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Selected Biomechanical Variables and Their Relationship with the Accuracy Index of the Forehand Topspin Stroke Among Table Tennis Players of Khanaqin Sports Club

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Abstract: *Table tennis is considered one of the sports with high physical demands, requiring a set of precise motor skills such as speed, strength, and accuracy to execute movements proficiently. Among the most prominent skills that a player needs to master in this game are the forehand and backhand spin shots, which require a high level of coordination among various biomechanical forces that control the player's motor performance. Problem of the Study: The main scientific problem is that traditional tests used to measure the accuracy of spin shots often rely solely on analyzing the ball's landing area, without considering the time taken to execute the shot, even though time is a critical factor that can directly affect the effectiveness and accuracy of performance. Hence, there is a need to adopt a new research perspective that considers the integration of racket angle, shot execution time, and ball trajectory as a methodological approach to developing more accurate and objective assessment tools. The researcher have adopted biomechanics as a means to achieve the following objectives: 1. To determine the accuracy index of forehand and backhand spin shots for players from Khanqin Sports Club in table tennis. 2. To explore the relationship between some biomechanical variables (racket angle and ball launch speed) and the accuracy index of forehand and backhand spin shots, aiming to identify how these variables affect performance. Hypothesis of the Study: There is a statistically significant relationship between some biomechanical variables (racket angle and ball launch speed) and the accuracy index of forehand spin shots for players from Khanqin Sports Club in table tennis. This chapter includes the methodology used by the researcher. The researcher employed various means and tools to collect information and samples, defined as "a set of units or observations taken from the research community through different methods known as sampling methods. Accordingly, the research sample included (75) observations divided among (5) players, with (15) observations taken from each player to select some biomechanical variables. Chapter Four. The results obtained through statistical treatments were presented and compared with the corresponding tabulated values. The results were then analyzed and discussed according to scientific sources, both Arabic and foreign. The researchers found significant and non-significant relationships among the studied research variables. 1.Slightly reduce ball speed when attempting to achieve higher accuracy. 2. Use a slightly larger racket angle (less acute) to improve control over the ball. If you need any further assistance or modifications, feel free to ask*

Keywords: *Biomechanics the Forehand Topspin Stroke Accuracy*

Introduction

Table tennis is regarded as one of the sports that demand high levels of physical and motor capabilities. It requires a combination of fine motor skills such as speed, power, and precision to execute movements with technical accuracy. Among the most essential skills that players must master in this sport are the forehand and backhand topspin strokes, which necessitate a high degree of coordination among various biomechanical forces that govern motor performance. Consequently, table tennis is a sport that demands continuous training and meticulous monitoring of performance in order to enhance skill execution and achieve optimal results.

It is also noted that table tennis differs significantly from many other team sports, as it primarily relies on high-speed execution, precise timing, and the application of force to perform strokes effectively. Achieving such timing and precision requires optimal synchronization among various biomechanical components. A lack of coordination between speed and force may lead to a noticeable decline in performance accuracy. Therefore, enhancing the precision of topspin strokes is considered a fundamental aspect of training table tennis players, particularly when investigating the relationship between key biomechanical variables such as angle, velocity, and timing.

The significance of this study lies in examining the relationship between selected biomechanical variables—such as the ball launch angle and ball launch velocity, defined as the time rate over the distance traveled (Omar, 2023:72)—and their impact on the accuracy of topspin stroke performance. The research also aims to develop new scientific approaches for measuring stroke accuracy, moving beyond traditional metrics such as ball landing distance to include the time taken during the stroke execution. Through this approach, the study seeks to establish a more precise and comprehensive methodology for evaluating player performance and analyzing the key factors that contribute to improving stroke accuracy.

The importance of the current lies in examining the relationship between selected biomechanical variables—such as the ball launch angle and ball launch velocity, defined as the time rate over the distance traveled (Omar, 2023:72)—and their influence on the accuracy of topspin stroke performance. The study also aims to develop novel scientific methods for measuring stroke accuracy, moving beyond traditional metrics that focus solely on ball landing distance to include the time duration of the stroke itself. Through this approach, the research seeks to establish a more precise and comprehensive methodology for evaluating player performance and analyzing the key factors that contribute to enhancing stroke accuracy.

