EFFECT OF IMAGERY DOSE VARIABLES ON PERFORMANCE IN SPORT

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ABSTRACT

The main aim of this thesis was to examine the imagery dose-response relationship of three key imagery dose variables to sport performance. Morris et al. (2012) proposed that key imagery dose variables of imagery repetitions, duration, and frequency are related to imagery effectiveness in the sport context. They explained that the number of imagery task repetitions in a session, duration of imagery sessions, and frequency of imagery sessions in a week can be defined as “imagery dose variables” that are incorporated in imagery training design. However, researchers have not examined these imagery variables systematically, so that sport imagery training interventions have involved widely varying doses of repetitions, duration, and frequency of sessions (Paravlic et al., 2018; Schuster et al., 2011). Thus, it is important to examine whether each key imagery dose variable has an independent effect on sport performance.

To examine this question systematically, I used the same research design across all three studies, following the proposal by Morris et al. (2012). I systematically varied one imagery dose variable, holding the other two imagery dose variables constant. In addition, I employed the same task, basketball free-throw shooting (FTS), and similar, moderate skill-level participants in all three studies. In Study 1, I examined the effect of three different numbers of imagery task repetitions in an imagery session on FTS performance, holding the imagery duration and frequency dose variables constant. I randomly allocated 36 male participants (M_{age} = 25.17, SD = 4.26) into four conditions, namely 10-repetitions, 20-repetitions, 30-repetitions, and Control conditions. I assessed imagery ability in participants using the Sport Imagery Ability Measure (SIAM) to ensure participants had at least moderate imagery ability (Watt, Klep, & Morris, 2018; Watt, Morris, & Andersen, 2004a). I checked that all participants had moderate FTS performance. The FTS test comprised two sets of 20 FTS with 2-minute rest interval between

sets. I measured shooting accuracy using a scoring system that awarded 3 points for a clean basket, 2 for the ball going in the basket off the ring, 1 for the ball missing the basket off the ring, and 0 for the ball completely missing the basket. I tested FTS at pre-test, and after the final imagery session in Weeks 1, 2, 3, post-test (Week 4), and retention test (Week 5). In the imagery training phase, imagery condition participants undertook the imagery training program for 12 sessions (three times a week over four weeks). Results showed that the 20-repetition condition had the highest FTS mean at post-test, which was significantly higher than the Control condition.

In Study 2, I varied imagery training session durations and examined the effect on FTS performance, while holding repetitions constant, based on the most effective number of repetitions in Study 1, and frequency of sessions per week constant at the same level as in Study 1. I randomly distributed 36 male basketball players (M_{age} = 25.17, SD = 4.26) into four conditions, namely 8-minute imagery session duration, 13-minute imagery session duration, 18-minute imagery session duration, and Control conditions. Results showed that the 13-minute duration condition had the highest FTS means at post-test and retention test between research conditions and had a significantly higher FTS mean than the Control condition at post-test.

In Study 3, I tested the effects of different frequencies of imagery training sessions in a week on FTS performance, and I held constant the most effective imagery repetitions and duration of sessions from Studies 1 and 2, respectively. I randomly allocated 40 male basketball players (M_{age} = 20.92, SD = 3.01) into four conditions, namely 3 imagery sessions per week, 4 imagery sessions per week, 5 imagery sessions per week, and Control conditions. The 4 imagery sessions per week condition had the highest FTS means at post-test and retention test, and its FTS means were significantly higher than the Control condition at post-test and retention test.

To conclude the thesis findings indicated that the most effective imagery dosages in three different dosages of each dose variable tested were 20 imagery task repetitions, imagery session duration of 13 minutes, and 4 imagery sessions per week. Also, all three imagery doses in each study showed substantial effects on performance compared to the no-imagery Control condition. I found positive results in each study suggesting that the new imagery dose-response protocol represents an appropriate research design. The findings in this thesis also provide guidelines for researchers to implement replication studies in terms of examining the three imagery dose variables together in imagery training programs. Thus, the present thesis reflects a high degree of originality in research on imagery training, and it contributed valuable new knowledge about the relative effectiveness of imagery training contexts.

STUDENT DECLARATION

I, Sho Itoh, declare that the PhD thesis entitled "Effect of Imagery Dose Variables on Performance in Sport" is no more than 100,000 words in length including quotes and exclusive of tables, figures, appendices, bibliography, references, and footnotes. This thesis contains no material that has been submitted previously, in whole or in part, for the award of any other academic degree or diploma. Except where otherwise indicated, this thesis is my own work.

Signature: [redacted] Date: 12-3-2020

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CHAPTER 1

INTRODUCTION

At all skill levels, athletes need to have appropriate physical and mental condition in which to acquire skills and perform during practice and competition. Specifically, low levels of certain psychological states (e.g., concentration, self-confidence) can affect athletes' performance in negative ways. Additionally, Olympic champions and world-record holders have been shown to possess superior psychological states than lower-level or even elite-level athletes in general (Gould, Dieffenbach, & Moffatt, 2002). Famous and successful athletes have reported using imagery in their sports. For example, Michael Phelps in swimming and Kohei Uchimura in artistic gymnastics explained that they use imagery for their training and competition. Hence, sport psychologists have examined and applied imagery effects to increase performance, as well as to enhance psychological variables. For example, imagery training can positively affect physical performance and psychological states, including self-confidence, anxiety, self-efficacy, concentration, flow, and motivation (Callow, Roberts, & Fawkes, 2006; Callow & Waters, 2005; Cumming, Nordin, Horton, & Reynolds, 2006). Thus, imagery is a substantial and prevalent research topic in sport psychology (Morris, Spittle, & Watt, 2005; Weinberg & Gould, 2015).

Imagery is a well-known psychological technique that people use to create and recreate their experiences mentally, involving all the appropriate sense modalities and emotion (Morris et al., 2005). It has been applied in a wide range of sport situations, such as skill practice, preparation for competition, and during competition. Imagery is widely used by athletes at various levels (Hall, Singer, Hausenblas, & Janelle, 2001; Nordin & Cumming, 2005). Athletes from novice to elite level often use imagery (Cumming & Hall, 2002; Fish, Hall, & Cumming, 2004; Weinberg, Butt, Knight, Burke, & Jackson, 2003). In studies, researchers have reported that sports performers use imagery for a range of purposes, including to learn new skills, to practice established skills, the learn new strategies, to rehearse strategies, to solve problems, to prepare to perform a task, such as a golf putt or a tennis serve, to increase confidence or motivation, to reduce anxiety, and to facilitate recovery from injury.

