ORIGINAL ARTICLE

Internal and external PETTLEP imagery training effects on three-point shooting performance in adolescent basketball players

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Abstract

Background and Study Aim: Motor imagery is widely used to enhance sport performance. Internal and external PETTLEP imagery perspectives are commonly applied to improve the execution of sport-specific skills, including basketball shooting. Despite the use of these imagery approaches in athletic training, their relative effectiveness in enhancing three-point shooting performance remains a matter of practical interest. This study examined the effects of Internal PETTLEP Imagery Training and External PETTLEP Imagery Training on three-point shooting performance in adolescent basketball players.

Material and Methods: Ninety male basketball players aged 15–18 years were randomly assigned to an Internal PETTLEP Imagery Group (n = 30), an External PETTLEP Imagery Group (n = 30), or an Active Control Group (n = 30). Participants completed a 12-week intervention with three supervised sessions per week. Three-point shooting performance was assessed at pre-test, post-test, and a two-week retention test.

Results: Both imagery groups improved from pre-test to post-test and maintained higher shooting scores at retention than the Active Control Group. Significant effects were observed for Time, $F(2, 172) = 18.42$, $p < .001$, $\eta^2p = .18$; Group, $F(2, 86) = 5.67$, $p = .005$, $\eta^2p = .12$; and the Group × Time interaction, $F(4, 172) = 9.83$, $p < .001$, $\eta^2p = .19$. Imagery ability was associated with shooting performance ($p = .009$), and self-confidence moderated the relationship between intervention condition and shooting performance ($\beta = 0.52$, $p = .015$).

Conclusions: Internal and external PETTLEP imagery were associated with improvements in three-point shooting performance and retention in adolescent basketball players. Imagery ability and self-confidence should be considered when implementing imagery-based training interventions.

Keywords: PETTLEP imagery, mental imagery, basketball shooting, shooting accuracy, retention, self-confidence.

Introduction

Basketball performance depends on the effective integration of technical, physical, cognitive, and psychological factors. Among technical skills, three-point shooting has become increasingly prominent in modern basketball because it can substantially influence game outcomes and tactical decision-making. Successful three-point shooting requires not only precise motor execution but also the ability to maintain concentration, regulate emotions, and perform consistently under competitive pressure. As a result, a variety of training methods are used to support the development and maintenance of shooting performance in basketball players and to increase the likelihood of successful shot execution.

Basketball is a complex team game in which technical, tactical, physiological, and psychological skills are interdependent to produce successful performance [1]. Shooting is one of the key technical skills used in competition, as points are awarded only when a shot is successfully made. Therefore, shooting skill is one of the factors that contribute to both individual and team success [2]. The importance of the three-point shot has grown significantly in modern basketball, influenced by changing playing styles and game demands. Modern basketball teams increasingly rely on perimeter shooting to create scoring opportunities, increase offensive spacing, and enhance offensive efficiency [3]. The ability to successfully execute three-point shots depends on motor coordination, balance, force control, movement consistency, attentional control, and decision-making under pressure. In addition to physical and technical factors, psychological factors such as confidence, emotional control, and attentional focus can significantly influence shooting performance. As a result, psychological skills training has come to play a significant role in contemporary basketball development programs.

Mental training is the systematic use of psychological methods to improve performance, learning, and readiness for competition. Motor imagery is one of the most researched and widely

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used techniques in sport psychology. Motor imagery is the mental simulation of a movement without actual movement while maintaining key perceptual and motor aspects of the task. Neurophysiological studies suggest that imagery recruits neural regions involved in movement planning and execution, such as sensorimotor networks, the supplementary motor area, the premotor cortex, and the cerebellum [4]. This functional overlap provides theoretical support for the use of imagery to enhance sport performance. Furthermore, a recent meta-analysis revealed that imagery interventions have positive effects on sport performance across a wide range of athletic populations [5]. Imagery is therefore recognized as an evidence-based strategy for enhancing sport-specific performance.

The PETTLEP model is one of the most influential and widely used imagery models in sport psychology. The PETTLEP model was developed by Holmes and Collins [6] to achieve the highest possible level of functional equivalence between imagery and actual performance. PETTLEP stands for Physical, Environment, Task, Timing, Learning, Emotion, and Perspective. The PETTLEP approach encourages athletes to develop imagery experiences that closely match actual performance situations. PETTLEP imagery is thought to have positive effects on sport-specific performance and performance outcomes. Recent research findings have consistently supported the effectiveness of PETTLEP-based imagery interventions in enhancing sport-specific performance and motor skill execution.

In the PETTLEP model, two imagery perspectives are typically used. When using internal imagery, individuals experience the movement from a first-person perspective, whereas when using external imagery, they imagine themselves from a third-person perspective [7]. Both perspectives have shown positive effects on performance, but findings regarding differences between them remain inconsistent.

