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Eye-Hand Coordination, Wrist Flexibility, and Long-Serve Performance in Beginner Badminton Players: A Cross-Sectional Correlational Study

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Abstract

Long-serve performance in badminton depends on directional accuracy, timing, and efficient coordination of the upper-limb kinetic chain; however, evidence-based assessment of service skills among beginner players remains limited. This study aimed to examine the associations between eye-hand coordination, wrist flexibility, and long-serve performance among players at SMKN 1 Sikur. A cross-sectional correlational design was applied involving 20 players. Eye-hand coordination was assessed using a tennis-ball throw-and-catch test, wrist flexibility was measured with a goniometer, and long-serve performance was evaluated using a standardized long-service test. Data were analyzed using Pearson correlation coefficients, coefficients of determination, and 95% confidence intervals to estimate the magnitude and precision of the associations. The findings showed that eye-hand coordination was not significantly associated with long-serve performance ($r = -0.318$, $p = 0.171$, 95% CI [-0.667, 0.144], $R^2 = 0.101$), whereas wrist flexibility demonstrated a moderate positive association with long-serve performance ($r = 0.487$, $p = 0.030$, 95% CI [0.056, 0.765], $R^2 = 0.237$). These results indicate that wrist flexibility may serve as a useful and low-cost screening and training target for developing long-serve performance among beginner badminton players. Conversely, generic eye-hand coordination tests should be complemented by badminton-specific perceptual-motor and technical assessments. The study contributes to service-skill assessment literature by identifying a practical physical factor associated with beginner long-serve performance, although the small sample size and cross-sectional design limit causal inference and highlight the need for replication using larger samples, reliability testing, and motion-analysis measures.

Keywords: Badminton; Long Serve Performance; Wrist Flexibility; Eye-Hand Coordination; Performance Assessment

INTRODUCTION

Badminton is an intermittent racket sport characterized by short high-intensity rallies, rapid changes of direction, repeated accelerations, and precise stroke control. Competitive analyses and physiological studies show that badminton performance depends not only on physical capacity but also on technical precision, tactical decision-making, and perceptual-motor control (Cabello Manrique & González-Badillo, 2003; Faude et al., 2007; Ooi et al., 2009; Phomsoupha & Laffaye, 2015). In this context, service skill is crucial because the serve initiates each rally and can determine whether the server immediately gains, maintains, or loses tactical advantage. The badminton serve has been examined in terms of accuracy, arousal, timing, fatigue, and shuttlecock trajectory. Edwards et al. (2005) reported that badminton service accuracy can vary according to time of day, while Duncan et al. (2017) showed that badminton-specific exercise and competitive climate can reduce short-serve performance. Vial et al. (2019) argued that serve accuracy cannot always be evaluated only from landing position because the shuttle is frequently intercepted by the opponent; therefore, more representative accuracy measures should consider shuttlecock trajectory. These findings are relevant to long service because long service demands both directional accuracy and sufficient shuttle displacement toward the rear service area.

Eye-hand coordination is frequently assumed to support badminton service because the player must visually track the shuttlecock, time racket contact, and regulate the racket path. Expertise research in racket and interceptive sports indicates that skilled performers use more effective visual search, anticipatory information, and perception-action coupling than novices (Abernethy & Russell, 1987; Farrow & Abernethy, 2003). The classic speed-accuracy framework also suggests that precise aiming movements require a trade-off between movement speed, target size, and control demand (Fitts, 1954). In badminton-specific research, Wong et al. (2019) found that amateur badminton players differed from active controls in balance, agility, eye-hand coordination, and sport performance. However, the extent to which a generic throw-and-catch eye-hand coordination test explains long-serve performance in beginner club players remains unclear.

Wrist flexibility may also be relevant to service performance. Racket-sport strokes are produced through a kinetic chain in which proximal segments generate and transfer energy while distal segments fine-tune racket orientation and contact precision (Lees, 2003). Badminton biomechanics studies highlight the role of upper-limb segment coordination, racket elasticity, racket-shuttlecock impact location, and joint moments in stroke performance (Kwan & Rasmussen, 2010; Li et al., 2017; McErlain-Naylor et al., 2020; Ramasamy et al., 2022; Sakurai & Ohtsuki, 2000). Although static flexibility alone does not guarantee sport performance, range of motion can influence technical execution when it supports task-specific movement control (Behm et al., 2016; Chaabene et al., 2019).

Most available evidence on badminton performance has focused on elite athletes, match demands, smashing, lunge mechanics, or short-serve accuracy. Less attention has been given to low-cost assessment of beginner players at the club level, especially in contexts where coaches rely on simple field tests rather than motion-capture systems. Therefore, this study examined the relationship between eye-hand coordination, wrist flexibility, and long-serve performance among SMKN 1 Sikur players. The study tested two hypotheses: (1) eye-hand coordination is significantly associated with long-serve performance, and (2) wrist flexibility is significantly associated with long-serve performance.

