A COMPARATIVE STUDY OF BALL VELOCITY WHILE PLAYING WITH DIFFERENT RACKET COVERINGS IN TABLE TENNIS

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ABSTRACT

This study aimed to analyze the ball velocity whilst playing forehand drive, forehand flick and forehand smash with two different racket coverings, i.e., inverted and short-pimpled.Ten female university-level table tennis players (20.0±3.5 years, 55.3±5.8 kg, 165.7±3.4 cm), who had sufficient game experience, were recruited for the study. Prior to data collection, it was ensured that all participants were physically fit and healthy to perform the task. Ball velocity was chosen as a kinematic variable. Two different racket coverings i.e., Inverted (without pips) and Short-pips were used while playing three different table tennis strokes i.e., forehand drive, forehand flick and forehand smash. The unit of measurement was kilometre per hour (kph). For the comparative analysis, IBM SPSS 26 software was used. The paired t-test was used as a tool to compare the findings, and the level of significance was set at 0.05.The study's result indicated that out of the three strokes, two strokes i.e., forehand drive and forehand smash showed a significant difference between playing with different racket coverings. Whereas forehand flick neither possessed a greater amount of velocity in comparison to the other two strokes, nor a significant difference was found between different racket coverings' velocity recordings.While playing forehand flick, there was no significant difference between inverted and short-pips racket coverings. However, significant differences were found while playing forehand drive and forehand smash with different racket coverings, in which short-pips racket covering possessed a higher amount of ball velocity than the inverted racket covering. This may be due to the fact that the conical pimples of the short-pips push the light table tennis ball with a greater force and hence a greater ball velocity was observed when playing with short-pips racket covering.

Keywords: *Media and Sports, Physical awareness, Mental Development, Sports Value*

INTRODUCTION: Table Tennis' origin is recognized to be traced to England in the nineteenth century's second half. The International Table Tennis Federation (ITTF) was established during the inaugural World Championship in London in 1926 (Fuchs et al., 2018; Weikert, 2017). Although there are no current data available about the number of table tennis players in the world, it was estimated in 1995 that almost 300 million individuals play table tennis worldwide (Sklorz & Michaelis, 1995), including 40 million players who compete (olympics.com). Hence, it may be concluded that this game is one of the most popular sports around the globe and this study may benefit those who want to take part in competitive table tennis.

Table tennis has evolved over time into a sport that places a greater emphasis than ever before on the development of exceptional speed, power, endurance, strength, flexibility, good reflexes, and agility. The top athletes prioritise attacking or counterattacking (Kahn et al., 2004). Physical preparation, strength training, and cutting-edge fitness training diagnostic techniques are all crucial components of today's sports training programme for table tennis (McCann & Bigliani, 1994). Table tennis coaches and trainers are using numerous training methods and equipment adjustments due to the sport's popularity and demanding nature (Mishra & Bhosle, 2022). Due to the intense competition in table tennis in modern times, players and coaches all over the world are utilising a variety of strategies, tactics, and technological advancements to improve their play and gain the upper hand over their opponents. One of them is using rackets with various rubber coverings, which can give them a range of ball-controlling techniques and shots while attacking and counterattacking. The expert's approach of valuation based on arbitrary numbers characterises the rubber racket coverings, determining the most fundamental characteristics of table tennis, the bounce and friction between the ball and the racket, and is thus historically referred to as "mystic and non-objective" (Tiefenbacher & Durey, 1994; Varenberg & Varenberg, 2014; Yamaoka, 1994).

The four types of rubber surfaces are short pips, long pips, antispin, and inverted. The term "pip" describes a raised, conical-shaped protrusion on the rubber sheet. Short pips rubber is rubber with tightly spaced, short, wide pips that face outward. This rubber is typically used for blocking and striking strokes. This kind of rubber is used by backhand players who need to improve their control over their opponents' spin. More play styles than in other racket sports are possible thanks to the variety of colours and designs available for racket coverings. Due to the vast variety of covers available, a player typically purchases the blade and rubbers separately. The rubbers are then joined using approved glues to make removal and replacement simple. All players should learn how to construct a racket, even if the majority of shops or dealers will do it for you. To boost their spin and speed, most rubber coverings have a sponge layer beneath them. The maximum thickness of the rubber and sponge is 4 millimetres (McAfee, 2009). In this study, we considered only two, among the above mentioned four, racket coverings i.e., short pips and inverted (without pips).

