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Effect Of Visual Mental Imagery Training On Vertical Jump Height And Lower Limb Explosive Power In Young Badminton Players: A Pre-Test–Post-Test Controlled Study

Dr. Atharva Mishra (PT)[1], Dr. Manish Sharma (PT)[2] , Dr. Supriyo Sarkar (PT)[3]
[1]Clinical Physiotherapist, Physio At Your Doorstep. ORCID ID: 0009-0009-5171-7152
[2]Clinical Physiotherapist, SPARC Physiotherapy Center. ORCID ID: 0009-0008-7498-9751.
[3]Author & Assistant Professor, Dept. of Allied Health Sciences, Brainware University, ORCID ID: 0009-0003-0045-1725
Corresponding Author: Dr. Supriyo Sarkar (PT), supriyo2015sarkar@gmail.com
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Abstract

Background: Mental imagery — the cognitive rehearsal of a motor skill in the absence of overt physical movement — is a widely used performance-enhancement strategy in applied sport psychology, but its effect on explosive lower limb power in racquet-sport athletes remains under-investigated.
Objective: To evaluate the effect of adding visual mental imagery training to a standard sport-specific exercise regimen on vertical jump height (VJH) and lower limb explosive power in young badminton players.
Methods: In this pre-test-post-test-controlled study, 30 badminton players (12–21 years) from a private sports academy in Jaipur, India, were assigned by convenience sampling to an experimental group (Group A, n = 15) or a control group (Group B, n = 15). Over 21 days, Group A received visuo-motor behavioral mental imagery training — two 7-minute video-based sessions per day depicting the smash stroke and vertical jump, viewed with headphones in an isolated setting — in addition to their regular sport-specific exercise regimen; Group B received the exercise regimen alone. VJH was measured using a standardized vertical jump test, and lower limb explosive power was derived from jump height and body mass using a validated peak-power equation. Within-group changes were analyzed with paired t-tests and between-group differences with independent-samples t-tests ($\alpha = .05$).
Results: Both groups showed statistically significant pre- to post-intervention improvements in VJH and lower limb power ($p < .001$). At baseline, the groups did not differ significantly on any outcome. At post-intervention, between-group VJH did not differ significantly (44.13 ± 12.42 cm vs. 45.60 ± 11.59 cm, $p = .74$), whereas lower limb power was significantly higher in Group B than in Group A (3709.71 ± 628.45 W vs. 3191.44 ± 727.04 W, $p = .046$).
Conclusion: Both regular sport-specific training alone and training combined with visual mental imagery produced significant within-group gains in vertical jump height and lower limb explosive power over 21 days. However, the addition of mental imagery did not confer an additional advantage over exercise alone; contrary to the study hypothesis, the exercise-only group showed significantly greater post-intervention lower limb power. These findings do not support mental imagery as an adjunct to short-term explosive-power training in youth badminton players and warrant replication with larger samples and longer intervention periods.

1. INTRODUCTION

Badminton is a multidirectional, explosive racquet sport that demands rapid shuffling, jumping, twisting, stretching, and striking, combined with superior reactive ability, aerobic stamina, agility, strength, speed, and precision (Ooi et al., 2014). Since its inclusion as an Olympic sport in 1992, badminton has grown into one of the most widely played racquet sports worldwide (Ooi et al., 2014). Of the six basic badminton strokes, the smash is the most powerful offensive technique, and its effectiveness is closely linked to jump height, lower limb explosive power, and shoulder strength (Asif et al., 2018). Explosive lower limb power enables a player to move instantaneously toward the shuttle and to elevate the body for overhead strokes, and is therefore considered a key determinant of performance in court sports such as badminton, basketball, and volleyball (Singh, 1995).

Explosive strength — the ability to generate maximal force in minimal time — underlies many sport skills, including jumping for height, striking, sprinting, and throwing (Vaczi et al., 2011). The vertical jump test is one of the most widely used field measures of lower limb explosive power because it is simple, reliable (reported reliability coefficients of 0.93–0.99), and reflects a coordinated, multi-joint kinetic chain in which the hip, knee, and ankle each contribute to total jump force (Considine & Sullivan, 1973; Robertson & Fleming, 1987). Smith (1961) demonstrated that strength measured against a fixed dynamometer engages a different neuromotor pattern than the strength expressed during a dynamic jumping movement, underscoring the specificity of training required to improve jump performance. Consistent with this, plyometric and resistance training protocols have been shown to produce meaningful improvements in vertical jump height (Markovic, 2007; Rahimi & Behpur, 2005), and sport-specific plyometric programs have been applied successfully in badminton players (Frohlich & Felder, 2014; Middleton et al., 2016; Ozmen & Aydogmus, 2017; Sabnis & Saini, 2011).