Imagery training has been found to enhance basketball-specific skills such as shooting accuracy, free-throw shooting, concentration, and confidence [8]. PETTLEP-based interventions have also been shown to improve skill execution and motor performance by increasing functional equivalence between imagined and actual skill practice [9]. Overall, positive results have been reported; however, some inconsistencies remain regarding the effectiveness of internal and external imagery perspectives. The use of internal and external imagery has been suggested for different purposes, including kinesthetic awareness and movement control, and technical form and movement observation, respectively [10].

Self-confidence has been well established as a key psychological component of sport performance. In sport, self-confidence is defined as an athlete's belief in their ability to perform successfully in a specific task or achieve a desired outcome [11]. Higher levels of confidence are associated with greater persistence, focus, resilience, and emotional control during competition [12]. Social cognitive theory proposes that efficacy beliefs influence motivation, effort, and performance behavior. Confidence may be especially important in basketball shooting, as shooting often occurs under conditions of uncertainty, fatigue, and competitive pressure. Previous studies have reported a positive relationship between confidence and sport performance outcomes [13].

Imagery interventions tend to be successful overall, but their effects may vary across individuals. One possible explanation for these differences is imagery ability, which is defined as the ability to generate, manipulate, and maintain detailed mental images [14]. The Movement Imagery Questionnaire-3 (MIQ-3), a widely used measure of internal visual, external visual, and kinesthetic imagery ability, was developed and validated by Williams et al. [7]. Athletes' imagery ability may influence their capacity to construct realistic mental images, thereby affecting the effectiveness of imagery interventions. Failure to account for imagery ability may complicate the interpretation of imagery training outcomes and contribute to inconsistent findings across studies. Therefore, imagery ability should be controlled for when evaluating imagery-based interventions.

Analysis of previous research findings has shown that PETTLEP imagery interventions can enhance sport-specific performance and motor skill execution, while both internal and external imagery perspectives have demonstrated positive effects across a range of sporting tasks. Researchers have emphasized that the effectiveness of imagery interventions may be influenced by multiple factors, including the imagery perspective adopted, imagery ability, and psychological characteristics such as self-confidence. At the same time, findings regarding the relative effectiveness of internal and external imagery perspectives remain mixed, and the interaction between imagery processes and self-confidence continues to present a complex area of investigation. Clarifying how different PETTLEP imagery perspectives operate in basketball shooting performance while accounting for individual psychological characteristics may contribute to a more comprehensive evaluation of imagery-based training in adolescent athletes.

Accordingly, the present study examined the effects of Internal PETTLEP Imagery Training and External PETTLEP Imagery Training on three-point shooting performance in adolescent basketball players. Based on the theoretical assumptions of the PETTLEP model, the following hypotheses were formulated. It was hypothesized that both PETTLEP imagery interventions would improve shooting

performance compared with an active control condition and that higher levels of self-confidence would be associated with greater performance improvements.

Materials and Methods

Participants

A total of 102 male high school basketball players aged 15–18 years were screened for eligibility. Twelve participants were excluded because they did not meet the inclusion criteria (n = 7) or declined to participate (n = 5). The remaining 90 participants were randomly assigned to the study groups. Inclusion criteria were: (a) at least two years of competitive basketball experience, (b) regular participation in structured basketball training, (c) medical fitness for sports participation, and (d) parental consent and participant assent. Exclusion criteria included musculoskeletal injury, neurological disorder, visual impairment, previous formal imagery training, attendance below 85% of intervention sessions, or incomplete outcome assessments. All participants completed the intervention and retention assessments and were included in the final analyses. The mean basketball experience of the participants was 3.0 ± 1.1 years. Participant recruitment, screening, randomization, follow-up, and analysis are presented in the CONSORT flow diagram (Figure 1), in accordance with the CONSORT 2010 reporting guidelines.

Sample Size Determination. An a priori power analysis was conducted using G*Power Version 3.1 [15]. Based on a medium effect size (f = 0.25), an alpha level of 0.05, a statistical power of 0.80, and a correlation of 0.50 among repeated measures, the required sample size was 84 participants. To account for potential attrition, 90 participants were recruited and randomly assigned to three groups (n = 30 per group).

