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The effect of training methods and hand–eye coordination on students' forehand shot accuracy

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ABSTRACT

This study examined the effects of training methods and hand–eye coordination on forehand drive accuracy among members of the Table Tennis Activity Unit at Padang State University. A quasi-experimental 2 × 2 factorial design was applied to 20 players selected through purposive sampling. Participants were trained using multiball or combination training methods and categorized based on high or low hand–eye coordination. Data were analyzed using two-way ANOVA. The results showed that the multiball training method significantly improved forehand drive accuracy and that a significant interaction existed between training method and hand–eye coordination. Multiball training was more effective for players with high coordination, while no significant difference was found for those with low coordination.

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Introduction

Table tennis is a high-speed, open-skill sport that demands precise motor execution, rapid visual processing, and continuous perceptual motor adaptation. At the university and developmental levels, athletes frequently experience fluctuations in technical consistency due to variations in ball speed, spin, and placement, which directly affect performance outcomes. Among fundamental offensive strokes, the forehand drive plays a central role in maintaining rally control, applying tactical pressure, and creating opportunities for attacking play (Muridhin et al., 2025; Santosa et al., 2025). Inaccurate forehand execution not only reduces rally effectiveness but also hinders long-term technical development, underscoring the importance of targeted training interventions aimed at improving stroke accuracy rather than merely increasing stroke speed or power.

To enhance technical performance, table tennis coaches commonly apply structured training approaches such as multiball training and combination training (Hidayatullah & Doewes, 2023; Mongsidi et al., 2023). Multiball training emphasizes high-repetition stroke execution through continuous and controlled ball feeding, which is theorized to facilitate motor learning by increasing practice volume, reinforcing movement patterns, and stabilizing timing mechanisms. In contrast, combination training integrates shadow practice with ball feeding drills to develop movement coordination, stroke sequencing, and technical rhythm in a more varied learning environment. Despite their widespread use, empirical evidence comparing the effectiveness of these methods remains inconsistent, particularly when stroke accuracy is considered as the primary outcome variable rather than speed or power (Fadjri et al., 2023; Zhang et al., 2023).

In parallel with training method research, sport science literature increasingly highlights hand–eye coordination as a key perceptual–motor ability underpinning performance in racket sports. Hand–eye coordination enables athletes to synchronize visual information with motor responses, thereby supporting precise timing, spatial judgment, and consistency during stroke execution (Haryanto & Becerra-Patino, 2023; Nugroho et al., 2023). Empirical studies consistently report that athletes with superior coordination demonstrate greater stability and adaptability in technical performance. However, most existing studies conceptualize hand–eye coordination as a static individual attribute or examine its direct relationship with performance, rather than considering its potential role as a moderating factor that shapes athletes' responsiveness to different training stimuli (Akbari et al., 2023; Nugroho et al., 2023; Nur et al., 2024).

Contemporary frameworks in skill acquisition, including constraint-led and individualized coaching approaches, emphasize that training effectiveness emerges from the interaction between task demands, training methods, and individual athlete characteristics (Singh et al., 2025; Steinhauer & Eichhorn, 2025). From this perspective, the same training method may yield different outcomes depending on an athlete's perceptual–motor profile. Nevertheless, research in table tennis has predominantly employed single-factor experimental designs or correlational analyses that examine training methods and coordination abilities independently. Such approaches limit understanding of how training methods and coordination interact to influence precision-based skills such as forehand drive accuracy (Jin et al., 2024; Sun et al., 2024; Tao et al., 2025).

This limitation points to a clear research gap: the lack of factorial experimental studies that simultaneously investigate training methods and hand–eye coordination in relation to forehand drive accuracy. Furthermore, many previous studies rely on subjective evaluations or conventional field tests, offering limited measurement sensitivity and objectivity. The underutilization of sensor-based assessment tools restricts the accuracy of coordination and stroke performance measurement, thereby constraining the development of evidence-based, individualized training recommendations for coaches (Inoue et al., 2023; Özyer et al., 2021; Pedro et al., 2021).

To address these gaps, the present study employs a 2 × 2 factorial quasi-experimental design to examine the effects of multiball and combination training methods and their interaction with hand–eye coordination on forehand drive accuracy among university-level table tennis players. The novelty of this study lies in positioning hand–eye coordination as a moderating variable within an experimental framework and in utilizing sensor-based performance assessment to enhance measurement objectivity and reliability. By identifying differential training effects across coordination levels, this study aims to contribute both theoretically to the understanding of skill acquisition mechanisms and practically to the development of individualized, evidence-based coaching strategies in table tennis (Ferrandez et al., 2021; Franz et al., 2023; Hua & Yang, 2025).

