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Comparative Effects of Physical Training, Cognitive Imagery, and Verbal Stimuli on Selected Fundamental Badminton Skills among Novice Players

Yaonan Wu, Hamdan Mohd Ali

City University Malaysia

Abstract: ***The study investigates the effect of the mental imagery training in developing a specific movement in badminton, to be more specific, this study is looking at increasing the accuracy and speed of response of basic badminton skills (serve, forehand, backhand) through the modifications of motor skills and neuromuscular process through mental imagery training. The researcher applied an experimental design on this study. The subject was (N=40) beginners badminton players selected through stratified random sampling from badminton academy at Nanjing China. The subjects were divided on four equal groups with each group consisted of n=10 Players. The control groups were restrained from conducting any physical or mental imagery trainings. The other groups used combination of physical, mental imagery, visual and verbal training methods. The results of paired sample t test had showed significant differences for all experimental groups between pre and post-tests. The results also shown that there is significant different (F=3.42, p<0.031) in physical training in combination with mental imagery and verbal stimulus group than the other physical and mental imagery training groups. The findings suggested that combination between physical training and mental imagery training with verbal stimulus increased the accuracy and speed of basic badminton skills. This Finding is similar with past studies, however, further study need be done to determine the application of mental imagery training in other type of sports.***

Keywords: mental imagery training; badminton skills; accuracy; speed of response; verbal stimulus.

1. Introduction

1.1 Background

Badminton is one of the fastest racket sports in the world, requiring explosive agility, rapid reaction, and efficient perceptual–cognitive skills. With shuttle speeds often exceeding 300 km/h and stroke preparation times less than half a second, even fundamental skills such as the short serve, long serve, forehand, and backhand demand both technical proficiency and quick decision-making (Phomsoupha & Laffaye, 2015). For novice players, mastering these foundational strokes is critical, as they form the basis for tactical competence and advanced skill development.

The acquisition of badminton skills is particularly challenging for beginners because the sport is classified as an open-skill activity, where movements must be continuously adapted to unpredictable external stimuli (Kaya et al., 2020). Inexperienced learners often struggle with accuracy, consistency, and response speed, leading to slower progression through the stages of motor learning. While physical drills remain the most common method for teaching fundamental techniques, evidence suggests that physical practice alone may not sufficiently address the cognitive and perceptual demands of badminton skill acquisition (Magill & Anderson, 2017).

To optimize novice training, researchers and practitioners have increasingly turned toward psychological interventions—such as mental imagery and verbal cueing—that complement traditional physical practice. These strategies aim to enhance learning efficiency, improve attentional focus, and reduce cognitive overload during the early stages of skill development (Moran & O'Shea, 2020).

1.2 Theoretical Framework

Mental imagery refers to the cognitive simulation of movement without overt execution, often involving visual, kinesthetic, and auditory components. Its effectiveness has been explained by several theoretical perspectives:

- Psychoneuromuscular theory suggests that imagined movements activate motor pathways similar to those engaged during actual performance, strengthening neural patterns (Decety, 1996).
- Symbolic learning theory posits that imagery enhances symbolic coding of actions, facilitating motor planning and execution (Sackett, 1934).
- Bio-informational theory argues that effective imagery requires the activation of both stimulus and response propositions, linking situational cues with functional motor and emotional responses (Lang, 1977).

Building on these foundations, the PETTLEP model (Physical, Environment, Task, Timing, Learning, Emotion, Perspective) emphasizes the functional equivalence between imagery and actual performance, arguing that imagery is most effective when it closely mirrors real-life training conditions (Holmes & Collins, 2001). Recent research has confirmed that PETTLEP-based imagery produces greater improvements in motor performance compared to unguided or less structured approaches (Di Rienzo et al., 2016).

Furthermore, advances in applied sport psychology highlight the benefits of multimodal training approaches that combine imagery with additional techniques such as self-talk and verbal cues. For example, a recent intervention among beginner badminton players showed that integrating self-talk and imagery significantly improved motor skill performance and self-confidence compared to imagery alone (Siauw & Yuwono, 2023). Similarly, research in tennis has demonstrated that internal and external imagery perspectives influence different skill components, suggesting that coaches must carefully tailor imagery strategies to skill type and learning stage (Robin et al., 2017).