Problem of the Study

Table tennis is a highly accurate and technically complex sport that relies heavily on a range of biomechanical factors influencing the quality and accuracy of performance—particularly during the execution of forehand topspin strokes. Despite the critical importance of these factors, many players at Khanaqin Sports Club lack a deep understanding of the motor variables that contribute to improving stroke accuracy. This deficiency negatively affects their technical execution and competitive performance.

A review of previous studies reveals a clear gap in applied research addressing the relationship between specific biomechanical variables—such as racket inclination angle and ball launch velocity—and the accuracy of forehand topspin strokes. This gap is particularly evident within the local training and field environment of Khanaqin Sports Club.

The central scientific problem lies in the limitations of conventional tests used to assess the accuracy of topspin strokes, which typically focus solely on analyzing the ball's landing zone without accounting for the time required to execute the stroke. However, time is a critical factor that can directly influence both the effectiveness and precision of performance. This highlights the need for a new research perspective that considers the integration of racket angle, stroke execution time, and ball trajectory as a methodological framework for developing more accurate and objective evaluation tools. Accordingly, this study aims to analyze these variables and determine their impact on the accuracy index of forehand topspin strokes, thereby contributing to the enhancement of training and assessment methods and improving the performance efficiency of players at Khanaqin Sports Club.

Aims of the Study:

The study aims at:

1. Measurement and Analysis of Selected Biomechanical Variables (Racket Angle and Ball Launch Velocity) During the execution of Forehand Topspin Strokes by table tennis players at Khanaqin Sports Club.
2. Assessment of the accuracy index of Forehand Topspin Strokes among Table Tennis Players at Khanaqin Sports Club.
3. Investigating the relationship between selected biomechanical variables (Racket angle and ball launch velocity) and the accuracy index of Forehand Topspin Strokes, aiming to determine how these variables influence performance.

Hypothesis of the Study:

There is a statistically significant relationship between selected biomechanical variables (racket angle and ball launch velocity) and the accuracy index of forehand topspin strokes among table tennis players at Khanaqin Sports Club.

a. **Domains of the Study**
b. **Human Domain:** Table tennis players affiliated with Khanaqin Sports Club.
c. **Spatial Domain:** The table tennis hall at Khanaqin Sports Club.
d. **Temporal Domain:** From June 8th, 2025, to August 1st, 2025.

Methodology

The researcher employed the descriptive method using a correlational approach, as this study focuses on identifying relationships between two or more variables and expressing the degree of association numerically (Shouk & Al-Kubaisi, 20040:57). This approach is deemed most appropriate for examining the relationship between biomechanical variables—such as angle, velocity, and time—and the accuracy level of forehand topspin stroke performance. The methodology relies on collecting performance-related data and analyzing it to reach precise scientific conclusions. Research methodologies serve to clarify the scientific procedures adopted by the researcher, as the scientific method is defined as "a systematic approach to thinking and working, used by the researcher to organize, analyze, and present ideas, ultimately leading to reasonable conclusions and factual insights about the phenomenon under investigation" (Alyan et al., 2000:53).

Community and Sample of the Study:

A. Community of the Study:

The community of the study encompasses all individuals, subjects, or entities that represent the focus of the research problem (Obaidan et al., 1982:105). Accordingly, the researcher identified the population as table tennis players affiliated with Khanaqin Sports Club.

B. Sample of the Study:

The sample is defined as "a group of units or observations selected from the study community using various sampling methods" (Radwan, Mohamed Nasr El-Din, 1988:48). Based on this definition, the research sample consisted of (75) observations distributed across (5) players, with (15) observations collected from each player. Due to the specific nature and requirements of the study, the sample was selected using a deliberate sampling method. In purposive sampling, selection is made freely by the researcher based on the characteristics of the study, ensuring that the sample aligns with the research objectives (Qandilji, Amer Ibrahim, 1999:147).