Randomization and Allocation Concealment. After baseline assessment, participants were randomly assigned to the Internal PETTLEP Imagery Group, the External PETTLEP Imagery Group, or the Active Control Group using a computer-generated

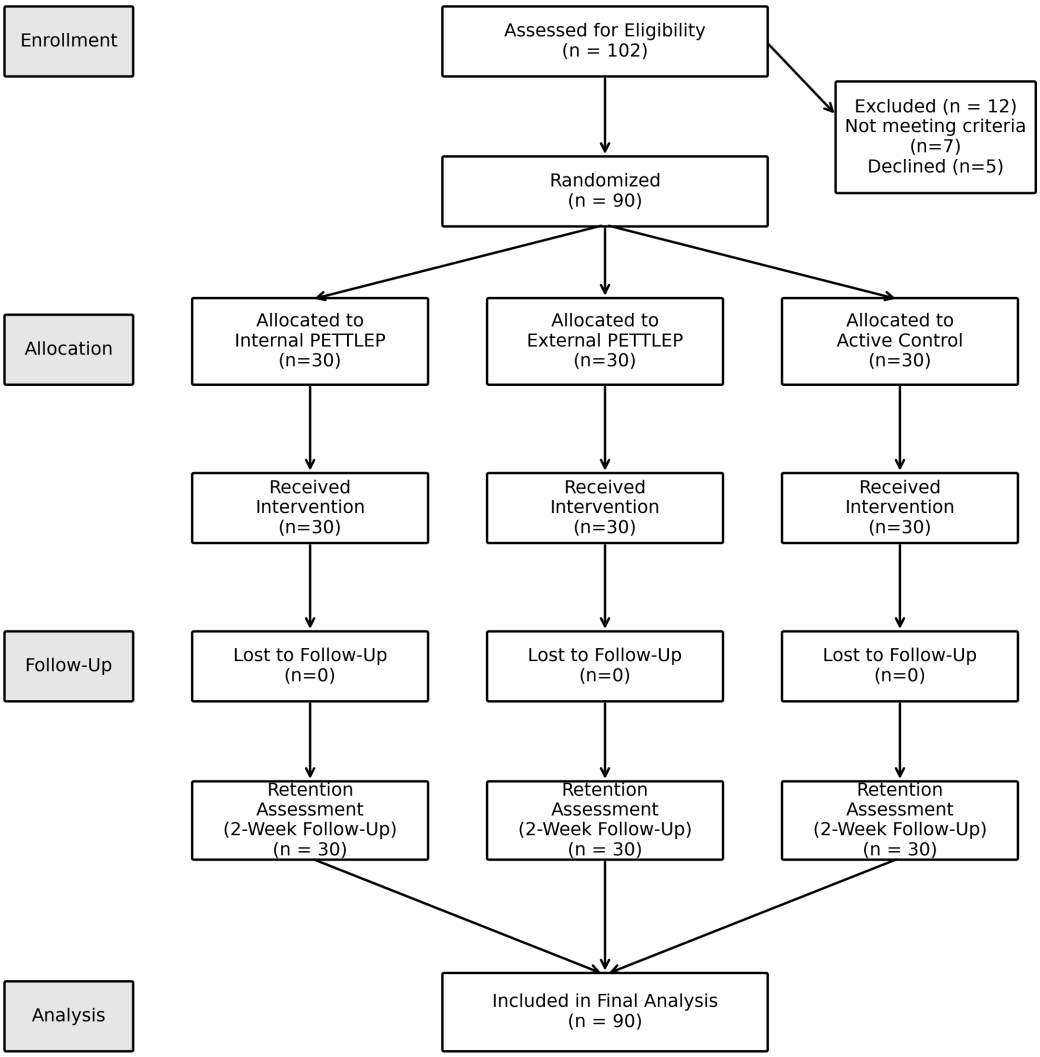

Figure 1. CONSORT flow diagram showing participant recruitment, eligibility screening, randomization, intervention allocation, follow-up, retention assessment, and final analysis.

randomization sequence. Stratified randomization based on baseline shooting accuracy was used to ensure group equivalence. Allocation was concealed using sequentially numbered, opaque, sealed envelopes prepared by an independent researcher who was not involved in participant recruitment, assessment, or intervention delivery.

Ethical Approval. Ethical approval for this study was obtained from the Institutional Research Ethics Committee of Hindustan Institute of Technology and Science, Chennai, Tamil Nadu, India (Approval No. HITS/CRC/004/20603034). Written informed consent was obtained from all participants before participation. The study was conducted in accordance with the Declaration of Helsinki [16].

Study Design

This study used a randomized controlled pretest, post-test, and retention test design. Participants were randomly assigned to the Internal PETTLEP Imagery Group (IPIG), External PETTLEP Imagery Group (EPIG), or Active Control Group (ACG). Assessments were conducted at baseline, after the 12-week intervention, and at a two-week retention test. Imagery ability was assessed before group allocation and included as a covariate. Self-confidence was assessed at all three time points.