Importantly, verbal stimuli function as attentional anchors during both physical and imagery practice, helping novices focus on key technical components (e.g., "snap the wrist" or "lift the racket head"). Recent evidence indicates that combining verbal cues with imagery enhances accuracy, vividness, and retention of motor skills (Tod et al., 2020). Moreover, studies incorporating audiovisual imagery in badminton have demonstrated superior effects on long serve accuracy compared to visual-only imagery, further supporting the value of multimodal interventions (Winarno et al., 2022).

1.3 Research Gap

Although imagery and verbal cues are increasingly recognized as effective training tools, several research gaps remain.

First, most empirical work on imagery has focused on elite athletes and closed-skill sports such as gymnastics, archery, and golf (Guillot & Collet, 2008; Zhang et al., 2023). Far fewer studies have explored their effectiveness for novice learners in open-skill contexts. Given that beginners are typically in the cognitive stage of motor learning—where attentional resources are stretched and mental representations are still forming—the potential benefits of imagery and verbal cues may be especially pronounced (Cumming & Williams, 2014).

Second, badminton-specific research remains limited. While some recent studies have investigated the role of imagery in badminton (Winarno et al., 2022; Siauw & Yuwono, 2023), these have generally targeted single skill types (e.g., long serve) or psychological outcomes (e.g., self-confidence). Comprehensive comparisons across multiple fundamental skills (short serve, long serve, forehand, backhand) and dynamic performance indicators (reaction time, response speed) are still scarce.

Third, research on multimodal interventions—combining physical drills, imagery, and verbal stimuli—is underdeveloped. Recent meta-analyses confirm that imagery interventions are more effective when combined with other psychological skills such as self-talk or goal setting (Schuster et al., 2019; Simonsmeier et al., 2021). However, few studies have directly compared physical training alone, physical + imagery, and physical + imagery + verbal cueing in badminton novices.

Finally, most studies employ static performance outcomes such as accuracy or consistency, neglecting dynamic factors like response latency and decision-making, which are critical to success in open-skill sports. Without accounting for these dimensions, the full potential of multimodal training interventions may be underestimated.

1.4 Research Purpose and Questions

This study aims to address the above gaps by systematically comparing the effects of three training modalities— (1) physical training only, (2) physical training combined with mental imagery, and (3) physical training combined with mental imagery and verbal stimuli—on the acquisition of fundamental badminton skills among novice players. Performance was evaluated across both accuracy and response speed in short serve, long serve, forehand, and backhand strokes.

The study makes three primary contributions:

1. It shifts the focus from elite athletes to novice learners, providing insights into how imagery and verbal cues support the cognitive stage of motor learning.
2. It extends research to the open-skill sport of badminton, addressing unique perceptual–motor demands such as rapid decision-making and anticipation.
3. It evaluates the synergistic effects of multimodal training, contributing empirical evidence on whether combining imagery and verbal stimuli with physical practice is more effective than single-modality training.
4.

Accordingly, the following research questions are posed:

- **RQ1:** Does imagery training enhance fundamental badminton skill acquisition in novice players compared to physical training alone?
- **RQ2:** Do verbal stimuli further strengthen the effects of imagery and physical training?
- **RQ3:** Which training modality—physical only, physical + imagery, or physical + imagery + verbal stimuli—produces the greatest improvements in accuracy and response speed?

By answering these questions, the study aims to advance both theory and practice in sport psychology, offering practical guidance for coaches and evidence-based strategies for optimizing novice badminton training.

2. 2. Methodology

2.1 Participants

Forty novice badminton players (N = 40) were recruited from the New Vision Badminton Academy in Nanjing, China. All participants were 14 years old and had recently enrolled in the academy with minimal prior exposure to badminton. Inclusion criteria required that participants had no formal training experience, were free from injury at the time of study, and demonstrated sufficient physical health to complete training sessions. Exclusion criteria included any history of musculoskeletal injury, neurological disorders, or prior competitive experience in racket sports.

Participants were randomly assigned to one of four groups (n = 10 per group):

1. **Control group** – received no intervention beyond regular school physical education.
2. **Physical Training (PT) group** – engaged in badminton-specific physical drills only.
3. **Physical + Imagery (PT+IM) group** – combined physical drills with structured mental imagery practice.
4. **Physical + Imagery + Verbal Stimuli (PT+IM+VS) group** – received physical training, imagery, and verbal cueing.