Alongside physical conditioning, mental imagery has been proposed as a complementary performance-enhancement strategy. Mental imagery is defined as a symbolic, quasi-sensory experience that can occur in the absence of the actual sensory stimuli it represents, and is considered an important cognitive process underlying skill acquisition, recollection, and creative problem-solving (Cumming & Williams, 2012; Denis, 1985). In sport, imagery is used to rehearse forthcoming performance demands and has been shown to enhance motor task performance across a range of disciplines (Di Corrado et al., 2019; Gill, 2000). The proposed mechanism is the psychoneuromuscular theory, which holds that imagined movement produces low-amplitude innervation in the same muscle groups recruited during the corresponding actual movement, thereby reinforcing the relevant neuromuscular pathways (Norris, 1986). Supporting this, Fontani et al. (2007) found that motor imagery training modified movement-related brain macro potentials and influenced measures of muscular strength and power in athletes performing a previously unlearned skilled action, and Liu et al. (2004) demonstrated that imagery training facilitated relearning of motor tasks after stroke. In elite athletes, imagery ability has also been shown to differ by sport type and competitive level, with more experienced athletes reporting greater imagery vividness and control (Di Corrado et al., 2019; Mohammadzadeh & Sami, 2014). Positive associations between imagery use and competitive performance have also been reported in combat-sport athletes (Parnabas et al., 2015).

Despite this evidence, the specific effect of visual mental imagery on lower limb explosive power in badminton players has not been well characterized. Most badminton conditioning research has focused on plyometric and resistance training (Frohlich & Felder, 2014; Middleton et al., 2016; Ozmen & Aydogmus, 2017), while imagery research has largely examined psychological skills, rehabilitation, or sports other than badminton (Liu et al., 2004; Mohammadzadeh & Sami, 2014; Parnabas et al., 2015). The present study therefore examined whether adding a short-term visual mental imagery protocol to a standard sport-specific exercise regimen would produce greater gains in vertical jump height and lower limb explosive power than the exercise regimen alone in young competitive badminton players.

1.1 Objective and Hypotheses

The objective of the study was to determine the effect of visual mental imagery training, added to a regular sport-specific exercise regimen, on vertical jump height and lower limb explosive power in young badminton players.

H_1 (Experimental Hypothesis): Mental imagery training combined with regular exercise produces a significantly greater improvement in vertical jump height and lower limb power than regular exercise alone.

H_0 (Null Hypothesis): Mental imagery training combined with regular exercise produces no significant additional improvement in vertical jump height and lower limb power compared with regular exercise alone

2. METHODS

2.1 Study Design and Setting

This was a pre-test–post-test-controlled study conducted at Pink City Sports Academy, Jagatpura, Jaipur, India, over a 21-day intervention period.

2.2 Participants

Thirty male and female badminton players aged 12–21 years, registered with the academy, were recruited by convenience sampling.

Inclusion criteria: at least 3 years of competitive badminton experience; a minimum performance level of district-level competition; systematic training of at least 3 hours per day; registered academy players; willingness to provide informed consent; comprehension of English; and a negative COVID-19 status at enrolment.

Exclusion criteria: players undergoing psychiatric treatment; players with visual disturbance or diagnosed eye disease; and players with any hearing impairment.

Written informed consent was obtained from all participants (or their parents/coach for minors) prior to enrolment. Participants were allocated to Group A (experimental, n = 15) or Group B (control, n = 15) in equal numbers.

2.3 Intervention

Group A (experimental) received a regular sport-specific exercise regimen combined with visuo-motor behavioural mental imagery training. Imagery sessions consisted of the participant watching pre-recorded video footage of the badminton smash stroke and vertical jump technique on a smartphone (Redmi Note 5 Pro), with headphones used to isolate auditory attention. Sessions were conducted twice daily for 7 minutes each (14 minutes/day) in an isolated, quiet setting, for 21 consecutive days.

Group B (control) received the same regular sport-specific exercise regimen alone, without the imagery component.

2.4 Outcome Measures

Vertical jump height (VJH, cm) was assessed using a standard field-based vertical jump test. The participant stood with equal weight on both feet and reached maximally overhead with one arm to mark a baseline reach height, then performed a maximal-effort jump (with arm swing permitted) to mark peak reach height; VJH was calculated as the difference between the two marks, measured with an inch tape. The vertical jump test is a validated, kinematic-chain measure of lower limb explosive power, with the hip, knee, and ankle contributing approximately 40%, 24%, and 36% of total jump force, respectively, and reported test–retest reliability of 0.93–0.99 (Considine & Sullivan, 1973; Gioftsidou et al., 2008; Robertson & Fleming, 1987).

