SPEED AND SPIN OF ∅40MM TABLE TENNIS BALL AND THE EFFECTS ON ELITE PLAYERS

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The ∅40mm table tennis ball has been officially used by ITTF since October 2000. The aim of this study was to identify the characteristics of the large (∅40mm) ball and the effects on the technique of elite players. In this study, Singapore elite players received both topspin and backspin balls from a robot. Three video cameras were applied to capture video data of Singapore elite players for three-dimensional motion analysis at a rate of 200 fields/second. Both speed and spin of ∅38mm and ∅40mm balls were calculated. The men and women players of different styles using different techniques including attack, loop and service, were analyzed and compared quantitatively and the effects of these differences on these elite players is discussed.

KEY WORDS: table tennis, ball, speed, spin.

INTRODUCTION: The International Table Tennis Federation (ITTF) decided to officially apply the ∅40mm ball from the October of year 2000. Since then the bigger balls have been used in all international table tennis competitions organized by ITTF. The new ball is different from the old ∅38mm ball in both diameter and weight. This change will result in difference in speed and spin characteristics. It is very important for players and coaches to understand these differences and change their techniques to adapt to the large ball. The aim of this paper is to (1) compare the speed and spin of the large (∅40mm) ball with old (∅38mm) ball, (2) investigate the technique of Singapore elite table tennis players.

METHODS: The data was collected between December 2000 and February 2001, after the ∅40mm ball have been used for about three to five months. Seven (three male and four female) elite players from the Singapore national table tennis team were tested. It is assumed that the tested players have been already used to the ∅40mm ball through more than three months' intensive training and competition. The balls were projected from a robot and then struck by the players with their own rackets. The same scale of speed and spin of the ball projected from the robot were used for testing the same technique. Three synchronized video cameras (PEAK HSC-200) were applied to record the video images at 200 fields/sec for measuring the velocity of COM (center of mass) and spin of the table tennis balls. Figure 1 shows the setup of the test equipment in the laboratory, where C1, C2 and C3 are video cameras. The captured analog video is then converted into digital image and analyzed by PEAK motion analysis system.

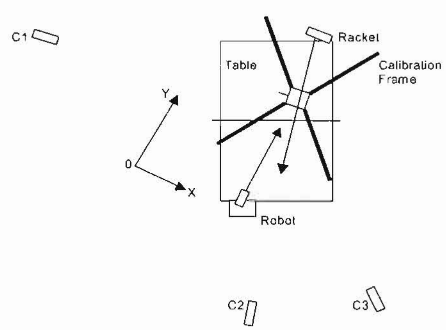

Figure 1. Setup of equipment.

Measurement of velocities of COM of the balls: The video images from C1 and C3 is used to calculate the coordinates and velocities of COM. Firstly the two-dimensional raw coordinates are digitized from the two synchronized video image. The three-dimensional coordinates are obtained by Direct Linear Transformation (DLT). Then the corresponding velocities are calculated based on the coordinates. The sample size of speed was seven (N=7) for each technique and player.

Measurement of spin of the balls: Half of each of the yellow balls was painted black to enable counting of the spin. The spin of balls is calculated from the digital image of C2 that is located in front of players. It is described as the average value of spin (N) derived from the number of rotations divided by the time taken. The sample size of spin was eight (N=8) for each technique and player.

Nine of techniques were measured: Forehand smash (FS), forehand drive loop return topspin (FDL), forehand high loop return backspin (FHL), forehand attack (FA), forehand chop (FC), backhand smash (BS), backhand attack (BA), backhand chop (BC), services (spin only) (S).

Equipment and setup for the test:

Nittaku ∅40mm (average 2.67g) and ∅38mm (average 2.49g) yellow ball (three stars) painted half black.

Nittaku blue table tennis table.

ROBO PONG 2000 (NEWGY) robot (feeding machine) was fixed on the edge of the table to feed both the ∅40mm and ∅38mm balls at various speeds, spin and projection angle for measuring different techniques.

Three synchronized PEAK HSC-200 (50/200) video cameras are applied to capture video at the rate of 200 fields/sec and the shuttle speed of 1/2000sec.

PEAK Motus ver 4.3 motion analysis system was used to process video image, digitize and calculate the data of speed and spin.

Data definition: Speed of COM of ball (V_c) is the amplitude of the resultant velocity of the COM, and the unit is meters/second (m/s).