As in everyday life, athletes can experience negative outcomes from using imagery. Negative images are often related to decreases in athletes' performance (Post, Muncie, & Simpson, 2012). This can happen in those contexts where individuals' imagery occurs without conscious planning. For example, a golfer stands on the tee and, with no intention, imagines hitting a drive that hooks into the trees down the right of the fairway. Then the golfer actually hits the drive into those trees. Negative outcomes of imagery can also occur when sports performers intentionally use imagery, but because they have had no training in imagery use they apply it badly. For example, a developing gymnast watches a more experienced performer executing a complex vault. The learner imagines themselves undertaking the vault a number of times, and performs the vault unsuccessfully causing injury. Perhaps this happens because, although they can visualize the vault using imagery, having watched the expert do it, their lack of actual experience of doing it means that they do not know, so cannot rehearse through imagery, the kinaesthetic sensations that produce the correct vault.

Because research and anecdotal evidence suggests that imagery that is not managed appropriately can result in negative outcomes, researchers have invested a great deal of time in determining how to use imagery effectively in sport (Kuan, Morris, Kueh, & Terry, 2018; Weinberg & Gould, 2015). Researchers have presented guidelines for applied sport psychologists, and the coaches and athletes with whom they work, on effective use of imagery in sport (Morris et al., 2005; Weinberg & Gould, 2019). This includes ensuring that imagery delivery is conducted in language that matches the capacity of the targeted performers, that the amount of imagery content is commensurate with athletes' capability to retain it, that athletes' imagery ability is tested in advance to ensure that they can benefit from the imagery, and that the context in which imagery is performed is conducive to the generation of rich, vivid imagery (Gregg, Hall, & Nederhof, 2005; Watt et al., 2018; Williams, Cooley, & Cumming, 2013). Imagery ability has been studied, leading to the development of instruments to measure imagery ability. In sport, Watt, Morris, & Andersen (2004) developed the Sport Imagery Ability Measure (SIAM), which includes 12 components of imagery ability that are important for creating imagery. These include five imagery dimensions, namely vividness, controllability, duration, ease of generation, and speed of formation, imagery in six sense modalities, visual, auditory, kinaesthetic, tactile, olfactory, and gustatory imagery, and imagery associated with emotion.

Researchers have also examined aspects associated with the effective delivery of imagery. These include whether imagery is more effectively delivered live and face-to-face or whether it can be recorded on audio or video devices for delivery, whether a combination of these is a more efficient way to deliver imagery training, whether the use of video-modelling can enhance the richness of ensuing imagery of a task (Atienza, Balaguer, & García-Merita, 1998; Waraphongthanachot, 2019), and whether a consistent imagery program that is repeated in each of a number of sessions is more effective than an imagery program that changes every few sessions to increase the richness of the context (Fazel, Morris, Watt, & Maher, 2018; Marshall & Wright, 2016), for example, by adding imagery of opponents, an audience, or a high pressure situation.

Another way in which researchers have examined the effective delivery of imagery programs has been to examine how much imagery should be presented in a session. A large amount of research has been conducted on the most effective duration of imagery sessions. In major reviews of imagery duration, researchers have reported that anything from one minute to at least 30 minutes was most effective (Hinshaw, 1991; Schuster et al., 2011). A problem with this research is that the tasks, participants, and levels of other variables have been so diverse that these apparently contradictory results should not be unexpected. The most effective number of sessions per week is another imagery delivery variable that has been studied. Again, results are not consistent because tasks vary, along with participant characteristics, including age and skill level. Discrete sports tasks, such as basketball shooting, golf putting, and soccer penalty taking, take just a few seconds, whereas continuous tasks, like gymnastics floor routine, figure skating, and slalom skiing, take several minutes, which must impact on the number of times the task can be imagined in a session, that is, the most effective number of repetitions per session.

It is likely that each of these delivery variables, namely repetitions per imagery session, duration of imagery sessions, and frequency of imagery sessions per week, which might be characterized as imagery dose variables, affect the other two dose variables. For example, 30 repetitions of imagery of golf putting in 10 minutes might not give individuals much time for cognitive processing of each experience of imagery, whereas 30 repetitions in 30 minutes might present long gaps during which focus could be lost. With reference to duration and frequency of sessions per week, again for a discrete task, such as basketball shooting, one session of 30 minutes per week might lead to forgetting of the imagery by the next week, whereas a 10-minute session every day could lead to physical or mental fatigue or boredom. Thus, it would appear that researchers proposing to conduct studies on imagery dose variables would be wise to consider these three dose variables together, so that the dose variables that are not the focus of each study are managed, rather than being allowed to act as uncontrolled, confounding variables, as has been the case in much of the published imagery research.

This is not an approach that has been adopted in the research that has examined imagery dose variables. For example, a study conducted by Kremer, Spittle, McNeil, and Shinners (2009) is an example of research on number of imagery repetitions that does not explicitly control or examine number of imagery sessions or their frequency. Similarly, in otherwise promising studies of frequency of imagery sessions per week, Wakefield and Smith (2011; 2009) did not control repetitions or duration. Nor do these studies control the nature of the task, such as gross motor control, fine motor skills, and strength tasks, or characteristics of the participants, such as age, gender, and skill level, all of which could affect the most effective number of imagery repetitions, imagery session duration, or imagery session frequency.

In this thesis, I aim to examine each of the dose variables of repetitions, duration, and frequency, by varying one of these factors in each of three studies, while systematically controlling the other two dose variables. At the same time, I keep the task constant and recruit volunteers with similar experience in that task in each study. Further, once the most effective number of repetitions is identified in Study 1, that number is employed in Studies 2 and 3. Similarly, once the most effective duration is identified in Study 2, that duration is used in Study 3 to examine frequency of sessions per week.

CHAPTER 2 LITERATURE REVIEW

Introduction

Imagery is a well-known psychological skill that has been shown to have positive effects on sport performance in imagery training studies (Morris et al., 2005). Despite the evidence that imagery can enhance performance, the research literature provides little guidance on how much imagery athletes should engage in to enhance performance. The question is, what is the imagery dose that is required in training to gain maximum benefits for improving skill learning and performance? The literature generally offers no clear guidance as to what may be the most appropriate duration, frequency of imagery sessions, and number of repetitions, with a range of different doses being employed in imagery training research (Dana & Gozalzadeh, 2017; Guillot, Tolleron, & Collet, 2010; Kuan et al., 2018; Yue & Cole, 1992). Thus, for imagery interventions and the applied use of imagery, it is important for researchers to examine the imagery dose-response relationship for number of repetitions in an imagery session, duration of imagery sessions, and frequency of imagery sessions per week in imagery training programs (Morris et al., 2012). In this chapter, I review the use of imagery in imagery training, particularly in relation to the amount of imagery that theory and research has indicated is most effective in imagery training programs in sport.

