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Defining the Influence of Age and Gender on Key Performance Metrics in Badminton

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Abstract

Background. Badminton, a racquet sport that has gained global popularity, demands technical precision, tactical awareness, and exceptional physical fitness. Skills such as smashing, footwork, and minimizing errors are critical to success. However, the specific influence of age and gender on these metrics, especially among younger players, remains underexplored.

Objectives. This study aimed to examine the effect of age and gender on key badminton performance metrics, including smash ability, footwork, and unforced errors, in order to identify developmental and demographic factors influencing skill acquisition and execution.

Materials and methods. A quantitative descriptive study involved 24 athletes (aged 9–14) from the Wincorp badminton organization in Surakarta, Indonesia. Participants were grouped by age (9–10, 11–12, 13–14 years) and gender, ensuring equal representation. Over two months, data on smashing, lobbing, driving, footwork, and error rates were collected. Descriptive statistics and MANOVA analyzed differences, with a significance level set at $p < 0.05$.

Results. MANOVA revealed significant age-related effects on smashing ($p = 0.000$), footwork ($p = 0.000$), and error points ($p = 0.000$), with beginners (13–14 years) excelling in most metrics. Gender differences were also found to be substantial for smashing ($p = 0.000$), footwork ($p = 0.000$), and error points ($p = 0.003$), with males outperforming females in most categories. Interaction effects between age and gender were significant for smashing and footwork ($p < 0.05$). However, no considerable differences were observed for netting and serving strokes across age or gender.

Conclusions. The study indicates that age and gender significantly influence badminton performance metrics. Beginner athletes (13–14 years) demonstrated superior skills compared to younger groups, while males generally outperformed females. These findings highlight the importance of tailoring training programs by age and gender to optimize skill development and reduce performance gaps. Further studies should be performed to investigate biomechanical and psychological factors to refine coaching strategies.

Keywords: badminton, athlete characteristics, age, gender, performance metrics, smash skills, footwork.

Introduction

Badminton is widely regarded as one of the fastest racquet sports globally (Ali Siong, 2023; Pan et al., 2024; Pratama, et al., 2024; Rusdiana et al., 2023; Zubir et al., 2022), offering opportunities for players of all ages to compete across varying skill levels, including in Indonesia, where it is trendy (Sepdanius, Rifki & Gemaini, 2023; Loureiro & Freitas, 2012). This sport is characterized by its demand for quick planning and execution of movements, rapid reaction speed, and precise temporal and spatial control, especially in positioning the racket to intercept the shuttlecock, making these competencies essential for successful players (Huang, 2023; Prajongjai et al., 2023; Lam et al., 2018). Players must also exhibit exceptional athleticism and adapt to the sport's high physical and cognitive demands (Setijono et al., 2024; Stovba et al., 2020).

In addition to the technical and tactical requirements, Malwanage, Senadheera & Dassanayakeand (2022) and Woodward (2013) emphasized that aerobic stamina, agility, strength, explosive power, speed, flexibility, balance, and coordination are critical components of physical fitness in badminton. Research has shown that specially selected exercises significantly improve the speed and accuracy of attacking strokes in young badminton players, underscoring the role of targeted training in enhancing performance (Shevchenko et al., 2023). Elite-level players display a superior ability to integrate visual cues from opponents' movements, enabling them to anticipate actions effectively and outperform lower-level competitors (Abdullah et al., 2023). Furthermore, badminton is distinguished by the shuttlecock's extreme speed during elite matches, where it can exceed 250 km/h (Abián et al., 2017). Alongside its physical demands, the sport involves a high level of perceptual-motor performance, tactical acumen, and psychological resilience in competitive scenarios (Arnando et al., 2023; Hülsdünker et al., 2021; Jaworski & Żak, 2016; Munzert et al., 2008). Given these complexities, evaluating game activities during tournaments is crucial for advancing high-level performance. Players must perform rapid directional changes, lunges, jumps, and arm movements, requiring significant postural adjustments (Nugroho et al., 2022; Nugroho et al., 2021; Özgür & Hotaman, 2020; Rusdiana et al., 2021). Recent research has highlighted the significant association between the Medial Longitudinal Arch (MLA) and static balance in recreational badminton players, emphasizing the importance of considering foot structure in performance enhancement (Han et al., 2022). Key skills in badminton include stroke play and footwork, which rely heavily on hand-eye coordination and balance, respectively (Woodward & Williams, 2017). Effective footwork entails quick directional changes, precise acceleration or deceleration, and enhanced shot accuracy (Ferrauti et al., 2013). Navigating the six court zones (frontcourt, midcourt, backcourt, and lateral zones) involves diverse stepping techniques, lunges, and arm motions (Wang et al., 2024). As such, agility in footwork is a central focus in training and competition (Gusliandi et al., 2020; Pratama, et al., 2024).