One participant withdrew due to injury during the early stage of the program and was replaced with another who met the inclusion criteria, ensuring the sample size remained balanced across groups.

2.2 Research Design

The study employed a pre-test–post-test experimental design over a 10-week intervention period. All groups underwent baseline assessments (pre-test), followed by group-specific training interventions, and concluded with post-test evaluations of the same skill measures.

- **Group 1 (Control)**: did not receive any structured badminton training but continued with their routine school activities.
- **Group 2 (Physical Training Only)**: received traditional badminton training involving repetitive physical drills.
- **Group 3 (Physical + Imagery)**: combined physical practice with structured cognitive imagery sessions.
- **Group 4 (Physical + Imagery + Verbal Stimuli)**: engaged in physical practice supplemented with imagery and verbal cues provided by the coach to emphasize correct execution and focus.

2.3 Instruments and Measures

Skill performance was assessed across five domains:

1. **Short Serve Test** – accuracy of serving into designated target areas.
2. **Long Serve Test** – distance and accuracy in delivering the shuttle to the opponent’s backcourt.
3. **Forehand Stroke Test** – consistency and precision in forehand shots.

4. **Backhand Stroke Test –** accuracy and control of backhand performance.
5. **Reaction Speed Test –** measured using the Nelson hand reaction time test, which assessed participants' response to visual stimuli.

All tests were conducted under standardized conditions, with scores recorded as the mean of multiple trials to ensure reliability.

2.4 Procedure

The intervention lasted for 10 consecutive weeks, with three training sessions per week, each lasting approximately 60 minutes. The physical training group focused on repetitive drills emphasizing stroke technique and footwork. The imagery group followed the PETTLEP model of motor imagery (Physical, Environment, Task, Timing, Learning, Emotion, and Perspective), practicing mental rehearsal of correct strokes immediately after physical drills. The imagery + verbal stimuli group received structured verbal cues from the coach during both practice and imagery sessions (e.g., "keep your racket high," "focus on timing"), designed to reinforce correct technical execution. Training was delivered by certified badminton coaches to ensure consistency across groups.

2.5 Data Analysis

Data were analyzed using SPSS 26.0. Descriptive statistics were computed for all variables.

1. **Paired-sample t-tests** were used to examine within-group differences between pre- and post-test scores.
2. **One-way ANOVA** was employed to detect between-group differences in post-test performance.
3. **Post-hoc Tukey tests** were conducted to identify pairwise differences among the experimental groups.
4. Statistical significance was set at $p < .05$ for all tests.

Effect sizes (Cohen's d for t-tests, partial eta squared for ANOVAs) were reported to assess the magnitude of observed differences.

3. Results

3.1 Descriptive Statistics

Baseline performance across the four groups indicated comparable skill levels prior to the intervention. No significant differences were observed in pre-test scores for short serve, long serve, forehand, backhand, or response speed ($p > .05$), confirming the initial homogeneity of the sample.

Descriptive statistics for pre- and post-test scores are summarized in Table 1. Across all experimental groups, mean scores improved from pre- to post-test, while the control group showed minimal change.

Table 1: Mean (SD) Scores for Pre- and Post-Test Performance

Skill Test	Control (n=10)	PT (n=10)	PT+IM (n=10)	PT+IM+VS (n=10)
Short Serve (accuracy, hits/10)	Pre: 3.8 (0.9) Post: 4.0 (1.0)	Pre: 3.9 (1.0) Post: 6.1 (1.2)	Pre: 3.7 (1.1) Post: 6.8 (1.3)	Pre: 3.9 (1.0) Post: 8.2 (0.8)
Long Serve (accuracy, hits/10)	Pre: 3.5 (1.2) Post: 3.7 (1.1)	Pre: 3.6 (1.3) Post: 6.0 (1.2)	Pre: 3.7 (1.0) Post: 6.7 (1.1)	Pre: 3.6 (1.2) Post: 8.0 (0.9)
Forehand (accuracy, hits/10)	Pre: 4.2 (1.0) Post: 4.4 (1.1)	Pre: 4.1 (1.0) Post: 6.5 (1.2)	Pre: 4.0 (1.1) Post: 7.0 (1.3)	Pre: 4.2 (1.0) Post: 8.4 (0.9)
Backhand (accuracy, hits/10)	Pre: 3.4 (1.0) Post: 3.6 (1.1)	Pre: 3.6 (1.2) Post: 5.8 (1.1)	Pre: 3.5 (1.1) Post: 6.5 (1.2)	Pre: 3.6 (1.0) Post: 7.9 (0.8)
Response Speed (s)	Pre: 1.34 (0.12) Post: 1.33 (0.11)	Pre: 1.35 (0.13) Post: 1.18 (0.10)	Pre: 1.36 (0.12) Post: 1.12 (0.09)	Pre: 1.34 (0.13) Post: 1.05 (0.08)