Method

This study employed a quasi-experimental design using a 2 × 2 factorial to examine the effects of training methods and hand–eye coordination on forehand drive accuracy in table tennis. The independent variables consisted of training method (multiball training and combination training involving shadow practice and ball feeding) and hand–eye coordination (high and low), while forehand drive accuracy served as the dependent variable. Participants were 20 male students who were active members of the Table Tennis Activity Unit at Padang State University, selected through purposive sampling based on training attendance and playing experience. Hand–eye coordination was measured using a sensor-based coordination test, and forehand drive accuracy was assessed through a standardized accuracy test focusing on forehand drive strokes. Participants were assigned to experimental groups according to their coordination level and training method. Data were analyzed using two-way analysis of variance (ANOVA) after meeting the assumptions of normality and homogeneity, with a significance level set at $\alpha = 0.05$.

Results and Discussions

Prior to conducting inferential analyses, homogeneity of variance was tested to verify that the data met the assumptions required for parametric statistical procedures. Homogeneity testing was performed at a significance level of $\alpha = 0.05$.

Variance homogeneity for the main factor groups (training method: A1 and A2; hand–eye coordination: B1 and B2) was examined using the variance test, while Bartlett's test was applied to the four experimental cells (A1B1, A2B1, A1B2, and A2B2). The results showed that the calculated chi-square values were lower than the critical chi-square values (χ^2_calculated < χ^2_table), indicating homogeneous variances across all groups.

Table 1. Summary of Homogeneity Test Results

Group / Cell	Test Used	χ^2_calculated	χ^2_table ($\alpha = 0.05$)	Decision
A1	Variance Test	< χ^2_table	χ^2_table	Homogeneous
A2	Variance Test	< χ^2_table	χ^2_table	Homogeneous
B1	Variance Test	< χ^2_table	χ^2_table	Homogeneous
B2	Variance Test	< χ^2_table	χ^2_table	Homogeneous
A1B1	Bartlett Test	< χ^2_table	χ^2_table	Homogeneous
A2B1	Bartlett Test	< χ^2_table	χ^2_table	Homogeneous
A1B2	Bartlett Test	< χ^2_table	χ^2_table	Homogeneous
A2B2	Bartlett Test	< χ^2_table	χ^2_table	Homogeneous

Based on these results, all data satisfied the homogeneity assumption, allowing further analysis using two-way ANOVA.

A two-way Analysis of Variance (ANOVA) was conducted to examine the main effects of training method (multiball vs. combination), hand–eye coordination level (high vs. low), and their interaction effect on forehand drive accuracy.

The analysis revealed a significant main effect of training method on forehand drive accuracy. The calculated F-value ($F = 4.61$) exceeded the critical F-value (F_table = 4.49), indicating a statistically significant difference between participants trained using the multiball method and those trained using the combination method ($p < 0.05$).

In addition, the interaction effect between training method and hand–eye coordination was also statistically significant ($F = 4.51 >$ F_table $= 4.49$, $p < 0.05$). This finding indicates that the effectiveness of the training methods varied depending on the level of hand–eye coordination.

Table 2. Two-Way ANOVA Summary for Forehand Drive Accuracy

Source of Variance	df	F_calculated	F_table ($\alpha = 0.05$)	Significance
Training Method (A)	1	4.61	4.49	Significant
Hand–Eye Coordination (B)	1	–	–	–
A × B Interaction	1	4.51	4.49	Significant
Error				

These results confirm that training method independently affects forehand drive accuracy and that its effectiveness is moderated by hand–eye coordination level.

Given the presence of a statistically significant interaction effect, post hoc comparisons were conducted using Tukey's Honestly Significant Difference (HSD) test to identify specific differences between group means.

The Tukey test results indicated a significant difference in forehand drive accuracy between the multiball and combination training methods among participants with high hand–eye coordination. The calculated Q value exceeded the critical Q value (Q_calculated = 3.94 > Q_table = 3.64), demonstrating that the multiball training method resulted in superior performance compared to the combination method.

In contrast, for participants with low hand–eye coordination, the Tukey test revealed no significant difference between the multiball and combination training methods. The calculated Q value was substantially lower than the critical value (Q_calculated = 0.02 < Q_table = 3.64), indicating comparable effectiveness of both training methods for this group.

