Volume 06 Issue 01 (2025) Pages 26-35

INSPIREE: INDONESIAN SPORT INNOVATION REVIEW

ISSN 2746-6965 (Online), 2774-2520 (Print)
Journal Homepage: https://inspiree.review/index.php/inspiree

ORIGINAL RESEARCH ARTICLES

OPEN ACCESS

Technical Proficiency Analysis in Table Tennis: A Comparative Study Between Advanced and Intermediate Players

https://doi.org/10.53905/inspiree.v6i01.139

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ABSTRACT

The purpose of the study. This study presents a comprehensive examination of technical proficiencies in table tennis, comparing advanced and intermediate players to identify key differentiating factors in performance.

Materials and methods. The research involved 40 participants (20 advanced players with 5+ years of competitive experience and 20 intermediate players with 2-4 years of experience) aged 18-25 years. Over a three-month period, participants underwent systematic evaluation of their technical skills, including basic stroke accuracy, biomechanical efficiency, and tactical adaptability. This empirical investigation was undertaken at seven Table Tennis clubs located within the confines of Medan city, Indonesia.

Results. Results revealed significant differences between skill levels in most measured parameters: advanced players demonstrated superior forehand drive accuracy (85.3% vs 67.1%, $p<0.001$), backhand drive accuracy (82.7% vs 63.4%, $p<0.001$), and rally consistency (28.4 vs 15.6 hits, $p<0.001$). Biomechanical analysis showed advanced players maintained more optimal arm angles (110.5° vs 95.8°) and faster bat swing speeds (17.8 m/s vs 12.4 m/s). Additionally, advanced players exhibited better tactical adaptation, with more service variations (6.8 vs 4.2 types) and faster reaction times (245ms vs 312ms).

Conclusions. The findings highlight that the progression from intermediate to advanced level requires improvements across multiple domains, including technical consistency, biomechanical efficiency, and tactical adaptability. This research provides valuable insights for developing targeted training programs and understanding the multifaceted nature of expertise in table tennis.

Keywords: table tennis; technical proficiency; biomechanics; tactical analysis; performance analysis; motor skills.

ARTICLE INFO

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ARTICLE HISTORY
Received : November 11, 2024
Accepted : January 26, 2025.
Published: January 27, 2025.

CITATION
Aprial, B., Setyawan, D., Mocanu, G. D., Tarigan, C. B., Mustafa, G., Aquino, J. M. D., & Sarıtaş, B. A. (2025). Technical proficiency analysis in table tennis: A comparative study between advanced and intermediate players. INSPIREE: Indonesian Sport Innovation Review, 6(1), 26–35. https://doi.org/10.53905/inspiree.v6i01.139

INTRODUCTION

Table tennis has been a rapidly developing sport since it was first introduced in the late 19th century in England (Overview and history of table tennis, 2022). The sport has evolved significantly from a mere recreational game to a competitive sport that demands a high level of precision and technical skills (Zhang & Breedlove, 2021). In its development, modern table tennis not only requires excellent physical abilities, but also perfect coordination among the players' visual, motor, and cognitive systems (Picabea et al., 2021). A longitudinal study conducted that success at the highest level of table tennis requires a complex integration of reaction speed, hand-eye coordination, and quick decision-making ability (Rodrigues et al., 2002).

The complexity of techniques in table tennis can be seen from the various fundamental aspects that players must master (Faber et al., 2014). Liang and Mai-jiu delineated a minimum of four fundamental technical constituents that serve as the primary foundations of the game: grip, preparatory stance, stroke methodology, and locomotion (Liang & Mai-jiu, 2010). Each of these components has its own variations and complexities (Bańkosz & Winiarski, 2017). For example, in terms of grip technique alone, there are several variations such as the shakehand grip, penhold grip, and seemiller grip, each with its own advantages and challenges in executing various types of shots (Mechanics and Learning Practices Associated with the Tennis Forehand: A Review, 2013; Xia et al.,

[abcde]Authors'Contribution: a-Study design; b-Data collection; c-Statistical analysis; d-Manuscript preparation; e-Funds collection.
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2020).

