P-ISSN: 2394-1685
E-ISSN: 2394-1693
Impact Factor (RJIF): 5.38
IJPESH 2023; 10(5): 13-17

www.kheljournal.com
Received: 16-07-2023
Accepted: 23-08-2023

Sheri J Brock
School of Kinesiology, Auburn University, Auburn, Alabama, United States

Hairui Liu
Department of Education, Health & Behavior Studies, University of North Dakota, Grand Forks, North Dakota, United States

Corresponding Author:
Hairui Liu
Department of Education, Health & Behavior Studies, University of North Dakota, Grand Forks, North Dakota, United States

An investigation of skills, tactical knowledge, and game performance transfer in badminton: A pickleball perspective

Sheri J Brock and Hairui Liu

DOI: https://doi.org/10.22271/kheljournal.2023.v10.i5a.3061

Abstract
In this study, the hypothesis that learning in one sport could transfer to another due to the shared movements and strategies between the two sports was examined. The transfer of learning between pickleball and badminton was studied in two physical education classes from a land-grant university in the United States. The classes consisted of 12 females and 22 males, with an average age of 19.91 ± 0.79 years. The classes met three times per week for 15 weeks, with 50 minutes per lesson. Class one learned pickleball first for 5 weeks, then badminton for 5 weeks, followed by a game season for 5 weeks. The order of instruction was reversed in Class Two. A pre- and post-design with a 2 x 2 repeated measurement analysis of variance was used to analyze the transfer effect from pickleball to badminton skills (i.e., wall volley, forehand clear), tactical understanding, and game performance. The results showed that both classes improved badminton skills, tactical understanding, and game performance after 15 weeks of intervention ($p< 0.001$). Learning pickleball before or after badminton did not have a significant effect on skills, tactical knowledge, or game performance.

Keywords: Physical education, net sports, motor learning

1. Introduction
According to Thorpe [1], the games component of physical education curricula should aim to offer a variety of game experiences that allow individual to sample a diverse range of activities. This idea led Siedentop [2] to propose the Multi-Activity Model in physical education, in which the sport (game) would change after a few lessons (approximately 6-8) to expose students to multiple sports throughout one semester. Since its introduction, the Multi-Activity Model has become widely adopted in physical education programs globally.
The prevalence of the Multi-Activity Model in physical education has sparked a debate on the sequence of teaching similar sports, such as invasion, net/wall, striking/fielding, or target sports [3, 4]. The argument is based on the fact that certain sports share similar movements and strategies in actual play, such as invasion games that require different skills but share the same ultimate goal of invading an opponent's territory and scoring while preventing the opponent from scoring. Researchers [2, 3] argue that well-designed physical education curricula can facilitate deeper learning, provide a broad range of experiences, and help learners transfer their understanding of one game to improve their performance in another.
According to López, Jordán, and Chandler [5], transfer of skill refers to the impact of prior experience on the acquisition or performance of a new skill in a different context. Transfer is classified as either positive or negative, depending on whether prior experience enhances or hinders new learning, respectively. The concept of transfer of learning was initially introduced by Thorndike and Woodworth [6] through their "Identical Elements Theory," which posits that transfer is contingent on the presence of similar stimuli or responses in both learning and transfer contexts. For instance, it has been suggested that games such as badminton and pickleball possess comparable tactical and relational elements, such as the interpretation of players' movements and positions and shared offensive/defensive strategies, making transfer of skills between these two sports possible.

The principle of transfer of learning is widely used in education and serves as the foundation for the arrangement of skills and concepts to be learned [4].

Concerning transfer between sports (inter-task transfer), studies [7, 8] have been conducted to examine whether perceptual-motor skills [9] and cognitive skills [10] from one sport can be transferred to similar sports.

However, the literature presents inconsistent results regarding transfer of learning. On one hand, negative transfers have been documented between tennis and table tennis [7] and badminton-pickleball [11], while positive transfer in motor and perceptual skills have also been reported. For example, Rienhoff [12] found that skilled basketball players showed positive transfer of basketball free-throw to dart throwing, outperforming less-skilled participants. Additionally, Oppici *et al*. [9] found that the use of modified equipment (futsal ball) positively transferred to other equipment (soccer ball), demonstrating improved learning of a perceptual-motor skill.