Instruments

Movement Imagery Questionnaire-3 (MIQ-3). Imagery ability was assessed using the Movement Imagery Questionnaire-3 (MIQ-3) [7]. The questionnaire measures internal visual imagery, external visual imagery, and kinesthetic imagery ability. Responses are rated on a seven-point Likert scale, with higher scores indicating greater imagery ability. The MIQ-3 has demonstrated acceptable reliability and validity in athletic populations.

Competitive State Anxiety Inventory-2 Revised (CSAI-2R): Self-Confidence Subscale. Self-confidence was assessed using the self-confidence subscale of the Competitive State Anxiety Inventory-2 Revised (CSAI-2R) [17]. Responses were rated on a four-point Likert scale ranging from 1 (not at all) to 4 (very much so). Higher scores indicated greater sport-specific self-confidence.

Three-Point Shooting Accuracy Test. Three-point shooting performance was assessed using a standardized protocol on an official indoor basketball court. Participants attempted 75 three-point shots from five designated positions around the arc (15 shots per position: right corner, right wing, top of the key, left wing, and left corner). Each successful shot was awarded one point, yielding a maximum score of 75 points. A standardized 10-minute warm-up was completed before testing, and a one-minute rest period was provided between positions. Identical basketballs, basket height (3.05 m), court conditions, and testing procedures were maintained across all assessments. Two trained evaluators recorded successful shots, and the total number of successful attempts was used as the performance score at pre-test, post-test, and the two-week retention assessment. Any discrepancies in scoring were resolved through discussion between the evaluators.

Familiarization Session. One week before baseline testing, all participants completed a familiarization session. The session included study orientation, administration of questionnaires, demonstration of the shooting test, practice trials, and instruction in imagery procedures. The familiarization session was conducted to minimize learning effects and ensure consistency in testing procedures.

Intervention Protocol. The intervention lasted 12 weeks, with three supervised sessions per week (36 sessions in total) [18]. The PETTLEP implementation framework is presented in Table 1. Each session lasted approximately 60 minutes and followed a fixed structure: 10 minutes of warm-up, 15 minutes of imagery and video observation, 30 minutes of shooting practice, and 5 minutes of cool-down.

Internal PETTLEP Imagery Group. Participants performed first-person PETTLEP imagery focusing on kinesthetic sensations, movement timing, emotional control, and successful shooting execution. Standardized imagery scripts were used and delivered under the researcher's supervision before shooting practice.

External PETTLEP Imagery Group. Participants performed third-person PETTLEP imagery using personalized video recordings of successful shooting performances. They imagined themselves executing the movement from an observer's perspective before completing the same shooting practice protocol.

Active Control Group. Participants viewed basketball instructional videos focusing on technical and tactical content. The videos did not include imagery instructions, visualization practice, or psychological skills training. Participants then completed the same shooting practice protocol as the imagery groups.

Intervention Fidelity. Researchers recorded attendance at each session. Participant inclusion required a minimum attendance rate of 85%. Participants in the imagery groups completed weekly adherence logs. Supervising researchers used a standardized fidelity checklist during all sessions. Overall intervention fidelity exceeded 95% across groups.

Outcome Assessment. Trained evaluators who were blinded to group allocation conducted all assessments. Evaluators completed pre-test assessments before randomization, post-test assessments immediately after the 12-week intervention, and retention assessments two weeks later without further intervention or imagery practice.

Statistical Analysis

Statistical analyses were performed using IBM SPSS Statistics Version 25.0. Data were reported as mean ± standard deviation. Normality was assessed using the Shapiro–Wilk test, homogeneity of variance using Levene's test, and sphericity using Mauchly's test, with Greenhouse–Geisser corrections applied when necessary. A 3 × 3 mixed-design ANCOVA was conducted with Group (Internal PETTLEP, External PETTLEP, Active Control) as the between-subjects factor and Time (Pre-test, Post-test, Retention) as the within-subjects factor, controlling for MIQ-3 scores. Significant effects were followed by Bonferroni-adjusted pairwise comparisons. Effect sizes were reported as partial eta squared (η^2p). Moderation analysis was conducted using Hayes› PROCESS Macro Version 4.2 (Model 1) with 5,000 bootstrap samples. Self-confidence scores were mean-centered before analysis. Results included unstandardized coefficients, 95% confidence intervals, and ΔR^2 values. Statistical significance was set at $p \leqslant .05$.

Results

Baseline participant characteristics are presented in Table 2. No significant between-group differences were found for age, basketball experience, self-confidence, or pre-test shooting performance (all $p > .05$), indicating baseline equivalence across the Internal PETTLEP Imagery Group, the External PETTLEP Imagery Group, and the Active Control Group.

