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POSSIBILITIES TO REDUCE SPEED AND SPIN BY CHANGING THE THICKNESS OF SPONGE, UPPER LAYER OR TOTAL THICKNESS OF SANDWICH RUBBER

Abstract

Table tennis is without no doubt the fastest game in the world. As table tennis has developed during last decade and player's techniques have improved, the ball's speed and spin have become too fast and that's why rallies are shorter. The aim of our research was to find out what are the differences in results when strokes are performed with rubbers of different thicknesses.

For this purpose the impact has been investigated, and a simple impact model has been proposed on the basis of the idea that the contact duration is determined by the natural period of a whole system composing the mass of ball, the nonlinear stiffness of ball and rubber.

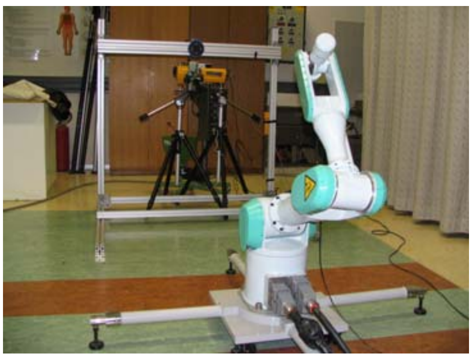
Different rebound angles from the racket on the robot arm determine different trajectories of parabolic shape. Therefore, at another angle where the parabolas are higher and the ball flight paths longer, the quartiles are wider since even a slight change in the rebound angle affects the duration of the ball flight more than when parabolas are lower, that is the flights of the ball are more direct.

These measurements and results of measurements show us that there is a big potential to regulate table tennis rules regarding to slow down a game and take into consideration health of table tennis players. We can do this with limitation of rubbers or with prohibition of speed gluing. Even though results show us differences in different kind of rubbers there is still a lot of work to be done.

Key words: *table tennis, rubber, speed, spin*

1 INTRODUCTION

Modern table tennis is a sport game that demands great speed, strength, power, endurance, flexibility, agility and good reflexes. The majority of top-level players prefer to concentrate on attacking or counter-attacking. Most international competitors favor the forehand spin stroke to produce high velocity and high rotation. However, a stroke angle has been changed since the circumference of the ball has been enlarged. The shoulder girdle muscles are today exposed to different loads than before because shoulder abduction should be performed more quickly now. As table tennis has developed during last decade and player's techniques have improved, the ball's speed and spin have become too fast and that's why rallies are shorter. In order to regain interest of spectator and make table tennis more attractive again, International Table Tennis Federation has made some rule changes in last few years, but it looks like that these measures have not been effective in improving the attractiveness for table tennis spectators.



After Olympic Games in Sidney, ITTF replaced 38mm ball with 40mm ball. It was expected that the new, bigger ball will not only make the ball better visible for the players and spectators but will as well to some extent reduce the speed in the game. At the beginning it was the case, not quite as much as expected, but due to development of equipment and playing techniques today the speed in the game is quite the same as before with the smaller ball and there is still the tendency to make the game even faster. It seems necessary to run experiments to find out possibilities to reduce the speed of the ball without any drastic changes of equipment and rules, without making table tennis more expensive as it already is. We have to take in consideration different materials we play with. Rubbers are probably most important part of modern table tennis equipment. We have a lot of different rubbers today that we can find in table tennis stores. The same stroke produced with different rubbers will result with different ball speed and rotation due to different characteristics of the rubber.

The aim of our research is to find out what are the differences in results when ball hits the bat with rubbers of different thicknesses.

2 GOAL OF THE EXPERIMENT

To test the possibility of reducing the speed and spin in the game by reducing the total thickness of the sandwich rubber and/or reducing the thickness of the sponge and/or reducing the thickness of the upper layer of the sandwich rubber.

For this purpose the impact has been investigated, and a simple impact model has been proposed on the basis of the idea that the contact duration is determined by the natural period of a whole system composing the mass of ball, the nonlinear stiffness of ball and rubber.