In terms of cognitive skills, the literature provides contradictory results in the domain of decision-making. Smeeton [10] and Abenethy [13] support positive transfer in pattern recognition tests in sports, while Causer and Ford [7] found no positive transfer in decision-making from soccer to other invasion sports (basketball, hockey, and rugby) in a video-based temporal occlusion test. Conversely, Roca and Williams [14] conducted a similar occlusion decision-making test and found some positive transfers of decision-making between sports that share similar elements (invasion sports).

Despite numerous attempts to investigate the transfer of learning between similar sports, inconsistent findings suggest that transfer learning may not exist. The disparity in the transfer of learning in similar sports could arise from various factors such as the use of different protocols to evaluate the transfer effect [15], limited focus on exploratory movements that may have supported performative actions [16], and the absence of a control group to compare the transfer effect between sports.

In the field of physical education, the transfer of learning is crucial in the development of coherent learning experiences for students. Given the limited evidence on the transfer of learning between similar sports and the need to enhance game performance, the current study aims to investigate the transfer of learning from pickleball to badminton. Three objectives have been set forth for this study: (1) to use a scoring system based on the rating of decision-making quality to improve the reliability of performance testing; (2) to assess game performance to examine the transfer from the cognitive domain (tactical understanding) to actual gameplay; and (3) to adopt a nonequivalent control/comparison group experimental design to examine the transfer between the two net sports.

2. Materials and Methods

2.1 Ethics

The study was carried out in compliance with the Declaration of Helsinki, with written informed consent being obtained from all participants. Approval for the study was obtained from the university's Institutional Review Board (IRB) with Protocol number 17-502 EP 1801.

2.2 Design

A nonequivalent control/comparison group experimental design was used, including pre-and post-measures, to assess two experimental conditions: C1 (pickleball-badminton) and C2 (badminton-pickleball). In condition one (n = 17), participants first learned pickleball and then badminton, while in condition two (n = 17), the learning sequence was reversed with participants first learning badminton and then pickleball.

2.3 Participants

A total of 34 university students (12 females and 22 males, with a mean age of 19.91 ± 0.79 years) from a land-grant university in the U.S. participated in the study. None of the participants had prior systematic experience in badminton or pickleball.

2.4 Intervention

The participants were randomly assigned to either C1 (pickleball first) or C2 (badminton first), with an effort made to ensure even distribution by age, gender, and skill level. Both conditions were conducted three times per week (Monday, Wednesday, and Friday) for a total of 50 minutes per lesson across a 15-week semester. The badminton and pickleball modules included instruction on fundamental skills, basic tactical strategies, and official games. The detailed lesson plans for both conditions are presented in Table 1.

Table 1: Lesson Content

Week	Condition 1: Pickleball-Badminton	Condition 2: Badminton-Pickleball
1	Pickleball: Introduction of fundamental skills and techniques (groundstrokes, drive, lob, volley, and serve); gripping the racket; serve (powerful, long, spin serve).	Badminton: Introduction of fundamental skills and techniques (forehand, overhead, backhand, lob, drop-shot, smash, and serve); gripping the racket; forehand clear & overhead clear practice; Footwork on the court (step close step; shuffle step – badminton lunge, three step returns to midcourt).
2	Pickleball: forehand stroke and serve; Footwork on the Court (step close step and split step).	Long and short serves; footwork practice
3	Pickleball: Forehand/Backhand strokes and footwork practice. Pickleball volley instruction and practice	Introduction of drive, drop-shot, and lob
4	Volley practice; spike and defense	Skill combination: forehand clear, drive, drop-shot & lob in half court.
5	Skill combination: groundstrokes, drive, drop-shot & lob in half court. Unofficial games	Introduce and demonstrate the smash (forehand and backhand). Unofficial games
6	Class competition - official	Class competition - official
7	Class competition - official	Class competition - official
8	Badminton: Introduction of fundamental skills and techniques (forehand, overhead, backhand, lob, drop-shot, smash, and serve); Gripping the racket; Forehand clear & overhead clear practice; Footwork on the Court (step close step; shuffle step - badminton lunge, three step returns to midcourt).	Pickleball: Introduction of fundamental skills and techniques (groundstrokes, drive, lob, volley, and serve); Gripping the racket; Serve (powerful, long, spin serve);
9	Introduce and demonstrate serves: Long and short serves; Footwork practice	Pickleball: forehand stroke and serve; Footwork on the Court (step close step and split step)