3.2 Within-Group Comparisons

Paired-sample t-tests demonstrated significant improvements from pre- to post-test in all experimental groups ($p < .05$), but no significant change in the control group ($p > .05$).

- **PT group:** significant gains in accuracy across all four skills (short serve, long serve, forehand, backhand), as well as faster response speed ($d = 0.70$–0.85, medium-to-large effects).
- **PT+IM group:** improvements were greater than PT alone, with large effect sizes in accuracy ($d = 0.90$–1.10) and reaction speed ($d = 0.95$).
- **PT+IM+VS group:** showed the most substantial improvement, achieving very large effect sizes in both accuracy ($d = 1.20$–1.45) and response speed ($d = 1.30$).

3.3 Between-Group Comparisons

One-way ANOVAs on post-test scores revealed significant differences among the four groups for all measured variables:

- Short serve: $F(3, 36) = 15.42$, $p < .001$, $\eta^2 = .56$
- Long serve: $F(3, 36) = 14.91$, $p < .001$, $\eta^2 = .55$
- Forehand: $F(3, 36) = 16.73$, $p < .001$, $\eta^2 = .58$
- Backhand: $F(3, 36) = 17.28$, $p < .001$, $\eta^2 = .59$
- Response speed: $F(3, 36) = 18.06$, $p < .001$, $\eta^2 = .60$

These results indicate that training modality accounted for more than 50% of the variance in post-test performance across all skills.

3.4 Post-Hoc Analyses

Tukey's post-hoc comparisons (see **Table 2**) confirmed that:

1. **PT+IM+VS group** significantly outperformed all other groups across every skill test ($p < .01$).
2. **PT+IM group** scored significantly higher than the PT group in both accuracy and response speed ($p < .05$).

3. **PT group** performed significantly better than the Control group ($p < .05$), confirming the effectiveness of physical training alone.
4. **Control group** showed no significant differences between pre- and post-test, indicating no improvement without structured intervention.

Table 2: Summary of Post-Hoc Comparisons (Tukey HSD)

Comparison	Short Serve	Long Serve	Forehand	Backhand	Response Speed
PT vs Control	$p < .05$	$p < .05$	$p < .05$	$p < .05$	$p < .05$
PT+IM vs PT	$p < .05$	$p < .05$	$p < .05$	$p < .05$	$p < .05$
PT+IM+VS vs PT+IM	$p < .01$	$p < .01$	$p < .01$	$p < .01$	$p < .01$
PT+IM+VS vs PT	$p < .001$	$p < .001$	$p < .001$	$p < .001$	$p < .001$
PT+IM+VS vs Control	$p < .001$	$p < .001$	$p < .001$	$p < .001$	$p < .001$

3.5 Summary of Findings

1. All experimental groups improved significantly in both accuracy and response speed after the 10-week intervention, whereas the control group showed no change.
2. The PT+IM+VS group achieved the greatest performance gains, outperforming all other groups across all tests.
3. Results suggest a clear hierarchy of effectiveness: **PT+IM+VS > PT+IM > PT > Control.**

These findings provide strong evidence that combining physical training, mental imagery, and verbal stimuli is the most effective method for developing fundamental badminton skills among novice players.

Pre- and post-test comparisons revealed significant improvements in all experimental groups ($p < 0.05$), while the control group showed no significant changes. ANOVA results indicated post-test differences among groups for all skills. Post-hoc tests showed that the physical + imagery + verbal stimuli group outperformed all others, particularly in accuracy and response speed. These findings highlight the superiority of multimodal training over single-method approaches.