There is not enough information in the literature about studies of shot kinematics in table tennis, The majority of them are focused on the body's kinematics (Bańkosz & Winiarski, 2017), hence the ball velocity was considered for the study purpose.

Because of the fact that there isn't much research on female table tennis players online, this study was conducted with female players as the subjects of the study. The subjects used two distinctive table tennis racket coverings, namely Inverted and Short-Pips, to conduct three different strokes: forehand drive (FHD), forehand flick (FHF), and forehand smash (FHS), while the kinematic variable ball velocity was measured. Based on the research of Maheshwari et al., 2022, it was assumed that there would be no discernible difference in ball velocity, after the ball's contact with the racket, between playing with two different racket coverings.

Table 1. List of abbreviations

Abbreviation	**Full form**
FHD	Forehand drive
FHF	Forehand flick
FHS	Forehand smash
IV	Inverted
SP	Short-pips

MATERIALS AND METHODS:

Study participants

Ten female table tennis players (20.0±3.5 years, 55.3±5.8 kg, 165.7±3.4 cm) with an average competition experience of 3.3±2.1 years and a collegiate level volunteered to take part in the study. All the players were participants of west-zone inter-university, whereas seven of them were members of state team possessing a stable playing technique. Before the data was collected, the health and injury status of each player was evaluated to make sure they were all sufficiently fit to do the task. The participants were requested to fill out written consent forms before to the study in order to indicate their desire to participate. They were told of the study's protocols and potential results. This study was a part of Ph.d. thesis and the departmental research committee approved this study.

PROCEDURE:

Evaluation of ball velocity was measured by a Bushnell® Velocity™ radar gun, model 101911 (bushnell.com). Radar device was placed right behind the player, in the direction of outgoing stroke hit on the ball. The gun sends out a stream of radar pulses, a small proportion of which bounce off the ball and are received back at the gun. The time between pulses sent (i.e., their frequency) is known, and the time between pulses received is measured and compared with it. Because the ball is moving, the pulses bounce off it at a different frequency from the one at which they left the gun, since the distance from gun to ball changes for successive pulses. If the ball is moving towards the gun each reflected pulse sets off back towards the gun from a point nearer than the last one did, and so is closer behind the last one. Since the speed of travel of the pulses (the speed of light) is unchanged, the pulses arrive closer together than when they left, and so the received pulse frequency is higher than that transmitted, and this is how the mechanism of radar gun works to calculate the object velocity (in this case, the table tennis ball) (Figure 1). The participants were wearing half-sleeves t-shirt so that it wouldn't affect the readings of the radar gun.

Figure 1. the researcher taking a trial for the placement of speed radar gun.

Two rackets having different rubber racket coverings i.e., inverted (without pips) and short-pips were used (figure 2). All the participants were using the same table tennis rackets for the trial. Three table tennis strokes FHD, FHF and FHS were performed by the players one by one. For better results, 3 trials were given to each participant. There was 20 second rest between each trial. Average of three trials was analyzed.

Figure 2. Inverted (without pips) and Short-pips racket coverings used for the study.

All the participants were instructed about the task well in advance. Prior to the stroke-making, a 10-minute standardized warm up was given. The measurement's unit was kilometre per hour (kph). The readings were noted on the paper. A target area (55 cm x 55 cm) on the table was marked as per Drive Ability Test given by Purashwani et al., 2010 (figure 3).