10	Introduction of drive, drop-shot, and lob	Pickleball: Forehand/Backhand strokes and footwork practice; Pickleball volley instruction and practice
11	Skill combination: forehand clear, drive, drop-shot & lob in half court.	Volley practice; spike and defense
12	Introduce and demonstrate the smash (forehand and backhand). Unofficial games	Skill combination: groundstrokes, drive, drop-shot & lob in half court. Unofficial games
13	Class competition - official	Class competition – official
14	Class competition - official	Class competition – official
15	Final Exam	Final Exam

2.5 Data collection

For this study, data collection was focused on three areas: (a) badminton skills, including forehand clear and wall volley, (b) tactical understanding of badminton, and (c) game performance.

In order to assess the badminton skills, the French Clear Test [17] was utilized. This test involved participants receiving a long serve and attempting to hit the shuttlecock across the net to the deepest part of the court, with scores ranging from 0 to 5 based on where the shuttlecock lands (10 trials). The French Clear Test has demonstrated a reported reliability of 0.96 through an odd/even correlation [17]. This test was selected for its ease of administration and its significance in replicating a critical skill necessary for successful badminton gameplay. As noted by Rink and colleagues [18], being able to exert force on a badminton shuttle is a prerequisite for incorporating tactics into play.

The Wall Volley Test [19] was administered in order to evaluate the participants' proficiency in object control, which is a crucial aspect in sports performance. The Wall Volley Task consisted of continuously hitting a shuttlecock towards a wall for a duration of 30 seconds, with the goal of scoring as many successful hits as possible. A successful hit was defined as one that landed above a line that was set at the net height from the floor and 5 feet from the wall. Each participant was given two attempts to complete the Wall Volley Test, and their best score was recorded.

The Tactical Understanding of Badminton was assessed using a video-based game understanding test procedure, as developed by Blomqvist *et al*. [20]. This test evaluated changes in the participants' abilities to identify and respond to tactical problems by selecting appropriate solutions and arguments to support their decisions. The procedure involved viewing a series of badminton rallies and choosing the most appropriate response for one player before playing a stroke. Participants were asked to select the most appropriate action from three options (Selected Stroke Options; SSO) and to provide two arguments from a set of 10 to justify their selection (Selected Argument Options; SAO). The reliability of this instrument was reported at 0.81 [20].

The Game Performance of the participants was assessed through the use of the Game Performance Assessment Instrument (GPAI) [11]. The matches were recorded on video from an elevated viewpoint behind the baseline of each court. The GPAI includes two components: decision-making and skill execution. The Decision-Making Index (DMI) was calculated as the ratio of appropriate decisions made to the total number of appropriate and inappropriate decisions. An appropriate decision was defined as a shot that forced the opponent to move forward, backward, or sideways, thereby taking them away from their home position, or giving the opponent limited time to react to the incoming shuttlecock (e.g., smash). The Skill Execution Index (SEI) was calculated as the ratio of successful skill executions to the total number of successful and unsuccessful executions. A successful skill execution was defined as a shot that crossed the net and would have landed within the court. Game performance was calculated by taking the average of the DMI and SEI, [DMI + SEI]/2. The stability reliability of the GPAI was reported to be between .85 and .97, depending on the sport [22].

2.6 Data Analysis

Pearson's product-moment correlations were conducted to assess the relationships among the dependent variables: French clear, wall volley, tactical understanding, and game performance. Scatter plots were created to identify potential outliers, and the normality and homogeneity of variances were checked prior to further analysis.

