Journal of Physical Education and Sport ® (JPES), Vol. 23 (issue 10), Art 310, pp. 2710 - 2717, October 2023
online ISSN: 2247 - 806X; p-ISSN: 2247 – 8051; ISSN - L = 2247 - 8051 © JPES

Original Article

Exploring the impact of eye-hand coordination on backhand drive stroke mastery in table tennis regarding gender, height, and weight of athletes

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Published online: October 31, 2023
(Accepted for publication : October 15, 2023)
DOI:10.7752/jpes.2023.10310

Abstract
Introduction: Backhand drive stroke is very important in table tennis, demanding a harmonious connection between the eyes and hands. Although many studies describe the importance of eye-hand coordination in sports, its precise correlation with backhand drive stroke accuracy in table tennis requires further investigation. **Objective**: This study aimed to investigate the tricky connection between eye-hand coordination and backhand drive stroke accuracy in table tennis while considering factors such as gender, height, and weight among participants. **Method**: The study group comprised 42 participants, consisting of 32 males (average age 19.10±0.30 years) and 10 females (average age 18.18±0.39 years). All participants were enrolled in table tennis II courses in the coaching department. Consequently, eye-hand coordination data were collected using a specialized test, and data on backhand drive stroke accuracy were obtained through a validated and reliable test. Descriptive analyses utilized included mean, standard deviation, and other measures, while bivariate and multivariate analyses made use of Pearson's correlation coefficient, the multiple correlation coefficient, and the RV coefficient. Inferential analyses consisted of the two-means t-student test, multivariate analysis of variance (MANOVA), and various correlation tests. **Results:** The results showed that there was a significant positive correlation between eye-hand coordination and backhand drive stroke accuracy in table tennis ($r=0.53$, $p<0.05$). The marginal evaluation showed statistically significant differences in both backhand stroke accuracy ($p<0.05$) and eye-hand coordination ($p<0.05$). Specifically, males significantly outperformed females in both variables, scoring higher (0.49, $p<0.05$) than females (-0.46, $p=0.17$). **Conclusions:** Athletes with superior eye-hand coordination tended to achieve higher accuracy in backhand drive stroke. Also, this study showed the practical importance of integrating eye-hand coordination development into table tennis training programs. Coaches were encouraged to incorporate targeted exercises such as eye-hand coordination drills and rapid reaction exercises to improve the total performance of athletes.
Keywords: eye-hand coordination, backhand drive stroke, table tennis shot, stroke technique

Introduction

Gender is a factor in coordination levels, specifically in sports that require eye-hand coordination (Becerra et al., 2023). Meanwhile, table tennis, a popular sport (Li & Li, 2016), demands high technical skills, particularly in mastering various punches and moves (Oagaz et al., 2022; Qian et al., 2016), including the crucial backhand stroke (Van Soest et al., 2010; Akbari et al., 2023). Athletes often practice this stroke extensively to perfect their movements (Li et al., 2020), resulting in smoother and more precise motions after some time (Chen et al., 2022).

Backhand stroke technique relies on effective coordination between the eyes and hands, and the ability to execute accurate and powerful shots is often the key to success in matches. This implies that good eye-hand coordination is crucial for precise and swift strokes (Firdaus & Mario, 2022; Yendrizal et al., 2023). In particular, the eye functions as a visual detection tool, providing information about the ball's position and movement, while the hand processes this information for precise shots (Piras et al., 2016; Padli et al., 2023).

Eye-hand coordination significantly affects decision-making in sports (Nascimento et al., 2021). Athletes with efficient coordination can rapidly process visual data, consider multiple factors simultaneously, and make effective decisions regarding their actions, tactics, or strategies (Athanasakis et al., 2021).

This cognitive ability is crucial for success in fast-paced sports (Büchel et al., 2022; Lappi, 2022; Yongtawee et al., 2022). Additionally, it improves adaptability and learning capabilities, allowing for quick adjustments based on visual information (Kelly et al., 2021; Zapała et al., 2021). This scenario enables the effective response to changing game situations and efficient learning of new skills (Wei & Meng, 2022).

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Beyond performance benefits, eye-hand coordination also contributes to injury prevention. Athletes with good coordination can anticipate and react to potential dangers, reducing the risk of collisions, falls, and impacts (Avedesian et al., 2021). In summary, eye-hand coordination is a fundamental skill that profoundly impacts performance, precision, decision-making, adaptability, and safety in sports. This simply means that developing and improving this skill through targeted training can significantly contribute to success in sports (Yeomans et al., 2021).