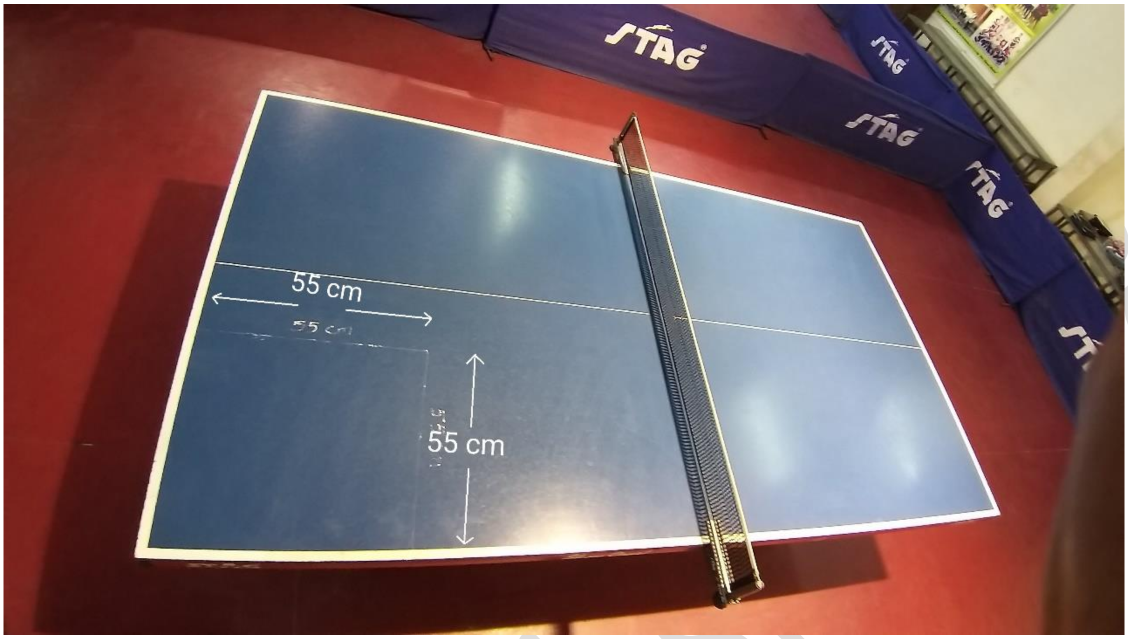

Figure 3. Target area (55 cm x 55 cm).

All players were right-handed hence the target area was drawn so that they focus on maintaining the accuracy. Strokes that made the ball go outside the table or struck to the net were not considered and the data was recorded until the successful trial. To serve the ball, a table tennis ball feeding robot was positioned in front. The idea behind utilising a ball-feeding robot was to ensure that all players received the ball at roughly the same speed and direction so that response return shots would be consistent.

Statistical analysis

The paired t-test was used as the statistical tool to compare the ball velocity difference between the different racket coverings' readings while playing different strokes i.e., FHD, FHF and FHS. Mean and standard deviation values were considered for descriptive statistics. For all the statistical calculations, the level of significance was set at 0.05. IBM SPSS Version 26 was used for all statistical analysis.

Since the Bushnell speed radar gun provides speed unit in kph without decimals, the provided values were considered for data analysis. The findings were as follows:

Table 2.1 FHD recd. Velocities **Table 2.2** FHF recd. Velocities **Table 2.3** FHS recd. velocities

Sub.	Velocity (in kph)	
	FHD_IV	FHD_SP
1.	48	53
2.	49	43
3.	47	56
4.	43	43
5.	36	52
6.	40	62
7.	38	59
8.	42	55
9.	39	41
10.	45	50

Sub.	Velocity (in kph)	
	FHF_IV	FHF_SP
1.	38	34
2.	28	29
3.	32	35
4.	37	43
5.	23	22
6.	25	26
7.	31	30
8.	24	29
9.	30	28
10.	34	33

Sub.	Velocity (in kph)	
	FHS_IV	FHS_SP
1.	78	77
2.	69	80
3.	66	69
4.	62	66
5.	62	65
6.	63	71
7.	73	85
8.	74	87
9.	68	78
10.	64	79

*recd. – Recorded, sub. – Subjects, FHD – Forehand Drive, FHF – Forehand Flick, FHS – Forehand Smash, IV- Inverted, SP – Short-pips

RESULTS:

For the statistical procedure, IBM SPSS 26 software was used to calculate the findings. The data was analyzed by using paired samples t-test as the subjects were in a single group while they were using two different racket coverings to perform the three strokes i.e., forehand drive, forehand flick and forehand smash. The analyzed findings were as follows:

Table 3.1 Descriptive statistics FHD velocity comparison.

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	FHD Inverted	42.70	10	4.473	1.415
	FHD Short-pips	51.40	10	7.137	2.257

The output for the analysis of FHD velocity is presented in Table 3.1. This table (Paired Samples Statistics) provides descriptive statistics for each measure. It appears that the mean for FHD Short-pips (51.40) is higher than the mean for FHD Inverted (42.70); as higher scores on the FHD Short-pips represent greater velocity, it appears that the short-pips racket might have produce greater velocity while playing FHD.

Table 3.2 FHD t-test results.

