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Original Scientific Article

Self-Confidence and Cognitive Speed: Key Predictors of Topspin Accuracy in Competitive Table Tennis

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Abstract

Background. Table tennis players often use topspin shots in order to score. For many athletes, this stroke is crucial to winning, making it a favorite among players. It is more probable that accurate topspin strokes will make it harder for opponents to return the ball. As a result, players who can maintain topspin stroke accuracy over time are more likely to win matches.

Objectives. This study aimed to examine the association between self-confidence (SC) and cognitive processing speed (CPS) with topspin accuracy (TPA) in table tennis.

Materials and methods. This study used a correlation method with a quantitative approach. A total of 82 participants (aged: 20.0 ± 0.6 years) were involved in this study. Data on topspin accuracy was collected by administering a topspin accuracy test, followed by administering a self-confidence questionnaire and cognitive processing speed test. Pearson correlation and linear regression analysis were used to determine the association between the variables.

Results. The findings of this study show (1) a positive relationship between self-confidence and topspin accuracy ($r = 0.430$, $p < 0.05$); (2) a positive relationship between cognitive processing speed and topspin accuracy ($r = 0.374$, $p < 0.05$).

Conclusions. Topspin accuracy is influenced by cognitive processing speed and self-confidence. Therefore, in order to improve table tennis topspin performance, coaches should take these factors into account. The results of this study can have a significant impact on training programs, where mental skills training, such as boosting self-confidence and enhancing cognitive processing speed, should be integrated into technical and tactical training routines. This approach will allow athletes to not only refine their physical skills but also strengthen their psychological resilience, ultimately leading to better performance in competitive matches.

Keywords: intelligence capability, emotion state, cognitive response, stroke precision, accuracy in racket sport.

Introduction

It has long been known that table tennis is a sport that emphasizes quick reflexes, accuracy, and strategic gameplay (Huang et al., 2023). Table tennis stands out as a fast-paced sport demanding exceptional speed and precision. This dynamic requires athletes to swiftly process visual and spatial information, ensuring swift and accurate responses during gameplay. Understanding the nuanced interplay between physical agility and cognitive acuity in table tennis is essential for optimizing training methodologies and enhancing competitive performance (Zhang, 2022). Precision in executing targeted hitting techniques allows athletes to strategically position the ball in challenging

areas for their opponents, thereby optimizing scoring opportunities. In sports, precision serves as a fundamental determinant that significantly influences competitive results, highlighting its critical role in enhancing performance outcomes (Amaro et al., 2022; Özdalyan et al., 2022). In the increasingly competitive landscape of table tennis, the ability to achieve precise shot execution, notably in topspin shots, is recognized as pivotal for determining competitive outcomes. This underscores the significance of accuracy in technique as a decisive element in achieving success in high-level competition (Iordan et al., 2021). The topspin technique, which imparts forward rotation to the ball, enhances players' ability to control both the speed and trajectory of their shots, thereby presenting added challenges for opponents in returning these balls (Kidokoro et al., 2022). Accurate topspin execution plays a pivotal role in table tennis, allowing players to finely control the ball and dictate the pace of the game. The ability to consistently deliver precise topspin strokes frequently dictates match outcomes, especially in competitive settings (Firdaus & Mario, 2022). Moreover, athletes who demonstrate high accuracy in their performance are more likely to achieve victory compared to those with lower levels of accuracy (Karišik et al., 2018).