Over time, badminton has undergone significant transformations, highlighting the importance of performance analysis as an integral part of training programs. These analyses provide athletes with critical insights for improving their skills. For example, the modern scoring system, which requires players to achieve 21 points in two sets, assigns points for each successful stroke and penalizes unforced errors (UEs). Coaches and sports scientists thus analyze match-related performance metrics to inform tactical and technical training strategies. Technical skills, including reducing UE) and increasing winner points (WPs), are crucial markers of a player's proficiency (Barreira & Chiminazzo, 2020). Hughes and Bartlett (2002) state that WPs and UEs are the primary metrics for assessing technical competence. UEs are particularly prevalent among players who lose high-level matches (Laffaye, Phomsoupha & Dor, 2015). For them, UE and WP are the leading performance metrics that change depending on the qualities of players in badminton matches. Blomqvist, Luhtanen & Laakso (1998) highlighted that analyzing a match's technical elements, particularly UEs and WPs, is critical to understanding player performance. Prior research has consistently shown that players who lose matches, regardless of gender, nationality, or performance level, tend to commit more UEs than WPs (Abian-Vicen et al., 2014; Abián et al., 2013).

Although many studies have examined WPs and UEs as performance indicators in badminton, detailed analyses of specific skills like hitting ability, footwork, and error points across various player categories still need to be included. This gap is particularly evident among younger or beginner-level athletes, where the relationship between these skills and match outcomes is poorly understood. Despite the acknowledged importance of balance and footwork for high-level badminton performance (Malwanage, Senadheera & Dassanayake, 2022), existing research has yet to explore how age and gender influence these critical metrics comprehensively.

The study aims to investigate the influence of age and gender on smashing skills, footwork, and error points, analyze the interaction between these factors on performance metrics, and identify the age and gender groups that demonstrate optimal performance to inform tailored training programs for young athletes in Indonesia.

Materials and Methods

Participants

This study employed a purposive sampling method to recruit 24 participants from the Wincorp badminton organization in Surakarta, Indonesia. The inclusion criteria required participants to meet the following conditions: (1) be a member of the Wincorp organization, (2) have a minimum of three years of playing experience, (3) fulfil predetermined anthropometric criteria, and (4) fall within the age range of 9 to 14 years. The participants were then divided into three distinct age categories based on their developmental stage: (1) early-age players (9–10 years), (2) children 's-age players (11–12 years), and (3) beginner-age players (13–14 years). Each group consisted of 8 participants, ensuring equal representation across the categories. Data collection occurred over two months, from 15 September to 16 November 2023, during which participants were observed and evaluated to assess the influence of their characteristics on badminton performance. Data collection in this study was conducted following the Declaration of Helsinki and received approval from the University Ethics Committee.

Research Design

The study utilized a quantitative descriptive research design to explore the relationship between athlete characteristics (such as age and gender) and specific performance metrics in badminton. The research focused on three primary performance variables: smash skills, footwork, and error points (unforced errors). These variables were selected based on their relevance to badminton performance and their established role in evaluating player skills. The design was chosen to provide a clear, structured assessment of how individual characteristics influence these key aspects of the sport.

Variables Observed

The primary variables observed in this study were:

Smash and Hitting Skills: This category included techniques such as smash, lob, netting, drive, underhand, drop shot, and serve. These skills were assessed based on their execution and effectiveness during match play.

Footwork Performance: Footwork was evaluated in terms of agility, court coverage, and the ability to change direction quickly and effectively.

Error Points (Unforced Errors): These were defined as mistakes made by the players that led to points being awarded to the opponent. Unforced errors were recorded and analyzed to measure the players' technical proficiency and decision-making during play.

These variables were chosen because they are widely recognized as core elements of badminton performance and are essential for evaluating players' skill levels.

Data Collection

Data were collected through direct observations of participants during regular training and match play. During the two-month data collection period, each participant was observed multiple times to ensure a comprehensive and accurate assessment of their performance in the targeted areas: smash skills, footwork, and error points.