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference: Lower	Upper			
Pair 1	FHD Inverted - FHD Short-pips	-8.700	9.214	2.914	-15.291	-2.109	-2.986	9	.015

Table 3.2 shows the results of the t-test. The mean difference −8.700 (mean of FHD Inverted − mean of FHD Short-pips) is negative because the FHD Short-pips scores are higher than the FHD Inverted scores. The standard deviation of the differences between pairs of variables is 9.214, and the correlated difference standard error of the mean is 2.914. The value of the t statistic is −2.109; with 9 degrees of freedom (N − 1), the calculated $t_{0.05}$ at 9 df; is -2.986 which is greater than tabulated $t_{0.05}$ at 9 df; i.e., -2.262. We therefore conclude that the short-pips racket covering's velocity is found to be significantly higher in comparison to inverted racket covering's velocity while playing FHS.

Table 4.1 Descriptive statistics FHF velocity comparison.

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	FHF Inverted	30.20	10	5.245	1.659
	FHF Short-pips	30.90	10	5.744	1.816

The output for the analysis of FHF velocity is presented in Table 4.1. This table (Paired Samples Statistics) provides descriptive statistics for each measure. It appears that the mean for FHF Short-pips (30.90) is slightly higher than the mean for FHF Inverted (30.20); however slightly higher scores doesn't seem to represent greater velocity, it appears that there is no statistically significant difference between the two racket coverings while playing FHF.

Table 4.2 FHF t-test results.

Paired Samples Test

		Paired Differences							
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference: Lower	95% Confidence Interval of the Difference: Upper	t	df	Sig. (2-tailed)
Pair 1	FHF Inverted - FHF Short-pips	-.700	3.164	1.001	-2.963	1.563	-.700	9	.502

Table 4.2 shows the results of the t-test. The mean difference −.700 (mean of FHF Inverted − mean of FHF Short-pips) is negative because the FHF Short-pips scores are higher than the FHF Inverted scores. The standard deviation of the differences between pairs of variables is 3.164, and the correlated difference standard error of the mean is 1.001. The value of the t statistic is −0.700; with 9 degrees of freedom (N − 1), the calculated $t_{0.05}$ at 9 df; is -0.700 which is lesser than tabulated $t_{0.05}$ at 9 df; i.e., -2.262. We therefore conclude that there is no statistically significant difference between the velocities produced by both racket coverings i.e., IV and SP's velocities while playing FHF.

Table 5.1 Descriptive statistics FHS velocity comparison.

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	FHS Inverted	67.90	10	5.567	1.760
	FHS Short-pips	75.70	10	7.646	2.418

The output for the analysis of FHS velocity is presented in Table 5.1. This table (Paired Samples Statistics) provides descriptive statistics for each measure. It appears that the mean for FHS Short-pips (67.90) is higher than the mean for FHS Inverted (75.70); as higher scores on the FHS Short-pips represent greater velocity, it appears that the short-pips racket might have produce greater velocity while playing FHS.

Table 5.2 FHS t-test results.

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Pair 1	FHS Inverted - FHS Short-pips	-7.800	5.266	1.665	-11.567	-4.033	-4.684	9	.001

Table 5.2 shows the results of the t-test. The mean difference −7.800 (mean of FHS Inverted − mean of FHS Short-pips) is negative because the FHS Short-pips scores are higher than the FHS Inverted scores. The standard deviation of the differences between pairs of variables is 5.266, and the correlated difference standard error of the mean is 1.665. The value of the t statistic is −4.684; with 9 degrees of freedom (N − 1), the calculated $t_{0.05}$ at 9 df; is -4.684 which is greater than tabulated $t_{0.05}$ at 9 df; i.e., -2.262. We therefore conclude that the short-pips racket covering's velocity is found to be

significantly higher in comparison to inverted racket covering's velocity while playing FHS.

DISCUSSION OF FINDINGS:

Though, all necessary efforts were made to find the related literature, there still seems to be lack in the ball velocity related studies in table tennis as it was reported by Iino et al., 2008. To the best of our knowledge, no data on the ball velocity while executing forehand drive, forehand flick or forehand smash in table tennis has been reported. However, based on the current findings we may recommend few conclusions that may be beneficial for the future studies.