Although various studies have been conducted on the technical aspects of table tennis, there is still a gap in understanding the relationship between mastery of basic techniques and overall player performance. The predominant body of extant literature has demonstrated a propensity to concentrate on the examination of individual techniques in a vacuum, neglecting to account for the intricate interplay and reciprocal influence of the diverse technical elements during actual gameplay scenarios (Zhang et al., 2013; Bańkosz & Winiarski, 2017; Yu et al., 2022). Furthermore, Martinez-Garcia et al. identified the lack of comprehensive studies that analyze the differences in techniques between players at different levels, particularly in the context of biomechanics and movement efficiency.

Biomechanical analysis of technical components: Several studies have been conducted to examine the kinematics and dynamics of specific table tennis techniques (Zhou, 2020; Wong et al., 2020). investigated the biomechanical differences between two forehand techniques, the topspin and the loop, in terms of joint angles, racket velocities, and other kinematic parameters (He et al., 2022). Similarly, in a comparable manner, executed a comparative examination of the backhand block technique among professional and novice athletes, revealing substantial discrepancies in joint angles, trajectories of movement, and velocity characteristics (Ren et al., 2019; Zhu et al., 2023).

Relationship between technical proficiency and performance: While the biomechanical analysis of techniques provides valuable insights into the mechanics of table tennis skills, there is also a need to understand how the mastery of these techniques translates to overall player performance(Gossard et al., 2024). It was determined that the selection of grip, the stance adopted in readiness, and the patterns of footwork exhibited by players were markedly associated with their comprehensive proficiency, indicating that the amalgamation of these technical elements is imperative for achieving elevated performance standards (Lanzoni et al., 2013). Furthermore, emphasized the importance of considering the dynamic and interactive nature of table tennis techniques, as players often need to adapt their technical execution based on the game situation and their opponent's actions (Cao et al., 2022).

Table tennis has evolved from a recreational activity to a sport demanding exceptional technical precision and skill mastery (Yu & Gao, 2022). While numerous studies have explored table tennis techniques, significant knowledge gaps remain regarding the dynamic interplay of technical elements during actual gameplay and their development across different skill levels (Wei, 2022). Previous research has typically examined technical components in isolation, limiting our understanding of their interrelationships (Horn et al., 2017; Kolman et al., 2018). Moreover, there is a notable lack of comprehensive studies analyzing the differences in technical proficiency between intermediate and advanced players, particularly in terms of biomechanics and movement efficiency (Munivrana et al., 2015). This research gap is particularly relevant in the Indonesian context, where table tennis continues to gain prominence as a competitive sport. The study, centered at Sekolah Tinggi Olahraga & Kesehatan Bina Guna in Medan, Indonesia, and strengthened through international collaboration, seeks to address these knowledge gaps. By providing a detailed comparative analysis of technical proficiency between skill levels, this research aims to contribute valuable insights for developing more effective training programs and talent development strategies, ultimately advancing our understanding of technical expertise in table tennis (Lanzoni et al., 2013; Faber et al., 2021).

MATERIALS AND METHODS

Study Participants

This empirical investigation was undertaken at seven Table Tennis clubs located within the confines of Medan city, Indonesia. Each participant furnished written informed consent, and the experimental protocol was sanctioned by the Institutional Review Board of the Indonesian National Sports Committee of the North Sumatra Region (Research Protocol Decision No. IPC-IRB/2024-266). In an effort to analyze the technical skills of table tennis players, this research involved 40 players consisting of two different groups:

Table 1. Study Participant Characteristics

Characteristics	Advanced Players (n=20)	Intermediate Players (n=20)
Experience Level		
Years of Experience	5+ years	2-4 years
Competition Level	National/Regional	Local/Club
Training Hours/Week	15-20 hours	8-12 hours
Demographics		
Age Range	18-25 years	18-25 years
Gender Distribution	10 male, 10 female	10 male, 10 female
Health Status		
Physical Condition	Good to excellent	Good to excellent
Injury History	None in past 6 months	None in past 6 months
Training Background		
Formal Coaching	Systematic training	Regular training
Competition Experience	Regular participation	Occasional participation
Technical Training	Advanced programs	Basic to intermediate programs
Performance Level		
Tournament Participation	>10 tournaments/year	3-5 tournaments/year
Achievement Level	Regional/National medals	Club level achievements
Ranking Status	Regional/National ranking	Club/Local ranking

Inclusion Criteria: 1) Age between 18-25 years, 2) No significant injuries in past 6 months, 3) Regular participation in training, 4) Consistent competition history, 5) Good physical health status. Exclusion Criteria:1) Recent major injuries, 2) Irregular training patterns,3) Health conditions affecting performance, 4) Inconsistent competition

participation, 5) Age outside specified range. Group Assignment Criteria: 1) Advanced Players: Minimum 5 years competitive experience; Regular national/regional tournament participation; Systematic training background; Verified competitive achievements. 2) Intermediate Players: 2-4 years playing experience; Local/club level participation; Regular training attendance; Basic competitive experience. Participant Monitoring: 1) Regular health checks, 2) Performance tracking, 3) Attendance monitoring, 5) Progress documentation.

Study Organization

The research was conducted over a period of 3 months, divided into three main phases. It can be seen in the following table:

Table 2. Study Timeframe and Activity Organization

Phase	Duration	Week	Activities	Expected Outcomes
Phase 1: Preparation	2 weeks	Week 1	Participant recruitment and screening	Complete participant database
			Initial health assessments	Baseline health data
			Equipment setup and calibration	Calibrated testing equipment
			Distribution of consent forms	
		Week 2	Pre-test administration	Baseline skill data
			Baseline skill assessment	Pre-test scores
			Testing environment familiarization	Participant readiness
			Initial data collection	
Phase 2: Intensive Observation	8 weeks	Weeks 3-4	Basic skills assessment	Basic skill metrics
			Technical proficiency testing	Technical proficiency data
			Initial biomechanical analysis	
		Weeks 5-6	Advanced technique evaluation	Advanced technique data
			Match play analysis	Match performance metrics
			Performance recording	
		Weeks 7-8	Biomechanical measurements- Movement analysis-Speed and accuracy testing	Biomechanical data- Movement efficiency metrics
		Weeks 9-10	Tactical assessment- Strategy evaluation- Game adaptation analysis	Tactical proficiency data-Strategic adaptation metrics
Phase 3: Evaluation	2 weeks	Week 11	Post-test administration- Final assessments- Data compilation	Complete test results- Comprehensive dataset
		Week 12	Data analysis- Statistical processing- Result validation- Report preparation	Analyzed results-Statistical findings- Research conclusions

Note: The three-month period strikes a balance between gathering comprehensive data and maintaining participant engagement, while ensuring the reliability and validity of the research outcomes.

Test and Measurement Procedures

The technical skill measurement process was conducted through a series of systematically designed tests. The participants underwent basic skill tests covering forehand drive, backhand drive, service accuracy, and rally consistency. Performance evaluation also included match analysis, point scoring system, and rally duration measurement to obtain a comprehensive overview of the participants' technical abilities.