Group comparisons for imagery ability and self-confidence are presented in Table 3. No significant between-group differences were found for MIQ-3 internal visual imagery, external visual imagery, or kinesthetic imagery at baseline (all $p > .05$). Self-confidence also did not differ significantly at pre-test. At post-test and retention, significant between-group differences were observed in self-confidence. Both the Internal PETTLEP and External PETTLEP groups showed higher self-confidence than the Active Control Group. A slight decrease was observed at retention; however, self-confidence remained above baseline levels in both imagery groups.

Table 1. PETTLEP imagery intervention framework applied during the 12-week training program

PETTLEP Component	Internal PETTLEP Imagery Group	External PETTLEP Imagery Group
Physical	Participants held a basketball during imagery sessions to simulate actual shooting conditions.	Participants held a basketball during imagery sessions to simulate actual shooting conditions.
Environment	Imagery was performed on the basketball court where training and testing took place.	Imagery was performed on the basketball court where training and testing took place.
Task	Imagery focused on the successful execution of three-point shooting.	Imagery focused on the successful execution of three-point shooting.
Timing	Imagined movements were performed in real time, matching the speed of actual shooting execution.	Imagined movements were performed in real time, matching the speed of actual shooting execution.
Learning	Imagery scripts were progressively adapted to reflect skill improvements throughout the intervention.	Imagery scripts were progressively adapted to reflect skill improvements throughout the intervention.
Emotion	Participants incorporated confidence, concentration, and competition-related emotions into imagery.	Participants incorporated confidence, concentration, and competition-related emotions into imagery.
Perspective	First-person (internal) perspective emphasizing kinesthetic sensations and the feeling of movement.	Third-person (external) perspective emphasizing observation of shooting technique and movement form.

Note. PETTLEP = Physical, Environment, Task, Timing, Learning, Emotion, and Perspective. Both intervention groups completed identical shooting practice sessions; only the imagery perspective differed between the groups.

Table 2. Baseline characteristics of participants

Variable	Internal	External	Control	p
Age (years)	16.3 ± 1.1	16.1 ± 0.9	16.4 ± 1.0	.61
Experience (years)	3.1 ± 1.2	2.9 ± 1.0	3.0 ± 1.1	.74
Self-Confidence	24.7 ± 3.0	25.7 ± 2.9	24.3 ± 2.8	.41
Shooting pre-test	10.7 ± 2.2	10.9 ± 2.1	10.5 ± 2.3	.78

Note. Values are presented as mean ± standard deviation.

Descriptive statistics for three-point shooting performance across testing occasions are presented in Table 4. Both imagery groups showed improvements from pre-test to post-test and maintained higher performance scores at retention than the Active Control Group. Figure 2 illustrates the progressive improvement in both PETTLEP imagery groups and the maintenance of performance gains at retention. Error bars represent one standard deviation from the mean values reported in Table 4.

Bonferroni-adjusted pairwise comparisons presented in Table 5 showed that both the Internal PETTLEP and External PETTLEP groups had significantly higher post-test and retention shooting scores than the Active Control Group (both $p < .01$). No significant differences were found between the Internal and External PETTLEP groups at post-test or retention (both $p > .05$).

Moderation analysis was conducted using Hayes' PROCESS Macro (Model 1) to examine whether self-

Table 3. Imagery ability and self-confidence scores by group

Variable	Internal PETTLEP (n = 30)	External PETTLEP (n = 30)	Active Control (n = 30)	F	p	η_p^2
MIQ-3 Internal Visual Imagery	4.61 ± 0.58	4.71 ± 0.63	4.51 ± 0.67	0.40	.671	.01
MIQ-3 External Visual Imagery	4.84 ± 0.59	4.94 ± 0.62	4.74 ± 0.65	0.41	.664	.01
MIQ-3 Kinesthetic Imagery	4.79 ± 0.55	4.89 ± 0.58	4.69 ± 0.61	0.45	.639	.01
Self-Confidence (Pre-Test)	24.70 ± 2.95	25.70 ± 2.88	24.30 ± 2.84	0.91	.406	.02
Self-Confidence (Post-Test)	28.70 ± 2.76	29.70 ± 2.84	25.70 ± 2.91	18.42	< .001	.30
Self-Confidence (Retention)	27.90 ± 2.81	28.70 ± 2.76	25.10 ± 2.87	14.63	< .001	.25

Note. MIQ-3 = Movement Imagery Questionnaire-3; η_p^2 = partial eta squared. Self-confidence was assessed at pre-test, post-test, and retention.

Table 4. Three-point shooting accuracy across testing occasions

Group	Pre-Test	Post-Test	Retention
Internal PETTLEP	10.7 ± 2.2	14.8 ± 2.1	13.6 ± 2.3
External PETTLEP	10.9 ± 2.0	14.5 ± 2.4	13.4 ± 2.2
Active Control	10.5 ± 2.3	11.7 ± 2.2	10.8 ± 2.4

Note. Values are presented as mean ± standard deviation.