This literature review chapter is presented in five sections. First, I outline what imagery is and some of the theories underpinning its effectiveness in enhancing the performance of sport skills. In the second section, I overview applied models of imagery use in sport to outline the use of imagery and imagery functions in sport. In the third section, I review variables that influence the effective use of imagery in sport, including imagery ability, imagery perspectives, and characteristics of the imager and the task. In the fourth section, I review imagery training studies on sport performance and psychological states to provide information on the effectiveness of imagery in sport. In the fifth and final section, the discussion focuses on the imagery dose-response relationship between key imagery variables and performance to provide an overview of what the most effective imagery dose for the major dose variables might be in imagery training in sport.

Definition of Imagery

In a number of fields, including sport psychology, researchers have created broad imagery definitions (Denis, 1985; Matlin, 1989; Moran, 2004; Murphy, 1994; Solso, 1991; Suinn, 1994; Vealey & Greenleaf, 2001). Although there is a plethora of imagery research, the definition of imagery is still a debatable topic (Morris et al., 2005). Imagery is an unobservable and internal process, so measurement of imagery is challenging, which makes it difficult to define imagery precisely. Hence, various imagery definitions are based on different structures and mechanisms, which accounts for the continued debate about the definition of imagery. Another issue is that any attempt to arrive at a consensual imagery definition in sport is affected by the broad range of words and terms that can be used to explain imagery. These include, for example, symbolic rehearsal (Sackett, 1934), imaginary exercise (Shaw, 1938), imagery practice (Perry, 1939), covert rehearsal (Corbin, 1967), implicit practice (Morisett, 1956), mental rehearsal (Whiteley, 1962), conceptualizing practice (Egstrom, 1964), mental preparation (Weinberg, 1982), visualisation (Seiderman & Schneider, 1983), mental practice (MP) (Jacobson, 1931), and imagery training (Fujita, 1973). MP and imagery training are frequently used terms, but it is important to clarify the differences between MP and imagery training studies. For example, they have different characteristics, such as study designs (e.g., pre- and post-test design), imagery intervention designs (e.g., imagery variables of repetition, duration, and frequency), and research aims.

Mental Practice (MP)

MP has been examined extensively in psychology and sport psychology (Bach, Allami, Tucker, & Ellis, 2014; Feltz & Landers, 1983; Gentili & Papaxanthis, 2015; Ruffino, Papaxanthis, & Lebon, 2017; Ungerleider & Golding, 1991). MP is defined by Corbin (1972) as "the repetition of a task, without observable movement, with the specific intent of learning" (p. 94), and when people use MP it may involve imagery, but it may also involve other cognitive processes in their experience of learning a particular skill.

Research on MP also differs from imagery training research. MP studies generally provide one or two sessions lasting from one minute to 10 minutes (Driskell, Copper, & Moran, 1994; Feltz & Landers, 1983), and researchers often use a pre- and post-test design to ascertain whether MP has any effect on a performance task (e.g., Kremer et al., 2009). Furthermore, Morris, Spittle, and Perry (2004) indicated that researchers in laboratory-based MP studies often used novel analogue tasks (unusual and/or unnecessary activities that do not require the use of real-world skills). This meant that research participants had limited previous experience on the skills, which had limited practical relevance and, potentially, lower motivation during participation. Moreover, because these skills were novel to participants, participants had low skill levels in the skills being practiced, compared with the competitive or elite athletes who participate in most imagery studies. This means that their findings may not transfer readily to how imagery is used in training programs in sport where competitive athletes practice sport specific skills that they are familiar with. Researchers conducted several meta-analyses of MP, relatively early in the history of MP research, in which researchers described MP as being more effective than no practice (NP) in terms of motor skill performance enhancements (Feltz & Landers, 1983; Hinshaw, 1991). However, these useful findings included various MP forms (e.g., imagery, self-talk, and relaxation), which tempered their evidence in relation to imagery, especially the effect size of MP.

Imagery

In cognitive psychology, Finke (1989) extended the definition of imagery to "the mental invention or re-creation of an experience that in at least some respects resembles the experience of actually perceiving an object or event, either in conjunction with, or in the absence of, direct sensory stimulation" (p. 2). Paivio (1971) described imagery based on neurological functioning as follows: imagery is "used to refer to a memory code or associative mediator that provides spatially parallel information that can mediate overt responses without necessarily being consciously experienced as a visual image" (pp. 135–136), a definition that is based on Paivio's dual code theory of imagery function. This definition involves components in the role of visual and verbal imagery processing (Richardson, 1994). Wraga and Kosslyn (2003) defined imagery as "an internal representation that gives rise to the experience of perception in the absence of the appropriate sensory input" (p. 466). Their definition supports the idea that imagers can include realistic perceptual components in creating imagery, although external stimuli are not required in the process of creating imagery.

A number of researchers have provided imagery theories with operational imagery definitions. For instance, Lang (1979) introduced bioinformational theory, which describes the brain's information processing abilities. He defined imagery as "a finite information structure which can be reduced to specific propositional units" (p. 109).

Richardson (1969) defined imagery as:

> all those quasi-sensory and quasi-perceptual experiences of which we are self-consciously aware and which exist for us in the absence of those stimulus conditions that are known to produce their genuine sensory or perceptual counterparts, and which may be expected to have different consequences from their sensory or perceptual counterparts (pp. 2-3).

This definition was widely used in sport psychology for half a century. However, it does not include emotional. Further, Richardson's definition does not clearly indicate whether imagery is involuntary or volitional. Regarding an imagery definition that is designed to reflect the key features of the strongest previous definitions, Morris et al. (2005) described imagery as:

> creation or recreation of an experience generated from memorial information, involving quasi-sensorial, quasi-perceptual, and quasi-affective characteristics, that is under the volitional control of the imager, and which may occur in the absence of the real stimulus antecedents normally associated with the actual experience. (p. 19).

In this definition, Morris et al. provided vital concepts to clarify the nature of imagery. Firstly, creating imagery involves memories and previous experiences, so that the imagers can include diverse scenarios and desires in their images. Secondly, imagery experience makes it possible to include realistic sensory, perceptual, and affective characteristics. Thirdly, imagery is under the volitional control of the imager, so imagers can create and represent their imagery freely. In this thesis, I use this definition of imagery as it most comprehensively explains the components of imagery as applied in sport.