Statistical Analysis

Data analysis was performed using SPSS version 26. Descriptive statistics were first applied to summarize the participants' characteristics and the performance metrics across the three age groups. This included calculating the mean and standard deviation for each observed variable. To determine whether there were significant differences in performance between the groups based on age and gender, a Multivariate Analysis of Variance (MANOVA) was conducted. MANOVA was chosen because it allows for the simultaneous analysis of multiple dependent variables, which reduces the risk of Type I errors when assessing the effect of age and gender on performance (Finch, 2016).

Before conducting MANOVA, assumptions of multivariate normality, homogeneity of variance-covariance matrices (verified using Box's M test), and the absence of multicollinearity were tested to ensure the validity of the results. Following MANOVA, post hoc analyses using Tukey's test were performed to identify specific group differences when significant results were obtained. The significance level for all statistical tests was set at $p < 0.05$, and effect sizes (e.g., partial eta squared) were reported to provide further context on the magnitude of observed differences. This methodological approach was designed to provide a rigorous analysis of the impact of athlete characteristics on badminton performance, ensuring that the findings were both statistically valid and practically meaningful.

Results

Table 1 below presents the average values of the variables observed in the early age (9-10 years), children (11-12 years), and beginners (13-14 years) categories, as well as in the gender category.

As shown in Table 1, the average number of smash shots, lob shots, netting shots, drive shots, underhand shots, drop shots, service actions, and footwork was higher for early-aged athletes (aged 9–10 years) compared to children (10–11 years) and beginners (12–13 years). This trend was consistent regardless of the athlete's age category.

When the sample size (N = 8) includes four males and four females in each group, early-aged athletes displayed fewer average error points (7.00 for males and 8.50 for females) than children (14.00 for males and 22.50 for females) and beginners (13.25 for males and 15.00 for females). Based on gender, male athletes exhibited higher average numbers of smashes, lob shots, netting shots, drive shots, underhand shots, drop shots, service actions, and footwork than female athletes. Furthermore, male athletes consistently had fewer error points than their female counterparts (refer to Table 1 for detailed statistics).

Two critical assumptions must be verified before conducting a MANOVA test: normality and homoscedasticity (Finch & French, 2013). These assumptions were tested to determine whether they were satisfied using appropriate statistical procedures. Multivariate normality for MANOVA was evaluated using the Mardia (Korkmaz, Goksuluk & Zararzis, 2014; Oppong & Agbedra, 2016). According to the results presented in the Levene test table, all observed variables follow a multivariate normal distribution, as the p-values for both kurtosis and skewness were greater than 0.05 ($p > 0.05$). Additionally, the assumption of homogeneity of variances was tested using the Levene test. The results in the following table confirm that this assumption was also met, providing the necessary validation for performing the MANOVA analysis.

The homogeneity of variance test results, conducted using the Levene test on the variables of smash, lob, drive, underhand, and drop shots, revealed p-values > 0.05. Therefore, the homogeneity of variance assumption was met for these five of the nine variables tested. This suggests that the assumptions for these variables are valid, as their loading values are greater than 0.05. In contrast, netting shots, serve strokes, footwork, and error points had p-values < 0.05, indicating that the homogeneity of variance assumption was not satisfied for these variables.

The MANOVA significance test was performed to assess the effect of athlete age and gender on seven types of badminton strokes, footwork, and error points. However, it is recommended that the MANOVA significance test be conducted in both simultaneous and partial stages (Soc & Anderson, 2017).

Since not all homogeneity assumptions were validated, we relied on Pillai's Trace to perform the MANOVA test and obtain significant results simultaneously. Based on the simultaneous test results, it was found that the effects of age (F-Statistic = 15.577 > F-table = 3.554), gender (F-Statistic = 27.869 > F-table = 4.413), and their interaction (F-Statistic = 7.784 > F-table = 3.554) were statistically significant, with each p-value being 0.000 < 0.05. This indicates that age, gender, and the interaction between age and gender significantly influence the seven types of strokes, footwork, and error points in badminton matches across the three categories studied. The adjusted R^2 value for each model or observed variable was > 0.900, suggesting that the MANOVA model demonstrates a high validity and goodness-of-fit (Ozili, 2023).