Table 3. Tukey HSD Post Hoc Test Results

Coordination Level	Comparison	Q_calculated	Q_table (α = 0.05)	Decision
High	Multiball vs. Combination	3.94	3.64	Significant
Low	Multiball vs. Combination	0.02	3.64	Not Significant

The results of this study demonstrate that: (1) the training method significantly influences forehand drive accuracy, (2) hand–eye coordination significantly moderates the effect of training method, and (3) multiball training is particularly effective for individuals with high hand–eye coordination, whereas no differential advantage is observed for individuals with low coordination levels.

The present study investigated the effects of training methods and hand–eye coordination on forehand drive accuracy among members of the Table Tennis Activity Unit at Padang State University. The findings demonstrate that the training method significantly influences forehand drive accuracy, with the multiball training method producing superior outcomes compared to the combination training method. This result indicates that training approaches emphasizing high repetition, consistent ball feeding, and controlled technical execution are more effective in improving stroke accuracy (de Morais Machado et al., 2023; Ruiz-Malagón et al., 2022). Multiball training allows athletes to perform a large number of forehand strokes in a structured and continuous manner, thereby enhancing motor learning, timing, and stroke consistency, which are critical components of technical proficiency in table tennis (Ganesh et al., 2023; Van Herbruggen et al., 2024).

The significant interaction between training method and hand–eye coordination highlights the importance of individual physical attributes in determining training effectiveness. This interaction suggests that the benefits of a particular training method cannot be generalized across all athletes without considering their coordination level. Athletes with different hand–eye coordination capacities respond differently to training stimuli, supporting the notion that skill acquisition in racket sports is strongly influenced by perceptual–motor abilities (Firdaus & Mario, 2022). Therefore, training programs should be designed with consideration of both instructional methods and individual coordination profiles to optimize performance outcomes (Oagaz et al., 2022).

Further analysis revealed that among athletes with high hand–eye coordination, the multiball training method led to significantly higher forehand drive accuracy compared to the combination training method (Irawan et al., 2024). This finding suggests that athletes with superior coordination are better able to exploit the high-intensity and repetitive nature of multiball drills. Their ability to rapidly process visual information and synchronize hand movements enables them to maintain stroke accuracy despite increased ball frequency and speed. Consequently, multiball training appears particularly suitable for advanced or well-coordinated players who are ready to handle higher technical and perceptual demands (Liu et al., 2023).

In contrast, no significant difference was found between the multiball and combination training methods among athletes with low hand–eye coordination. This result indicates that for athletes with limited coordination abilities, both training methods yield comparable improvements in forehand drive accuracy (Host & Ivašić-Kos, 2022). It is possible that these athletes require more fundamental perceptual–motor development before they can benefit from high-intensity multiball training (Masrun, 2016). Combination training, which integrates shadow practice and feeding drills, may provide a more adaptable learning environment for beginners by allowing them to focus on movement patterns, stroke mechanics, and timing without excessive perceptual overload (Chen et al., 2024).

The findings of this study emphasize the need for differentiated training strategies in table tennis coaching. Coaches are encouraged to align training methods with athletes' coordination levels to maximize skill development, particularly in technical strokes such as the forehand drive. The results also reinforce the importance of hand–eye coordination as a moderating factor in skill acquisition and training effectiveness. Future research should explore larger samples, longer training durations, and additional performance indicators to further validate and extend these findings within competitive table tennis contexts.

Conclusions

This study concludes that training method and hand–eye coordination play a decisive role in determining forehand drive accuracy among university-level table tennis players. The multiball training method was found to be more effective than the combination training method in improving forehand drive accuracy, particularly for athletes with high hand–eye coordination, while no significant difference was observed between the two methods among athletes with low coordination levels. Furthermore, the significant interaction between training method and hand–eye coordination indicates that training effectiveness depends on athletes' perceptual–motor abilities. These findings underscore the importance of aligning training methods with individual coordination profiles to optimize technical skill development in table tennis.

References

Akbari, M., Valianlo, B., Lengkana, A. S., & Aim, S. (2023). Impact of reaction speed, eye-hand coordination, and achievement motivation on backhand drive skills of table tennis players. *Journal of Physical Education and Sport*, *23*(9), 2357–2367.

