CHAPTER TWENTY-THREE

A comparison of PETTLEP imagery, physical practice and their combination in the facilitation of non-dominant leg kicking accuracy

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1. INTRODUCTION

Developing expertise in soccer has been suggested to involve 10,000 hours of deliberate practice extended over 10 years (for reviews see Williams and Hodges, 2004). Traditionally, much of this deliberate practice has been completed in the form of physical practice. However, there are two obvious limitations to relying on physical practice: (i) the onset of muscle fatigue and (ii) the risk of overuse injuries. Therefore there may be value in identifying and refining alternative forms of deliberate practice to accompany and complement the physical form; one such alternative may be mental practice, which is a form of imagery. The aim of this study is to test the efficacy of an imagery intervention, a physical practice intervention and a combination of both interventions in the advancement of kicking accuracy in soccer players.

Imagery is a popular and diverse mental skill, and its use is advocated by sport psychologists (Driskell et al., 1994; Munroe et al., 2000). Cognitive specific imagery, or motor imagery, is one of imagery’s five key applications (Paivio, 1985) and can be used to rehearse a specific motor skill, for example kicking a ball. To optimise the efficacy of motor imagery, the functional equivalence between the imagined and motor tasks should be maximised (Hall, 2001).

The term functional equivalence has been used to describe the extent to which the processes of motor imagery, overt motor behaviour and action observation share common neural structures (Keil et al., 2000). For example, when an individual images, performs and observes a specific motor task, this procedure activates some similar neural structures, including the perietal cortex, the supplementary motor area, prefrontal cortex, cerebellum, primary motor cortex and the spinal cord (Papaxanthis et al., 2002). The PETTLEP model of motor imagery (Holmes and Collins, 2001) aims to functionalize the equivalence between imagery and overt motor behaviour, therefore attempting to maximise the activation of shared neural circuitry when imagining the performance of a motor task (Holmes, 2007).
Each letter of the acronym PETTLEP describes a component of physical practice that should be considered when performing motor imagery to enhance functional equivalence. For example, when imaging a motor task such as a penalty kick in a major cup final, PETTLEP suggests the following should be taken into consideration: Physical; imagery should contain movements which reflect those of motor preparation and execution in the physical skill, such as body position and stance in relation to a penalty kick. Environmental; elements such as crowd noise should be incorporated into the image. Task; the task being imaged should be specific to the performer in terms of how the task feels and looks when they are performing. Timing; the time taken to perform the imagery should reflect how long it takes to physically perform the penalty kick. Learning; performer-specific skill level should be given consideration - taking a penalty may be more automatic to skilled performers than novices, meaning that each may image the penalty kick differently. Emotion; athletes should generate emotional responses appropriate to the level of excitement or nervousness that may be induced by a penalty kick in an important event. Perspective; the optimal imagery perspective should be considered for the individual athletes, whether internal or external.

Several researchers have investigated and supported the efficacy of PETTLEP-based imagery (an adaptation of PETTLEP imagery) in facilitating the acquisition of sports specific motor skills (Smith and Collins, 2004; Ramsey et al., 2007; Smith et al., 2007). For example, Smith and Collins found no significant differences in the strength gains made during a finger strength intervention across the conditions of physical practice and adapted forms of PETTLEP-based imagery. Smith and colleagues found further support for the motor learning effects of PETTLEP-based imagery in hockey penalty and gymnastic beam tasks. Again motor improvements made in PETTLEP-based imagery conditions were statistically significant and very similar to improvements made in physical practise conditions. In comparison, traditional imagery interventions did not yield significant improvements from pre-test to post-test.

Further research has provided support for the combined effects of PETTLEP-based imagery and physical practice (Smith and Holmes, 2004; Smith et al., 2006). Smith and Holmes combined different imagery modality conditions with physical practice on a golf putting task. Post-tests revealed that participants using combinations of physical practice and imagery modalities which were strongly aligned to PETTLEP-based imagery (video and audio modalities) improved significantly more than participants using combinations of physical practice and a more traditional written imagery modality. Smith and colleagues also found support for the combined effect of PETTLEP-based imagery and physical practice in a golf bunker task. Further they found that participants in the combined PETTLEP-based imagery and physical practice group improved significantly more than participants in physical practice only and PETTLEP-based imagery-only conditions.