A partial test was conducted to determine whether a significant relationship exists between the independent and

Table 1. Mean values of variables based on age and gender categories

Variable	Age	Mean				SD	
		Male	n	Female	n	Male	Female
Smashing shot skill	Early age	14.25	4	11.00	4	1.25	1.15
	Children	24.00	4	13.25	4	1.82	1.89
	Beginner	49.75	4	23.25	4	5.37	3.20
Lob shot skill	Early age	41.75	4	39.00	4	2.21	1.15
	Children	44.00	4	55.00	4	6.73	1.63
	Beginner	72.50	4	58.75	4	10.40	7.36
Netting shot skill	Early age	20.25	4	20.25	4	1.25	1.70
	Children	18.75	4	22.50	4	3.77	3.31
	Beginner	31.50	4	26.75	4	3.78	17.55
Drive shot skill	Early age	28.75	4	26.00	4	1.25	.816
	Children	32.00	4	26.00	4	3.74	3.82
	Beginner	40.25	4	22.25	4	2.21	2.75
Underhand shot skill	Early age	18.00	4	19.00	4	2.44	1.15
	Children	21.25	4	22.50	4	1.25	2.38
	Beginner	35.75	4	23.75	4	3.30	3.94
Dropshot shot skill	Early age	13.50	4	14.25	4	1.00	1.50
	Children	29.00	4	23.75	4	9.66	3.86
	Beginner	55.50	4	36.75	4	5.44	4.78
Serving shot skill	Early age	39.00	4	38.75	4	.816	.957
	Children	39.75	4	39.25	4	2.62	3.20
	Beginner	40.25	4	38.75	4	3.30	2.36
Footwork shot skill	Early age	274.50	4	221.75	4	6.40	7.04
	Children	331.00	4	339.75	4	66.87	15.77
	Beginner	636.75	4	450.25	4	28.12	15.52
Error shot Point	Early age	7.00	4	8.50	4	1.41	.577
	Children	14.00	4	22.50	4	3.55	2.38
	Beginner	13.25	4	15.00	4	2.75	4.08

Table 2. Levene's test for equality of error variances

Variables	Levene's.	df1	df1	p-values	Description attributed
Smash shot	2.514	5	18	0.068	Assumption verified
Lob shot	2.698	5	18	0.055	Assumption verified
Netting shot	5.582	5	18	0.003	Assumption not valid
Driving shot	2.062	5	18	0.118	Assumption verified
Underhand shot	2.452	5	18	0.073	Assumption verified
Drop shot	2.636	5	18	0.059	Assumption verified
Serving shot	7.279	5	18	0.001	Assumption not valid
Footwork	5.430	5	18	0.003	Assumption not valid
Error Point	3.613	5	18	0.019	Assumption not valid

Test the null hypothesis that the error variance of the dependent variable is equal across groups. A. Design: Age + Gender + Age * Gender

dependent variables of interest or how the different groups/categories performed on the evaluated variables. If the F-test statistic exceeds the F-table and the p-value is < 0.05, the independent variable significantly affects the dependent variable. The partial test results are presented in Table 3, showcasing the MANOVA approach's findings.

Based on the results presented in Table 3 above, athlete age significantly affects smash shots, lob shots, drive shots, underhand shots, drop shots, footwork, and error points in badminton matches. This suggests differences in the number of smashes, lob shots, drive shots, underhand shots, drop shots, footwork, and error points across the early-aged, child-aged, and beginner-aged athlete categories. However, after analyzing all the data, we found that athlete age does not significantly affect netting and serving strokes in badminton matches. Thus, the number of netting and serving strokes within the group categories is similar.

Athlete gender also significantly affects the number of smashes, drive shots, underhand shots, drop shots, footwork, and error points in badminton matches. This indicates differences in these performance metrics between male and female athletes. However, as shown in the table, athlete gender does not significantly affect lob and netting shots. It serves in badminton matches, as the p-values for these

Table 3. Multivariate Tests

Effect		Value	F	Hypothesis df	Error df	Sig.
Age	Pillai's Trace	1.854	15.577	18	22	.000
	Wilks' Lambda	.002	27.288[b]	18	20	.000
	Hotelling's Trace	93.054	46.527	18	18	.000
	Roy's Largest Root	86.597	105.841[c]	9	11	.000
Gender	Pillai's Trace	.962	27.869[b]	9	10	.000
	Wilks' Lambda	.038	27.869[b]	9	10	.000
	Hotelling's Trace	25.082	27.869[b]	9	10	.000
	Roy's Largest Root	25.082	27.869[b]	9	10	.000
Age* Gender	Pillai's Trace	1.729	7.784	18	22	.000
	Wilks' Lambda	.015	7.936[b]	18	20	.000
	Hotelling's Trace	15.993	7.997	18	18	.000
	Roy's Largest Root	11.823	14.451[c]	9	11	.000

a. Design: Age + Gender subjects + Age* Gender subjects

b. Exact statistic

c. The statistic is an upper bound on F that yields a lower bound on the significance level