Chen, Y., Li, L., & Li, X. (2024). Correlation analysis of structural characteristics of table tennis players' hitting movements and hitting effects based on data analysis. *Entertainment Computing*, *48*, 100610.

de Morais Machado, E., Haik, M. N., Ferreira, J. K., da Silva Santos, J. F., Camargo, P. R., & Mendonça, L. D. M. (2023). Association of trunk and lower limb factors with shoulder complaints and sport performance in overhead athletes: A systematic review including GRADE recommendations and meta-analysis. *Physical Therapy in Sport*, *60*, 112–131. https://doi.org/10.1016/j.ptsp.2023.01.012

Fadjri, M., Primasoni, N., & As, J. (2023). The Effect of Multiball Training on The Target Accuracy of Forehand Strokes and Backhand Drives of Table Tennis Games: Literature Review. *Asian Journal of Social and Humanities*, *2*(4), 889–895.

Ferrandez, C., Marsan, T., Poulet, Y., Rouch, P., Thoreux, P., & Sauret, C. (2021). Physiology, biomechanics and injuries in table tennis: A systematic review. *Science & Sports*, *36*(2), 95–104. https://doi.org/10.1016/j.scispo.2020.04.007

Firdaus, K., & Mario, D. T. (2022). Development of service sensor tools on table tennis net. *Journal of Physical Education and Sport*, *22*(6), 1449–1456.

Franz, L., Markus, U., & Victor, P. (2023). Translational Sensor Technology: From the Laboratory to Industry. In R. Narayan (Ed.), *Encyclopedia of Sensors and Biosensors (First Edition)* (First Edition, pp. 755–771). Elsevier. https://doi.org/10.1016/B978-0-12-822548-6.00102-3

Ganesh, N., Shankar, R., Mahdal, M., Murugan, J. S., Chohan, J. S., & Kalita, K. (2023). Exploring Deep Learning Methods for Computer Vision Applications across Multiple Sectors: Challenges and Future Trends. *CMES - Computer Modeling in Engineering and Sciences*, *139*(1), 103–141. https://doi.org/10.32604/cmes.2023.028018

Haryanto, J., & Becerra-Patino, B. (2023). Exploring the impact of eye-hand coordination on backhand drive stroke mastery in table tennis regarding gender, height, and weight of athletes. *Journal of Physical Education and Sport*, *23*(10), 2710–2717.

Hidayatullah, D. N. M. F., & Doewes, M. (2023). Does Grip Strength, Performance, and Hand-Eye Coordination Affect Tennis Drive. *Proceedings of the International Conference on Learning and*

Advanced Education (ICOLAE 2022), *757*, 4.

Host, K., & Ivašić-Kos, M. (2022). An overview of Human Action Recognition in sports based on Computer Vision. *Heliyon*, *8*(6), e09633. https://doi.org/10.1016/j.heliyon.2022.e09633

Hua, Y., & Yang, R. (2025). Scalable manufacturing of tri-component auxetic yarn based mechanosensory fabric sensors for smart sportswear integration. *Applied Materials Today*, *45*, 102850. https://doi.org/10.1016/j.apmt.2025.102850

Inoue, Y., Yoshida, M., Swanson, S., & Medway, D. (2023). Tokyo 2020 and diversity attitudes of young residents: A latent change score analysis of effects of event identification. *Annals of Tourism Research Empirical Insights*, *4*(1), 100091. https://doi.org/10.1016/j.annale.2023.100091

Irawan, R., Yenes, R., Mario, D. T., Komaini, A., García-Fernández, J., Orhan, B. E., & Ayubi, N. (2024). Design of a sensor technology-based hand-eye coordination measuring tool: Validity and reliability. *Retos*, *56*, 966–973.

Jin, Z., Zheng, Y., Liu, J., & Yu, Y. (2024). A Semantic Web-Based Approach for Bat Trajectory Reconstruction With Human Keypoint Information. *International Journal on Semantic Web and Information Systems*, *20*(1). https://doi.org/10.4018/IJSWIS.338999

Liu, J., Huang, G., Hyyppä, J., Li, J., Gong, X., & Jiang, X. (2023). A survey on location and motion tracking technologies, methodologies and applications in precision sports. *Expert Systems with Applications*, *229*, 120492. https://doi.org/10.1016/j.eswa.2023.120492

Masrun, M. (2016). Pengaruh mental toughness dan motivasi berprestasi terhadap prestasi olahraga atlet PPLP Sumbar. *Jurnal Performa Olahraga*, *1*(01), 1–11.

Mongsidi, W., Arwih, M. Z., Rusli, M., & Marsuna, M. (2023). Improved table tennis forehand drive precision through multiball practice. *Jurnal SPORTIF: Jurnal Penelitian Pembelajaran*, *9*(3), 369–383.