Lower limb explosive power (W) was derived from VJH and body mass using the peak-power estimation equation:

$$\text{Peak power (W)} = 61.9 \times \text{jump height (cm)} + 36.0 \times \text{body mass (kg)} + 1{,}822$$

Both outcomes were recorded at baseline (Day 0) and after the 21-day intervention (Day 21) by the same assessor under standardized conditions.

2.5 Statistical Analysis

Data were analyzed using IBM SPSS Statistics (version 20.0; IBM Corp., Chicago, IL) and Microsoft Excel. Descriptive statistics (mean ± SD) were computed for age, body mass index (BMI), VJH, and lower limb power. Baseline comparability between groups was assessed with independent-samples t-tests. Within-group pre- to post-intervention changes were analyzed with paired-samples t-tests, and between-group post-intervention differences were analyzed with independent-samples t-tests, with Levene's test used to assess the equality of variances. Statistical significance was set at $p < .05$.

3. RESULTS

3.1 Participant Characteristics

Thirty participants completed the study (15 per group; no dropouts). Mean age was 15.93 ± 3.12 years in Group A and 16.53 ± 3.00 years in Group B ($p = .596$); mean BMI was 20.75 ± 2.81 kg/m² in Group A and 19.83 ± 1.14 kg/m² in Group B ($p = .250$). Groups did not differ significantly on age or BMI at baseline (Table 1).

Table 1. Age and BMI of Group A and Group B (Mean ± SD)

Variable	Group A (n = 15)	Group B (n = 15)	p value
Age (years)	15.93 ± 3.122	16.53 ± 2.997	.596
BMI (kg/m²)	20.75 ± 2.810	19.83 ± 1.144	.250

3.2 Baseline Comparison of Vertical Jump Height and Lower Limb Power

At baseline, VJH was 37.67 ± 11.32 cm in Group A and 36.20 ± 10.38 cm in Group B ($p = .714$); lower limb power was 2855.82 ± 719.25 W in Group A and 2994.49 ± 657.66 W in Group B ($p = .586$). No significant between-group difference was present at baseline for either outcome (Table 2), confirming comparability of the two groups prior to intervention.

Table 2. Baseline (Pre-Intervention) Comparison of Vertical Jump Height and Lower Limb Power

Variable	Group A (n = 15)	Group B (n = 15)	p value
VJH (cm)	37.67 ± 11.324	36.20 ± 10.380	.714
LL Power (W)	2855.82 ± 719.254	2994.49 ± 657.655	.586

3.3 Within-Group Change from Pre- to Post-Intervention

In Group A, VJH increased from 37.67 ± 11.32 cm to 44.13 ± 12.42 cm, and lower limb power increased from 2855.82 ± 719.25 W to 3191.44 ± 727.04 W; both changes were statistically significant ($p < .001$; Table 3).

Table 3. Within-Group Comparison of Vertical Jump Height and Lower Limb Power — Group A

Variable	Pre-test	Post-test	p value
VJH (cm)	37.67 ± 11.324	44.13 ± 12.415	< .001*
LL Power (W)	2855.82 ± 719.254	3191.44 ± 727.038	< .001*

In Group B, VJH increased from 36.20 ± 10.38 cm to 45.60 ± 11.59 cm, and lower limb power increased from 2994.49 ± 657.66 W to 3709.71 ± 628.45 W; both changes were statistically significant ($p < .001$; Table 4).

Table 4. Within-Group Comparison of Vertical Jump Height and Lower Limb Power — Group B

Variable	Pre-test	Post-test	p value
VJH (cm)	36.20 ± 10.380	45.60 ± 11.587	< .001*
LL Power (W)	2994.49 ± 657.655	3709.71 ± 628.452	< .001*

3.4 Between-Group Comparison at Post-Intervention

At post-intervention, VJH did not differ significantly between Group A (44.13 ± 12.42 cm) and Group B (45.60 ± 11.59 cm; $p = .74$). In contrast, lower limb power was significantly higher in Group B (3709.71 ± 628.45 W) than in Group A (3191.44 ± 727.04 W; mean difference = −518.27 W, 95% CI: −1026.54 to −9.99; $p = .046$) (Table 5). This result is opposite in direction to the study hypothesis: the exercise-only control group, not the imagery group, showed the significantly greater post-intervention value.

Table 5. Between-Group Comparison of Vertical Jump Height and Lower Limb Power at Post-Intervention

Variable	Group A (n = 15)	Group B (n = 15)	Mean difference (95% CI)	p value
VJH (cm)	44.13 ± 12.415	45.60 ± 11.587	−1.47 (−10.45, 7.52)	.74
LL Power (W)	3191.44 ± 727.038	3709.71 ± 628.452	−518.27 (−1026.54, −9.99)	.046*

*$p < .05$.

