Delta T}$$

$$V_{TD} = \left[\dot{X}_{TD}^{\,2} + \dot{Y}_{TD}^{\,2} \right]^{1/2}$$

$$\frac{\Delta Y_{out}}{\Delta T} = \dot{Y}_{LO} = \frac{Y_{n+1} - Y_n}{\Delta T}$$

$$W_{TD} = \frac{Arc\tan(Slop_{m+1}) - Arc\tan(Slop_m)}{\Delta T}$$

(Y_{in} X_{in} vertical and horizontal displacement between frame and frame impact before $Y'_{TD}X'_{TD}$ the vertical and horizontal velocity of the before touch-down court.)
(Y_{out} X_{out} vertical and horizontal displacement between frame and frame impact after $Y'_{LO}X'_{LO}$ the vertical and horizontal velocity of the ball of lift-down court.)

$$\frac{\Delta X_{out}}{\Delta T} = \dot{X}_{LO} = \frac{X_{n+1} - X_n}{\Delta T}$$

$$\theta_{TD} = Arc\tan\frac{\dot{Y}_{td}}{\dot{X}_{td}}$$

$$V_{LO} = \sqrt{\dot{X}_{LO}^{\,2} + \dot{Y}_{LO}^{\,2}}$$

RESULTS: The results of this research after data was run through software calculations analysis follows:

$$\theta_{LO} = Arc \tan\frac{\dot{Y}_{LO}}{\dot{X}_{LO}}$$

$$W_{LO} = \frac{Arc\tan(Slop_{n+1}) - Arc\tan(Slop_n)}{\Delta T}$$

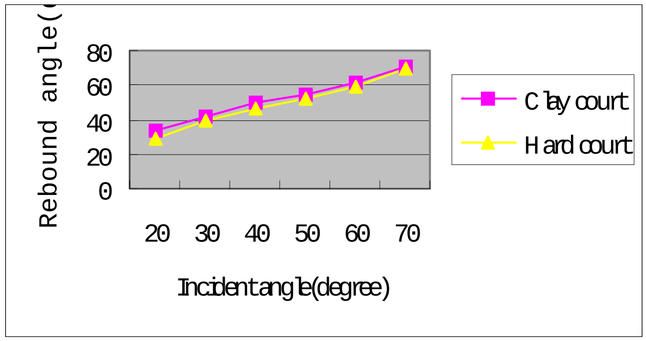

Figure 1 - Mean curves of rebound angle (n=10) of ball after the bounce for clay court and hard court.

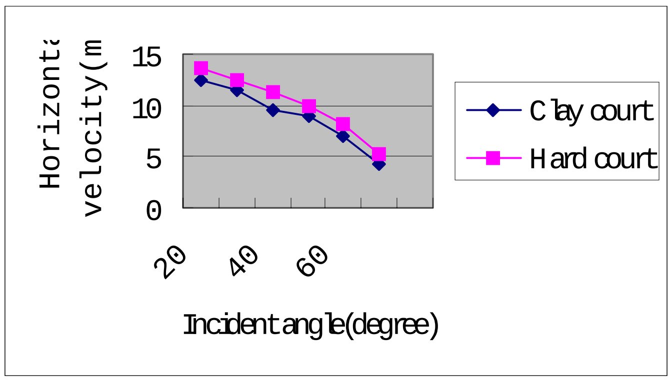

Figure 2 - Mean curves of horizontal velocity(n=10)of ball after the bounce for clay court and hard court.

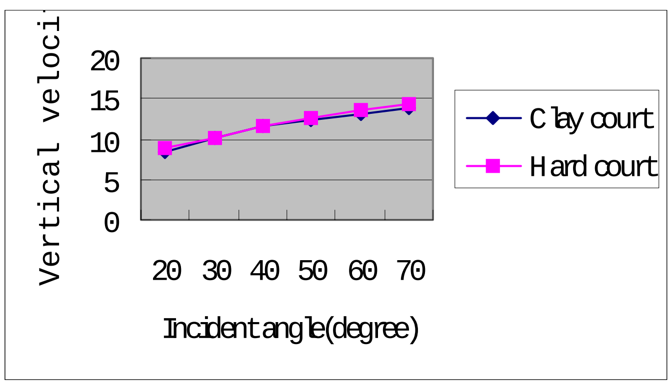

Figure 3 - Mean curves of vertical velocity(n=10) of ball after the bounce for clay court and hard court.

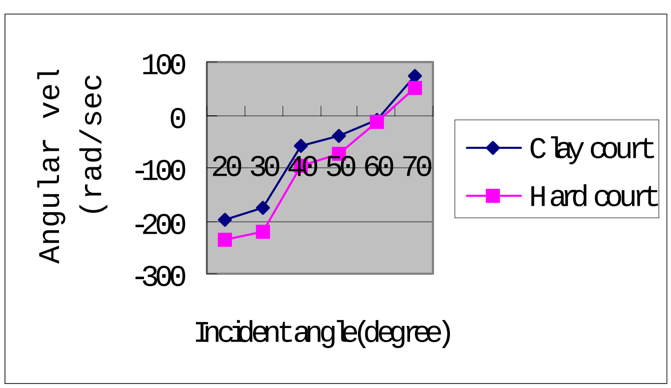

Figure 4 - Mean curves of angular velocity (n=10) of ball after the bounce for clay court and hard court.

DISCUSSION: Figure 2 shows the mean curves of horizontal velocity of ball after the bounce for clay court and hard court and tennis . The values of hard court were greater than clay court from differently incident angle, and decrease as the incident angle increased. When a tennis ball bounces on the court, its horizontal velocity is usually reduced somewhat by its interaction with the court surface. If the ball slows down a great deal upon bouncing, the court is slow (clay court), while a fast court does not affect the ball's horizontal speed as much. There are only two characteristics of a court surface that influence what the ball does when it bounces. These are the coefficient of restitution (COR) and the coefficient of friction (COF) between the ball and the surfaces. The COR tells you how high the ball will bounce if you drop it from a given height. A high-COR court surface gives a higher bounce than a low-COR surface. The COR is defined as the ratio of the vertical ball speed after the bounce to the vertical ball speed before the bounce. The COF is a measure of the frictional force of the court surface on the ball, in a direction parallel to the surface. It usually slows the ball down. A high value of the COF means that the frictional force on the ball is large. Figure 1 shows mean curves of rebound angle of ball after the bounce, clay court greater than hard court from differently incident angle. In addition to slowing down the ball's horizontal speed, friction causes the angle at which the ball rebounds to change. The more the friction, the larger the rebound angle will be: the less the friction, the smaller the rebound angle. Figure 4 shows mean curves of angular velocity of the ball after the bounce, clay court smaller than hard court from differently incident angle. As incident angle is small, the coefficient of friction and moment for ball have large values, leads to be large for angular velocity.

CONCLUSION: The friction between the ball and the court determines the speed of the court, hard courts have low friction - clay courts high friction. Under the different incident angles of top-spin, the horizontal velocity and angular velocity change in the hard court are greater than in the clay court. The rebound angle in the clay court is greater than in the hard court. The values of the above-mentioned parameters, expect the rebound angle and vertical velocity, will decrease as the incident angle increased.

REFERENCE

Brody, H. (1984). That's how the ball bounces. The Physics teacher,11, 494-497.