3 METHODS

3.1 Design

To design an optimal rubber which has positive influence on modern table tennis game, it is essential first to establish exactly how which thickness of rubbers affects speed and rotation of the ball. Therefore, we have measured the magnitude of the difference in speed of ball caused with rebound from different rubbers.

3.2 Materials

Physical parameters have been collected with measurement equipment located on the Faculty of Sport and Institute Jozef Stefan in Ljubljana. For this purpose we have used:

- »Microgate Polifemo Radio« photocell
- Two 6 dimenzional sensors Jr3
- A 2D Motion Analysis System
- Mini DV camcorder
- TTmatic 500 (table tennis machine)
- MHI General Purpose Robot PA10 Series- 7-axis redundancy control robotic arm (Mitshubishi heavy industries)
- Rubbers of different thickness have been provided free of charge by ESN and TIBHAR, Germany.

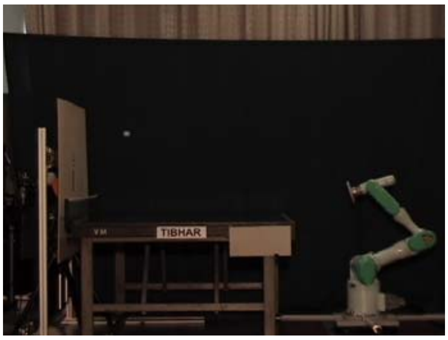
3.3 Procedure

Physical parameters of single rebounds and intensity have been measured on a professional engeneering system. The data has been collected and analysed both visually and quantitatively.

The measurements have been conducted during fifty rebounds (for each rubber) performed with the different rubbers on the same blade. The measurement has been filmed as table tennis machine launched the ball. To ensure the same condition for all the performances (the same approaching ball trajectory), a table tennis machine has been used.

The measurements have been taken at the Faculty of Sport and Institute Jozef Stefan in Ljubljana.

The measurement apparatus was put together as shown in following photo. The robot TTmatic 500 automatically launched balls with a frequency of approximately 10 min-^{1}. Immediately after being launched, the ball was intercepted by the »Microgate Polifemo Radio« photocell which triggered a specially designed program for capturing data from the computer AD card. Two 6-dimensional sensors Jr3 were plugged to the AD card for measuring force and torque in all three axes. The first, smaller sensor (maximum load 250 N) was plugged to the Mitshubishi Pa10 robot arm, which had a table tennis racket attached to it. The second, bigger sensor (maximum load 1 kN) was attached to a specially designed frame with a board. The ball bounced from the board after being returned from the racket. The board was placed 2 cm behind the edge of the middle of the table (see picture). The second computer controlled the Mitsubishi robot, and thus the appropriate racket settings – 2 positions wit corresponding orientations and angles. Data of all three force components of the smaller Jr3 sensor, and data of the main movement direction force component of the bigger Jr3 sensor was captured at a frequency of approximately 5.5 kHz.



The signals captured from the sensors show an impact force on the racket and an impact force on the rebound board. Using a specially developed program in the Matlab environment and a 1 N high trigger, we have determined the ball traveling times from the photocell to the racket and returning from the racket to the rebound board.

3.4 The task

- find out theoretically (computer calculations) the influence of different thickness of sandwich rubber, sponge, upper layer on speed and spin of the ball in the game,
- try in practice different total thickness of sandwich rubber, compare with the rubber in accordance with the present rule,
- try in practice different sponge thickness, compare with rubber in accordance with the present rule,
- try in practice different upper layer thickness, compare with rubber in accordance with the present rule,
- test the influence on the game, on the stroke technique,
- test the durability of such sandwich rubber when speed glued.