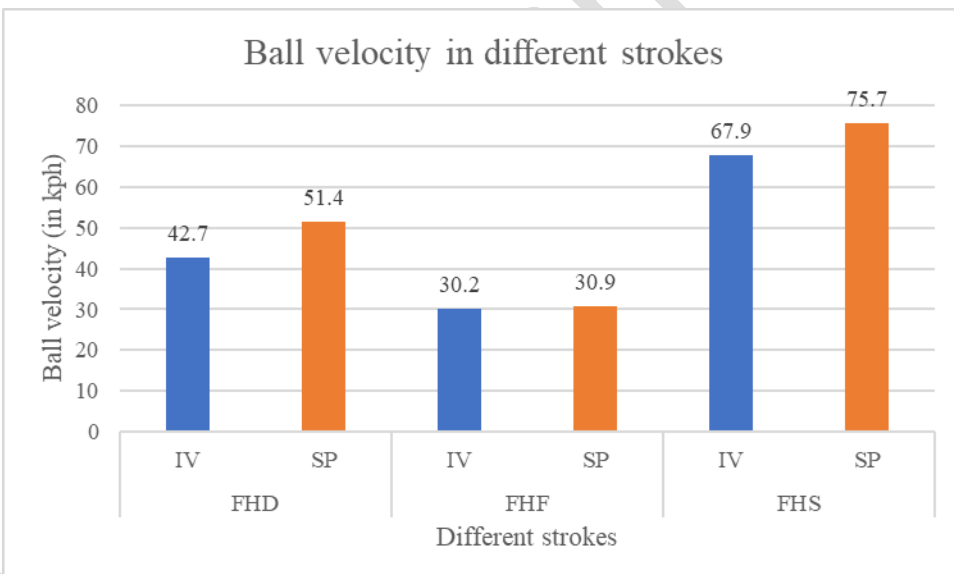

Figure 4. Ball velocity recorded while performing different strokes graphical presentation.

*IV – Inverted (in blue), SP – Short-pips (in orange)

The findings of the study shown that there was significant difference in ball velocity while playing forehand drive. Once the players begin consistently hitting forehand drives, they sprint off their drive in a ballistic manner. Professional players reportedly use highly reliable forehand drives under normal circumstances (Bootsma & van Wieringen, 1988). Thus, a higher ball velocity while playing FHD, in comparison to FHF, was observed.

The findings of the study shown that there was significant difference in ball velocity while playing forehand smash as well. Salim, 2008 and Ninglan et al., 2019 reported that table tennis players need strong arm muscles that are supported by the length of their arms to be able to receive and move towards the arrival of the ball because smashes, also known as killer punches, are fast forehand drives that include bats hitting the ball with an upward motion. Hence the higher velocities produced by participants while playing FHS, in comparison to other two strokes FHD and FHF, is justified.

The inverted racket covering's ability to produce more ball spin than the pimpled racket covering is mechanically explained by the larger ball contact. Thus, offensive players employ inverted racket covering, whilst defensive players use pimpled racket covering (Varenberg & Varenberg, 2014). Greater power is needed to control the spin of the ball in order to strike the target area designated on the table because the IV racket covering imparts greater spin to the ball. According to some authors, offensive strokes (such as top spin and smash) require more physical effort on the body than defensive strokes (i.e., controlling spin) (Kasai et al., 1994). These factors may be attributed to the fact why the ball velocity was found to be higher in number when played with SP racket covering while playing FHD and FHS.

As regard to FHF, when the opposition ball is sliced, the forehand flick, which creates spin in the ball, is typically utilised to launch the opening attack (Le Mansec et al., 2017). Hence this stroke requires more spin than the power, and this may be the reason of less ball velocity, in comparison to FHD and FHS, being observed while playing FHF.

CONCLUSIONS AND RECOMMENDATIONS:

The visible results and graphical presentation of the findings show that out of the three strokes played with two distinct racket coverings, only one of them did not show a significant difference in ball velocity recordings i.e., FHF and this may be attributed to the fact that this stroke requires more spin than power, and hence neither it possessed greater ball velocity in comparison to FHD and FHS nor it shown any significant difference between ball velocity while playing with different racket coverings.

The other two strokes i.e., FHD and FHS shown a higher amount of ball velocity in comparison to FHF. This may be due to the fact that both these strokes are offensive strokes and require a great amount of power to hit the ball in the target area resulting it in a greater amount of ball velocity recording. However, there was a significant difference found while playing with different racket coverings; the SP racket covering possessed a higher amount of ball velocity than that of IV racket covering. This may be due to the fact that the conical pimples of the SP push the light table tennis ball with a greater force and hence a greater ball velocity is observed when playing with SP racket covering.

This study was conducted on female athletes. The researchers suggest further studies on male athletes as well, in which more offensive and defensive strokes may be evaluated on the basis of other kinematic variables such as power, muscle activation and angular kinematics.

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