Table 4. Profile of Partial MANOVA Test

Factor/Effect	Variable	F-Statistic	F-table	P
Age	Smashing shot	151.107	3.554	.000
	Lob shot	36.188	3.554	.000
	Netting shot	3.432	3.554	.055
	Driving shot	4.186	3.554	.032
	Underhand shot	38.939	3.554	.000
	Drop shot	77.345	3.554	.000
	Service shot	0.177	3.554	.839
	Footwork	189.173	3.554	.000
	Error Point	29.905	3.554	.000
Gender	Smashing shot	133.898	4.413	.000
	Lob shot	0.558	4.413	.465
	Netting shot	0.011	4.413	.916
	Driving shot	65.925	4.413	.000
	Underhand shot	9.256	4.413	.007
	Drop shot	13.178	4.413	.002
	Service shot	0.574	4.413	.458
	Footwork	36.370	4.413	.000
	Error Point	12.295	4.413	.003
Interaction or Relationship	Smashing shot	34.485	3.554	.000
	Lob shot	8.510	3.554	.003
	Netting shot	0.618	3.554	.550
	Driving shot	17.833	3.554	.000
	Underhand shot	16.777	3.554	.000
	Drop shot	7.295	3.554	.005
	Service shot	0.149	3.554	.863
	Footwork	20.466	3.554	.000
	Error Point	4.213	3.554	.032

variables were greater than 0.05. Therefore, the number of lob, netting, and service shots is similar between male and female athletes.

The interaction between athlete age and gender significantly affects the variables studied in badminton matches. This means differences exist in the number of smashes, lob shots, drive shots, underhand shots, drop shots, footwork, and error points when considering the interaction between age and gender. However, the interaction between age and gender does not significantly affect netting and serving strokes. Therefore, it can be stated that the number of netting and serving strokes remains similar across age and gender interactions.

Following the MANOVA test, a Multiple Comparison Test using the Tukey test was performed to identify the age and gender categories of athletes who demonstrated the best badminton hitting skills, footwork, and error points. Notations with different alphabets indicate statistically significant differences in the observed variables between the groups tested (i.e., age and gender categories).

The information presented in Table 5 represents the SPSS output from the multiple comparison test based on age categories. The data collected and analyzed show significant differences in the number of smashes, lob shots, drive shots, underhand shots, drop shots, footwork, and error points across the early-age (9-10 years), child-age (11-12 years), and beginner (13-14 years) athlete categories. Specifically, beginner athletes (13-14 years) performed the best and scored significantly higher in smashes, lobs, drives, underhand shots, drop shots, and footwork. On the other hand, early-age athletes (9-10 years) recorded the lowest error points.

The number of netting and serving strokes across the early-age, child-age, and beginner categories was not significantly different. This is reflected in the similar notations assigned to these groups: (20.250 a) for early-age players, (20.625 a) for child-age players, and (20.125 a) for beginner athletes.

Significant differences were also observed in the gender-based comparison analysis. Male athletes outperformed

Table 5. Results of multiple comparison tests based on age and gender distribution

Model	Age	Notation	Gender	Notation
Smash shot	Ealy age group	12.625[a]	Female	15.833[a]
	Children group	18.625[b]	Male	29.333[b]
	Beginner group	36.500[c]		
Lob shot	Ealy age group	40.375[a]	Female	50.916[a]
	Children group	49.500[b]	Male	52.750[a]
	Beginner group	65.625[c]		
Netting shot	Ealy age group	20.250[a]	Female	23.167[a]
	Children group	20.625[a]	Male	23.500[a]
	Beginner group	20.125[a]		
Driving shot	Ealy age group	27.375[a]	Female	24.750[a]
	Children group	29.000[ab]	Male	33.667[b]
	Beginner group	31.250[b]		
Underhand shot	Ealy age group	18.500[a]	Female	21.750[a]
	Children group	21.875[b]	Male	25.000[b]
	Beginner group	29.750[c]		
Drop shot	Ealy age group	13.875[a]	Female	24.916[a]
	Children group	26.375[b]	Male	32.667[b]
	Beginner group	46.125[c]		
Service shot	Ealy age group	38.875[a]	Female	38.916[a]
	Children group	39.500[a]	Male	39.667[a]
	Beginner group	39.500[a]		
Footwork	Ealy age group	248.125[a]	Female	337.250[a]
	Children group	335.375[b]	Male	414.083[b]
	Beginner group	543.500[c]		
Error Point	Ealy age group	7.750[a]	Female	11.416[a]
	Children group	14.125[b]	Male	15.333[b]
	Beginner group	18.250[c]		