Imagery Training

Imagery training is applying the important psychological technique of imagery in terms of enhancing sport training and performance (Morris et al., 2005). In imagery training programs, sport psychologists organise systematic practice of imagery techniques, shown to be effective in research, for athletes to improve sport specific skills in various sport events (Dana & Gozalzadeh, 2017; Fazel et al., 2018; Lindsay, Spittle, & Larkin, 2019). In a meta analytic-review, Curran and Terry (2010) indicated a large effect size for imagery training in sport and exercise (d = 0.53). In another systematic review, Lindsay, Spittle, and Larkin (2019) also reported that imagery was effective at improving skill related outcomes across a range of sports. Despite the apparent effectiveness of imagery training in sport, there appears to be a great deal of variation in how imagery is applied in imagery training programs. For example, researchers have developed different models for effective delivery of imagery, such as Visuomotor Behavioral Rehearsal (VMBR) (Suinn, 1984), AIM strategy (Korn, 1994), and PETTLEP (Holmes & Collins, 2001).

Researchers have tended to provide a program in both the short- and long-term imagery training that depends on athletes' availability (e.g., competition seasons or not). In addition, imagery training programs are usually applied in a sport environment or a quiet place (e.g., one's own room at home) so that athletes can take the imagery training session in their usual location to manage their training conditions and schedules. For example, athletes can decide the location (e.g., sport environment or home), imagery training time, and body postures during an imagery session (such as with closed or opened eyes and sitting on a chair, lying down, or standing up). Furthermore, researchers instruct athletes to create a specific image of an ideal skill, such as golf putting (Smith & Holmes, 2004), a swimming stroke (Post et al., 2012), or a basketball shot

(Fazel et al., 2018) for enhancing their skill. In recent imagery training research, sport psychologists have recommended providing an imagery training program for three days a week (Smith, Romano-Smith, Wright, Deller-Rust, & Wakefield, 2019; Wakefield & Smith, 2009b, 2011), and often imagery training program length is three weeks or longer (Fazel et al., 2018; Schuster et al., 2011). However, the number of repetitions, the most suitable imagery duration in a session, and the frequency of imagery sessions per week have not been examined systematically, which means that various dosages of imagery are used in different imagery training studies. The imagery script is important in terms of designing imagery training programs. In imagery scripts, researchers design specific descriptions, such as situations (competitive or practice environment), people (e.g., audience and opponent), the physical environment (e.g., light, temperature, sounds, and smells), the psychological context (e.g., pressure, emotions, and motivation), and specific sport skills or performances (Morris et al., 2005; Weinberg & Gould, 2019).

There are clear differences between imagery training and MP. In imagery training programs, studies involving sport skills have proved to be more common, as opposed to laboratory-based MP studies that often employ analogue movement tasks that are novel to participants. Such novel tasks are used in MP studies to minimise variability caused by differences in participants' experience of the task. Moreover, in sport imagery studies, researchers have used various tasks from participants' own sport events, meaning that participants often have considerable experience with the skill compared to much of the MP research, where skills are often novel to the participants. Imagery training is generally organized over a substantial number of sessions, often involving a number of repetitions of discrete tasks in several sessions each week, over a number of weeks. On the other hand, in MP studies there are typically only one or two sessions, so that the total amount of MP is usually much less than the practice in imagery studies. This is because imagery training programs are aimed at using imagery in a sport environment, in which substantial periods of practice are commonplace. Thus, to be considered realistic tests of imagery programs, the imagery training lasts for a considerable time. Laboratory-based MP research often has a shorter, tight experimental design because its main purpose is to understand specific mental processes.

Theoretical Explanations for Imagery Effectiveness

A substantial number of theories have been proposed over the last 100 years to explain how imagery works. Imagery theories have contributed to researchers improving their understanding of imagery and how to use imagery effectively (Morris et al., 2005). Many of these theories can be applied to athletic performance, so that identifying theories is important to explain why imagery interventions are beneficial, as well as designing imagery interventions in terms of enhancing sport performance and mental states. It is important to identify theories that can both explain why imagery is effective in enhancing sport skill performance, as well as helping to design imagery interventions, including the examination of imagery dose variables. Morris et al. (2005) divided imagery theories that have made a notable impact in sport into four categories. These are: early theories, cognitive, neurophysiological, and psychological explanations. Here, I address two of the early theories, namely psychoneuromuscular theory (Carpenter, 1894; Jacobson, 1931) and symbolic learning theory (Sackett, 1934). I also address three cognitive theories, namely dual-code theory (Paivio, 1975), bio-informational theory (Lang, 1977, 1979), and triple code theory (Ahsen, 1984), and one neuropsychological theory, namely functional equivalence theory (Finke, 1980). Psychological theories, such as attention set theory (Schmidt, 1982) and self-efficacy theory (Bandura, 1977) have not made a notable impact in sport research, so I do not discuss them.

Psychoneuromuscular Theory

In the early years of psychology as a science of thoughts, feelings and behavior, Carpenter (1894) proposed the psychoneuromuscular theory. It was expanded and tested some time later by (Jacobson, 1930, 1931). Jacobson (1931) proposed that muscles appropriate to a specific movement are activated weakly during imagery of that movement, so that the movement does not occur, but the neural pathways associated with the production of that movement are trained. These low-level nerve impulses support the creation of a muscle memory for that movement (Hall, 2001; Vealey & Greenleaf, 2001). The neuromuscular activity pattern during imagery is similar to actual physical performance, while actual physical performance generates greater muscle activation (Janssen & Sheikh, 1994). Researchers have shown that when people imagine specific movements, the efferent nerves to those muscles are activated (Slade, Landers, & Martin, 2002; Wehner, Vogt, & Stadler, 1984), but there is no evidence that links that physiological effect to performance enhancement because performance was not measured in the studies that examined electromyographic (EMG) activity.

The psychoneuromuscular theory provides an explanation of imagery as a form of sport skill rehearsal, but the explanation provided by psychoneuromuscular theory does not adequately explain how imagery facilitates cognitive, perceptual, and motor skills. Further to this, findings in meta-analysis research indicate that imagery practice is more beneficial for cognitive tasks than it is for strength or physical tasks (Driskell et al., 1994; Feltz & Landers, 1983), suggesting a psychoneuromuscular explanation may not adequately capture the mechanisms behind the effectiveness of imagery. Therefore, the psychoneuromuscular theory may not provide a complete explanation for effectiveness of imagery training research in sport. While psychoneuromuscular theory may explain some aspects of the use of imagery for skill rehearsal in sport, it does not sufficiently explain how much imagery is required to facilitate performance of a sport skill.