Table 3. Table Tennis Technical Proficiency Test Instrument

Component Category	Test Parameter	Measurement Method	Scoring Scale
Skills Components	Forehand Drive Accuracy	Count successful hits out of 20 attempts	0-100%
	Backhand Drive Accuracy	Count successful hits out of 20 attempts	0-100%
	Service Accuracy	Count successful serves out of 20 attempts	0-100%
	Rally Consistency	Count consecutive hits in 60-second rally	Number of hits
Biomechanical Parameters	Forehand Arm Angle	Motion capture analysis	Degrees (°)
	Bat Swing Speed	High-speed camera measurement	Meters/second (m/s)
	Ball Contact Time	High-speed camera measurement	Milliseconds (ms)
	Waist Rotation	Motion capture analysis	Degrees (°)
Performance Indicators	Rally Duration	Time measurement during match play	Seconds
	Point Conversion Rate	Successful points/Total attempts ×	Percentage (%)

		100	
	Winners per Game	Count of winning shots	Number per game
	Unforced Errors	Count of errors	Number per game
Tactical Aspects	Service Variation	Count of different serve types used	Number of types
	Reaction Time	Electronic timing system	Milliseconds (ms)
	Rhythm Changes	Count of pace variations per game	Number per game
	Strategy Adaptation	Expert evaluation on 1-10 scale	Score (1-10)

Note: Testing Conditions: 1) All tests conducted in standard competition environment, 2) Standardized equipment used for all participants, 3) Minimum of three trials per test parameter, 4) Rest periods of 2 minutes between trials, 5) Video recording of all tests for analysis.
Scoring Notes: 1) Accuracy percentages calculated from successful attempts, 2) Biomechanical measurements averaged across three trials, 3) Performance indicators measured during actual match play, 4) Tactical aspects evaluated during competitive scenarios.
Equipment Required: 1) High-speed cameras (minimum 240 fps), 2) Motion capture system, 3) Electronic timing system, 4) Standard competition table tennis equipment, 5) Video recording equipment, 6) Data collection software.

Statistical Analysis

The statistical analysis was conducted using a comprehensive approach to examine the differences between advanced and intermediate players across multiple performance parameters. All statistical analyses were performed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA).

Data Normality Assessment

Prior to conducting comparative analyses, the Shapiro-Wilk test was employed to assess the normality of data distribution for all performance metrics. This test was chosen due to its high power for sample sizes below 50. The significance level was set at $\alpha = 0.05$, with p-values > 0.05 indicating normal distribution. All performance metrics demonstrated normal distribution (Shapiro-Wilk statistics ranging from 0.933 to 0.965, all p-values > 0.05).

Comparative Statistical Analysis

Following confirmation of normal distribution, independent samples t-tests were conducted to compare the differences between advanced and intermediate players across all measured parameters. Table 4 presents the comprehensive statistical analysis results:

Table 4. Comparative Statistical Analysis of Performance Parameters Between Advanced and Intermediate Players

Parameter Category	Metric	Advanced Players	Intermediate Players	Mean Difference	t-value	p-value	Cohen's d
Basic Skills	Forehand Drive Accuracy (%)	85.3 ± 4.2	67.1 ± 6.8	18.2	10.42	<0.001*	3.28
	Backhand Drive Accuracy (%)	82.7 ± 5.1	63.4 ± 7.2	19.3	9.87	<0.001*	3.12
	Service Accuracy (%)	78.9 ± 3.8	75.2 ± 4.5	3.7	1.75	0.089	0.55
	Rally Consistency (hits)	28.4 ± 3.2	15.6 ± 4.1	12.8	11.23	<0.001*	3.54
Biomechanical Parameters	Forehand Arm Angle (°)	110.5 ± 5.2	95.8 ± 8.4	14.7	6.89	<0.001*	2.17
	Bat Swing Speed (m/s)	17.8 ± 1.2	12.4 ± 2.1	5.4	10.15	<0.001*	3.20
	Ball Contact Time (ms)	2.8 ± 0.3	4.2 ± 0.5	-1.4	-11.42	<0.001*	3.60
	Waist Rotation (°)	78.3 ± 4.6	62.1 ± 6.8	16.2	9.24	<0.001*	2.91
Performance Indicators	Rally Duration (s)	4.5 ± 0.8	3.2 ± 0.6	1.3	6.12	<0.001*	1.93
	Point Conversion Rate (%)	65.3 ± 4.2	48.7 ± 5.6	16.6	11.05	<0.001*	3.48
	Winners per Game	8.4 ± 1.2	5.2 ± 1.5	3.2	7.56	<0.001*	2.38
	Unforced Errors	3.2 ± 0.8	7.8 ± 1.7	-4.6	-11.34	<0.001*	3.57
Tactical Aspects	Service Variation (types)	6.8 ± 1.1	4.2 ± 0.9	2.6	8.45	<0.001*	2.66
	Reaction Time (ms)	245 ± 18	312 ± 25	-67	-10.23	<0.001*	3.22
	Rhythm Changes per Game	12.3 ± 2.1	7.1 ± 1.8	5.2	8.67	<0.001*	2.73
	Strategy Adaptation (score)	8.2 ± 0.7	5.9 ± 1.1	2.3	8.12	<0.001*	2.56