Self-confidence in sports has garnered significant attention from researchers due to its crucial role in athlete performance. A study in martial arts explain that female athletes demonstrated greater self-confidence than male athletes. Moreover, younger athletes exhibited higher levels of cognitive anxiety compared to adult athletes. These results highlight gender and age as notable factors influencing psychological traits in athletes (Contessoto et al., 2020). In addition, athletes who accumulate more playing experience and invest greater time in training tend to demonstrate heightened levels of self-confidence. This observation underscores the importance of extensive experience and dedicated training regimens in fostering athletes' belief in their abilities, thereby enhancing their overall performance readiness and competitive outcomes. These insights underscore the significance of structured training programs and sustained participation in competitive settings as key contributors to athletes' psychological preparedness and confidence levels (Neves et al., 2022). A descriptive study identified that male swimmers exhibit higher levels of self-confidence and lower levels of anxiety compared to their female counterparts. Moreover, varying levels of self-confidence and types of anxiety are observed across different competitive specialties and ranks of competitions. This study also highlights gender differences and the nuanced psychological dynamics influenced by competitive contexts within swimming disciplines (Silva et al., 2019; Peron & Elsner, 2020). Furthermore, Para-athletes who possess emotional stability, cognitive flexibility, mental endurance, self-confidence, effective stress management, and emotional control tend to achieve greater success in sports. These attributes play crucial roles in navigating the challenges of competitive environments and optimizing performance outcomes in para-sport disciplines (Ersöz & Esen, 2023). The study reveals a significant correlation between physical appearance and self-confidence. Therefore, it is recommended that women be encouraged to engage in sports activities, as this can enhance their physical strength and bolster their self-confidence. Promoting active participation in sports can be a vital strategy for improving women's overall well-being and self-assurance (Basaran, 2022).

Cognitive processing speed is pivotal in sports performance, particularly in conjunction with accuracy. Research indicates that extended cognitive exertion during physical activity can compromise decision-making by lengthening reaction times and increasing variability, albeit without impacting accuracy (Tsukamoto et al., 2022).

Furthermore, studies investigating the speed-accuracy trade-off in cognitive tasks indicate that distinct neurocognitive systems are engaged in processing speed and accuracy independently. Research shows varying neural activities in the supplementary motor area and prefrontal cortex, reflecting individual preferences and abilities toward either speed or accuracy (Perri et al., 2014). Moreover, technological advancements such as the COGNIFOOT system enable objective, real-time assessments of cognitive-motor performance in sports. This system has demonstrated age-related enhancements in passing accuracy, speed, and reaction times among young elite soccer players (Hicheur et al., 2017). A recent study demonstrates that cognitive processing speed profoundly influences accuracy in cognitive tasks throughout the lifespan. This correlation suggests potential implications for sports performance, prompting a need for further investigation in this area (Bonnechère, 2022). The cognitive processing efficiency theory posits that in team sports, elevated cognitive anxiety and mental exertion are associated with performance outcomes, particularly noticeable in highly trait-anxious players during critical game moments (Smith et al., 2010).

Previous studies investigating hitting accuracy in table tennis have highlighted the significant impact of kinematic variables such as shoulder angular velocity, wrist angle, and racket horizontal velocity on topspin forehand accuracy. These findings underscore the complex biomechanical factors influencing shot precision (Alkhawaldeh, 2022). The precision with which an athlete directs the ball to a specific target area is influenced by both the athlete's skill level and the skill level of the opponent (Le Mansec et al., 2016). Furthermore, speed and accuracy in performance are influenced by an individual's cognitive function, which can be impacted by both physical and mental fatigue (Mikicin, 2022; Le Mansec et al., 2018). A study from Niźnikowski et al. (2022) involving novice table tennis players, indicated that those who focused on targeting the ball during their shots showed significantly greater improvements in hitting accuracy compared to those instructed to focus on correcting their grip. Shot accuracy in table tennis varies depending on the type of stroke used, exhibiting distinct differences in shot characteristics among female players. This underscores the need for a nuanced approach to analyze and enhance performance outcomes tailored to different player demographics (Wang et al., 2022). High accuracy in ball placement and the speed-ball placement index underscores the importance of precise control over the landing position of the ball on the table for successful shots in table tennis. Interestingly, shot accuracy is not solely contingent upon ball speed, highlighting the significant roles played by factors such as timing, angle, and spin in determining shot effectiveness (Belli et al., 2019). Moreover, an experimental study aimed at enhancing topspin shot accuracy involved providing elastic bands as a treatment to 12 table tennis players. The results of this study demonstrated a significant

improvement in topspin accuracy compared to players who did not receive elastic band training, attributed to enhanced muscle coordination and physical control abilities (Nikolakakis et al., 2020). Consistent with the previous statement, the velocity of the wrist joint during ball impact directly influences both the speed and rotation of the ball (Zheng et al., 2021). Both mental and muscular fatigue contribute to a decrease in the quality of players' strokes during competition (Le Mansec et al., 2017).