Symbolic Learning Theory

Turning to another early theory, Sackett (1934) proposed symbolic learning theory (SLT). Sackett argued that imagery is associated with the rehearsal of the key symbolic components of a movement or skill. Vealey and Greenleaf (1998) explained that imagery practice supports the creation of a mental map or blueprint of specific movements. Additionally, distinctive motor action components are symbolically coded so that imagers are able to (1) cognitively rehearse the sequence of components in tasks with multiple components, such as changing gear in a manual motor car or performing a series of moves in a gymnastics floor routine, (2) contemplate potential goals and prepare for possible risks involved in the task, and (3) plan the movement pattern and execution of the task (Fitts & Posner, 1967; Minas, 1978; Sackett, 1934; Wrisberg & Ragsdale, 1979). SLT researchers (Minas, 1978; Ryan & Simons, 1981; Wrisberg & Ragsdale, 1979) have stated that using imagery is more efficient for improving the cognitive elements of tasks than motor tasks. According to SLT, through imagery, athletes are able to improve cognitive aspects of sports tasks, especially timing, movement sequences, and the pattern of movement. For example, through imagery gymnasts can symbolically learn the sequence of movements in a routine, such as the pommel horse or uneven bars. Utilising imagery rehearsal develops important movement cues that prompt subconscious perceptual-motor plans or schemas in the premotor cortex (Morris et al., 2005). In a task that involves a set sequence of movements, imagery can help each movement to become a cue for the next movement, so the sequence becomes more fluent and automatic.

Sackett (1934) proposed that cognitive tasks or skills are easier to improve than strength or motor tasks. Driskell et al. (1994) and Feltz and Landers (1983) also supported the proposition that facilitation of cognitive performance with the use of imagery is more effective than using imagery for motor tasks. Together, these studies provide important insight into the ways in which imagery can facilitate understanding of the requirements in cognitive tasks, so that imagers are able to make their mental plan for the movements more sophisticated. A problem with SLT is that there has been little discussion about why imagery improves performance in strength and motor-based tasks (Morris et al., 2005). In addition, there is increasing concern that SLT researchers have argued that imagery is only effective, or is most effective, for the development of skilled performance in early stage learners because high-level players have already developed appropriate mental blueprints. Yet, both novice and experienced performers' movement patterns or skill levels have been improved by imagery rehearsal (Blair, Hall, & Leyshon, 1993; Guillot, Nadrowska, & Collet, 2009; Woolfolk, Murphy, Gottesfeld, & Aitken, 1985). Thus, at best, SLT provides only a partial explanation for the ways in which imagery works.

Dual-Code Theory

In cognitive psychology, imagery theories have highlighted explanations based on the central representation of imagery in the brain. As pointed out in such theories, individuals process, reduce, elaborate upon situations, store, recover, and use sensory input in the performance of imagery tasks (Moran, 2012; Neisser, 1976). Dual-Code theory was initially proposed by Paivio (1975). Paivio described mnemonic effects caused by the use of imagery. Paivio proposed that people mentally promote two distinct codes to represent the world. One is the verbal code, which represents aspects of the world in words. The other type of representation is the imagery code, which can be used to memorize or recall objects and actions. A key strength of individuals having access to two parallel cognitive codes is that, if individuals store the word "book" and an image of a book, it is possible to retrieve the concept of a book either from verbal memory or image memory. In the sport environment, individuals can apply this theory in the learning and performance of a gymnastics routine in which they may memorize or retrieve the sequence of movements in the routine verbally or through mental imagery. Thus, utilizing two memory codes is beneficial for enriching memory. Despite its mental imagery code, the dual-code theory only focuses on visual imagery, which does not adequately explain learning and performance in sport environments in which athletes use sensory modalities other than visual imagery in order to recall movements or performance routines. For example, auditory, tactile, and kinesthetic sense modalities can be helpful in imagining sports tasks effectively.

Bioinformational Theory

Lang (1979) proposed the bioinformational theory. This theory was initially developed to investigate how phobias and anxiety affect individuals' emotional and psychophysiological responses. Lang described an information-processing model (Pylyshyn, 1973), in which images are assembled as functionally organized propositions. Morris et al. (2005) explained that the theory is "a cognitive hypothesis, that uses an information-processing model of imagery stored as propositions but considers the psychophysiology of imagery" (p. 40). A proposition is the smallest adjunctive unit that recognizes whether a stimulus is true or false (Anderson, 1980).

Lang (1977) proposed that proposition units arise in abstract form. They are perceptually interpreted and stored within long-term memory. There are three main types of proposition in imagery, namely stimulus, response, and meaning propositions (Cuthbert & Lang, 1989; Drobes & Lang, 1995; Morris et al., 2005). Stimulus propositions are representations of the aspects of the situation that trigger movement. For instance, imagining a soccer ball, white colour goalposts, teammates and opponents on the pitch, and an audience sitting or standing around the pitch are common stimulus propositions in soccer. Response propositions are representations of behavioural outcomes involving cognitive, psychological, and emotional responses that would include athletes' experiences of confidence, anxiety, excitement, and all the psychophysiological sensations (e.g., muscle tension). In sport, the mental images associated with athletes' physical responses relevant to the game are key response propositions. The function of meaning propositions is to and interpret the significance of input and output, stimulus occurrence, and the consequences of action, so that imagers can deduce different meanings of a scenario and decide on the action they want to select during imagery. In these propositions in sport, response propositions have high adaptability because images can be involved in the motor programs that dictate specific commands for behaviour during performance (i.e., how to execute specific movements).