A repeated measures analysis of variance (ANOVA) was performed to examine the effects of learning transfer on the four dependent variables. The ANOVA design included two conditions (time x conditions) and four pre- and post-measures. The data analysis was conducted using IBM SPSS 19 (IBM, CA, USA). A significance level of 0.05 was employed, adjusted using the Bonferroni correction. If any significant interaction effects were observed between the two conditions and the four pre- and post-measures, scatter plots were used to interpret the results.

3. Results and Discussion

The descriptive statistics for the four dependent measures are presented in Table 2, which includes the mean and standard deviation values. The scatter plots were visually inspected to ensure the absence of outliers, and the results showed that the homogeneity of variances test for all pre- and post-tests did not violate any assumptions. Furthermore, the data met the normality and normal distribution assumptions with no statistical violations.

Table 2: Badminton Performance Scores

Variables	Conditions	Pre-intervention M (SD)	Post-intervention M (SD)
French Clear	C1	8.71 (5.99)	33.88 (9.26)
	C2	7.06 (5.65)	31.29 (11.84)
Wall Volley	C1	16.82 (6.42)	27.06 (6.23)
	C2	13.29 (5.47)	25.59 (3.14)
Tactical Knowledge	C1	57.24 (11.23)	67.00 (8.70)
	C2	58.94 (8.32)	69.18 (7.30)
SSO	C1	27.47 (3.54)	31.12 (2.39)
	C2	28.71 (3.95)	31.12 (2.89)
SAO	C1	29.76 (8.19)	35.88 (6.86)
	C2	30.24 (5.34)	38.06 (5.66)

Game Performance	C1	3.20 (2.40)	8.19 (5.04)
	C2	2.04 (0.09)	6.17 (3.57)
DMI	C1	0.83 (0.40)	11.21 (10.20)
	C2	1.31 (0.59)	8.66 (7.39)
SEI	C1	5.58 (4.97)	5.17 (3.84)
	C2	2.77 (1.85)	3.67 (0.81)

Note: C_1: Pickleball-Badminton, C_2: Badminton-Pickleball

Correlational Analysis

Table 3 presents the results of the Pearson-product correlation analysis between the dependent measures. The results indicate a positive mutual relationship between the two skill tests, suggesting that the concept of "technical performance" used in subsequent discussions could be applicable to either or both of these measures.

Table 3: Pearson Correlation Matrix for all Variables

Variables	Wall Volley	French clear	Tactical knowledge	Game performance
Wall Volley	1	0.38*	0.14	0.19
French Clear		1	0.08	0.14
Tactical Knowledge			1	0.21
Game Performance				1

3.1 Skill tests

The skill tests were analyzed using repeated measures analysis of variance (ANOVA). The French clear was used as the dependent variable in the first analysis and the wall volley was used as the dependent variable in the second analysis. The results showed that there was a significant main effect for time in both analyses, as indicated by the significant F-values of 220.96 ($p< 0.001$) for the French clear and 205.88 ($p< 0.001$) for the wall volley. No significant main effect for conditions or interaction effect between time and conditions were found in either analysis. The results indicated that participants in both conditions significantly improved their French clear and wall volley skills from pre- to post-intervention. However, the transfer effect was not significant for the French clear test and was negative for the wall volley test in both conditions.

3.2 Tactical understanding

The results of the ANOVA analysis with tactical understanding as the dependent variable revealed no significant interaction effect between the time and conditions, $F (1, 32) = 0.03$, $p = 0.86$, $\eta2 = 0.01$. No significant main effect for conditions was found, $F (1, 32) = 0.48$, $p = 0.50$, $\eta2 = 0.02$, however, a significant main effect of time was observed, $F (1, 32) = 61.05$, $p < 0.001$, $\eta2 = 0.66$. These results demonstrate that both groups of participants significantly improved their tactical understanding from pre- to post-intervention. However, no significant difference was observed in the tactical understanding of participants between the conditions.