While many studies have explored physical factors influencing athletic performance across sports, there is a significant gap in understanding correlation between self-confidence and cognitive processing speed with top spin stroke in table tennis. Topspin accuracy is crucial for precise ball control and game tempo regulation in table tennis. However, the psychological aspects such as self-confidence and cognitive processing speed impact for topspin accuracy remains unclear. This study aims to address this gap by investigating the association between self-confidence, cognitive processing speed and top spin stroke accuracy. By examining how these factors contribute to the precision and consistency of topspin strokes, the research seeks to inform more effective athlete training programs and advance knowledge in sports science literature.

Materials and Methods

Study Design and Participant

In this study, a quantitative correlational research design was utilized to investigate the relationship between upper relationship between self-confidence, cognitive processing speed and topspin accuracy and topspin accuracy in table tennis. The sample consisted of 82 students from the coaching department at the Faculty of Sports Science, Universitas Negeri Padang, Indonesia. These students were divided into two classes of Table Tennis II courses, with 55 males and 27 females, aged between 19 and 21 years. Participation in Table Tennis II required prior completion of the Table Tennis I course, ensuring that students had already mastered the proper topspin technique. Detailed characteristics of the participants are provided in Table 1.

Table 1. Descriptive characteristics for the total sample and separately for male and female participants. Values are mean ± standard deviation

Indicators	Total Sample (n = 82)	Female participants (n = 27)	Male participants (n = 55)
Age (years)	20.0 ± 0.6	20.0 ± 0.6	20.0 ± 0.5
Height (cm)**	159.4 ± 4.1	157.4 ± 4.5	160.4 ± 3.5
Body weight (kg)**	55.2 ± 4.4	52.1 ± 3.7	56.7 ± 3.9
BMI (kg/m^2)*	21.7 ± 1.8	21.1 ± 1.3	22.1 ± 1.9
Training experience (years)*	3.4 ± 1.2	2.9 ± 1.3	3.6 ± 1.1
Self-confidence (points)	97.6 ± 7.7	95.9 ± 7.6	98.5 ± 7.7
Cognitive processing speed (points)	31.9 ± 6.3	33.3 ± 5.7	31.2 ± 6.5
Topspin accuracy (points)	18.8 ± 3.4	18.8 ± 4.0	18.8 ± 3.1

** sig. sex difference, $p < 0.01$; * sig. sex difference, $p < 0.05$

Instrument

Self-confidence

The questionnaire used in this study is designed to assess the self-confidence levels of table tennis players. It consists of 7 items originally developed by Ibrahim et al., (2016) and subsequently refined by Yuda et al. (2022). The questionnaire's reliability has been confirmed through validation processes, yielding a high alpha coefficient of 0.85. Participants respond to each item using a Likert scale, where they indicate their level of agreement with statements ranging from "strongly disagree" (scored as 1) to "strongly agree" (scored as 4). This structured approach allows researchers to systematically gauge and analyze the self-confidence perceptions of the players involved in the study.

Cognitive Processing Speed

This test aims to measure the cognitive processing speed of table tennis players (Mohsen & Maleh, 2020). The test utilizes a table tennis table divided into five equal sections and a ball launcher that delivers 25 balls within 25 seconds. The balls are launched in random directions and colors. Participants must hit the balls towards the section of the table that matches the color of the ball launched by the robot (Huipang HP07). Each color has five balls, totaling 25 balls. Balls that land in a section that does not match their color are scored 1 point, balls that land in the correct color section are scored 2 points, and balls that go out are scored 0 points.