Researchers have shown that imagery of either stimulus propositions or response propositions enhances performance, but imagery of both has an even more powerfully beneficial effect in increasing functional equivalence and imagery vividness (Moran, 2012; Murphy, Nordin, & Cumming, 2008; Smith, Holmes, Whitemore, Collins, & Devonport, 2001). Cumming, Olphin, and Law (2007) investigated whether different motivational general imagery scenarios related to response propositions affected participants' psychological states (self-report) and physical responses (heart rate). Cumming et al. found that anxiety and heart rate results were higher in the response propositions condition than in the base-line results. Thus, they recommended that psychologists should consider the effect of imagery content on athletes' cognitive state in competitive situations. The application of Lang's (1977) bioinformational theory has made noteworthy contributions to sport imagery research because sport psychologists have developed imagery approaches to enhance the effectiveness of imagery training based on the concepts of stimulus, response, and meaning propositions. For example, Holmes and Collins (2001), in their PETTLEP model, and Guillot and Collet (2008), in their Motor Imagery Model, included the concept of propositions in the models they developed and applied to imagery in sport. These models involve psychological elements in imagery processes; therefore, imagers are able to experience both psychological aspects (e.g., fear, anxiety) and physical responses (e.g., fatigue, muscle tension). A valuable aspect of the bioinformational theory of imagery is that, in it, Lang considered imagery quality in terms of three propositions, namely the stimulus, response, and meaning aspects, rather than just providing imagery content as a means of improving physical performance. However, until recently, there has been limited evidence regarding the bioinformational theory of imagery as a systematic approach in sport psychology (Bakker, Boschker, & Chung, 1996; Cumming et al., 2017; Hale, 1982; Hecker & Kaczor, 1988; Marshall & Wright, 2016; Williams, Cooley, & Cumming, 2013). Thus, sport psychologists need to generate more empirically-based research to test the application of bioinformational theory in sport. The theory does indicate that in designing imagery interventions stimulus, response, and meaning aspects should be incorporated into design.

Triple-code Theory

Ahsen (1984) proposed a cognitive-based theory that he termed triple-code theory or ISM theory. Ahsen stated that the process of imagery has three vital elements, which are the image itself (I), the somatic response (S), and the meaning of the image (M), which, when combined, produce the acronym ISM. Subsequently, Ahsen (1997) argued for the importance of multi-sensory imagery, claiming that “performance, especially in sports, is never sensory-specific in an absolute way, as it involves other senses, such as muscles and other visceral feelings” (p. 13). In other words, imagers create the event, environment, or performance in their mind, elicited by imagery in which they include all relevant aspects of perception and sensation to make their imagery as realistic as possible. Moreover, they create specific representation of a psychological state, including perceptions and sensations of muscle tension and heart rate (Morris et al., 2005; Mulder, 2007). In triple-code theory, Ahsen included an important aspect of imagery, which is the meaning of imagery. He argued that individuals vary in the way they perceive the same imagery script and instructions because of their past experiences. In other words, imagers involve their background and experiences in the imagery, even when they follow an imagery instruction (Morris et al., 2005; Murphy, 2005; Weinberg & Gould, 2015). Hence, high-level athletes are likely to have richer imagery experiences (e.g., specific and clear kinaesthetic imagery) than novice athletes. For example, top-level gymnasts imagine a perfect high bar routine with feelings of bar elasticity, through which they are able to promote cognitive planning with technical skill aspects. Thus, Ahsen’s introduction of meaning has been noted by researchers in the subject of imagery in sport, who now recognize that imagery of the same event can have quite different meanings for different athletes (Morris et al., 2005). The triple-code theory has provided a useful theoretical framework for application to sport, although researchers still need to investigate the theory in sport because of the limited number of empirical studies on triple-code theory (Cumming et al., 2006).

Functional Equivalence Theory of Imagery

Functional equivalence theory is a relatively recent way of conceptualizing imagery effectiveness. It is a neuropsychological explanation based on the proposition that mental imagery has similarities or functional equivalence with cognitive processes. It is hypothesized that the mental imagery function involves similar processes in the brain to the processes involved in the production of physical actions (Finke, 1980; Jeannerod, 1995). That is, mental structures, processes, and neural networks are activated in similar ways during the creation of imagery and during physical performance (Kosslyn, Ganis, & Thompson, 2001; Martin, Moritz, & Hall, 1999). In other words, the brain processes that are activated during the use of imagery, but without physical movement, are the same as those that are required for physical performance (Morris et al., 2005). For instance, when creating imagery of basketball shooting, basketball players will utilize the same cognitive processes as the players do when they are conducting the physical execution of the shooting task. Following functional equivalence theory, during imagery, the brain processes the same stimuli to the muscles that would be produced and sent to the muscles to conduct physical performance of free-throw shooting, while a parallel message prevents the physical action, so that there is no actual execution of the skill (Holmes & Collins, 2002; Martin et al., 1999; Post, Williams, Simpson, & Berning, 2015; Wakefield, Smith, Moran, & Holmes, 2013). Therefore, according to the functional equivalence theory, imagery and performance involve similar preparation until the final execution of physical movement, which is why using imagery is like actual performance, and this means that imagery can promote the development of sport skills.

Functional equivalence researchers have empirically made comparisons between neurophysiological mechanisms in imagery and physical performance, and their findings have shown that cortical activation patterns during imagery and physical performance are similar. Several researchers have confirmed that the same processes are activated during imagery of a movement as are activated during overt physical production of the same movement (Annett, 1995; Denis, 1985; Finke, 1989; Grush, 2004; Guillot et al., 2009; Kidgell, Leung, & Spittle, 2013; Post et al., 2015; Smith et al., 2019; Wakefield & Smith, 2012; Weinberg et al., 2003). In a typical research design for examining functional equivalence theory, participants conduct a specific physical task in a single session, while relevant brain activity is monitored. Then they imagine performing the same task, with typical instructions to create images, and the same brain processes are monitored. Researchers then compare the brain activity during imagery with the brain activity during physical performance to examine consistencies or differences. Various measurement techniques have been used in the examination of neural activity – for instance, positron emission tomography (PET scan), transcranial magnetic stimulation (TMS), regional cerebral blood flow (rCBf), electroencephalogram (EEG), and functional magnetic resonance imaging (fMRI) (Morris et al., 2005). Researchers using these techniques have reported that cortical activation patterns and neural processes are equivalent during overt movement in the real world and imagined activity, although less intense muscle contraction is observed during imagery than in real-world performance (Finke, 1989; Grush, 2004; Jeannerod, 1995, 2001). At the same time, the extension into examination of neural activities is providing greater insights into how similarly the brain works during the application of imagery to the way it works during the generation and production of actual movement. Generally, sport psychologists examine functional equivalence between imagery and motor performance using behavioural, rather than neural measures. For example, researchers examine mental chronometry that they compare for motor imagery and actual physical performance (e.g., Calmels, Holmes, Lopez, & Naman, 2006; Montuori et al., 2018).