4 RESULTS

Table 1: *Differences between different rubbers (Bonferroni - Multiple Comparisons) – 1.8mm*

Dependent Variable	(I) RUBBER	(J) RUBBER	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
1.8 mm Angle 1	1	2	-32,70650(*)	7,63327	**,000**	-51,3283	-14,0847
		3	-18,82112	7,91094	,058	-38,1202	,4780
	2	1	32,70650(*)	7,63327	**,000**	14,0847	51,3283
		3	13,88538	7,49058	,201	-4,3883	32,1590
	3	1	18,82112	7,91094	,058	-,4780	38,1202
		2	-13,88538	7,49058	,201	-32,1590	4,3883
1.8 mm Angle 2	1	2	-24,92163	11,36688	,092	-52,6188	2,7755
		3	-13,44996	11,87509	,781	-42,3854	15,4855
	2	1	24,92163	11,36688	,092	-2,7755	52,6188
		3	11,47167	10,94554	,892	-15,1988	38,1422
	3	1	13,44996	11,87509	,781	-15,4855	42,3854
		2	-11,47167	10,94554	,892	-38,1422	15,1988

LEGEND:
Rubber 1 = Conventional 1.8
Rubber 2 = Tension 1.8
Rubber 3 = Test 1.8 (04/296)
Angle 1 = 112,8°
Angle 2 = 107,9°

Table 2: *Differences between different rubbers (Bonferroni - Multiple Comparisons) – 2.0mm*

Dependent Variable	(I) RUBBER	(J) RUBBER	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
2.0 mm Angle 1	4	5	-22,31870(*)	8,23259	**,023**	-42,3123	-2,3251
		6	-12,65694	8,08235	,360	-32,2856	6,9718
	5	4	22,31870(*)	8,23259	**,023**	2,3251	42,3123
		6	9,66176	8,13525	,712	-10,0954	29,4189
	6	4	12,65694	8,08235	,360	-6,9718	32,2856
		5	-9,66176	8,13525	,712	-29,4189	10,0954
2.0 mm Angle 2	4	5	-14,25836	9,17666	,370	-36,5846	8,0679
		6	-25,94011(*)	9,32379	**,019**	-48,6243	-3,2559
	5	4	14,25836	9,17666	,370	-8,0679	36,5846
		6	-11,68175	9,62014	,682	-35,0870	11,7235
	6	4	25,94011(*)	9,32379	**,019**	3,2559	48,6243
		5	11,68175	9,62014	,682	-11,7235	35,0870

LEGEND:
Rubber 4 = Conventional 2.0
Rubber 5 = Tension 2.0
Rubber 6 = Test 2.0 (04/297)
Angle 1 = 112,8°
Angle 2 = 107,9°

Table 3: *Differences between different rubbers (Bonferroni - Multiple Comparisons) – 2.2mm*

Dependent Variable	(I) RUBBER	(J) RUBBER	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
2.2 mm Angle 1	7	8	-39,00259(*)	7,58381	**,000**	-59,2831	-18,7221
		9	-24,72355(*)	7,88749	**,012**	-45,8161	-3,6310
		10	-11,21960	7,44791	,805	-31,1367	8,6975
	8	7	39,00259(*)	7,58381	**,000**	18,7221	59,2831
		9	14,27905	7,18900	,293	-4,9457	33,5038
		10	27,78299(*)	6,70378	**,000**	9,8559	45,7101
	9	7	24,72355(*)	7,88749	**,012**	3,6310	45,8161
		8	-14,27905	7,18900	,293	-33,5038	4,9457
		10	13,50394	7,04549	,343	-5,3370	32,3449
	10	7	11,21960	7,44791	,805	-8,6975	31,1367
		8	-27,78299(*)	6,70378	**,000**	-45,7101	-9,8559
		9	-13,50394	7,04549	,343	-32,3449	5,3370
2.2 mm Angle 2	7	8	-35,80558(*)	8,61573	**,000**	-58,8478	-12,7634
		9	-29,78131(*)	8,55593	**,004**	-52,6636	-6,8991
		10	-17,54027	8,74416	,280	-40,9259	5,8454
	8	7	35,80558(*)	8,61573	**,000**	12,7634	58,8478
		9	6,02427	8,77557	1,000	-17,4454	29,4939
		10	18,26531	8,95919	,260	-5,6954	42,2261
	9	7	29,78131(*)	8,55593	**,004**	6,8991	52,6636
		8	-6,02427	8,77557	1,000	-29,4939	17,4454
		10	12,24104	8,90170	1,000	-11,5660	36,0480
	10	7	17,54027	8,74416	,280	-5,8454	40,9259
		8	-18,26531	8,95919	,260	-42,2261	5,6954
		9	-12,24104	8,90170	1,000	-36,0480	11,5660

* The mean difference is significant at the .05 level.