*. The mean difference is significant at the .05 level.

female athletes in the number of smashes, drive shots, underhand strokes, and drop shots, demonstrating superior footwork, as shown in Table 5. Male athletes received the lowest error points (7.750 a). However, there were no significant differences between male and female athletes in the number of lob shots, netting shots, and serves, as these values were similar across both gender categories.

Discussion

In this study, we investigated the influence of athlete characteristics on smashing skills, footwork, and error points in badminton matches. The analysis targeted early-aged players (9–10 years), children (11–12 years), and beginners (13–14 years). Significant differences were identified in most performance metrics across age and gender categories, offering valuable insights into developmental and physiological factors influencing badminton performance. Previous research suggests inexperienced badminton players exhibit longer contact times and smaller foot strike angles during lunges than skilled players (Lam et al., 2018).

Our findings corroborate this observation, as significant differences in footwork performance were observed across age groups. For instance, beginner athletes scored higher in footwork metrics (543.500) compared to children (335.375) and early-aged players (248.125). Male athletes also outperformed female athletes in footwork, with average scores of 414.083 and 337.250, respectively. These results highlight the critical role of age and gender in developing footwork skills, which are essential for success in badminton. Future research should explore how biomechanical factors, such as joint angles and reaction times, contribute to these differences. The observed gender differences in performance align with earlier studies reporting higher injury risks among female athletes, particularly knee injuries in sports requiring rapid directional changes (Dugan, 2005; Stevenson et al., 1998). Our findings indicate a significant performance gap between male and female athletes, linked to individual traits evaluated using predetermined criteria, such as error points, footwork, and smashing skills. Recognizing the inherent differences between males and females, including greater loading rates and superior performance metrics among male subjects, is essential. These differences might be influenced by additional factors, such as speed, initial foot strike patterns, and contact times (Breine et al., 2019).

Male athletes exhibited lower loading rates on lob shots in the children's category than female athletes, with average rates of 44.00 and 55.00, respectively. Interestingly, no significant difference was found in netting shots among early-aged players (mean = 20.25 for both groups), while underhand shots were better performed by females, except in the beginner category. One plausible explanation is the difference in movement planes and tested parameters. The primary objective of this study was to employ MANOVA to assess how age affects badminton smashing abilities, footwork, and error points. The results revealed a significant impact of age, supported by a high F-statistic value (15.577), exceeding the F-table value (3.554), and p-values below 0.05. Gender differences also significantly influenced smashing, footwork, and error points, as indicated by an F-statistic of 27.869 (higher than the F-table value of 4.413). These findings align with the research of Putra et al. (2020), which emphasizes the influence of bio-motor conditions on movement patterns and the critical role of age in bio-motor maturity. In badminton, mastering techniques such as the forehand smash depends on proper movement patterns and bio-motor maturity, which are strongly age-dependent (Kusnandi, Asmawi & Tangkudung, 2019; Widiastuti et al., 2019). Therefore, the development of movement patterns is inevitably influenced by age and gender differences.

Our results confirm that the smash technique is one of the most effective methods for scoring points in badminton, as it allows athletes to produce high shuttlecock speeds (Putra et al., 2020). By identifying age and gender categories associated with optimal performance in smashing skills, footwork, and error points, this study provides evidence-based insights. For instance, multiple comparison tests based on age distribution revealed significant differences between males and females, such as 15.833 for females and 29.333 for males (see Table 5). Conversely, no significant differences were found in lob shots, netting shots, or serving shots based on age or gender. However, a notable disparity emerged in driving strokes, underhand shots, drop shots, footwork, and error point performance, emphasizing the influence of individual characteristics on badminton proficiency.