In conclusion, researchers have developed theories to explain how imagery works and several theories have generated research that has provided some support for the way that imagery can influence performance and psychological states in sport. The evidence largely supports the contention that imagery has the potential to enhance athletes' sport performance, cognition and emotions. However, no theory presently provides a complete explanation of the way in which imagery works. Morris et al. (2005) stated that there is insufficient research supporting any specific theory, but there is sufficient positive evidence to encourage researchers to continue studying the theoretical propositions presented in this section. The results from experimental research based on the theories have had positive effects on imagery training in sport performance and the useability of imagery in sport. Although researchers have focused on explanations of how imagery works for several decades, at this stage, no theory provides clear guidance on how much imagery is enough to produce efficacious performance outcomes. Functional equivalence theory indicates how the imagery process is similar to physical performance, which does not mean that imagery training and physical training enhance sport performance to the same degree. It does raise questions, however, as to whether imagery training should follow similar design processes to those used for physical practice in terms of the volume or dose of training, based on variables including number of repetitions in a session, duration of sessions, and frequency of sessions per week. There are no studies that have examined whether dosages of imagery training and physical training have similar effects on performance. Therefore, there are no explanations of the required amount of imagery that is needed to enhance sport performance, so that examining the most effective amount of imagery in sport performance has great potential for contributing to the imagery training literature.

Applied Models of Imagery Use in Sport

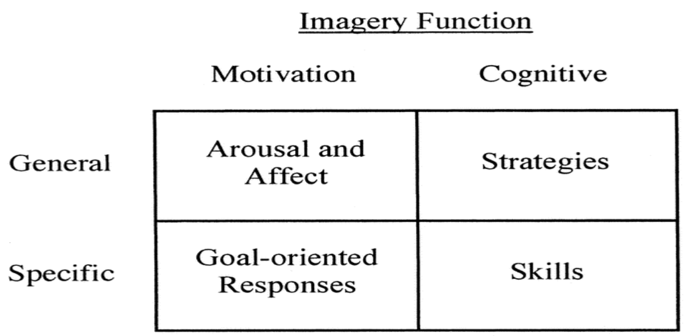
A range of imagery conceptualizations has been introduced to provide frameworks that highlight imagery types and key components for imagery effectiveness. Paivio (1985) introduced a proposition for a framework, which many imagery researchers have utilized since its conception several decades ago. The proposition describes how imagery has effects on performance and was classified as a 2 × 2 conceptual framework, with imagery of two functional types: cognitive and motivational, operating at general and specific levels. Thus, there are four types of imagery in this framework –namely Cognitive specific (CS), Cognitive general (CG), Motivational specific (MS), and Motivational general (MG), as shown in Figure 2.1.

Generally, cognitive imagery functions as a rehearsal of skills or strategy. Specifically, the CS function of imagery is about promoting and acquiring movement skills, such as basketball free-throw shooting or tennis serve. CG imagery functions in the development of strategy, tactics, and game plans – for example, a game plan to gain an advantage over a specific opponent or strategies for an attacking situation in a game. The motivational imagery function involves the imagining of particular goals and mental states. MS imagery functions in connection with specific goals and their achievement, for example, imagining achieving 80% accuracy in netball shooting. The MG imagery function is related to emotional and psychological arousal and mastery – for example, the sense of being successful in performance. Hall, Mack, Paivio, and Hausenblas (1998) developed the Sport Imagery Questionnaire (SIQ) to measure the use of imagery functions and types in sport. In the factor analysis of the validation study of the SIQ, items designed to measure Paivio's MG function of imagery formed two factors that Hall et al. identified as motivational general arousal (MG-A) and motivational general mastery (MG-M). MG-A is related to feelings of relaxation, stress, or arousal in a sport situation. Furthermore, in qualitative research, this imagery type is linked with body-related images (Mellalieu & Hanton, 2009), incorporating anatomically oriented images, such as posture and alignment (Hanrahan & Vergeer, 2000; Nordin & Cumming, 2005), health and appearance-related images (Gammage, Hall, & Rodgers, 2000; Giacobbi, Hausenblas, Fallon, & Hall, 2003), and internal physiological processes of healing (Driediger, Hall, & Callow, 2006; Hanrahan & Vergeer, 2000). The MG-M imagery function involves imagining being mentally tough and confident in competition (Murphy et al., 2008).

In recent imagery research in sport that has examined imagery effects with the SIQ, researchers have explored whether the imagery functions positively affect sport performance and mental states. For example, Westlund Stewart and Hall (2016) investigated the effects of a CG imagery intervention on strategic decision-making in curling. Curling players undertook a 6-week imagery intervention. Westlund et al. reported that decision-making speed, CG and MG-M imagery use, and kinesthetic imagery ability improved. This highlighted the role of the CG function in developing vital strategic curling knowledge. Ribeiro et al. (2015) investigated imagery function use for soccer goalkeepers in Portuguese leagues and reported that imagery motivational functions were employed slightly more than cognitive functions. Additionally, utilizing motivational functions had an effect on goalkeeper concentration, motivation, and mental toughness during games.

Figure 2.1

Analytic framework for imagery effects. (Reprinted from Paivio, A. Cognitive and motivational functions of imagery in human performance, 1985).



Munroe, Giacobbi, Hall, and Weinberg (2000) described athletes' imagery use of the four Ws, namely where, when, what, and why. This model is based on a qualitative approach. Researchers have identified how athletes harmonize imagery with their sport by means of a conceptual framework which has six levels. *Where* is related to the environment. For example, athletes use imagery in competition and practice. *When* represents the timing or time of imagery use, such as before, during, or after practice and competitions. *What* is related to the imagery contents of detailed aspects, which means imagery types, perspectives, senses, and the nature of imagery. *Why* represents the purposes of imagery use, especially the CS, CG, MS, MG-A, and MG-M functions of imagery. Furthermore, researchers (Fournier, Deremaux, & Bernier, 2008; Munroe et al., 2000; Nordin & Cumming, 2005) subdivided imagery characteristics. For instance, there are the following: ability (accuracy, vividness, manipulative ability, and difficulties), direction (facilitative or debilitative), deliberation (spontaneous or deliberate imagery), amount (how often imagery should be used), duration (how long it takes for an image to emerge), and senses (visual, kinaesthetic, tactile, auditory, gustatory and olfactory).