Data Collection Means

1. Arabic and International Sources.
2. Data Recording Form.
3. Statistical Means.
4. Supporting Team of the study.

Tools and Equipment Used in the Study

This refers to the means or methods through which the researcher seeks to solve the research problem, regardless of whether these involve tools, data, samples, or devices (Mahjoub & Wajih, 2000:163). Ensuring the availability and proper use of these instruments is essential for completing the experiment and achieving the research objectives. To address the research problem and fulfill its aims, the researcher employed the following supporting tools and equipment:

A. Equipment Used in the Study

i. **Ball Launcher Machine**.

ii. **High-Speed Video Cameras (3 units):** Employed to record and analyze players' performance during the execution of forehand topspin strokes, to record and analysis the performance while implementing the forehand topspin stroke.

B. Tools Used in the Research

i. Official table (Stiga type)

ii. Table tennis balls (60 units)

iii. Table tennis rackets (5 units)

iv. Stopwatch

Field Procedures

Identification of Study Variables

Through the researcher's review of numerous scientific sources, references, theses, and dissertations that addressed motor skills in general and the forehand topspin stroke in particular, certain biomechanical variables were selected. The variables identified were ball launch velocity and ball launch angle during the forehand topspin stroke, as this stroke is considered one of the most influential offensive techniques in the sport of table tennis (Faraj & Fikri, 2006:150).

Biomechanical Variables

Ball Launch Velocity: Ball launch velocity was calculated using a high-speed camera with a frame rate of 240 FPS (frames per second), by measuring a distance of 1 meter for all players, starting from the moment of impact until the ball covered the 1-meter distance, based on the scale diagram. The time was determined from the recorded duration required to cover this distance, and the velocity was calculated using the formula: V = D / T (Jasim & Fayadh, 2010:15) Where: Time = Frame Number / Camera Frame Rate (Omar, 2021:91) V = 1 / 240 = 0.0042 As shown in photo (1)

Photo (1)

Racket Angle: It is the angle between the racket surface and the table line, as illustrated in photos (2 and 3).

Photo (2)

Photo (3)

Tests of the Study

a. **Forehand Topspin Stroke Accuracy Test with the front side of the of the racket response to the slice skill.** (Ibrahim, Mohamed Ahmed Abdullah, 2007:319)

Objective of the Test: To measure the speed and accuracy of the forehand topspin stroke in response to the slice skill.

Tools used: Ball launcher device, adhesive tape, table tennis table divided as shown in the diagram, 60 table tennis balls.

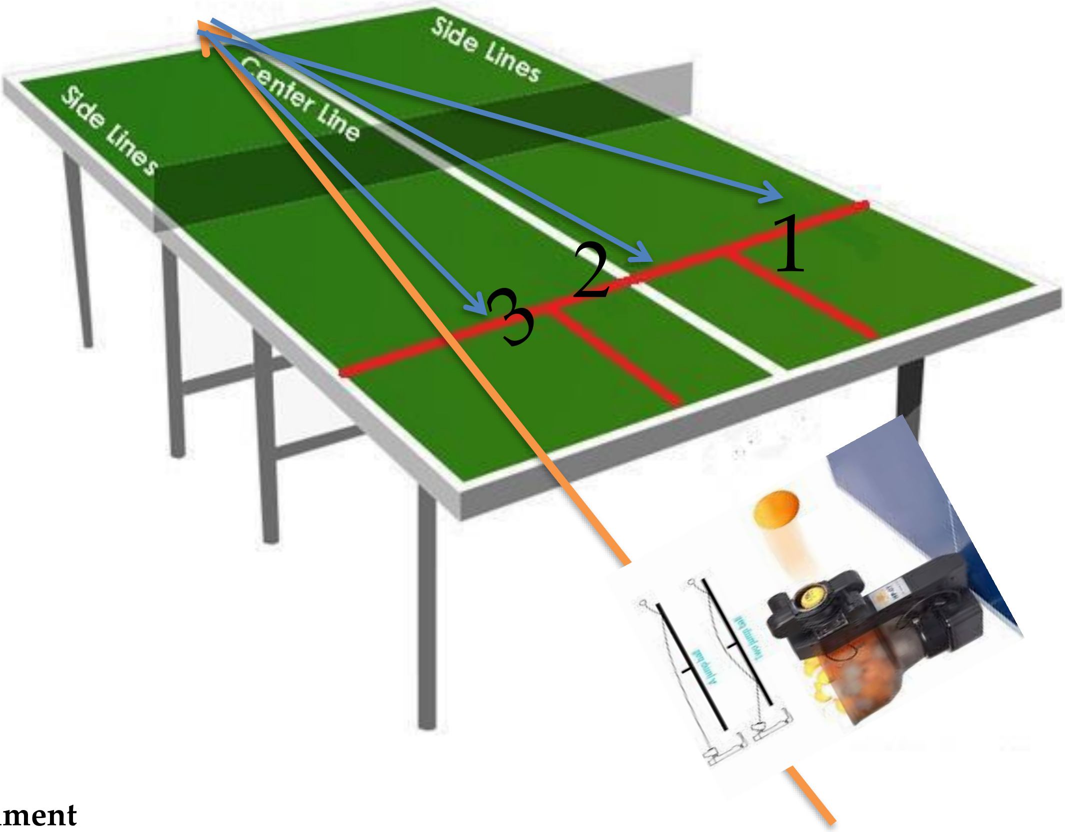
Performance Procedure: The tester stands in the ready position. The ball launcher is set to shoot (15) slice table tennis balls within 15 seconds toward the right side of the table. The tester returns the balls using a forehand topspin stroke, directing the ball as follows: Sequentially:

- 5 balls to zone (1)
- 5 balls to zone (2)
- 5 balls to zone (3)

Scoring: The tester receives two points when the ball lands in the intended zone in sequential order (1–2–3).

- One point is awarded if the ball lands anywhere else on the table.
- No points are awarded if the ball goes off the table.
- The tester’s total score is calculated based on the sum of points from all 15 balls, as shown in figure (1).

Figure (1)



Pilot Experiment

A pilot experiment was conducted on one table tennis player on 10th of July 2025 for the following purposes:

- To ensure the suitability of the filming location.
- To calibrate and adjust the camera used.
- To determine and fix the appropriate distance for the cameras.
- To identify potential issues during filming and prevent any errors.
- To prepare the hall and position the cameras at suitable angles for recording performance.
- To conduct preliminary training for the players before starting the tests to ensure natural performance.

Main Experiment

The main experiment was conducted following the pilot experiment on 11th of July 2025.

Statistical Methods

The Statistical Package for the Social Sciences (SPSS) will be used to analyze the data, including the following methods:

1. **Pearson Correlation Coefficient:** To measure the relationship between biomechanical variables and performance accuracy.
2. **Paired Samples T-Test:** To compare players' performance under different conditions.

Result and Discussion

This chapter presents an analytical overview of the research findings and their discussion, as derived by the researcher through the analysis of selected biomechanical variables and their relationship with the accuracy index of the forehand topspin stroke among table tennis players at Khanaqin Sports Club. The results were presented in tabular form, as this reduces the likelihood of error in subsequent research stages, strengthens scientific evidence, and enhances its validity (Shtemler, 1973:35).

Presentation of Descriptive Values for Independent and Dependent Variables of the Study Sample

Table (1) Presentation of Descriptive Values for Independent and Dependent Variables of the Study Sample

Variable	N	(Min)	Max)	(Mean)	(Std.Dviation)	Skewness	Kurtosis
Accuracy index (mark)	75	0.000	2.00	1.1867	0.816	-0.360	-1.410
Racket angle (mark)	75	33.00	40.60	36.982	1.660	-0.468	-0.419
Velocity Launch of the ball (m\s)	75	34.00	42.00	37.986	2.030	0.357	-1.134

Presentation of Descriptive Values for Independent and Dependent Variables of the Study Sample

Based on Table (1), the studied research variables—namely the accuracy index, racket angle, and ball launch velocity—achieved descriptive values represented by maximum and minimum scores. The accuracy index variable had a minimum value of (0), a maximum value of (2), a mean of (1.1867), a standard deviation of (0.816), a skewness coefficient of (-0.360), and a kurtosis of (-1.410), indicating variation in stroke accuracy among players. The racket angle variable had a minimum value of (33.00), a maximum value of (40.60), a mean of (36.982), a standard deviation of (1.660), a skewness coefficient of (-0.468), and a kurtosis of (-0.419), reflecting differences in stroke style. Ball launch velocity had a minimum value of (34.00), a maximum value of (42.00), a mean of (37.986), a standard deviation of (2.030), a skewness coefficient of (0.357), and a kurtosis of (-1.134). This indicates that the distribution of the three variables is not ideal, as the values tend to be negatively skewed (less than 0) for the accuracy index and racket angle, while ball velocity shows a slight positive skew.