The aim in the current investigation was to increase understanding of the learning effects PETTLEP-based imagery might have when combined with physical practice in a pragmatic soccer coaching context. Specifically, we investigated the effect of PETTLEP-based imagery, physical practice and a
combination of the two on the kicking accuracy of the non-dominant leg in soccer players.

2. METHODS

2.1 Participants

Twenty male university soccer players participated in the present study (mean age = 21.1 years, SD ± 0.72 years). Participants provided informed consent before the study commenced. Testing complied with the ethical guidelines of Leeds Metropolitan University. Participants were randomly assigned to one of four groups: PETTLEP-based imagery; physical practice; combined group (physical practice and PETTLEP-based imagery); control group.

2.2 Measures

Participants completed the Movement Imagery Questionnaire – Revised (MIQ-R) (Hall and Martin, 1997), which is an eight-item inventory measuring an individual’s ability to perform kinaesthetic and visual imagery. Four items assess kinaesthetic imagery ability; e.g. Item 1: attempt to feel yourself making the movement just performed without actually doing it, with four items for visual imagery ability e.g. Item 2: attempt to see yourself making the movement just performed with as clear and vivid a visual image as possible. In line with previous research and recommendations (see Hall, 1998; Smith and Collins, 2004; Smith et al., 2007) potential participants were excluded if they scored lower than 16 on either the kinaesthetic or visual subscales. Furthermore, participants were retained in the study only if they had a preference for external visual imagery, as in the intervention phase only realistic external images of the participants taking penalty kicks (external visual primers) could be generated by the researchers. These visual primers were key features in two of the four intervention groups.

2.3 Equipment

In line with previous soccer specific research (see Finnoff et al., 2002) two identical soccer-specific targets measuring 1210 mm x 1210 mm were built for this study. The targets were attached to the framework of a five-a-side soccer goal (3800 mm x 1300 mm) for the purposes of ecological validity.

Targets were placed in adjacent corners of the goal (see Figure 1). The targets were coated in plain white paper with sheets of A4 carbon paper stapled on the exterior. Carbon paper was used to mark the connection between the ball and the target.
Two Sony Mini DV Handy Cam video cameras were used to record participants who had been randomly assigned to either the PETTLEP imagery or the combined group. This provided an imagery source for the intervention. These clips were edited and saved to DVDs using Dartfish software. Edited video footage provided visual primers to control for imagery perspective, agency and modality. All visual primers were of an external imagery nature. In accordance with Hardy and Callow (1999), external images were captured by a camera placed 8 m away from the penalty spot at a 60° angle from the ball, and a second camera placed 4 m away from the penalty spot at a 160° angle (see Figure 2).

2.4 Procedure

The criterion task used was a soccer penalty kick. Each penalty kick was taken from the regulation position - 12 yards (11 metres) from the midpoint between the goalposts and equidistant to them (Federational Internationale de Football Association, 2007). Targets were placed within both corners of the goal frame. A ball of standard size 5 and inflation (pressure: 0.8 bar) was used for both pre-test and post-test condition. Participants were advised that accuracy was being assessed in relation to how close they could get the ball to the centre of the target and power was of minor significance, although they should be striking to score past a goalkeeper. No goalkeeper was present, as variability in participant responses and goalkeeper behaviour may have confounded results (Smith et al., 2001).
Participants were instructed to adopt a three-step approach prior to striking the ball with the non-dominant foot. In the pre-test players kicked the ball at the right-hand target five times and then the left-hand target five times. This same procedure was conducted for the post-test. In accordance with Smith et al. (2007), the participants were permitted five practise shots with their non-dominant foot at both targets before pre-tests and post-tests.

![Figure 2. Camera angles in relation to penalty taker and the goal.](image)

2.5 Scoring

Scores were based on measuring the distance between the centre point of the target and the centre point of the mark left by the ball. Scores that deviated away from the centre point of the target were considered to be absolute error (i.e., the distance between the mark left by the carbon paper and the target centre point). The closer the ball was to the centre point of the target, the lower the absolute error. To enhance reliability, the same individual scored all kicks. An arbitrary score of 1000 mm was assigned for attempts missing the target entirely. This value was thought to be a valid and reliable marker of missed attempts. Intervention effectiveness was measured by comparing the difference between pre-test and post-test mean kicking accuracy data.
2.6 Intervention

Following the pre-test data collection, participants were randomly assigned, in relation to the order that they were tested, into one of the four intervention groups, with each group containing five participants. The researchers provided participants within the PETTLEP imagery and combined groups with individual specific edited video footage that contained observational primers of their performance to control for imagery perspective, agency and modality. All participants were provided with diaries subsequent to pre-tests. The diaries were used to record structured qualitative information relating to specific questions concerning their specific interventions and it was thought that they would help to enhance adherence (Smith and Holmes, 2004).