METHODS

1. Study design

This study used a cross-sectional correlational design. The design was appropriate because the purpose was to estimate the magnitude and direction of association among measured variables rather than to test the causal effect of an intervention. The reporting was strengthened to align with international journal expectations by presenting effect sizes, confidence intervals, and explicit limitations of causal inference.

2. Participants and Measures

The participants were 20 SMKN 1 Sikur players. The original dataset used a total-population sampling approach because all available players at the club were included. Participant names were removed from the main manuscript and replaced by aggregate statistics to support privacy and publication ethics. Future submission should add participant age, sex, playing experience, dominant hand, weekly training frequency, and ethics approval or informed-consent details. Eye-hand coordination was measured using a tennis-ball throw-and-catch test, with higher scores indicating better coordination.

Wrist flexibility was measured using a goniometer and expressed in degrees. Long-serve performance was assessed using a standardized long-service test, with higher scores indicating better performance. Because reliability coefficients were not available in the source manuscript, future replication should report intra-rater or test-retest reliability; intraclass correlation coefficients are recommended for repeated measurement reliability (Koo & Li, 2016).

3. Procedure

Testing was conducted in one session at PB Portema Masbagik. Participants first completed the eye-hand coordination test, followed by wrist flexibility measurement and the long-serve performance test. A standardized warm-up, equal testing order, and consistent rest interval should be documented in future studies to reduce fatigue and order effects, as badminton-specific exercise and arousal can influence service performance (Duncan et al., 2017; Edwards et al., 2005).

4. Statistical analysis

Descriptive statistics were calculated as mean, standard deviation, minimum, and maximum. Pearson product-moment correlation was used to examine the linear association between each predictor and long-serve performance. The coefficient of determination (R^2) was calculated to estimate explained variance. Ninety-five percent confidence intervals for correlation coefficients were estimated using Fisher z transformation. Correlations were interpreted by considering direction, magnitude, statistical significance, and practical relevance rather than relying solely on p values (Schober et al., 2018). The alpha level was set at 0.05.

RESULTS

The digitized individual scores from the three performance tests are presented in Table 1. Participant names in the original field record were anonymized as P01-P20 to support ethical reporting. The descriptive statistics are presented in Table 2. Eye-hand coordination scores ranged from 9 to 15 (M = 12.45, SD = 1.57). Wrist flexibility ranged from 63° to 75° (M = 69.80°, SD = 3.69°). Long-serve performance ranged from 48 to 78 (M = 60.35, SD = 7.27).

Table 1. Digitized individual scores for the three badminton performance tests.

Participant ID	Eye-hand coordination score	Wrist flexibility (°)	Long-serve performance score
P01	15	64	58
P02	15	72	55
P03	13	75	54
P04	14	65	53
P05	13	65	51
P06	12	70	66
P07	12	69	60
P08	14	63	48
P09	12	73	78
P10	13	64	57
P11	12	70	60
P12	10	70	61
P13	13	71	58
P14	10	70	61
P15	13	71	65
P16	9	73	56
P17	13	75	62
P18	12	71	74
P19	11	72	66
P20	13	73	64

Table 2. Descriptive statistics for study variables.

Variable	N	Minimum	Maximum	Mean	SD
Eye-hand coordination	20	9	15	12.45	1.57
Wrist flexibility (degree)	20	63	75	69.80	3.69
Long-serve performance	20	48	78	60.35	7.27

The correlation results are presented in Table 3. Eye-hand coordination was negatively but not significantly associated with long-serve performance (r = -0.318, p =

0.171, 95% CI [-0.667, .144]). The coefficient of determination indicated that eye-hand coordination explained approximately 10.1% of the variance in long-serve performance. Wrist flexibility showed a moderate positive and statistically significant association with long-serve performance (r = 0.487, p = 0.030, 95% CI [0.056, 0.765]), explaining approximately 23.7% of the variance. The correlation between eye-hand coordination and wrist flexibility was negative and non-significant (r = -0.373, p = 0.105).

Table 3. Pearson correlations Among Eye-Hand Coordination, Wrist Flexibility, And Long-Serve Performance.

		Wrist flexibility	long service life
Wrist flexibility	Pearson Correlation	1	0.487*
	Sig. (2-tailed)		0.030
	Sum of Squares and Cross-products	259.200	248.400
	Covariance	13.642	13.074
	N	20	20
Long Service Life	Pearson Correlation	0.487*	1
	Sig. (2-tailed)	0.030	
	Sum of Squares and Cross-products	248.400	1004.550
	Covariance	13.047	52.871
	N	20	20

An exploratory two-predictor regression model including eye-hand coordination and wrist flexibility explained 25.9% of the variance in long-serve performance, but the overall model did not reach conventional statistical significance, $R^2 = .259$, $F(2, 17) = 2.97$, $p = .079$. In this exploratory model, wrist flexibility had the larger standardized coefficient ($\beta = .428$, $p = .075$) than eye-hand coordination ($\beta = -.159$, $p = .490$). Because of the small sample size, these regression findings should be interpreted as exploratory rather than confirmatory.

