# Research work and the development of rotation theory of table tennis in China

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## 1. Introduction

The rotation of a table tennis ball combined with other factors such as speed, strength, curve, placement etc. promote the renewal and development of various skills and tactics. In China, from the 1950's to the present, table tennis researchers have been making unremitting efforts on rotation. From the shallower to the deeper, from the perception to the rationale, and from quality to quantity, they gradually formed a systematic, complete, and scientific theory, and made outstanding achievement. In this work, we consulted a large quantity of literature and other material on table tennis rotation theory research in China and we now present a summary. Our goal is to expound on the history, current situation and the latest trend in the field of table tennis rotation research, and to supply enriched information for the table tennis researchers in this field.

## 2. In the 1950's and 60's preliminary research on table tennis rotation was conducted. In the 1970's, qualitative and practical research became the main stream.

2.1 Cause of table tennis rotation

In the 1950's, Liang Zhuohui[2] asserted that when the racket touches the ball, the ball is drawn by the racket producing various rotations. In the 1960's, Wu Huanqun pointed out while studying the loop that when the direction of an applied force does not pass through ball's dead center, an arm of force is generated. The product of the applied force and the arm of the force, namely the moment of the force, is what produces the ball's topspin. In the 1970's, Shen Zhengting asserted that the little ball's rotation is caused by a couple acting on the ball's center of gravity. Luo Shengxian[4] advocated that it is just friction that produces ball's rotation. Zhang Huiqin asserted that the existence of vertical distance between the path of all applied force and the ball's barycentre makes the moment of force larger than zero, constituting the first cause for table tennis rotation.

In a word, three explanations of the cause of rotation. (1)the moment of force (2)the friction force (3)a couple.

2.2 Rotation axes of a table tennis ball

"When a ball rotates, it has an axis. This imaginary axis is a diameter that pass

through the center of the sphere. Because it is imaginary, innumerable axes such as up, down, left and right are all possible"(Wu Huanqun 1961). "The rotation of a table tennis ball should be classified according to three basic axes namely up-down, left-right and front-back."(Wang Jiazheng 1972). "An oblique axis may be comprehended as a sub-axis of the three basic axes. It emphasizes on basic axis on which the maximum component of the oblique is based."(Liu Wenzeng 1972). The concept of all oblique axis opened a wider field for research.

2.3 Classification of table tennis rotation

In the 1950's "Rotation in table tennis is classified as topspin, backspin and side spin."[1] In the 1960's "Rotation of table tennis is classified as topspin, backspin, left side spin, left side topspin,left side backspin,right side spin,right side topspin,right side backspin,quick topspin or quick backspin according to the direction and intensity of rotation."(Wu Huanqun 1965) The existence of clockwise and anticlockwise spin was acknowledged in the 1970's, and they were differentiated from side-spin. "Clockwise rotation around the front-back axis is clockwise spin, and anticlockwise spin around the front-back axis is anticlockwise spin."(Wang Jiazheng 1972)

2.4 Character of rotation

In the 1950's, a flat-block experiment was used to observe the rebound character of ball. In the 1960's, attention was focused on a mechanistic explanation for rotation based on the rebound character of the loop. In the 1970's, "The rebound angle of a topspin ball is smaller than that of a normal ball"(Shen Zhengting 1979) and later the parallelogram law of the components and resolution of force was acknowledged. In expounding the trajectories of various spinballs, the Magnus effect of fluid mechanics states that a higher current velocity causes lower pressure and lower current velocity causes higher pressure.

## 3. In the 1980's, rotation theory research in China became more systematic. The fabrication and application of a table tennis dynamic spin-surveying meter (TTDSSM) marked a transition from qualitative to quantitative research.

3.1 The book Rotation in Table Tennis[5] made a complete qualitative description of the cause, property and character of rotation.

3.1.1 Methods to increase rotation

Adjusting the angle of the racket while striking to amplify the arm of force; Accelerating the velocity of the arm to strengthen the striking force; Striking the ball with a part of the racket with higher linear velocity; Increasing the distance that the racket rubs the ball; Striking the ball with intro-arc swing to lengthen action time of friction force; Accelerating the velocity at the instant of striking the ball; Making use of the rotation of the oncoming balling; Making use of the velocity of coming ball to increase the pressure between racket and ball.

3.1.2 Determination of the rotation axis and classification of the rotation

Based in left-right, up-down and front-back axes, Zhang[5] derived thirteen axes, each corresponding to two opposite rotations. So altogether he summarized twenty-six kinds of rotation. Further more he divided each type of spin into four: strong, fairly strong, weak and feeble.

3.2 Wang[8] referred to research on the components of rotation.He pointed out that the direction and magnitude of the returning ball's spin are affected by the spin caused by the strikers(SS) and the spin of the oncoming ball(CS).