4. DISCUSSION

This study examined whether adding a short-term visual mental imagery protocol to a regular sport-specific exercise regimen would enhance vertical jump height and lower limb explosive power in young badminton players beyond the effect of exercise alone. Both groups improved significantly over the 21-day period on both outcomes, confirming that the underlying sport-specific exercise regimen was an effective stimulus for lower limb power development in this population — consistent with prior evidence that structured plyometric and resistance-based training reliably improves vertical jump performance (Markovic, 2007; Ozmen & Aydogmus, 2017; Rahimi & Behpur, 2005; Sabnis & Saini, 2011).

Contrary to the study hypothesis, however, the addition of mental imagery did not confer an additional advantage. Post-intervention vertical jump height did not differ between groups, and lower limb power was significantly higher in the exercise-only control group than in the imagery-plus-exercise group. This finding diverges from reports that imagery training can enhance motor performance and modify neuromuscular activity relevant to strength and power expression (Fontani et al., 2007; Liu et al., 2004). Several factors may account for this discrepancy. First, the imagery dose used here (two 7-minute sessions/day for 21 days) was brief relative to protocols in which imagery effects on strength and power have been demonstrated, such as the month-long daily training used by Fontani et al. (2007); a longer or more intensive imagery exposure may be required before neuromuscular adaptations attributable to imagery become measurable as gains in an anaerobic power outcome. Second, imagery ability and vividness vary considerably between individuals and by sport and competition level (Di Corrado et al., 2019); imagery training was not individually tailored or preceded by an assessment of participants' imagery ability, which may have diluted any true effect. Third, because lower limb power in this study was a derived variable calculated from jump height and body mass, it is disproportionately sensitive to body-mass differences between groups; the significant between-group difference in power without a corresponding difference in directly measured jump height suggests that this result should be interpreted with particular caution rather than as clear evidence of a training effect. Finally, it is also plausible that the time allocated to imagery sessions in Group A came at the expense of additional physical practice time, or that the imagery task — passively watching pre-recorded video rather than engaging in active, self-generated first-person kinaesthetic imagery — did not sufficiently engage the neuromuscular pathways proposed by the psychoneuromuscular theory (Norris, 1986).

These findings should be considered alongside the broader literature on imagery in sport, which reports predominantly positive but heterogeneous effects depending on imagery modality (visual vs. kinaesthetic), athlete skill level, and outcome measured (Cumming & Williams, 2012; Mohammadzadeh & Sami, 2014; Parnabas et al., 2015). Imagery may plausibly exert a larger influence on skill accuracy, decision-making, or psychological readiness (e.g., confidence, arousal regulation) than on raw explosive power output, which is more directly determined by muscular and neuromuscular conditioning (Gill, 2000). Future work directly comparing imagery's effects on technical/skill outcomes versus physical performance outcomes in the same cohort would help clarify this distinction.

5. CONCLUSION

Over a 21-day period, both a standard sport-specific exercise regimen alone and the same regimen combined with visual mental imagery training produced significant improvements in vertical jump height and lower limb explosive power in young badminton players. However, the addition of mental imagery did not produce an additional benefit over exercise alone; vertical jump height did not differ between groups, and the exercise-only group showed significantly greater post-intervention lower limb power. These findings do not support the study's experimental hypothesis and instead lend support to the null hypothesis for the outcomes and protocol used here. Coaches and practitioners should not assume that adding a brief, passive video-based visual imagery protocol to physical training will enhance explosive lower limb power in youth badminton players; any performance benefit of imagery in this population may lie in domains other than raw explosive power.

6. LIMITATIONS AND FUTURE DIRECTIONS

This study has several limitations. The sample size was small (n = 30) and drawn by convenience sampling from a single academy, limiting statistical power and generalizability. The intervention period was short (21 days), which may be insufficient to detect imagery-related neuromuscular adaptation. Lower limb power was estimated using a jump-height-and-body-mass-based equation rather than measured directly (e.g., via force plate), which may have introduced measurement bias. Imagery ability was not assessed or controlled for at baseline, and the imagery protocol relied on passive video observation rather than active, individualized kinaesthetic imagery. Other potentially confounding factors, such as training load, sleep, and nutrition, were not controlled.

Future studies should consider larger, randomized samples; longer intervention periods; direct force-plate measurement of power; baseline assessment and stratification by imagery ability; comparison of visual versus kinaesthetic imagery modalities; and inclusion of skill-based and psychological outcome measures (e.g., smash accuracy, self-confidence) alongside physical performance measures. Sex-based and experience-based subgroup comparisons, and objective neuromuscular measures such as electromyography, may also help clarify the mechanisms underlying any true imagery effect.

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