Forehand and backhand strokes, as well as backhand lobs, are the primary stroke techniques widely used by C1 category Paralympic athletes (Guarnieri et al., 2023). A study has shown that success in matches greatly depends on technical-tactical skills (Yu, 2023). To increase stroke technique proficiency in table tennis, robots are being used, which causes students to be happy seeing robotic trainers for stroke practice (Tahki et al., 2022). In addition, training models have been developed continuously using technology in order to support the progress of athletes. In line with this development, various countries are also competing to improve their training processes for athletes (Siregar et al., 2019).

This technological development also extends to Paralympic athletes, with their stroke movements being analyzed to provide valuable feedback for future improvement (Yam et al., 2021). Efforts have been made to improve backhand stroke accuracy associated with athletes' eye-hand coordination in order to improve the hitting skills in table tennis. However, a full understanding of this aspect remains incomplete. Therefore this study investigates the relationship between eye-hand coordination and backhand stroke accuracy in table tennis, considering gender, height, and weight. The objective is to provide new insight into the critical role of eye-hand coordination in achieving high accuracy in backhand. Additionally, the study intends to establish a strong foundation for coaches and athletes in order to develop more effective training techniques, benefiting from knowledge transfer (Becerra Patiño & Escorcia-Clavijo, 2023). This paper is expected to make a meaningful contribution to the sports literature, particularly in the context of table tennis. The results may have significant implications for improving the performance of athletes through effective training.

Method

Study design

In this study, a quantitative approach with a correlational method was used to analyze the correlation between eye-hand coordination and backhand drive stroke in table tennis.

Participants

The participants in this study were 42 students from the coaching department at the Faculty of Sports Science, Universitas Negeri Padang, Indonesia. Participants were from two classes of table tennis II courses, consisting of 32 males (average age 19.10±0.30 years) and 10 females (average age 18.18±0.39 years). These participants selected table tennis II as an elective course, and none of them had prior experience regarding the sport.

Procedure

The study process began by requesting for approval from lecturers in charge of table tennis courses and obtaining consent from students enrolled to participate as subjects. Initially, a clear description was provided to both lecturers and students regarding the purpose and the nature of the tests that would be administered. On the day of data collection, the objectives were further clarified and the correct techniques for performing the tests were demonstrated, to ensure that all participants comprehended the procedures thoroughly to maintain data validity. Participants were considered to be in good health and were also given an opportunity to get familiar with the tests. Efficiency was enhanced during data collection by setting up two test stations instead of just one. The coordinators at each test station had received comprehensive training and were well-equipped in the correct test implementation procedures.

Instrument

Eye-hand Coordination

Eye-hand coordination data, considered valid and reliable, were gathered using tests developed by Utama et al. (2023). The test administration comprised a team of three individuals, with the first serving as a counter for the throwing and catching actions, the second recorded the scores, and a third operated the timer. Participants were positioned close to a designated line with their feet shoulder-width apart, maintaining a slightly bent posture, with one leg positioned in front. Furthermore, the participants executed throws in a manner consistent with table tennis stroke, aiming for the designated target. A score of 1 was assigned when participants executed the throw and catch correctly, ensuring the ball hit the target accurately. A score of 0 was given when 1) any incorrect movements occurred, 2) the ball missed the target, or 3) the ball was not caught. As a result, the testing process continued for a duration of 30 minutes.

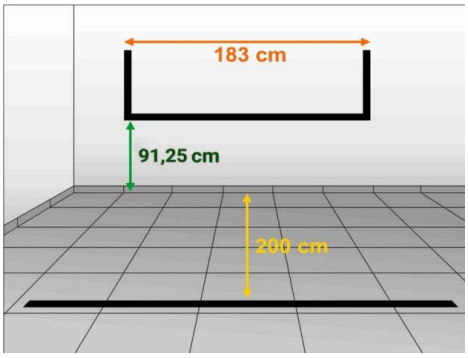

Figure 1. Eye-hand coordination test for table tennis. Source: (Utama et al., 2023)

Precision Backhand drive stroke

Backhand drive stroke accuracy data were collected using a backhand drive stroke accuracy test designed by Tomoliyus (2017), which showed high validity and reliability of 0.90 and 0.94, respectively. Participants were required to perform 50 backhand strokes toward a predetermined target. Scores ranged from 0, 1, 3, to 5, with 5 indicating the highest accuracy, and 0 assigned for shots that missed the target, hit the net, or fall off the table. The test was facilitated by a ball observer and a scorekeeper, and the final score was a sum of all the shot results.