Muridhin, M., Mushofi, Y., Afandi, A., Junaidi, A., Yahya, A., & Ernata, Y. (2025). Analysis of Table Tennis Forehand Drive Ability in Table Tennis Extracurricular Students. *Jurnal Moderasi Olahraga*, *5*(1), 105–114.

Nugroho, D., Hidayatullah, M. F., Doewes, M., & Purnama, S. K. (2023). Does Grip Strength, Performance, and Hand-Eye Coordination Affect Tennis Drive Skills? *International Conference on Learning and Advanced Education (ICOLAE 2022)*, 4–11.

Nur, M., Mappaompo, M. A., Juhanis, J., Awal, A., & Purwanto, D. (2024). Improving drive strokes of beginner tennis players through hand-eye coordination-based training methods. *Jurnal SPORTIF: Jurnal Penelitian Pembelajaran*, *10*(2), 305–319.

Oagaz, H., Schoun, B., & Choi, M.-H. (2022). Real-time posture feedback for effective motor learning in table tennis in virtual reality. *International Journal of Human-Computer Studies*, *158*, 102731. https://doi.org/10.1016/j.ijhcs.2021.102731

Özyer, T., Ak, D. S., & Alhajj, R. (2021). Human action recognition approaches with video datasets—A survey. *Knowledge-Based Systems*, *222*, 106995. https://doi.org/https://doi.org/10.1016/j.knosys.2021.106995

Pedro, B., Cabral, S., & Veloso, A. P. (2021). Concurrent validity of an inertial measurement system in tennis forehand drive. *Journal of Biomechanics*, *121*, 110410. https://doi.org/10.1016/j.jbiomech.2021.110410

Ruiz-Malagón, E. J., Delgado-García, G., Castro-Infantes, S., Ritacco-Real, M., & Soto-Hermoso, V. M. (2022). Validity and reliability of NOTCH® inertial sensors for measuring elbow joint angle during tennis forehand at different sampling frequencies. *Measurement*, *201*, 111666. https://doi.org/10.1016/j.measurement.2022.111666

Santosa, T., Pratama, R. S., Hafidz, A., Nurhasan, N., Nadzalan, A. M. D., Tulyakul, S., Pranoto, N. W., Kurnaz, M., Eken, Ö., & Purwoto, S. P. (2025). Enhancement Table Tennis Forehand Drive Ability After Exercise Using the Return Board Junior High School Students. *Retos: Nuevas Tendencias En Educación Física, Deporte y Recreación*, *62*, 637–645.

Singh, S. P., Pancham, P. P., Chen, R., Liu, C.-W., Szałapak, J., Jakubowska, M., Yamane, D., Panda, D., Fujita, H., Lin, K.-H., & Lo, C.-Y. (2025). Smart sensors for sports science industry: Device, system, manufacturing, and architecture that monitor and advance the performance. *Sensors and Actuators A: Physical*, *394*, 116967. https://doi.org/10.1016/j.sna.2025.116967

Steinhauer, K., & Eichhorn, K. (2025). Effect of Practice Structure and Feedback Frequency on Voice Motor Learning in Older Adults. *Journal of Voice*, *39*(6), 1508–1525.

https://doi.org/10.1016/j.jvoice.2023.04.006

Sun, T., Yao, C., Liu, Z., Huang, S., Huang, X., Zheng, S., Liu, J., Shi, P., Zhang, T., Chen, H., Chen, H., & Xie, X. (2024). Machine learning-coupled vertical graphene triboelectric pressure sensors array as artificial tactile receptor for finger action recognition. *Nano Energy*, *123*, 109395. https://doi.org/10.1016/j.nanoen.2024.109395

Tao, X., Sáenz-Lechón, N., & Eckert, M. (2025). Mapping the landscape of Artificial intelligence for serious games in Health: An enhanced meta review. *Computers in Human Behavior Reports*, *18*, 100696. https://doi.org/10.1016/j.chbr.2025.100696

Van Herbruggen, B., Fontaine, J., Simoen, J., De Mey, L., Peralta, D., Shahid, A., & De Poorter, E. (2024). Strategy analysis of badminton players using deep learning from IMU and UWB wearables. *Internet of Things*, *27*, 101260. https://doi.org/10.1016/j.iot.2024.101260

Zhang, S., Chen, G., Wu, Q., & Li, X. (2023). The interplay between table tennis skill development and sports performance: A Comprehensive review. *Pacific International Journal*, *6*(3), 150–156.