Average spin of ball (N) is the number of rotations in a second, and the unit is 1/second (1/s). It's the average value in the counted segment.

Relative edge speed (V_e) is the maximum speed of the edge relative to COM, equal to $2\pi RN$, where R is the radius of the ball.

Speed ratio of edge to COM of ball (R_{ec}) is the speed ratio of edge to COM, equal to V_e divided by V_c.

Starting speed (V_0) and spin (N_0) are the speed and spin immediately after the ball leaves the racket, shown in figure 2.

Final speed (V_f) and spin (N_f) are the speed and spin after flying a distance (1.8m) before contacting the table, shown in figure 2.

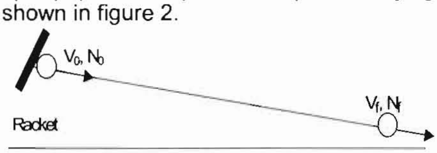

Figure 2. Starting and final speed and spin.

RESULT AND DISCUSSION: *Comparison the speed and spin of ∅40mm ball with ∅38mm ball:* Table 1 gives the range of starting speeds V_0 and starting spins N_0 of both ∅40mm and ∅38mm balls. They are personal average values of each player. The data shows that both speed and spin of ∅40mm are less than that of ∅38mm for most of the tested techniques except just one player's speed of FDL increased 0.5%. The first column of the table 1 lists the tested techniques. Among them the FS, FHL and FDL are three significant techniques for comparing the speed and spin: FS has the fastest speed, FHL has the strongest spin, and FDL is frequently used for attacking and also has both fast speed and strong spin. The data shows that the FS for ∅40mm ball is 0.0% ~ 7.9% less than that for ∅38mm ball in speed, FHL is 2.0%~7.7% less in spin, and FDL is up to 2.8% less in speed and 1.7%~12.0% less in spin. As can be seen from the results, percentage reduction is dependent upon the players and technique. Some of them performed better, with less loss in speed and spin. This test of speed and spin can therefore clearly assess how the table tennis players have handled the larger ball. The speed of the ball determines how fast and powerful the strike is. A faster ball means stronger impact and shorter reaction time for the opponent.

Table 1. Starting speed, spin and their difference between ϕ38mm and ϕ40mm ball.

	Speed V_0 (m/s)		**$\Delta V_0/V_{0(38)}$**	**Spin N_0 (1/s)**		**$\Delta N_0/N_{0(38)}$**
Tech	**Ø38**	**Ø40**	**(%)**	**Ø38**	**Ø40**	**(%)**
FS(n=6)	22.3~29.6	21.7~27.4	-7.9~ 0.0	58.5~98.0	49.5~84.3	-15.4~ -4.3
FDL(n=6)	18.2~ 24.0	18.3~23.6	-2.8~ 0.5	111.7~155.9	109.8~137.2	-12.0~ -1.7
FHL(n=4)	12.9~16.3	12.3~15.4	-6.8~ -2.3	107.0~159.0	102.9~146.8	-7.7~ -2.0
FA(n=1)	16.8	15.8	-6.0	57.5	53.2	-7.5
FC(n=1)	-	-	-	97.9	92.0	-6.0
BS(n=1)	19.1	18.1	-5.2	69.9	62.9	-10.0
BA(n=2)	19.1~19.6	16.6~19.2	-13.1~ -2.0	56.9~57.6	49.6~50.7	-13.9~ -11.0
BC(n=1)	-	-	-	82.0	81.4	-0.7
S(n=5)	-	-	-	54.8~64.5	48.9~ 63.1	-10.8~ -2.2

* Here n is the number of tested players. $\Delta V_0=V_{0(40)}-V_{0(38)}$. $\Delta N_0=N_{0(40)}-N_{0(38)}$

The spin of the ball contributes to the shape of ball's path and the result of collision with table and racket. Controlling the spin may result in higher hit rates and also make difficult for the opponent to return the ball. So the data of speed V_0 and spin N_0 would be useful for coaches and players aiming to improve their techniques and training efficiency. For example, if the reduction of spin is more than that of speed, it would be advisable for the players to pay more attention to increasing the spin in the forehand smash, especially if the hit rate has already been reduced.