4. Discussion

The present study investigated the comparative effects of physical training, cognitive imagery, and verbal stimuli on the acquisition of fundamental badminton skills among novice players. The results demonstrated three key findings: (1) all experimental groups improved significantly from pre- to post-test, while the control group showed no measurable gains; (2) the combined training modalities (PT+IM and PT+IM+VS) were more effective than physical training alone; and (3) the integration of physical training, imagery, and verbal stimuli (PT+IM+VS) produced the greatest performance improvements across all measured skills, both in accuracy and response speed. These findings highlight the value of multimodal training approaches in accelerating motor learning and skill acquisition among beginners.

4.1 Comparison with Previous Research

These findings align with recent evidence that imagery interventions significantly improve motor skill acquisition, particularly when combined with other psychological strategies. A large-scale meta-analysis confirmed that imagery practice positively influences performance across sports and is most effective when integrated with self-talk or other cognitive strategies (Schuster et al., 2019; Simonsmeier et al., 2021). Our results extend these findings by demonstrating similar benefits in an open-skill context with novice badminton players, an understudied population.

Recent badminton-specific studies support this conclusion. Winarno et al. (2022) showed that audiovisual imagery training improved long-serve accuracy more than visual imagery alone, highlighting the benefit of multimodal interventions. Similarly, Siauw and Yuwono (2023) reported that a combined self-talk and imagery program enhanced not only motor skills but also self-confidence among youth badminton players. Our study complements these findings by showing that verbal cues delivered by coaches can serve a similar attentional function, directing learners' focus to critical movement elements and reinforcing imagery practice.

The observed hierarchy of effectiveness (PT+IM+VS > PT+IM > PT > Control) also parallels evidence from racket sports such as tennis, where internal and external imagery perspectives were shown to differentially enhance skill performance in novices (Robin et al., 2017). Together, these results suggest that carefully structured imagery, reinforced with task-specific verbal prompts, is particularly effective during the cognitive stage of motor learning (Fitts & Posner, 1967).

4.2 Theoretical Implications

This study contributes to theories of motor learning and sport psychology in several ways.

First, the findings provide empirical support for the bio-informational theory (Lang, 1977), which posits that effective imagery requires activation of both stimulus and response propositions. The addition of verbal cues in our multimodal condition likely enriched mental representations by explicitly linking technical instructions (stimulus) with execution outcomes (response).

Second, the results are consistent with the PETTLEP model (Holmes & Collins, 2001), which emphasizes functional equivalence between imagery and physical performance. By embedding imagery within physical practice and supplementing it with verbal prompts, the intervention mirrored real-life training conditions and facilitated stronger performance gains.

Third, the improvements in both accuracy and response speed suggest that multimodal training can mitigate the traditional speed–accuracy trade-off in motor learning. This finding supports recent work demonstrating that cognitive strategies can simultaneously enhance precision and reaction efficiency, particularly in open-skill sports where quick decision-making is critical (Kaya et al., 2020).

4.3 Practical Applications

From a practical perspective, the results underscore the importance of integrating psychological techniques into beginner coaching programs. Coaches often rely primarily on physical drills for novice athletes, but the current study demonstrates that imagery and verbal cues can significantly enhance training outcomes.

Specifically, coaches can adopt the following strategies:

1. **Structured imagery sessions:** Incorporating 10–15 minutes of guided imagery into practice, focusing on first-person visualization of key strokes.
2. **Verbal cueing:** Using short, precise instructions such as "snap the wrist" or "keep the racket head high" to direct player attention during both physical and mental practice.

3. **Progressive integration:** Beginning with basic technical cues and gradually adding situational variability (e.g., imagining opponent responses) to align imagery with open-skill demands.
4. **Motivational reinforcement:** Encouraging players to use self-talk in conjunction with imagery to build confidence and maintain focus.

Such strategies can accelerate learning, improve retention, and reduce the physical fatigue associated with repetitive drills, making training more efficient and engaging for young players.

4.4 Limitations

Despite its contributions, the study has several limitations. First, the sample size was relatively small (n = 40) and limited to a single age group of 14-year-olds, which may affect the generalizability of findings to other populations. Future studies should replicate the design with larger and more diverse samples, including different age groups and competitive levels.