Topspin Stroke

Topspin accuracy was evaluated using a previously developed assessment tool, which has been demonstrated to provide valid and reliable data on topspin accuracy (Haryanto et al., 2023). During the test, participants were positioned at the center of the table. A feeder delivered the ball to the participants, who then executed topspin strokes aimed at pre-marked target areas on the table. Each successful stroke was scored based on accuracy, with points typically assigned as 3, 2, 1, or 0. A score of 0 was given when the ball failed to hit the table, while higher scores reflected greater accuracy in hitting the target areas.

Procedure

This research began with obtaining permission from Universitas Negeri Padang, Faculty of Sports Science, and the lecturer in charge of the table tennis course. After obtaining campus approval, researchers approached potential participants and requested their willingness to participate in the study. A team was assembled to assist in data collection, and they received training to ensure accuracy during the process. Before data collection commenced, researchers conducted health checks on all participants to confirm their readiness and good health. Participants were briefed in detail on the testing procedures and provided with simulated tests to ensure a clear understanding of the process. Prior to the actual tests, all participants completed a self-confidence questionnaire. They were then instructed to warm up and attempt both cognitive processing speed and topspin accuracy tests.

Statistical analysis

Descriptive statistics were computed to summarize the characteristics of the sample, both overall and for male and female participants separately. Normal distribution was verified using z-scores for skewness and kurtosis < 3.29. Hypothesis testing involved Pearson correlation analysis and linear regression to explore the associations between self-confidence, cognitive processing speed, and topspin stroke accuracy. Data were meticulously documented, and all analyses were conducted using the most recent version of SPSS software, with statistical significance set at $p < 0.05$.

Results

A total of 82 participants (67.1% male) provided valid data. Descriptive characteristics are shown in table 1. Male and female participants were of similar age but men were significantly taller and heavier women ($p < 0.01$). Average BMI was also significantly higher male compared to female participants ($p = 0.02$). While all female participants were classified as normal weight two men were classified as overweight and 1 man was classified as underweight. Years of training experience was also higher in male compared to female participants ($p = 0.02$) but there were no sex differences in topspin accuracy, self-confidence and cognitive processing speed.

Both, self-confidence and cognitive processing speed were significantly correlated with topspin accuracy (rSC = 0.430, rCPS = 0.374; $p < 0.01$). Sex-specific analyses revealed similar results among female and male participants (Women: rSC = 0.451, rCPSy = 0.428; Men: rSC = 0.431, rCPSy = 0.362). Both variables explained 26.3 % of the variability in topspin accuracy, with a more pronounced association of self-confidence with topspin accuracy compared to total processing speed (Table 2). The inclusion of training experience did not enhance the regression model and, therefore, only self-confidence and cognitive processing speed were included in the sex-specific analyses. Even though results were similar for men and women significant beta coefficients were only observed in men, which may be attributed to the small number of female participants.

Table 2. Linear regression analysis for topspin performance as independent variable for the total sample and separately for male and female participants

Indicators	R^2	Self-Confidence		Cognitive Processing Speed	
		beta	Sig.	beta	Sig.
Total Sample	0.263	0.362	<0.001	0.289	0.005
Female Participants	0.269	0.326	0.106	0.286	0.154
Male Participants	0.265	0.374	0.003	0.288	0.021