LEGEND:
Rubber 7 = Conventional 2.2
Rubber 8 = Tension 2.2
Rubber 9 = Test 2.2 (04/298)
Rubber 10 = Test 2.2 (04/299)
Angle 1 = 112,8°
Angle 2 = 107,9°

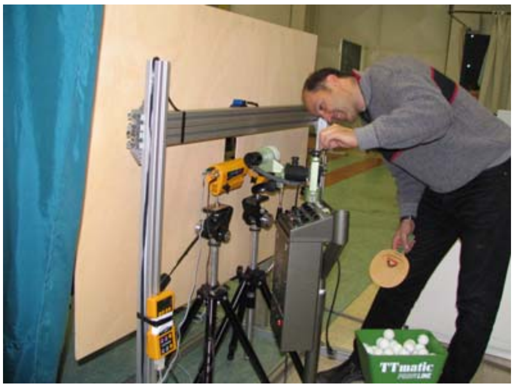
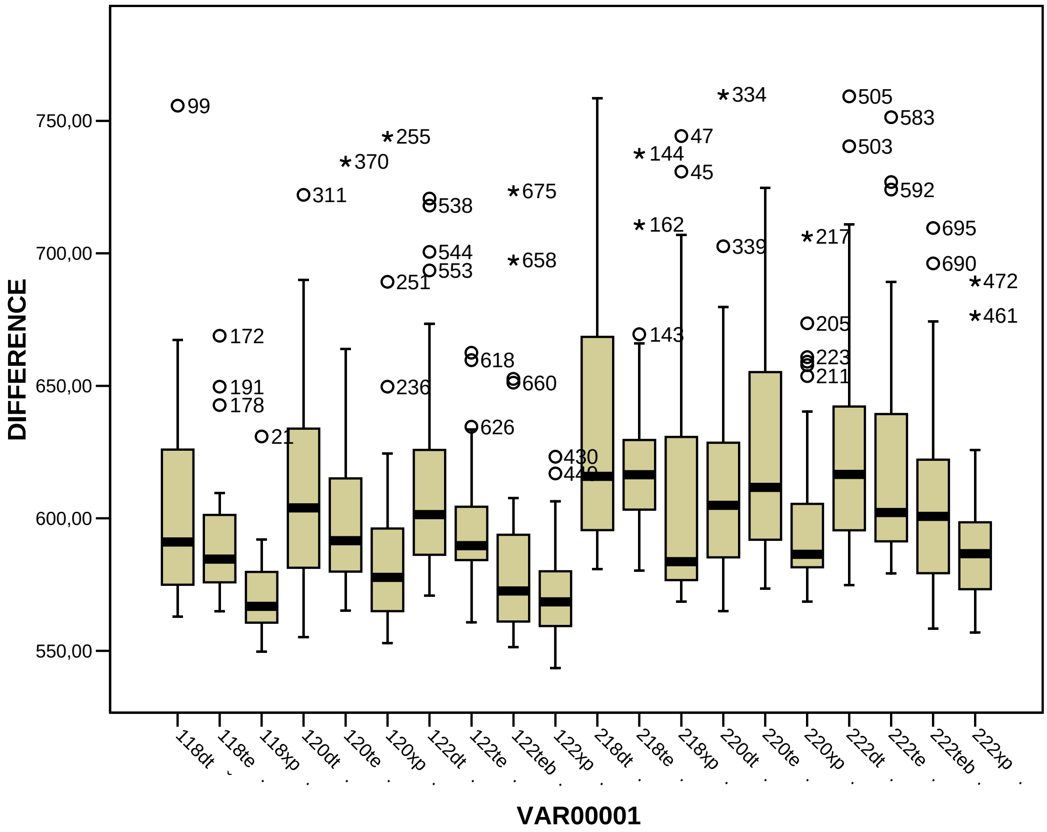