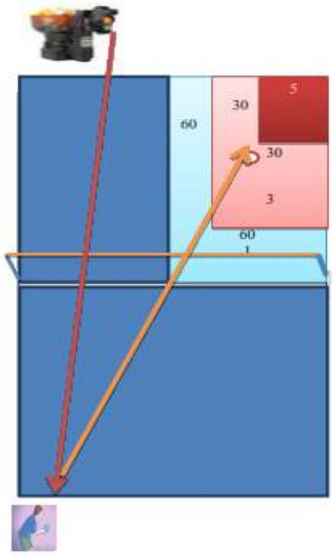

Figure 2. The target area of backhand drive stroke accuracy test and the score. Source: (Tomoliyus, 2017)

Data analysis

In the descriptive analysis, the mean was used to measure central tendency, and the standard deviation was utilized to evaluate dispersion. Subsequently, measures related to position and extreme values were also considered. In the bivariate descriptive analysis, Pearson's correlation coefficient served as the key metric, and in the multivariate analysis, both the multiple correlation coefficient and the RV coefficient were used. Additionally, inferential analysis was conducted and it incorporated the two-sample t-test, multivariate analysis of variance (MANOVA), as well as examinations pertaining to Pearson's correlation coefficient, the multiple correlation coefficient, and the RV coefficient.

Results

This study consisted of 42 participants, namely 32 men and 10 women, and their characteristics were shown in Table 1.

Table 1. Characteristic of Participants

Variables	N	Minimum	Maximum	Mean	Std. Deviation
Age	42	19.00	20.00	19.1190	0.32
Height	42	152.00	170.00	163.2857	5.08
Body Weight	42	41.00	63.00	55.4048	6.24

Before conducting the data analysis using the Pearson correlation, a data normality test was conducted using the Shapiro-Wilk test. The results showed a normal distribution with *p*-values of 0.35 for eye-hand coordination variable and 0.24 for backhand stroke accuracy variable. Subsequently, an analysis of the correlation between these two variables was carried out, showing a significant value of r = 0.53, $p < 0.05$.

Table 2 showed the descriptive statistics based on gender, indicating that, on average, males outperformed females in both backhand drive stroke accuracy and eye-hand coordination tests.

Table 2. Gender variable analysis

Statistics	Backhand drive Stroke Accuracy		Eye-Hand Coordination	
	Female	**Male**	**Female**	**Male**
Average	87,2	106,34	21	24,71
Standard deviation	4,63	8,70	3,09	4,21
Minimum	79	87	17	16
First quartile	84,5	102	19	22
Median	87,5	107	21,5	23,5
Third quartile	90	111,25	22,75	27,25
Maximum	93	124	27	36

According to Table 3, the marginal evaluation showed statistically significant differences for both backhand drive stroke accuracy ($p < 0.05$) and eye-hand coordination ($p < 0.05$) variables. In both cases, males scored higher (0.49, $p < 0.05$) than females (-0.46, $p = 0.17$). Additionally, the combined evaluation showed a statistically significant correlation between the two variables ($p < 0.05$).

Table 3. Marginal evaluation and joint evaluation of the variables

Marginal evaluation	
Variable	***p*-value**
Backhand Drive Stroke Accuracy	<0.05
Eye-Hand Coordination	<0.05
Joint assessment	
Statistics	*p*-value
Pillai's trace	<0.05

In the evaluation of the correlation coefficient, no statistically significant differences were found for both backhand drive stroke accuracy and eye-hand coordination tests in relation to height and weight of subjects, as shown in Table 4. Similarly, in the combined evaluation, no correlation between height and weight was observed, as shown by the coefficient RV = 0.01 ($p = 0.70$) in Table 5.

Table 4. Marginal evaluation (Pearson correlation) in response to height and weight.

	Pearson's correlation	
Variable	**Height**	**Weight**
Backhand Drive Stroke Accuracy	0.085144524 (p= 0.5919)	-0.007061488 (p= 0.9646)
Eye-Hand Coordination	-0.1307780 (p= 0.4091)	-0.2541943 (p= 0.1043)

Table 5. Joint assessment in response to height and weight

Multiple correlation coefficient	
Variable	**Height**
Height	0.2231 (p= 0.3693)
Weight	0.2944 (p= 0.1705)

Discussion

The results of this study showed a strong correlation between eye-hand coordination and backhand drive stroke accuracy in table tennis. This was consistent with Basiri et al. (2020), suggesting that incorporating visual exercises could enhance the ability to execute forehand stroke effectively. Similar findings were supported by Piras et al. (2019), which described the crucial role of precise visual observation in predicting and executing shots in table tennis. For example, athletes had to foresee the ball trajectory and angle of impact when responding to the opponent serve. Furthermore, this study showed that accuracy in ball throwing and speed in spinning the ball served as essential predictive factors for athletes' future success. These factors were particularly significant for males, but females needed to focus on speed in dribbling the ball, as it also contributed to identifying the talents and potential for future success (Faber et al., 2017). Alexandru et al. (2014) also showed that athletes with top national rankings possessed excellent coordination skills, a strong ability to concentrate, effective self-motivation, and a positive attitude. The attributes were important and strongly correlated with athletes' achievements at the national level.