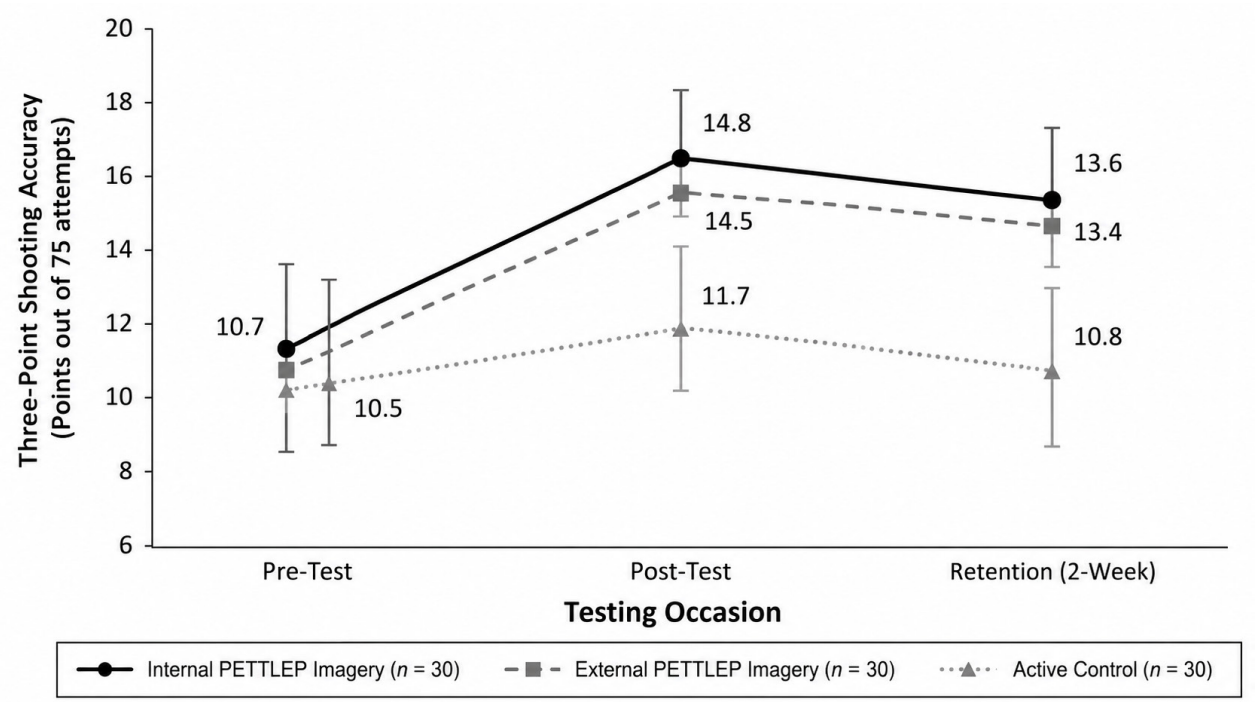

Figure 2. Three-point shooting accuracy (mean ± SD) at pre-test, post-test, and retention for the internal PETTLEP imagery group, the external PETTLEP imagery group, and the active control group. error bars represent one standard deviation.

confidence moderated the relationship between intervention condition and shooting performance. The results are presented in Table 6. Self-confidence was a significant predictor of three-point shooting performance. In addition, the significant Group × Self-Confidence interaction indicated that the effectiveness of the intervention varied according to participants' levels of self-confidence. The overall regression model was statistically significant and explained 38% of the variance in shooting performance.

Predicted shooting performance increased across intervention conditions and was consistently higher among athletes with greater self-confidence (Figure 3). Table 6 shows that both PETTLEP imagery groups

Table 5. Mixed ANCOVA results for three-point shooting accuracy

Source	df	F	p	Partial η_p^2
Time	2, 172	18.42	< .001	.18
Group	2, 86	5.67	.005	.12
Group × Time	4, 172	9.83	< .001	.19
MIQ-3 (Covariate)	1, 86	7.14	.009	.08

Note. Significant main effects were found for Time and Group. A significant Group × Time interaction indicated that changes in shooting performance differed between groups. Imagery ability (MIQ-3) had a significant effect on shooting performance. η_p^2 = partial eta squared.