Presentation, Analysis, and Discussion of the Correlation Matrix Results Between Selected Biomechanical Variables and the Accuracy Index

Presentation and Analysis of the Correlation Matrix Results Between Selected Biomechanical Variables and the Accuracy Index

Table (2). Presents the correlation matrix between the study variables.

Variables	Velocity Launch of the ball	Racket angle	Accuracy index

Velocity Launch of the ball	1.000	-0.905**	-0.968**
Racket angle	-0.905**	1.000	0.922**
Accuracy index	-0.968**	0.922**	1.000

Statistically significant level p<0.01

Table (2) shows a very strong negative correlation between the accuracy index and ball launch velocity (−0.968), indicating that as ball speed increases, stroke accuracy decreases. The researcher explains that this correlation reflects a natural principle: the higher the speed, the lower the accuracy. There is a known relationship between speed and accuracy, whereby skills classified as speed-based prioritize training for velocity at the expense of precision. Conversely, accuracy-based skills emphasize precision in training, often at the expense of speed (Sabr, 2012:61). In the same table, a strong positive correlation appeared between the accuracy index and racket angle (0.922), indicating that increasing the racket angle may improve accuracy.

The researcher attributes this high correlation to the trajectory of the ball being directed at an appropriate angle to achieve the primary goal of the forehand topspin stroke, which is speed and accuracy. The emergence of this relationship is also due to the experience and practice duration of the research sample, which enabled this variable to fulfill the mechanical objective of the skill. It represents the actual path taken by the racket after launch, considering that the launch point is above ground level. This allows the ball to be struck at a suitable angle above the net, landing in an appropriate location according to the player's perception and experience. This is what made this variable highly correlated with the accuracy index, as noted by Elian and Wadie Faraj, who stated that the correct height for striking the ball is the point at which the racket surface meets the ball (Faraj, 2007:123). As for the relationship between racket angle and ball launch velocity, a strong negative correlation was observed (−0.905), indicating that an increase in velocity corresponds to a lower racket angle.

Presentation of the results of multiple correlation coefficient and coefficient of determination among the accuracy Index, motor transfer, and the biomechanical Variables under study, and their discussion

Table (3) Presents the multiple correlation coefficient, contribution ratio, and standard error of estimation between the variables under study.

R	R2	Corrected R2	Standard error of estimation
0.974 **Accuracy**	0.949	0.947	0.187

Based on Table (3), the multiple correlation coefficient between the accuracy index and the biomechanical variables reached (0.949), with a coefficient of determination of (0.947) and a standard error of estimation of (0.187). The researcher attributes the high correlation value and significant contribution ratio to the fact that the combined effect of racket angle and ball launch velocity was achieved through the actual trajectories of these components in a correct sequence, with the research sample adopting optimal positions and the required racket angle to direct the ball toward the appropriate location in the opponent's court. Thus, these variables collectively—racket angle and ball launch velocity—proved to be effective and influential in achieving the required accuracy, in accordance with appropriate performance and timing. That is, the more fluid and sequential the motor transfer is along the movement path and racket angle at the moment of ball contact, the greater the opportunity to generate higher ball launch velocity with a wider launch angle, resulting in precise ball placement. These are mechanical facts that cannot be disputed.

Presentation, analysis, and discussion of the results of variance analysis for multiple regression of the variables under study

Table (4) Presents the results of the regression variance analysis to examine the degree of model fit for integrated simple model combining variables under study.

Source	SS	df	MS	Calculated F	Sig*
Regression	46.860 in between	2	23.430	667.621	000
Error	2.527within	72	0.035		
Total	49.387	74			

***Significant (α) (0.05), if less than (0.05)**

Table (4) shows the values of the sum of squares between groups and within groups, which were (46.860) and (2.527), respectively. The degrees of freedom were (2) and (72), and the mean squares were (233.430) and (0.035) for between and within groups, respectively. The calculated F-value was (667.621) with a significance level of (0.000), which is statistically significant at the adopted level (0.05).