3.2.1 chopping a chop

| (striking) | | | (oncoming ball) | (returning ball) |
|---|---|---|---|---|
| backspin | ss | > | topspin cs | backspin |
| backspin | ss | < | topspin cs | topspin |
| backspin | ss | = | topspin cs | dummy spin |

3.2.2 topspin against topspin

| (striking) | | | (oncoming ball) | (returning ball) |
|---|---|---|---|---|
| topspin | ss | > | topspin cs | topspin |
| topspin | ss | < | topspin cs | backspin |
| topspin | ss | = | topspin cs | dummy spin |

3.3 "Research on table tennis rotation"[9] is the first thesis in the world on the quantification of spin ability. In this thesis the TTDSSM was used. The main conclusions are as follows:

3.3.1 Comparison of spin between the Chinese youth team and the national team

3.3.1.1 For the youth team, the average spin of the high-loop and the forward loop was 126.7 c/s with maximum of 143.5 c/s; For the national team, the values were 128.4 c/s and 145.3 c/s respectively. The differences are not significant($p>0.50$).

3.3.1.2 The youth team's average and maximum spins for heavy chop were lower than national team's.

3.3.2 comparison of spins between the high loop and the forward loop

The average spin of the high loop was 127.8 c/s with a maximum of 144.8 c/s. For the forward loop, they were 134.2 c/s and 151.5 c/s respectively. The difference are very significant ($p<0.01$).

3.3.3 comparison of pips-out and pips-in rubbers, and the pen-hold and the tennis grip

3.3.3.1 For the high loop, the forward loop, heavy chop and service, pips-in rubber produces more spin than pips-out rubber.The difference is very significant($p<0.01$).

3.3.3.2 Pen-hold pips-out rackets and tennis-grip pips-out rackets produce the same spin.

3.4 Research on the spin service in the Chinese national table tennis team[7]

This paper measured service spins of 49 national team members (men and women) and 36 youth team members (men and women)

3.4.1 There was no significant difference between the men and women of the national team.

3.4.2 The spin produced by the service in the crouching position is higher than that in the normal position.

3.4.3 Pips-out rubber produces significantly higher spin than pips-in rubber in the side-backspin service($p<0.01$). For the side-topspin service, there was no significant difference between them.

3.4.4 The long service always has higher spin than the short service. We can see that the long service is best for spin.

3.4.5 Side topspin is stronger that backspin or side backspin.

## 4. In the early 1990's, the paper "Relative law of speed and rotation" [10] first revealed the relation between spin and speed; The research on a static ball developed into today's dynamic research.

4.1 Definition of "Relative law of spin and speed"

Consider a spinning ball in motion. It has a linear circumferential velocity and also a linear velocity of the motion of its center. These two velocities are addictive, and the ball may show the character of one of them if it plays a leading role. When the circumferential velocity is higher than that of the ball center, the trajectory is governed largely by spin. When it is lower, speed provides the main influence. And when the two velocities are approximately equal, the trajectory is governed by both factors.

4.2 Conclusions on dimensionless number of character(DNC)

4.2.1 The Dimensionless number of character(DNC) is the quotient of the product of rotation($kg \cdot m/s$) and product of linear inertia($kg \cdot m/s$). It is the criterion for judging the character of the ball. The formula is as follows:

$$DNC=(r \cdot w \cdot m) / (Vc \cdot m)$$

r : the radius of the ball
w : angle-speed of the ball
m : mass of the ball
Vc : linear velocity of the ball center

4.2.2 When DNC is larger than 1, linear velocity of the surface of the sphere prevails over the forward velocity, and spin becomes the main character. The more significant the difference, the more obvious is the rotation character.

4.2.3 When DNC is smaller than 1, velocity on the sphere is smaller than the forward-motion velocity. At this time, speed character prevails over the rotation character, so the speed character plays a leading role now. The more significant is the difference between the two velocities, the more obvious is the speed character.

4.2.4 When DNC is equal or approximately equal to 1, linear velocity is approximately equal to forward-motion velocity. At this time, the ball shows the characteristics of both rotation and speed at the same time.

4.2.5 Neglecting the effect of gravity, the motion of sphere consists of rotation and forward motion. It is unavoidable to use the resultant of the two velocities.

## 5. Prospects

In the past 40 years, table tennis rotation research in China has developed both from

its perception to rational, practical observation, qualitative to quantitative, and from static research to dynamic. In 80's and 90's, a break-through was achieved. We assert two main arguments namely the skill-spin constant and the Relative law of spin and speed. In the coming years, China will make great efforts to make theoretical research on table tennis synchronous with advances in science and technology. Equal attention will be paid to theoretical research and applied research on spin. Quantitative research on table tennis spin based on experiment will be emphasized. Further more, comprehensive exploration with the tool of fluid mechanics, advanced mathematics, human biomechanics, artificial intelligence and material science will be carried out. Naturally, improving the athlete's skill in taking advantage of spin during training and competition should not be ignored either.

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