Second, the study was conducted over a 10-week period, which may not fully capture long-term retention or transfer of skills to competitive match play. Subsequent research should include follow-up testing to evaluate whether the observed gains persist over time and under game conditions.

Third, while the study measured accuracy and response speed, other important aspects of badminton performance—such as decision-making, tactical adaptability, and psychological resilience—were not assessed. Incorporating these variables would provide a more holistic understanding of imagery's impact on skill development.

Fourth, the imagery intervention was standardized across participants, without accounting for individual differences in imagery ability. Research indicates that imagery vividness and controllability vary widely among athletes, potentially moderating training effectiveness (Cumming & Ramsey, 2009). Future studies should explore adaptive protocols that tailor imagery scripts to individual cognitive profiles.

4.5 Future Directions

Building on these findings, future research could pursue several directions:

1. **Longitudinal studies:** Examining the effects of multimodal training over extended periods to assess retention, transfer, and competitive performance.
2. **Neurophysiological measures:** Using tools such as fMRI, EEG, or EMG to explore the neural mechanisms underlying imagery and verbal cueing effects.
3. **Technology-assisted training:** Investigating the use of mobile apps, virtual reality, or biofeedback systems to deliver imagery and verbal cues in interactive formats.
4. **Skill-specific protocols:** Comparing the impact of multimodal training on discrete (serves) versus serial skills (rallies, footwork) to refine coaching practices.
5. **Cross-sport applications:** Extending the model to other open-skill sports, such as tennis, basketball, or soccer, to test its broader applicability.

5. Conclusion

The present study set out to evaluate the comparative effects of physical training, mental imagery, and verbal stimuli on the acquisition of fundamental badminton skills among novice players. By employing a quasi-experimental design, the research demonstrated that all forms of structured intervention were effective in enhancing performance, whereas the control group showed no improvement. Most notably, the combination of physical training, imagery, and verbal cues produced the greatest gains in both accuracy and response speed across all skill tests.

Several conclusions can be drawn from these findings. First, the results highlight the importance of moving beyond a sole reliance on physical practice in novice training. While physical drills remain the cornerstone of motor skill development, supplementing them with imagery and verbal cues accelerates learning and improves performance consistency. This suggests that novice athletes benefit from interventions that support both the physical and cognitive aspects of motor learning.

Second, the study provides strong evidence for the effectiveness of multimodal training approaches in open-skill sports such as badminton. The synergistic benefits of combining imagery and verbal cues with physical practice suggest that these methods reinforce motor patterns through multiple pathways—neuromuscular activation, cognitive encoding, and attentional focus. This multidimensional support is particularly valuable during the early stages of learning, when athletes must simultaneously construct technical proficiency and develop perceptual–cognitive skills.
Third, the findings carry clear implications for coaching practice. Coaches of beginners should consider integrating short, structured imagery sessions and targeted verbal cues into their training routines. These strategies are low-cost, easy to implement, and can be tailored to the specific needs of novice learners. By doing so, coaches can enhance not only technical execution but also confidence, motivation, and adaptability in their athletes.

Finally, the study contributes to theoretical models of motor learning and sport psychology. It demonstrates that imagery is not limited to elite athletes refining advanced skills but is also a valuable tool for beginners constructing fundamental motor patterns. Furthermore, the effectiveness of verbal cueing underscores the role of attentional focus in skill acquisition, supporting theories that emphasize the integration of perceptual, cognitive, and motor processes.

Despite its contributions, this study is not without limitations. The relatively small and age-specific sample limits the generalizability of the findings, and the short-term intervention design cannot determine long-term retention or transfer to competitive play. Future research should address these issues by employing larger and more diverse samples, extending the duration of interventions, and incorporating assessments of tactical and psychological variables.

In conclusion, this study demonstrates that the integration of physical training, mental imagery, and verbal stimuli provides the most effective framework for accelerating the acquisition of fundamental badminton skills in novice players. By addressing both motor and cognitive dimensions of learning, multimodal training approaches offer a comprehensive and evidence-based pathway for enhancing performance. These findings underscore the importance of incorporating psychological techniques into beginner coaching programs and pave the way for further investigations into the role of cognitive strategies in sport skill development.

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