**PETTLEP group:** The PETTLEP group members viewed their observational primer once, before then imaging themselves performing the penalty kick. They were instructed to do this in a quiet place of their convenience. Participants performed their imagery in the appropriate sportswear, including footwear (physical component), and were instructed to image themselves executing the penalty kick perfectly with their non-dominant foot in real time (timing and task components) and from an external perspective (perspective component). Participants imagined performing the kick ten times, with five kicks aimed to the left of the target and five kicks aimed to the right. This was repeated three times a week, resulting in 180 imaged penalty kicks over a six-week period. Participants were encouraged to incorporate any of their usual pre-kick routines into their imagery to replicate the real penalty-taking scenario as much as possible (physical component).

**Physical practice:** Physical practice participants were required to take 10 penalty kicks three times a week for six weeks with their non-dominant foot. Participants undertook their practice on an astroturf pitch, using goals and imaginary targets of a similar size to those used in the pre-tests and post-tests. Five shots were taken at the right imaginary target and five at the left imaginary target. The physical practice group completed 180 penalty kicks over a six-week period.

2.6.1 Combined group

The combined group completed one physical practice session and two PETTLEP sessions per week, as described above. The combined group completed 60 physical penalty kicks and 120 imaged penalty kicks over a six-week period.

2.6.2 Control group

Control participants were required to read literature related to soccer, specifically match reports located on the Sky Sports website; questions within the diary relating to the literature were then answered. The control participants were required to spend 10-15 minutes engaging in their reading and answering the questions,
matching the time that the other three groups spent on their intervention activity. This procedure was completed three times a week over a six-week period.

2.6.3 General intervention procedures

All participants across all intervention groups were instructed to adopt precisely the same process for each session. After each session participants completed the questions in their respective diaries. Questions within the diaries were related to their allocated intervention activity. Whilst engaging in this study, participants were instructed to carry out their normal soccer practices and behaviour. This was believed to be an approximately equivalent level of soccer activity across all participants. It was explained to all participants that they should not engage in any physical practice that simulate the current study, unless this was a requirement of their intervention. After the six-week period all diaries were collected and all participants completed the post-tests.

2.7 Statistical analysis

Data were screened via t-tests to confirm assumptions of normality. Preference for these conservative measures was made given the likelihood of low recruitment numbers. The data conformed to assumptions of ANOVA testing.

3. RESULTS

3.1 Performance data

Statistical analysis using an ANOVA revealed no significant treatment effects. However, in a second stage of analysis, which excluded target misses (73 trials), an ANOVA showed a treatment effect where the combination intervention was significantly more effective than the control intervention ($F_{3,113} = 3.97, P<0.01$). The average intervention advantage was 251.29 (SD ± 77.03) mm. No other treatment effects were found according to measured variables.

Descriptive analysis of the mean kicking accuracy (Figure 3) revealed a 24.2% (pre-713 mm vs post-540 mm) increase in the combined group, a 21.74% increase (pre-730 mm vs post-571 mm) in the physical group, a 18.6% (pre-test 700 mm vs post-test 570 mm) increase in the PETTLEP group and a 3.3% increase in the control group.
3.2 Self-report data

Due to injury following pre-testing, one participant from the PETTLEP group was unable to complete the intervention. Therefore PETTLEP group data relied on information gained from four participants. Manipulation checks were carried out to ensure participants had adhered to their intervention programmes by inspecting their diaries. Adherence to the study was as follows: PETTLEP group 100%; physical practice group 88%; combined group 88%; control group 100%.