Discussion

The results of this research indicate a clear association between self-confidence and topspin stroke accuracy, highlighting the critical influence of self-confidence on the precise execution and efficacy of topspin strokes in table tennis. These findings underscore the importance of psychological factors in enhancing technical performance and overall competitive outcomes in sports. The significance of self-confidence in enhancing table tennis ball-hitting accuracy is well-established in the literature. Studies indicate a notable correlation between self-determined motivation, adaptive coping strategies, and performance levels among table tennis athletes, highlighting the pivotal role of intrinsic motivation in achieving superior outcomes (Martinent et al., 2018). Additionally, it has been noted through longitudinal studies that the dynamics of self-confidence tend to grow stronger over time, particularly during phases of psychological momentum experienced by athletes. This observation highlights the pivotal role of self-confidence not only in initial performance but also in its sustained enhancement throughout an athlete's competitive journey. Understanding these dynamics can provide valuable insights into how athletes can effectively manage and optimize their mental states to consistently achieve peak performance levels (Briki et al., 2012). Furthermore, the skill to discern the trajectory and spin of the ball in table tennis is essential for optimal performance. Research indicates that auditory cues play a significant role in this identification process, influencing players' abilities regardless of their training or experience levels. This highlights the universal importance of auditory perception in enhancing ball recognition and, consequently, overall game strategy and effectiveness (Santos et al., 2017). Therefore, the maintenance of elevated self-confidence levels is crucial in positively influencing a player's capacity to achieve precise ball placement in table tennis, ultimately shaping their overall performance outcomes. This underscores the pivotal role of self-confidence as a determinant factor in enhancing athletic proficiency and competitive success in the sport.

Our research results show a significant positive correlation between cognitive processing speed and topspin shot accuracy in table tennis. These findings support previous research suggesting that Athletes with strong cognitive abilities tend to exhibit superior performance in their gameplay. This relationship underscores the importance of cognitive training as a vital component in the holistic development of competitive athletes. Enhancing cognitive skills can lead to improved strategic decision-making and reaction times, thereby positively impacting overall athletic performance (Tsai et al., 2023). The cognitive abilities of athletes are integral to their sports performance, with professional athletes often demonstrating superior cognitive functions compared to their non-professional counterparts. This disparity highlights the significance of cognitive training in elevating athletes to elite levels, emphasizing its role in enhancing strategic thinking, decision-making, and overall gameplay (Hernández-Mendo et al., 2019). The ability to process information swiftly is crucial not only in academic settings but also in sports, where athletes must make rapid and accurate decisions. This quick decision-making capability is essential for adapting to dynamic game situations, ultimately contributing to superior athletic performance (Lovett et al., 2022). Enhanced cognitive processing speed enables players to anticipate opponents' movements more effectively, resulting in greater accuracy when executing topspin shots. Sustaining high cognitive performance throughout a match further contributes to maintaining accuracy and speed, ensuring consistent and superior performance over time (Díaz-García et al., 2023).

A study found that children with high cognitive processing speed and good muscular fitness exhibit significantly shorter cognitive reaction times compared to those with slower cognitive processing speed (Tsai et al., 2020). Research on the motivation for learning, physical activities, and intellectual development in table tennis players indicated that incorporating chess-pong elements enhanced the players' cognitive abilities. Additionally, the inclusion of chess elements in training positively affected the psychological and pedagogical conditions, thereby promoting a high level of motivation for participating in this sport (Stovba et al., 2023).

The findings from this research offer valuable applications for training and coaching in table tennis. Coaches may consider incorporating exercises that specifically enhance cognitive processing speed, such as reaction drills and decision-making scenarios. A comprehensive approach to training that integrates cognitive and self-confidence dimensions can further elevate a player's overall performance. By understanding the intricate relationship between psychological factors and technical skills, coaches can develop tailored training programs that meet the individual needs of table tennis players. However, it is important to note that this study did not include professional athletes, and further research is necessary to explore these associations at higher levels of play. Additionally, self-confidence was not assessed in real match situations. Employing other methods, such as direct observation during matches or match simulations during training, could provide a more thorough understanding of this concept and its impact on playing performance. Limitations of this study include a small participant sample size and a lack of variation in playing ability. Differences in rackets used may also influence topspin performance, despite participants reporting comfort with their respective rackets.