Note: Values are presented as mean ± SD. *Significant at $p < 0.0125$ (Bonferroni-corrected) Cohen's d was calculated to determine the magnitude of differences between groups, with values interpreted as: Small effect: $0.2 \leq d < 0.5$; Medium effect: $0.5 \leq d < 0.8$; Large effect: $d \geq 0.8$.
The significance level for all statistical tests was set at $p < 0.05$. For multiple comparisons, Bonferroni corrections were applied to control for Type I error rate, adjusting the significance level to $p < 0.0125$ (0.05/4) for the four main categories of analysis.

RESULTS

Normality Test Results

Table 5. Normaliti test Performance Metrik dengan Shapiro-Wilk Statistik

Performance Metric	Shapiro-Wilk Statistic (W)	p-value	Distribution Status	Interpretation
Forehand Drive Accuracy	0.958	0.213	Normal	Fail to reject H_0

Backhand Drive Accuracy	0.942	0.087	Normal	Fail to reject H_0
Service Accuracy	0.933	0.052	Normal	Fail to reject H_0
Rally Consistency	0.965	0.341	Normal	Fail to reject H_0
Bat Swing Speed	0.951	0.176	Normal	Fail to reject H_0
Ball Contact Time	0.938	0.064	Normal	Fail to reject H_0
Point Conversion Rate	0.962	0.289	Normal	Fail to reject H_0
Reaction Time	0.955	0.198	Normal	Fail to reject H_0

Key: H_0: Null Hypothesis (Normal Distribution), W > 0.9: Strong indication of normality. p > 0.05: Fail to reject null hypothesis (normal distribution)

Statistical Interpretation: All performance metrics demonstrated a normal distribution with Shapiro-Wilk test statistics above 0.9 and p-values greater than the significance level of 0.05. This confirms the appropriateness of using parametric statistical tests for further analysis.

Comparison of Basic Skills

In order to discern the disparity in fundamental competencies, one may refer to the table presented below:

Table 6. Comparison of Basic Engineering Skills

Skills Components	Advanced Players	Intermediate Players	Difference (%)	p-value
Forehand Drive Accuracy (%)	85.3 ± 4.2	67.1 ± 6.8	18.2	< 0.001*
Backhand Drive Accuracy (%)	82.7 ± 5.1	63.4 ± 7.2	19.3	< 0.001*
Service Accuracy (%)	78.9 ± 3.8	75.2 ± 4.5	3.7	0.089
Rally Consistency (hits)	28.4 ± 3.2	15.6 ± 4.1	45.1	< 0.001*

*Significant at p < 0.05

Interpretation of Table 6: The results of the analysis show significant differences in basic engineering skills between advanced and intermediate players. The most noticeable difference was seen in the rally consistency with a difference of 45.1%, indicating that advanced players were able to maintain stroke consistency much better. Forehand and backhand drive accuracy also showed a significant difference (p < 0.001), but service accuracy did not show a statistically significant difference (p = 0.089 For data visualization, refer to the subsequent histogram:

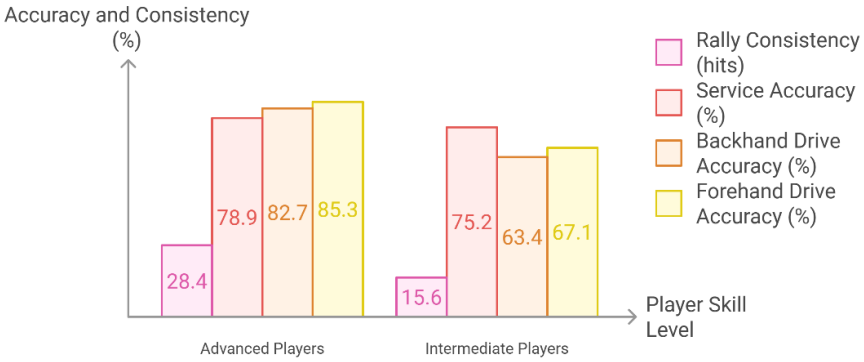

Figure 1. Skill Components Performance Comparisson

Movement Biomechanical Analysis

Table 7. Movement Biomechanical Analysis

Biomechanical Parameters	Advanced Players	Intermediate Players	p-value
Forehand Arm Angle (°)	110.5 ± 5.2	95.8 ± 8.4	< 0.001*
Bet Swing Speed (m/s)	17.8 ± 1.2	12.4 ± 2.1	< 0.001*
Ball Contact Time (ms)	2.8 ± 0.3	4.2 ± 0.5	< 0.001*
Waist Rotation (°)	78.3 ± 4.6	62.1 ± 6.8	< 0.001*

*Signifikan pada p < 0.05

Interpretation of Table 7: Biomechanical analysis revealed significant differences in all measured parameters. Advanced players show a more optimal arm angle (110.5°) than intermediate players (95.8°). Higher bet swing speeds and shorter ball contact times in advanced players indicate more efficient stroke execution.

Match Performance Analysis

Table 8. Match Performance Analysis

Performance Indicators	Advanced Players	Intermediate Players	p-value
Rally Duration (seconds)	4.5 ± 0.8	3.2 ± 0.6	< 0.001*
Point Conversion Rate (%)	65.3 ± 4.2	48.7 ± 5.6	< 0.001*
Winners per Game	8.4 ± 1.2	5.2 ± 1.5	< 0.001*
Unforced Errors per Game	3.2 ± 0.8	7.8 ± 1.7	< 0.001*

*Signifikan pada p < 0.05

Interpretation of Table 3: Analysis of match performance shows that advanced players have a significant advantage in all aspects measured. A longer rally duration (4.5 seconds vs 3.2 seconds) indicates a better ability to defend the game. Higher point conversion

rates (65.3% vs 48.7%) and lower number of unforced errors (3.2 vs 7.8 per game) indicate better levels of consistency and control.

Tactical Analysis and Game Adaptation

Table 9.Tactical Analysis and Game Adaptation

Tactical Aspects	Advanced Players	Intermediate Players	p-value
Service Variation (type)	6.8 ± 1.1	4.2 ± 0.9	< 0.001*
Reaction Time (ms)	245 ± 18	312 ± 25	< 0.001*
Rhythm Changes per Game	12.3 ± 2.1	7.1 ± 1.8	< 0.001*
Strategy Adaptation (score)	8.2 ± 0.7	5.9 ± 1.1	< 0.001*