This indicates, based on the significance level of the F-test, that the integrated linear regression model achieved a high level of fit in light of the adopted significance level (0.05). In other words, the relationship between the accuracy index and the biomechanical variables is acceptable, and the integrated linear regression model demonstrates a high degree of precision or reliability. The F-value reflects the proportion of variance explained by the integrated linear regression model.

Results of Simple Linear Regression Between Biomechanical Variables and the Accuracy Index in the Test, Including Standard Errors, Actual Significance Levels, and Significance of Differences.

Table (5) Presents results of simple linear regression between biomechanical variables and the accuracy index in the test, including standard errors, actual significance levels, and significance of differences

Variable	Non-standard "B" coefficient	Standard error	Standard "Beta" coefficient	T	Sig*
(Stable)	7.882	2.045	-	3.854	0.000
Velocity Launch of the ball	-0.297	0.025	-0.739	11.812	0.000
Racket angle	49.387	0.031	0.253	4.044	0.000
***Significant (α) ≤ (0.05)**					

Based on Table (5), the intercept showed an effect value of (7.782) with a standard error of (2.045). The calculated T-value for the constant was (3.854) with a significance level of (0.000). As for the ball launch velocity variable, the effect value was (0.297) with a standard error of (0.025), and the calculated T-value was (−11.812) with a significance level of (0.000). For the racket angle variable, the effect value was (0.124) with a standard error of (0.031), and the calculated T-value was (4.044) with a significance level of (0.000).

Discussion of simple linear regression results for motor transfer, biomechanical variables, and the accuracy index in the test, including standard errors, actual significance levels, and significance of differences

Table (5) shows the value of the intercept in the relationship between biomechanical variables and the accuracy index, which reached (7.782) with a standard error of (2.045). The calculated t-value for the constant was (3.854) with an actual significance level of (0.000), indicating statistical significance at the adopted level (0.05). The review of the simple linear regression model results reveals a high intercept value, which indicates the significant influence of other unseen factors on the accuracy index. The intercept reflects the impact of unspecified variables on accuracy, rather than being solely attributed to the biomechanical variables under study. As for ball launch velocity, its effect was (−0.297) with a sharp error level, meaning it is statistically acceptable at the recorded error level of (0.025). This indicates a substantial negative effect: for every 1 m/s increase in ball velocity, the accuracy index decreases by (0.297).

Table (5) explains the effect value of the racket angle, which was (0.124) with a standard error of (0.031). The calculated T- value for the racket angle was (4.044), with an actual significance level of (0.000), indicating statistical significance at the adopted level (0.05). The results clearly demonstrate the significance of the slope value for the racket angle, confirming its important influence on the accuracy index. A one-unit change in the standardized scale of the racket angle variable leads to a corresponding change of (0.124) in the accuracy index. This reflects the critical role of racket angle in determining the accuracy of straight serves among the research sample. The emergence of this relationship is attributed to the experience and practice duration of the participants, which made this variable effective in achieving the mechanical objective of the skill.

The racket angle represents the actual trajectory taken by the racket after ball contact, which is directly linked to high launch velocity. This connection explains the strong correlation between racket angle and the accuracy variable.

Conclusion

In light of the results presented in Chapter Four, the researcher reached the following conclusions:

1. Racket angle and ball velocity have a statistically significant effect on stroke accuracy, with ball velocity exerting the stronger influence.
2. An increase in ball velocity leads to a noticeable decrease in accuracy, highlighting the importance of controlling stroke speed.
3. A more open (larger) racket angle may slightly reduce accuracy, which necessitates careful adjustment during strokes.

Recommendations

1. Slightly reduce ball velocity when aiming for higher accuracy.
2. Use a slightly larger (less sharp) racket angle to improve ball control.
3. Enhance motor ability to regulate the relationship between speed and angle.
4. Coaches should be well-versed in the principles of biomechanics and movement analysis, along with other scientific disciplines, to ensure proper training based on sound scientific foundations and accurate information.

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