Conclusion

The topspin shot is an essential offensive maneuver in table tennis, and achieving accuracy in its execution is crucial for athletes aiming for success. This research investigated how cognitive processing relates to the precision of topspin shots, alongside examining the influence of self-confidence on topspin accuracy. Recognizing the direct correlation between cognitive abilities and topspin performance underscores the importance for coaches to integrate these aspects into their training regimens, which should encompass short-term, medium-term, and long-term strategies. Coaches can design specific training programs to enhance athletes' cognitive processing speed and self-confidence, incorporating exercises in quick reaction and decision-making scenarios. A holistic approach integrating psychological aspects such as stress management and confidence development is also essential in training to consistently improve athletes' topspin performance. Ongoing evaluation and detailed feedback on athletes' psychological and cognitive progress will guide the development of effective long-term training programs, ensuring athletes can achieve their optimal potential in competition. Recommendations for future research include conducting comparative studies between professional and non-professional table tennis athletes to gain deeper insights into the relationships among cognitive processing speed, self-confidence, and topspin performance. Furthermore, expanding research to explore the role of emotional intelligence in the context of real match situations, and investigating other physical factors influencing topspin technique such as physical strength and movement techniques, is warranted. The use of direct observation methods during matches or match simulations is also recommended to obtain a more comprehensive understanding of the complex interactions among psychological, cognitive, and technical factors in athletes' performance in competition.

Conflict of Interest

The authors declare that there is no conflict of interest.

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Впевненість у собі та когнітивна швидкість: Ключові предиктори визначення точності виконання топ-спіну в змаганнях з настільного тенісу

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Реферат. Стаття: 8 с., 2 табл., 42 джерела.

Історія питання. Гравці з настільного тенісу часто використовують топ-спін з метою досягнення результату. Для багатьох спортсменів цей удар має вирішальне значення для перемоги, що робить його фаворитом серед гравців. Існує велика ймовірність того, що виконання точних ударів топ-спін ускладнить опонентам повернення м'яча. Як наслідок, гравці, які можуть зберігати точність удару топ-спін протягом тривалого часу, мають більше шансів на здобуття перемоги в матчах.

Мета дослідження. Метою цього дослідження було вивчити зв'язок між впевненістю у собі (ВС) і швидкістю когнітивної обробки (ШКО) з точністю виконання топ-спіну (ТТ) в настільному тенісі.

Матеріали та методи. У рамках дослідження застосовано кореляційний метод з кількісним підходом. Загалом у дослідженні взяли участь 82 учасники (вік: 20,00 ± 0,60 років). Збір даних щодо точності виконання топ-спіну проводився за допомогою тесту з визначення точності виконання топ-спіну з подальшим застосуванням опитувальника для визначення рівня впевненості в собі та тесту з оцінки швидкості когнітивної обробки інформації. З метою встановлення зв'язку між змінними використовували кореляційний аналіз Пірсона та лінійну регресію.

Результати. Результати цього дослідження показують (1) позитивний взаємозв'язок між впевненістю в собі і точністю виконання топ-спіну ($r = 0{,}430$, $p < 0{,}05$); (2) позитивний взаємозв'язок між швидкістю когнітивної обробки і точністю виконання топ-спіну ($r = 0{,}374$, $p < 0{,}05$).

Висновки. Точність виконання топ-спіну залежить від швидкості когнітивної обробки та впевненості в собі. Отже, тренери повинні враховувати зазначені фактори задля поліпшення результативності виконання топ-спіну в настільному тенісі. Результати цього дослідження можуть суттєво вплинути на тренувальні програми, де тренування ментальних навичок, як-от підвищення впевненості в собі та поліпшення швидкості когнітивної обробки, слід інтегрувати в технічні

та тактичні режими тренування. Такий підхід дозволить спортсменам не тільки вдосконалити свої фізичні навички, але й зміцнити психологічну стійкість, що в кінцевому підсумку призведе до покращення результативності у змагальних матчах.

Ключові слова: інтелектуальна здатність, емоційний стан, когнітивна реакція, влучність удару, точність в ракетковому виді спорту.

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