DISCUSSION

This study examined whether eye-hand coordination and wrist flexibility were associated with long-serve performance in beginner badminton players. The main finding was that wrist flexibility showed a moderate positive association with long-serve performance, whereas the generic eye-hand coordination test was not significantly associated with the long-serve score. These results partly support the original assumption that physical and perceptual-motor factors may contribute to service performance, but they also indicate that not all general field tests transfer equally to a badminton-specific skill.

The non-significant relationship between eye-hand coordination and long-serve performance may be explained by task specificity. A tennis-ball throw-and-catch test measures a general form of visual-motor coordination, but long service in badminton involves a racket, shuttlecock, controlled underarm mechanics, target direction, and force regulation. Expertise studies in racket and interceptive sports show that perceptual information is most useful when the test preserves the action requirements of the sport (Abernethy & Russell, 1987; Farrow & Abernethy, 2003). Therefore, a more badminton-specific coordination test—such as repeated shuttle feeding, service trajectory control, or video-based timing assessment—may better represent the perceptual-motor demands of long service. The negative direction of the correlation should not be overinterpreted because the confidence interval was wide and included zero.

The significant association between wrist flexibility and long-serve performance is practically meaningful. Long service requires the player to send the shuttlecock high and deep toward the back court, which depends on racket face orientation, contact control, and coordinated contribution of the upper limb. Prior racket-sport and badminton studies indicate that distal segment control, racket elasticity, and impact location influence shuttle outcome and stroke quality (Kwan & Rasmussen, 2010; McErlain-Naylor et al., 2020; Ramasamy et al., 2022; Sakurai & Ohtsuki, 2000). In beginner players, adequate wrist range of motion may help players adjust the racket path and shuttle trajectory more effectively. However, wrist flexibility should not be treated as the only determinant of service quality; strength, timing, shoulder-elbow coordination, trunk position, fatigue state, and tactical intention are also relevant (Ali et al., 2017; Lees, 2003; Li et al., 2017; Phomsoupha & Laffaye, 2015).

The findings should also be interpreted in light of contemporary stretching literature. Flexibility may support movement options, but acute static stretching immediately before explosive actions can sometimes reduce strength or power output depending on duration and context (Behm et al., 2016; Chaabene et al., 2019). For practical coaching, wrist mobility training should therefore be integrated with dynamic warm-up, progressive strength, racket-control drills, and technical feedback rather than isolated passive stretching. This is especially important in beginner players, who may benefit from learning consistent contact mechanics before increasing serve power. From a coaching perspective, the results support the use of simple screening tests as a preliminary diagnostic tool, not as the only basis for talent identification or training prescription. A player with limited wrist flexibility may need mobility and racket-control drills, while a player with poor serve accuracy may need trajectory-based practice, feedback on racket angle, and controlled repetition under fatigue or competition-like conditions. Since service performance can be influenced by physiological arousal, fatigue, and testing context (Duncan et al., 2017; Edwards et al., 2005), future training assessments should combine physical measures with representative badminton tasks.

This study has several limitations. First, the sample size was small (N = 20), which reduced statistical power and produced wide confidence intervals. Second, the cross-sectional design prevents causal interpretation. Third, the original dataset did not include age, sex, playing experience, dominant hand, training history, or reliability coefficients for the tests. Fourth, the long-serve test was based on field scoring rather than three-dimensional shuttle trajectory analysis. Fifth, the study did not include kinematic variables such as wrist angular velocity, racket face angle, or shuttlecock impact location. Future studies should use larger samples, report test reliability, include both Pearson and non-parametric sensitivity analyses when assumptions are uncertain, and combine field tests with video or wearable-sensor analysis to clarify how wrist mobility and coordination influence long-serve mechanics (Huang et al., 2019; Vial et al., 2019).

CONCLUSION

Among 20 beginner badminton players from PB Portema, wrist flexibility was moderately and significantly associated with long-serve performance, whereas a generic eye-hand coordination test was not significantly associated with long-serve performance. The results suggest that wrist flexibility may be a useful low-cost assessment and training consideration for developing long service in beginner players. However, due to the small sample and correlational design, the findings should be interpreted cautiously and validated through larger, more controlled, and biomechanically informed studies. Coaches may include wrist range-of-motion screening as part of beginner badminton service assessment. Wrist mobility exercises should be integrated with dynamic warm-up, racket-control drills, and repeated long-serve practice. Eye-hand coordination assessment should be made more badminton-specific, for example through shuttle-based timing and trajectory-control tasks. Service tests should be conducted under standardized warm-up, rest, time-of-day, and fatigue conditions to improve measurement consistency.

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