![Figure 3. Group means and standard deviations for pre-tests and post-tests.](image)

4. DISCUSSION

We examined the effects of PETTLEP imagery, physical practice, and a combination of the two on the kicking accuracy of the non-dominant leg in recreational university soccer players. Results supported previous researchers (Smith et al., 2006) in demonstrating that a combination of PETTLEP-based imagery and physical practice can have a significant impact on the acquisition of sport specific skills. However, results from this study did not support researchers (Smith and Collins, 2004; Smith and Holmes, 2004; Smith et al., 2007) who have reported PETTLEP-based imagery only (i.e., not in combination with physical practice) to have a significant impact on sport-specific skill acquisition. Furthermore, these results showed no significant impact on the learning of sport specific skills through physical practice alone.

In the present study the combined intervention did not allocate practice resources evenly between physical practice and imagery. As the combined group participants completed 60 physical and 120 imagined penalty kicks the findings, therefore, lend some support to the efficacy of PETTLEP-based imagery engaging...
shared neural circuitry and facilitating the acquisition of a sports-specific motor task (Holmes and Collins, 2001).

There are a number of possible explanations for the success of the combined group in significantly improving kicking accuracy while the physical practice and PETTLEP-based imagery groups did not. First, participants in the combined group may have been more motivated by the variety in their intervention, which may have been amplified by the duration of the trial. Groups completing physical practice or PETTLEP-based imagery only may have experienced boredom over the period of their intervention which may have reduced the mental effort that they invested into each individual practice trial. These issues were not measured in our manipulation checks and therefore we do not have direct evidence to support this explanation. Second, participants were instructed to undertake their practice schedules in a highly blocked format. Motor control research would suggest that random, serial or variable practice would increase contextual interference and enhance the benefits of practice for performers at the skill level depicted by university-level soccer players. Further, this may support the significant learning effects observed in the combination group due to the mixture of practice methods used.

We provided clearly written imagery instructions and observational primers to control for imagery perspective, agency and modality. These were provided in an attempt to maximise shared neural circuitry in the PETTLEP-based imagery intervention. However, since kicking performance was not significantly improved in the PETTLEP only intervention group, procedures should be reconsidered in order to increase shared neural circuitry further. In future, researchers might, for example, allow participants access into the data collection hall to increase the environmental stimulus in the imagery. Furthermore, the perspective component of the PETTLEP model may be advanced by including 360 degree video clip angles of participants kicking the ball to replace the potentially limiting external perspective used in the present study.

There are several further limitations to the present study, which should subsequently be addressed. First, the target used to measure kicking accuracy lacked the sensitivity to distinguish penalties directed more than 1000 mm from the target centre. Second, there was only limited capacity to control participants’ imagery ability. Although potential participants were excluded from the study if they scored lower than 16 on either the kinaesthetic or visual subscales of the MIQ-R, random allocation to intervention groups might have been conducted according to imagery ability to reduce imagery ability bias in any one group. Moreover, participants’ imagery ability could have been re-tested during post-tests to monitor any changes in imagery skill. Third, although participants were all university-level players and randomly assigned to intervention groups, the researchers could have optimised the group allocation process. One such option could have been to rank participants by pre-test scores and use these ranks to determine group allocation, so helping to balance the distribution of skills between treatment groups. However, there is a possibility that with such a small sample size a ranking system may have falsely smoothed raw scores and therefore given a false sense of balance to the groups. Fourth, this small sample size resulted in low statistical power and this
should be considered in light of statistically significant increases in kicking accuracy in the combined group. Finally, clear manipulation checks specifically measuring the self-reported mental effort invested in every single intervention trial would have given the researchers a better understanding of each participant’s trial by trial mental engagement across interventions.

5. CONCLUSION

The present study provides evidence that PETTLEP-based imagery can be used effectively in combination with physical practice to enhance soccer specific motor skills. The limitations of this study may have restricted our capacity to illuminate the potential of PETTLEP in improving performance in closed-skill tasks like penalty taking. However, coaches should consider PETTLEP-based imagery to be another tool in their armoury as our descriptive data cautiously suggested that PETTLEP-based imagery did have a positive effect on participants’ kicking ability. Most players from junior to elite level will openly admit that they can improve their non-dominant kicking leg. Conversely, attempts to develop this area are often inhibited by players avoiding using their non-dominant leg in training to save embarrassment, or because players are often unwilling to engage in extra physical practice with the non-dominant leg. PETTLEP-based imagery could provide an effective and novel tool to help coaches impact on this area of performance and go some way to optimising player potential.

References


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