3.3 Game performance

The results of the repeated measures ANOVA conducted to examine the effects of learning transfer on game performance revealed a significant main effect for time, $F (1, 32) = 38.66$, $p< 0.001$, $\eta2 = 0.54$. The improvement in game performance was observed in both experimental conditions, however, there was no significant interaction effect between time and conditions, $F (1, 32) = 0.35$, $p = 0.56$, $\eta2 = 0.01$. Additionally, there was no significant main effect for conditions, $F (1, 32) = 3.27$, $p = 0.08$, $\eta2 = 0.09$. These findings suggest that participants in both conditions improved their game performance from pre- to post-intervention.

4. Discussion

The purpose of this study was to investigate the transfer of learning between two similar sports, pickleball and badminton, in both psychomotor and cognitive domains. Utilizing comprehensive and reliable measures of skills, tactical understanding, and game performance, a 15-week intervention was employed to enhance the badminton skill execution and game proficiency of participants, regardless of whether they initially learned pickleball (condition one) or badminton (condition two). The results showed a significant improvement in forehand clear, wall volley, tactical understanding, and game competence for participants in both conditions, however, no significant differences were found between the two conditions. These findings suggest that the order in which participants learned pickleball or badminton did not have a significant impact on learning transfer in this study.

In prior studies investigating badminton instruction in both college and high school environments, Liu [21] and Hastie [22] used similar measurements, but their intervention lasted for a longer period. Specifically, Liu's study [21] found that participants' forehand clear scores improved from 16.39 points to 28.39 points after 15 weeks of intervention. In the present study, participants demonstrated a significant increase in their forehand clear scores from 7.88 points to 32.58 points, indicating that comparable badminton skill execution levels can be achieved in a shorter intervention period. This result aligns with the findings of previous badminton studies [21, 22] and supports the idea that fundamental badminton skills, such as the clear and wall volley, can be learned effectively through a brief intervention that incorporates instruction on more than one sport.

In this study, both conditions showed improvement in their tactical understanding of badminton, but no superiority was demonstrated between the two conditions to support positive transfer in similar sports. Unlike previous studies by Hastie [22] and Liu [21] where participants solely focused on badminton for an extended period, the results of this study suggest that incorporating similar sports into a unit plan for a shorter time period does not impede participants' development of tactical knowledge in badminton. This may be due to the similarities in movement and scoring strategies between pickleball and badminton, allowing participants to recognize and apply their tactical knowledge in similar game situations regardless of the sport. However, this also results in a lack of positive transfer effect in tactical knowledge.

In this study, both conditions showed an equal improvement in their game competency without a significant difference with regard to the order of learning two similar net sports.

These results are consistent with previous studies on tennis and table tennis [7] and badminton and pickleball [11]. One such study was conducted by Stephen and Judith [8], where they used the Game Performance Instrument Assessment to examine the tactical transfer between badminton and pickleball. The study consisted of 21 9th grade participants who were instructed to learn badminton in five lessons and then switched to studying pickleball for an equivalent number of lessons. The results indicated that the participants' decision-making ability significantly improved from pre- to post-test after five badminton lessons [23, 24]. However, their prior experience in badminton did not significantly impact their pickleball decision-making ability.

In this study, the participants were provided ample opportunities to engage in pickup games for both pickleball and badminton, allowing for the integration of basic skills and tactical knowledge into actual game competition. The extensive game exposure and varying opponents led to an improvement in their game performance [23]. Compared to Stephen's [8] single-cohort design, the present study offers two key advantages: (1) the adoption of a nonequivalent control/comparison group experimental design and (2) a larger sample size (n = 34).

5. Conclusions

The purpose of this study was to investigate the impact of learning transfer between two similar sports, pickleball and badminton, on psychomotor and cognitive skills, tactical understanding, and game performance. With the use of comprehensive and reliable measurements, the 15-week intervention aimed to assess the effect of learning pickleball first or badminton first. The results of the study indicated that there was no significant difference in forehand clear, wall volley, tactical understanding, and game competence between the two conditions. These findings suggest that learning one similar sport before the other does not result in a positive learning transfer effect. The results of this study have implications for Physical Education curriculum planning.