Good eye-hand coordination had a broad influence on entire physical performance, as stated by Tangkudung et al., (2021), Kelly et al. (2021), Kelly et al. (2022), Tsang et al. (2016), Kelly et al. (2022), and

Tsang et al. (2016). In this context, the eye served as a visual detection tool, providing information on the ball's position and movement, while the hand processed this information to deliver an accurate shot (Fooken et al., 2021; Wong et al., 2019). In a backhand stroke, the eyes' ability to precisely track the ball was important for signaling the hand muscles to execute the shot with the correct speed and angle (Niechwiej-Szwedo et al., 2021).

Imbalances in eye-hand coordination could lead to inaccuracies in backhand drive stroke, thereby affecting athletes' performance. According to Fu et al. (2016), athletes needed to master precise foot movements when executing these strokes. Additionally, seasoned athletes with proficient strokes showed swift and more agile footwork compared to novice athletes (C. Yu et al., 2019). Well-trained and accurate athletes could often anticipate opponent moves and respond effectively to attacks (Russo & Ottoboni, 2019). Improving hand coordination was achieved through specialized perceptual-motor exercises, resulting in improved coordination as well as enhanced balance, reaction speed, and optimized visual responses (Tajari et al., 2023)

The results of another experimental study conducted by Coetzee & de Waal (2022) supported the notion that sports vision programs had a positive impact on improving athletes' eye coordination and reaction time. Typically, it was observed that technology played a critical role in advancing stroke proficiency. The evolving technology landscape introduced novel training opportunities for athletes to, improve their experiences. Technological tools including feeder robots allowed coaches to focus on analyzing movements and providing feedback, rather than feeding balls to athletes (Siekańska et al., 2021). In the context of sports, across all disciplines, eye-hand coordination assumed a crucial role, consisting of numerous aspects. Its primary function was to grant athletes the capacity to execute movements with precision and accuracy. This coordination empowered athletes to finely control the actions and interact precisely with objects or equipment, whether by hitting a ball, swinging a bat, or shooting a basketball.

This study had significant practical implications for the teaching and development of technical skills in table tennis athletes. Coaches could integrate specific activities into the training routines designed to enhance eye-hand coordination. Athletes were required to develop the eye-hand coordination through exercises, visualization drills, and rapid-response activities. Technological advancements also offered opportunities to improve eye-hand coordination, such as using virtual reality simulators. Moreover, a deeper understanding of the connection between backhand stroke precision and eye-hand synchronization could influence table tennis strategies. Through this knowledge, athletes could apply the strategies in different match scenarios to improve the power and precision of backhand stroke. However, it was essential to recognize that eye-hand synchronization was just one factor impacting backhand stroke accuracy. Other factors, such as stroke technique, physical strength, and experience level, contributed to the precision and success of backhand stroke. The sample size in this study was relatively small, which could affect the entire generalizability of the results.

Conclusions

In conclusion, this study examined the correlation between eye-hand coordination and backhand drive accuracy in table tennis concerning sex, height, and weight. Based on the analysis, when each test was considered individually, males consistently outperformed females in both backhand drive stroke accuracy and eye-hand coordination. In the same manner, when the correlation between these two tests was evaluated, males continuously showed superior performance. However, it should be acknowledged that the height and weight variables did not significantly affect the study sample, as no statistically significant correlation was found.

The results showed the critical role of eye-hand coordination in achieving high accuracy in backhand drive stroke. The practical implications of this study could benefit table tennis coaches and athletes looking to improve their technical skills. Meanwhile, it should be noted that eye-hand coordination represented just one aspect of all table tennis skills, and other factors needed to be considered.

In summary, this study provided fresh insights into the significance of eye-hand coordination in achieving precise backhand drive stroke in table tennis. This knowledge had the potential to significantly contribute to the development of technical skills and tactical approaches in the sport.

Limitations

The primary limitations centered on the exclusion of other performance variables associated with table tennis, such as balance, striking power, execution speed, etc. Additionally, the limited representation of female participants in this study may limit the generalizability of the results.

Future perspectives and practical applications

This study described the importance of various variables, including accuracy and coordination, in a sport such as table tennis. Future exploration should consider additional factors namely strength and execution speed to create a more comprehensive athlete profile for this sport. Additionally, this study provided opportunity for further investigations into the elements influencing sports performance and the development of more effective training programs.

Conflicts of interest

The authors have no conflict of interest

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