Figure 1: *Difference between different rubbers – angle 1 and angle 2*



LEGEND:
Name convention: XYYAAA:
X=1 ... angle 1 = 112.8°
X=2 ... angle 2 = 112.8°
YY ... rubber thickness [mm]
AAA ... rubber type

- xp = Conventional 2.2
- dt = Tension 2.2
- te = Test 2.2 (04/298)
- teb = Test 2.2 (04/299)

Table 4: *Significant differences between different rubbers (One-way ANOVA)*

(I) Rubber	(J) Rubber	Sig	Angle
Conventional 1.8	Tension 1.8	,000	Angle 1
Conventional 2.0	Tension 2.0	,023	Angle 1
Conventional 2.0	Test 2.0 (04/297)	,019	Angle 2
Conventional 2.2	Tension 2.2	,000	Angle 1
Conventional 2.2	Test 2.2 (04/298)	,012	Angle 1
Test 2.2 (04/299)	Tension 2.2	,000	Angle 1
Conventional 2.2	Tension 2.2	,000	Angle 2
Conventional 2.2	Test 2.2 (04/298)	,004	Angle 2

4 DISCUSSION

The coefficient of restitution is closely related to the impact's energy losses. Racket vibration induced by impact seems to be one of the main sources of energy loss. The impact force and contact duration have strong influence on the racket vibrations. But there are still a number of unclarified points regarding impact phenomenon between a ball and a racket as well.

In this research rebound of a ball caused by different rubbers has been investigated.

The results (qualitative) demonstrate very well how a small modification (5 degrees) enormously affects the flight of the ball, which is extremely significant when performing spins.

Different rebound angles from the racket on the robot arm determine different trajectories of parabolic shape. Therefore, at another angle where the parabolas are higher and the ball flight paths longer, the quartiles are wider since even a slight change in the rebound angle affects the duration of the ball flight more than when parabolas are lower, that is the flights of the ball are more direct (as shown in Figure 1).

Different rebounds and the coefficient of quality impact depend not only on the rubber thickness, the type of rubber etc., but also on the point where the ball hits the racket (Tiefenbacher & Durey, 1994). Any deviation from the 'sweet point' on the racket results in a different or worse rebound. These are the very deviations in all directions (resulting from the dispersion of the robot induced ball flight trajectories), which cause the upper edge of the quartile width (longer times than the median) is further from the median than the lower edge of the quartile (shorter times than the median). The same behaviour can be observed with all rubbers and both rebound angles.

A similar effect of widening the area of the quartiles can be observed with rubbers, particularly at the first angle. Faster, conventional rubbers have a smaller dispersion of the ball flight trajectory and from the players point of view, this could mean these rubbers are more accurate, that is the good hit racket area (sweet area in terms of 'point') is wider – assumed that the effect of different parabolas is not the cause for differences in times. In the course of this project extension, we intend to further investigate the problem of trajectories with the help of mechanical modeling and the kinematic measurements that was taken at the same time.

It is necessary to consider the fact that at this time by the first method no ball rotation was measured (the racket was namely firmly fixed to the robot arm), since this research was focused solely on observing rubber at racket-ball impact. Spin measurement has been done by the second Wassing dom method by Tiefenbacher.

5 CONCLUSION

These measurements and results of measurements show us that there is a big potential to regulate table tennis rules regarding to slow down a game and take into consideration health of table tennis players. We can do this with limitation of rubbers or with prohibition of speed gluing. Even though results show us differences in different kind of rubbers there is still a lot of work to be done, but first we need to know in which direction we should take our researches. Namely, those researches are very expensive.

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