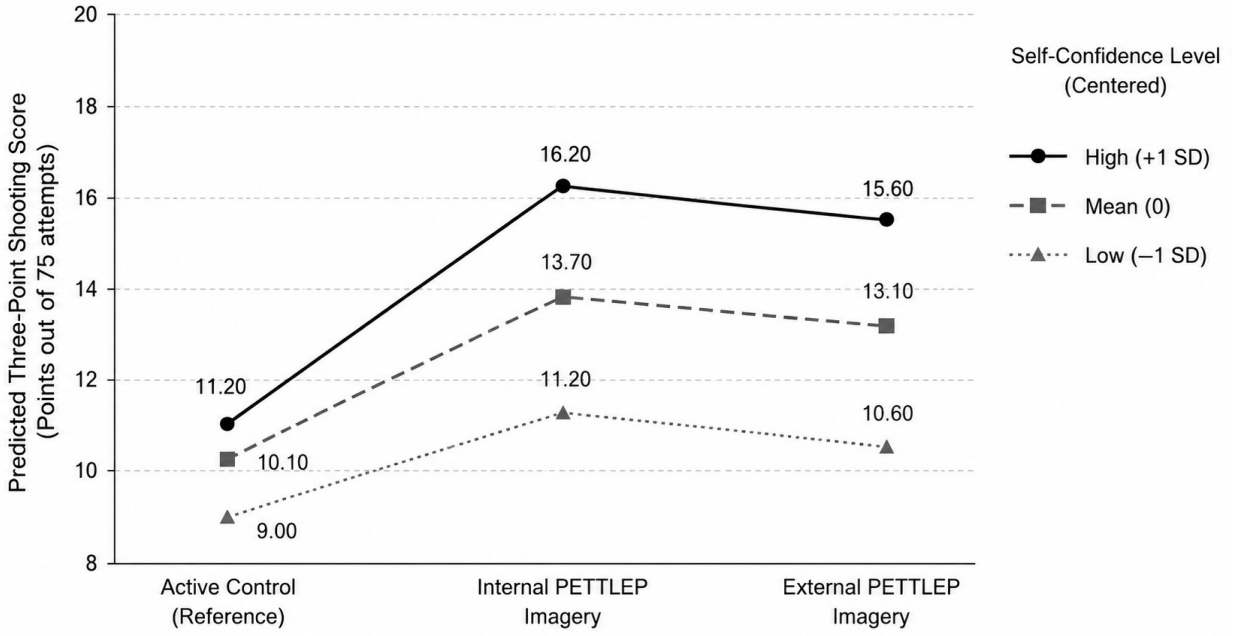

Figure 3. Moderating effect of self-confidence on the relationship between intervention condition and three-point shooting performance. Values represent model-predicted shooting scores derived from Hayes' PROCESS Macro (Model 1) at low (-1 SD), mean (0), and high (+1 SD) levels of self-confidence.

Table 6. Moderation analysis of self-confidence on three-point shooting performance

Predictor	β	SE	t	p	95% CI
Group Condition	2.84	0.62	4.58	< .001	1.61, 4.07
Self-Confidence	0.41	0.15	2.73	.008	0.11, 0.71
Group × Self-Confidence	0.52	0.21	2.48	.015	0.10, 0.94

Model Statistics

Statistic	Value
R^2	.38
F	17.45
p	< .001
ΔR^2 (Interaction)	.05

Table 7. Within-group effect sizes for three-point shooting accuracy

Group	Pre–Post d	Magnitude	Pre–Retention d	Magnitude
Internal PETTLEP	1.81	Large	1.36	Large
External PETTLEP	1.62	Large	1.14	Large
Active Control	0.54	Medium	0.13	Trivial

Note. Interpretation of Cohen's d: Trivial (<0.20), Small (0.20–0.49), Medium (0.50–0.79), Large (⩾0.80).

demonstrated superior predicted shooting scores compared with the Active Control Group, with the strongest performance observed among athletes with high self-confidence (+1 SD), supporting the significant moderation effect.

As shown in Table 7, both PETTLEP imagery groups demonstrated larger within-group improvements than the Active Control Group across post-test and retention assessments.

Discussion

The present study examined the effects of Internal PETTLEP Imagery Training and External PETTLEP Imagery Training on three-point shooting performance in adolescent basketball players while controlling for imagery ability and investigating the moderating role of self-confidence. The findings indicated that both PETTLEP imagery interventions resulted in greater improvements in shooting accuracy than the Active Control condition. Furthermore, performance gains were maintained at the two-week retention assessment, indicating that the effects of the interventions were retained beyond the immediate training period.

Descriptive and inferential analyses revealed improvements in three-point shooting performance in both imagery groups from pre-test to post-test, whereas the Active Control Group showed smaller improvements. The Group × Time interaction indicated that changes in shooting performance differed across intervention conditions. These findings are consistent with previous evidence indicating that PETTLEP imagery can be used as a psychological strategy to support sport-specific performance when integrated with regular practice.