Speed ratio of edge (V_e) to COM (V_c) of ball -- R_{ec}.: In this study, R_{ec} is defined as the percentage of the V_e to the V_c. Table 2 gives the R_{ec} of various tested techniques for the players. The V_c is higher than the V_e for all techniques except FHL. Except for FHL of player C, the R_{ec} of FHL of the rest players is above 100%. It means that only the V_e of C's FHL is lower than its V_c.

Table 2. Speed ratio of edge to COM of ball (R_{ec}).

Tech	**FS**		**FDL**		**FHL**		**FA**		**BS**		**BA**	
Player	**Ø38**	**Ø40**	**Ø38**	**Ø40**	**Ø38**	**Ø40**	**Ø38**	**Ø40**	**Ø38**	**Ø40**	**Ø38**	**Ø40**
A	37.8	40.0	73.5	75.4	-	-	-	-	-	-	36.0	37.5
B	42.6	42.4	91.7	90.9	-	-	-	-	-	-	34.7	33.2
C	29.6	26.9	-	-	78.4	84.0	40.9	42.3	43.7	43.7	-	-
D	49.0	46.1	76.4	72.1	123	135	-	-	-	-	-	-
E	34.7	34.1	77.5	73.1	144	150	-	-	-	-	-	-
F	39.4	35.5	77.5	77.7	138	145	-	-	-	-	-	-
G	-	-	70.7	71.3	-	-	-	-	-	-	-	-
Ave	38.9	37.5	77.9	76.8	121	129						

Comparing the player's R_{ec}, some of the players' emphasis is on the speed of COM while others are better at playing with more spin. This depends very much on the style of the players. Another significant factor would be the rubber. R_{ec} may be used to classify the style of the players. A player with a low R_{ec} would be good at playing fast-ball whereas one with high R_{ec} would have a strong spin. Among the players in table 2, player C's emphasis is on V_c and whereas player B's emphasis is on V_e. Their playing styles are different. R_{ec} may also be helpful for evaluating individual techniques. The result also shows that S has the lowest R_{ec} and FHL has the highest. Players using the FHL technique emphasized more on spin

(higher R_{ec}) while using ∅40mm ball as compared with ∅38mm ball. In contrast, players using the FS technique emphasized more on speed of COM (lower R_{ec}) except player A.
Effect of air resistance: Once table tennis ball completes contact with and leaves the racket, air resistance would be a major force acting on it other than gravity. The resistance causes a reduction in the speed V_c and spin N. Figure 3 shows the starting spin N_0 and final spin N_f of the FDL and figure 4 shows the curve of speed V_c while the ball is airborne. The reduction in N is about 3%~4% before the ball contacts the table, while the V_c is reduced by about 29%, showing that the speed V_c decreases more rapidly than spin N. The air resistance is affected by different air density at different altitude, temperature and humidity. The above data shown in figure 3 and 4 were obtained at sea level, 24°C and relative humidity 60%.

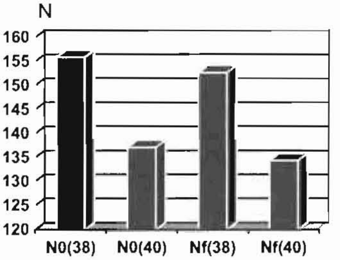

Figure 3. Average starting and final spin of the FDL for both ∅40mm and ∅38mm.

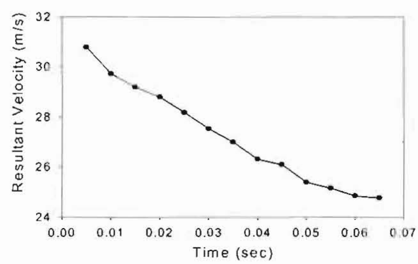

Figure 4. A curve of speed V_c reducing while flying in air.

CONCLUSION: The results show that both the speed and spin of ∅40mm (2.67g) ball are less than that of the ∅38mm (2.49g) ball, with the reduction in speed being more than the loss of spin. This can be attributed to air resistance as the ball travels through air. The extent of reduction is different for different players and different techniques. For example, in this study, the reduction in speed for the forehand smash is ranged from 0.0% to 7.9% and reduction in spin for forehand high loop is ranged from 2.0% to 7.7%. This evaluation of the speed and spin may be used as a tool for coaches and players to monitor the players' techniques. The speed ratio of the edge to COM of ball may be applied to evaluate the players' technical style, which may emphasize on speed or spin.

REFERENCES:

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