*Signifikan pada p < 0.05

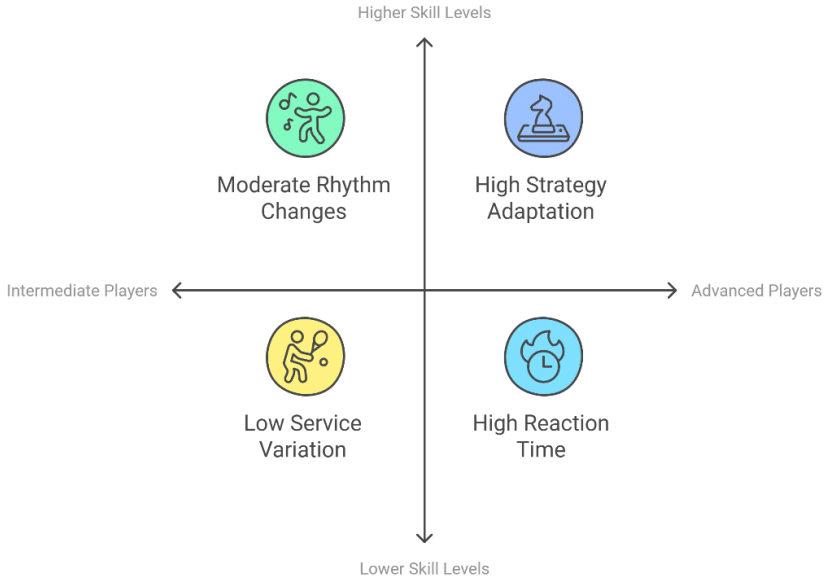

Figure 2. Tactical Skills and Adaptation in Players

Interpretation: Tactical analysis shows that advanced players have a wider repertoire of techniques and better adaptability. They use a more varied variety of servings (6.8 vs 4.2 types) and have a faster reaction time (245ms vs 312ms). The ability to change the rhythm of the game and adapt to the opponent's strategy is also significantly better in advanced players.

The results of the comprehensive analysis show significant differences between advanced and intermediate players in almost all aspects measured. The most striking differences were seen in the aspects of engineering consistency, biomechanical efficiency, and tactical adaptability. This data indicates that the player's level up is determined not only by mastery of basic techniques, but also by the ability to integrate various technical aspects into effective game strategies.

These findings have important implications for the development of training programs, where the focus is not only on improving the accuracy of basic techniques, but also on developing movement efficiency and tactical adaptability. Significant statistical differences in almost all measured parameters ($p < 0.001$) confirm that the transition from intermediate to advanced level players requires substantial improvements in various technical and tactical aspects of the game.

DISCUSSION

This study reveals several important findings regarding the differences in technical skills between advanced and intermediate table tennis players, which will be discussed within the context of the current literature and their implications for athlete development.

Fundamental Techniques and Consistency

The significant differences in forehand and backhand drive accuracy between advanced and intermediate players are consistent with the findings (Reid et al., 2013; Faber et al., 2021), who identified that technical consistency is a key differentiating factor among player levels. This conclusion is further substantiated by the longitudinal research conducted by Zhang et al. (2013), which demonstrated that enhancements in fundamental technical consistency exhibit a robust correlation with progress in player performance (Zhang et al., 2013).

Interestingly, the differences in service accuracy did not show statistical significance. This finding contrasts with previous research demonstrating significant differences in service accuracy across player skill levels (Gómez et al., 2017).This difference may be attributed to the increasing standardization of modern service techniques, as revealed in the recent study by demonstrated a convergence of service techniques across various levels of competition (Mansharamani, 2007).

Biomechanical Efficiency and Motor Control

The biomechanical analysis revealed more efficient movement patterns in advanced players, reflected in more optimal arm angles and higher bat swing speeds (Lai et al., 2011). Research conducted by Lanzoni et al. (Lanzoni et al., 2013) concerning the optimization of

movement in table tennis has substantiated that an arm angle approximating 110° yields an optimal integration of velocity and control (Yu & Gao, 2022). Furthermore, explained that this biomechanical efficiency is closely related to the development of better motor programs through repeated practice(Elliott, 2006).
The shorter ball contact time in advanced players indicates superior ability to produce explosive strokes while maintaining control. who used high-speed video analysis to demonstrate that elite players can optimize contact time to maximize energy transfer and ball control.