A finding of the present study was that Internal and External PETTLEP imagery produced comparable improvements in shooting accuracy. Although both imagery groups outperformed the Active Control Group, no differences were observed between the two imagery perspectives at post-test or retention. This finding suggests that both first-person and third-person PETTLEP imagery can support basketball shooting performance when imagery sessions closely replicate the physical, environmental, emotional, and temporal characteristics of actual performance. Similar findings have been reported in previous sport psychology research, indicating that imagery effectiveness may depend more on the quality and functional realism of the imagery experience than on imagery perspective alone [19, 20].

The comparable effects of the two imagery perspectives may be particularly relevant in basketball shooting, where successful performance requires the integration of technical execution, attentional focus, confidence, and consistency. Internal imagery may emphasize first-person movement experiences, whereas external imagery may facilitate observation of shooting technique and body positioning [21]. The absence of differences between the imagery groups suggests that coaches and practitioners may select either perspective according to athlete preference, training objectives, and individual comfort without affecting the outcomes of the intervention [10, 22].

Another finding was the moderating role of self-confidence. Athletes with higher self-confidence demonstrated greater improvements in shooting performance following PETTLEP imagery training than athletes with lower confidence levels. This result is consistent with previous research showing that confidence is associated with concentration, persistence, emotional regulation, and performance execution in sport settings [23]. Athletes who possess greater confidence may engage more fully with imagery interventions, which may contribute to differences in performance outcomes. The present findings are also consistent with previous evidence indicating that psychological characteristics may influence responses to mental skills training programs [24, 25].

The maintenance of higher confidence levels at retention may indicate that imagery interventions are associated with psychological changes in addition to changes in performance. Previous studies have reported that repeated imagery practice can reinforce perceptions of competence and readiness for performance situations, thereby influencing confidence-related beliefs [5, 26]. Consequently, coaches implementing PETTLEP imagery may consider strategies that also support confidence development alongside imagery training.

Imagery ability was also identified as a covariate of shooting performance. Participants with higher MIQ-3 scores generally demonstrated higher shooting scores across assessment occasions. This finding is consistent with previous evidence indicating that athletes who can generate vivid, controllable, and realistic mental images may derive

different responses to imagery-based interventions [27]. By statistically controlling for imagery ability, the present study reduced the potential influence of baseline differences in imagery capacity, thereby helping to distinguish intervention-related effects from pre-existing individual characteristics.

The study included a two-week retention assessment. Both PETTLEP imagery groups maintained higher shooting scores than baseline levels, whereas the Active Control Group demonstrated limited retention of performance improvements. These findings suggest that PETTLEP imagery may contribute to the maintenance of performance changes following the cessation of structured intervention. Similar observations have been reported in imagery research, indicating that mentally rehearsed performance experiences may contribute to the retention of sport-specific performance changes over time [5, 28].

The findings have practical implications for coaches, physical education teachers, and sport psychologists. PETTLEP imagery can be incorporated into regular basketball training programs alongside shooting practice. The comparable effects of internal and external imagery perspectives provide flexibility in intervention design, allowing practitioners to tailor imagery programs to individual athlete preferences. Furthermore, the moderating role of self-confidence highlights the relevance of considering psychological readiness when implementing imagery-based training interventions. In the present study, imagery sessions lasting approximately 10–15 minutes were implemented before shooting practice.

Limitations

Several limitations should be acknowledged. The study included only male adolescent basketball players, which may limit the applicability of the findings to female athletes and other competitive levels. Shooting performance was assessed under standardized testing conditions and may not fully reflect performance during competitive game situations. In addition, the study focused on shooting performance and retention outcomes and did not include biomechanical, kinematic, or perceptual-cognitive measures. Consequently, the mechanisms associated with changes in performance could not be directly examined. Future research may incorporate movement-process analyses, biomechanical assessments, and longer follow-up periods to examine PETTLEP imagery interventions in basketball and other sport contexts.

Conclusions

Internal and external PETTLEP imagery can be incorporated into basketball shooting training and may be used as complementary approaches to practice in adolescent athletes. The findings indicate that imagery perspective alone may not be the primary factor influencing the outcomes of PETTLEP-based interventions. Instead, individual characteristics, including imagery ability and self-confidence, appear to be relevant considerations when implementing imagery training. These observations support the use of structured PETTLEP imagery within basketball training programmes and suggest that psychological factors should be taken into account when planning and applying imagery-based interventions.

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Data Availability Statement

The data supporting the findings of this study are part of the author's ongoing PhD research and are not publicly available due to institutional and ethical restrictions. Data may be available from the corresponding author upon reasonable request and subject to institutional approval.

Conflict of Interest

The authors declare no conflict of interest.

AI Transparency Statement

The authors confirm that no artificial intelligence tools were used to generate the scientific content of this manuscript. Language-editing support was used to improve clarity and readability. All content was reviewed and approved by the authors.

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