These findings highlight the value of statistical analysis in identifying performance determinants in badminton. Five of the nine variables tested demonstrated strong correlations

with individual characteristics, as shown in Table 2 (Levene test results). Further research should investigate the interplay of biomechanical and physiological factors to deepen our understanding of age- and gender-related differences in badminton performance. This study contributes to the growing body of evidence emphasizing the importance of tailoring training programs to the unique needs of different athlete demographics.

This study's findings are limited by its relatively small sample size and focus on a specific population of young athletes from a single badminton organization, which may not represent the broader badminton community. Additionally, the exclusion of biomechanical and psychological factors and the reliance on observational data limit the depth of analysis regarding performance mechanics. Expanding future research to include more diverse populations and advanced assessment techniques would provide more comprehensive insights.

Conclusions

The study demonstrates that age and gender significantly shape key badminton performance metrics, such as smashing skills, footwork, and error points. Beginner athletes (13–14 years) consistently outperformed younger groups, while male athletes performed more in most categories than their female counterparts.

These findings underscore the importance of developing tailored, age- and gender-specific training programs that address athletes' unique needs and developmental stages. Coaches and sports scientists can optimize skill development and enhance competitive performance by implementing targeted interventions, such as improving footwork efficiency in younger players or reducing error rates among female athletes.

However, future studies with larger and more diverse samples and advanced biomechanical and psychological assessments are needed to deepen the understanding of these influences and further refine training strategies.

Acknowledgment

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Conflicts of Interest

The authors declare no conflicts of interest.

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Визначення впливу віку та гендеру на ключові показники результативності в бадмінтоні

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Авторський вклад: A – дизайн дослідження; B – збір даних; C – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 10 с., 5 табл., 50 джерел.

Історія питання. Бадмінтон, ракетковий вид спорту, що набув світової популярності, вимагає технічної точності, тактичної обізнаності та виняткової фізичної підготовки. Для досягнення успішного результату критично важливими є такі навички, як виконання атакуючого удару (смеш), робота ніг та мінімізація помилок. Однак специфічний вплив віку та гендеру на зазначені показники, зокрема серед молодих гравців, залишається недостатньо дослідженим.

Мета дослідження. Це дослідження мало на меті вивчити вплив віку та гендеру на ключові показники гри в бадмінтон, включаючи вміння виконувати смеш, роботу ніг та невимушені помилки задля визначення розвивальних та демографічних чинників, що впливають на набуття та реалізацію навичок.

Матеріали та методи. У кількісному описовому дослідженні взяли участь 24 спортсмени (віком 9-14 років) з бадмінтонної організації "Wincorp" у Суракарті, Індонезія. Учасників було згруповано за віком (9-10, 11-12, 13-14 років) та гендером, забезпечуючи рівнозначну репрезентативність. Протягом двох місяців було зібрано дані щодо виконання смешу, високо-далекого та плоского ударів, роботи ніг та кількості помилок. Відмінності проаналізовано за допомогою описової статистики та багатовимірного дисперсійного аналізу (MANOVA), рівень значущості встановлено в межах $p < 0,05$.

Результати. Метод багатовимірного дисперсійного аналізу встановив значний віковий вплив на виконання смешу ($p = 0,000$), роботу ніг ($p = 0,000$) та моменти помилок ($p = 0,000$), при цьому гравці-початківці (13-14 років) досягли кращих результатів за більшістю показників. Гендерні відмінності також виявились суттєвими щодо виконання смешу ($p = 0,000$), роботи ніг ($p = 0,000$) та моментів помилок ($p = 0,003$), причому учасники чоловічої статі випереджали учасників жіночої статі в більшості категорій. Ефекти взаємодії між віком та гендером показали значущість щодо виконання смешу та роботи ніг ($p < 0,05$). Однак жодних істотних відмінностей у виконанні ударів біля сітки та подач не спостерігалося, незалежно від віку чи статі.

Висновки. Дослідження свідчить про те, що вік і гендер суттєво впливають на показники результативності в бадмінтоні. Спортсмени-початківці (13-14 років) продемонстрували відмінні навички порівняно з молодшими групами, тоді як хлопці загалом перевершували дівчат. Отримані дані підкреслюють важливість адаптації тренувальних програм до віку та гендеру з метою оптимізації розвитку навичок та зменшення прогалин у результативності. Задля вдосконалення тренувальних стратегій необхідно провести подальші дослідження щодо вивчення біомеханічних і психологічних чинників.

Ключові слова: бадмінтон, характеристики спортсменів, вік, гендер, показники результативності, навички виконання смешу, робота ніг.

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