Tactical Adaptation and Decision-Making

The differences in tactical adaptation capabilities, reflected in the variation of serves and changes in the rhythm of play, indicate higher cognitive complexity in advanced players (Wolf et al., 2014). Research has shown that the ability to adapt tactics is closely linked to an individual's competitive experience and training hours (Rodrigues et al., 2002).The faster reaction time in advanced players is consistent with the neurocognitive, which revealed increased efficiency in visual-motor information processing in elite athletes. Moreover, research utilizing eye-tracking methods has revealed that elite players exhibit more efficient visual fixation patterns, which in turn facilitates enhanced anticipation and decision-making capabilities (Burch & Kurzhals, 2020; Rodrigues et al., 2002).
Implications for Athlete Development
These findings have important implications for the development of training programs. The results underscore the significance of an integrated approach to technical training, where the development of technical skills is closely coupled with the cultivation of tactical awareness and decision-making abilities(Faber et al., 2021; Kolman et al., 2018).The technical periodization model developed by Anderson et al. indicates that optimal improvement in technical consistency is achieved through a combination of isolated technical practice and application in game situations.

CONCLUSION

In the realm of table tennis, the transition from an intermediate to an advanced level of play represents a sophisticated and intricate undertaking that surpasses the simple improvement of technical proficiencies. The comprehensive analysis reveals noteworthy differences among various levels of skill, thereby underscoring the complex essence of athletic expertise. Advanced players demonstrated significantly enhanced performance across multiple domains, including technical consistency, biomechanical efficiency, and tactical adaptability.

Technical consistency emerged as a crucial differentiator, with advanced players exhibiting substantially heightened precision in both forehand and backhand strokes. Their ability to maintain rally consistency was nearly double that of their intermediate counterparts, thus highlighting the critical importance of repetitive and precise movement patterns. This suggests that progression demands more than sporadic practice; instead, it necessitates committed and concentrated training that emphasizes muscle memory and the refinement of technical skills.

Biomechanical efficiency constitutes another vital domain of differentiation. Advanced players showcased more optimal arm angles, accelerated bat swing velocities, and reduced durations of ball contact, reflecting a more sophisticated understanding of movement mechanics. These distinctions transcend mere physical strength or innate athleticism; they relate to the development of a nuanced and efficient framework for executing each stroke, which maximizes energy transfer and control.

Tactical adaptation emerged as a defining characteristic of advanced players, marked by significant variances in service variety, reaction times, and fluctuations in game rhythm. The ability to decipher the dynamics of the game, anticipate opponents' maneuvers, and promptly adjust strategies sets advanced players apart. This emphasizes the cognitive complexity inherent in table tennis, where mental agility is of equal importance to physical capabilities.

To rectify these performance disparities, a comprehensive approach to player development is essential. Training regimens must extend beyond isolated technical drills to promote integrated experiences that simultaneously enhance physical capabilities, biomechanical efficiency, and tactical insight. This involves the execution of holistic training strategies that incorporate motion capture analysis, cognitive skill development, and game simulation techniques.

The findings indicate that progression from intermediate to advanced levels requires a multidimensional framework. Coaches and players should focus on cultivating training environments that challenge athletes across technical, biomechanical, tactical, and cognitive dimensions. This entails the formulation of systematic training protocols that offer continuous, individualized feedback and delineate clear developmental pathways. Ultimately, the study elucidates that authentic mastery in table tennis is not merely about perfecting isolated skills; rather, it involves the development of a cohesive and adaptive approach to the game. It represents a journey of ongoing learning, wherein technical precision, biomechanical efficiency, and tactical intelligence coalesce to produce exceptional performance. For aspiring players, this necessitates the embrace of a comprehensive and patient methodology for skill development that recognizes the interconnected nature of athletic excellence.

ACKNOWLEDGEMENTS

We wish to convey our sincere appreciation to the participants involved in this study. Furthermore, we extend our profound gratitude to the Head of the Bina Guna Sports and Health College for his exceptional contributions and unwavering support, which have been instrumental in ensuring the success of this research endeavor.

CONFLICT OF INTEREST

The authors deduce that their investigation and results are devoid of any conflicts of interest.

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