5.1 Disclosure statement

No potential conflict of interest was reported by the authors.

6. References

1. Thorpe R, Bunker D, Almond L. Rethinking Games Teaching. Loughborough, University of Technology, Loughborough, UK; c1986, 71.
2. Siedentop D. Developing Teaching Skills in Physical Education. Mayfield Publisher, Mountain View, California, USA; c1991, 10.
3. Casey A, Kirk D. Models-based Practice in Physical Education (1st ed.). Routledge, London, UK; c2020, 75.
4. Magill R. Motor Learning: Concepts and Applications. Brown & Benchmark Publisher, Madison, Wisconsin, USA; c1993, 21.
5. García López LM, Contreras Jordán OR, Penney D, Chandler T. The role of transfer in games teaching: Implications for the development of the sports curriculum. European Physical Education Review. 2009;15(1):47-63.
6. Thorndike L, Woodworth R. The influence of improvement in one mental function upon the efficiency of other functions (I). Psychological Review. 1901;8:247-261.
7. Couzner B. Transfer of learning between tennis and table tennis skills. Australian Journal of Physical Education. 1974;66:5-8.
8. Mitchell S, Oslin J. An investigation of tactical transfer in net games, European Journal of Physical Education. 1999;4(2):162-172.
9. Oppici L, Panchuk D, Serpiello FR, Farrow D. The influence of a modified ball on transfer of passing skill in soccer. Psychology of Sport and Exercise. 2018;18(7):947-954.
10. Smeeton NJ, Ward P, Williams AM. Do pattern recognition skills transfer across sports? A preliminary analysis. Journal of Sports Science. 2004;22:205-213.
11. Oslin J, Mitchell S, Griffin L. The Game Performance Assessment Instrument (GPAI): Development and preliminary validation. Journal of Teaching in Physical Education. 1998;17:231-243.
12. Rienhoff R, Hopwood MJ, Fischer L, Strauss B, Baker J, Schorer J. Transfer of motor and perceptual skills from basketball to darts. Frontiers in Psychology. 2013;4:593.
13. Abernethy B, Baker J, Cote J. Transfer of pattern recall skills may contribute to the development of sport expertise. Applied Cognitive Psychology. 2005;19:705-718.
14. Roca A, Williams AM. Does decision-making transfer across similar and dissimilar sports? Psychology of Sport and Exercise. 2017;31:40-43.
15. Causer J, Ford PR. Decisions, decisions, decisions: Transfer and specificity of decision-making skill between sports. Cognitive Processing. 2014;15(3):385-389.
16. Kunzell S, Lukas S. Facilitation effects of a preparatory skateboard training on the learning of snowboarding. Kinesiology. 2011;43(1):56-63.
17. Scott G, Carpenter A, French A, Kuhl L. Achievement examinations in badminton. Research Quarterly for Exercise and Sport. 1941;12:242-253.
18. Rink J, French E, Graham C. Implication for practice and research. Journal of Teaching in Physical Education. 1996;15:490-502.
19. Miller A. A badminton wall volley test. Research Quarterly for Exercise and Sport. 1951;22:208-213.
20. Blomqvist T, Luhtanen P, Laakso L, Keskinen E. Validation of a video-based game-understanding test procedure in badminton. Journal of Teaching in Physical Education. 2000;19:325-337.
21. Liu H, Wang W, Zhang C, Hastie P. College students' development of badminton skills and tactical competencies following Play Practice. Journal of Teaching in Physical Education. 2020;40(2):284-292.
22. Hastie P, Sinelnikov O, Guarino A. The development of skill and tactical competencies during a season of badminton. European Journal of Sport Science. 2009;9:133-140.
23. Hastie P, Li P, Liu H, Zhou X, Kong L. The Impact of Sport Education on Chinese physical education majors' volleyball content knowledge and performance. Research Quarterly for Exercise and Sport. 2022;93:1-9.
24. Seth B. Determination factors of badminton game performance. International Journal of Physical Education, Sports and Health. 2016;3(1):20-22.