Ribeiro et al. (2015) examined and applied the four Ws model of imagery use by soccer goalkeepers. The goalkeepers frequently used imagery during competitive circumstances, especially while sitting on the bench, as well as during and after training. The researchers reported that regarding the *where* and *when* in soccer, goalkeepers received key information from their teammates' and opponents' tactical conditions, so that they frequently created images on the bench during games. Imagery use of *what* was measured by imagery perspectives to determine whether players utilized internal or external perspectives and imagery senses. Players preferred to use internal and visual imagery. Finally, the question of *why* players used imagery was focused on the cognitive and motivational imagery functions of their performance goals. Using interviews, Driediger et al. (2006) qualitatively explored how injured players from various sports used imagery during rehabilitation periods. The interviews comprised three sections: questions of imagery use during practice and competition, imagery use in periods of recovery from injury, which were based on the four Ws concept, and participants asking questions from sections 1 and 2. Athletes reported that they often used imagery during their rehabilitation time in which their images were positively focused, such as on fully recovering from their injury, improving self-confidence and mental toughness, playing their sport, and winning in competition. Both cognitive and motivational imagery functions were employed during periods of injury. However, imagery was used less frequently during periods of injury than during training and competition periods. Nordin and Cumming (2005) explored imagery use in dancers, especially "How" the dancers utilized imagery. They reported that the dancers utilized six imagery types. These were execution images (e.g., skill learning, planning, and strategies), metaphoric and artistic images (e.g., colour, objects, and themes), context images (e.g., the environment, other people, and specific situations and venues), body-related images (e.g., anatomy, appearance, and health concerns), character and role images (e.g., imagining a specific environment for their performance), and irrelevant images. Additionally, Nordin and Cumming clarified the means by which the dancers obtained their images (external stimuli and retrieving memories), interpreted images (their imagery feelings converted to their movement), and created layers of images (create skill images first, after that include more qualitative elements of emotion and characterization).

Holmes and Collins (2001) introduced the well-known imagery model of PETTLEP, which includes seven components that are reflected in the acronym PETTLEP. These are the physical, environmental, task, timing, learning, emotional, and perspective elements of imagery. The PETTLEP model follows the functional equivalence theory (Wakefield & Smith, 2012), in that Holmes and Collins aimed to highlight the functional equivalence between physical and imagery experience. The element of physical (P) involves creating images incorporating physical characteristics that athletes can reflect on as though it is their real performance. In other words, by instructing athletes to wear sport uniforms or shoes, hold the equipment (i.e., balls or racket), and adopt their actual performance posture (i.e., shooting poses) during their imagery, researchers could potentially enable an increase in functional equivalence (Ramsey, Cumming, Edwards, Williams, & Brunning, 2010). In the environmental (E) element, imagers should involve the actual performance environment and its components in imagery, such as sensation (e.g., smell, sights, and sounds) (Ramsey et al., 2010). For instance, swimmers could incorporate the chlorine smell, and their start position and swimming lane.

The task (T) element means athletes should imitate real performance and their current performance level during the use of imagery. Furthermore, players should also involve feelings, thoughts, and actions in imagery that are equivalent to those experienced during the actual physical execution of the task (Murphy, 2005). Consequently, there may be differences between the imagery thoughts of novice and elite athletes as their experience and performance aims are different (Holmes & Collins, 2001). For instance, novice basketball players might focus on thoughts of skill or technique (e.g., free-throw shooting) improvement by using imagery, whereas, elite basketball players might emphasize thoughts of best performance in the game. The timing (T) element is imagining the skill at the same speed of motion in imagery as in actual physical movement. In particular, the timing of performance is important, for instance, imagining releasing a basketball in free-throw shooting. Hence, imagining a task slower or faster than the actual physical performance may be less effective in imagery as it is a different mental representation of the movement (Murphy et al., 2008). The element of learning (L) is considered to be athletes' learning stage of physical performance matched with the imagery training task level, so that athletes imagine at an appropriate skill development level. In addition, imagery training should be adjusted to match the actual skill level as athletes' skill level develops (Ramsey et al., 2010). Consequently, novice gymnasts should not create imagery of a double tuck front sault until they have acquired the skill of a one tuck front sault. The emotion (E) element indicates that involving all emotions and arousal is necessary because athletes have emotions and arousal in real performance that are helpful for promoting a memory representation (Murphy et al., 2008). For instance, Australian football players should incorporate relatively intense emotional arousal levels during imagery before starting a game because football is played with a high level of emotional arousal. On the other hand, archery players may need to incorporate relaxed emotions in imagery because archery requires the body to be stable, with little unnecessary movement to ensure accuracy.

The last element of perspective (P) is that a visual perspective (i.e., internal and external) should be activated because athletes have these perspectives during real performance. Mahoney and Avener (1977) discovered that internal and external perspectives operate when people see images in their mind. They defined the internal perspective as people imagining being inside their body, from which they experience, feel, and look during executing performances in their mind (first-person perspective). For example, to imagine a tennis serve, players might imagine themselves behind the service line, feeling the ball and racquet in their hands, concentrating on their opponent and target point, and then tossing and hitting the ball from inside their body as they would when actually doing it. In external imagery, people watch their performance from outside of their body, which is like watching a movie (Mahoney & Avener, 1977). External imagery is activated when imagers use a third-person perspective. In an external image of a soccer free kick, athletes' experience is of watching themselves performing the kick from outside of their body, such as standing behind, to either side, in front of, or even looking down from above or up from below their body as they perform the movement. The PETTLEP model indicates that involving all the elements of the model has the potential to increase the functional equivalence of imagery with physical performance of the task and, subsequently, increase the effectiveness of imagery for athletes.

Several researchers have stated that the athlete is another key variable that needs to be considered when examining imagery perspective effects. For example, Hall (1997) stated that athletes can decide which imagery perspectives they prefer to use and they can also rely on their feelings for their performance outcomes. Moreover, athletes' imagery experience is different for each individual (White & Hardy, 1995). Furthermore, Vealey and Greenleaf (2001) also stated that choosing an imagery perspective is up to the athletes, and determining which perspective works for them is important. Fogarty and Morris (2003) determined the use of imagery perspectives in junior elite tennis players during different types of serve, return of serve, and groundstrokes. They reported that regarding imagery perspective use, there were no differences between open and closed tennis skills. Spittle and Morris (2011) also revealed that there was no difference in terms of internal and external imagery perspectives use between open and closed skills. Moreover, they showed that extreme internal or external perspective imagers can train to use alternative imagery perspectives. On the other hand, Dana and Gozalzadeh (2017) reported that tennis players in their study preferred to utilize internal imagery perspectives, rather than external imagery perspectives. This highlights the distinction between athletes' preferences for one imagery perspective or the other and the most effective perspective to employ to achieve particular goals in sport. There is still limited research into the mechanisms and the outcomes of athletes deciding or tending to use particular imagery perspectives. Thus, researchers should examine various combinations of internal and external imagery perspectives in imagery training in sport to find out more about the effects of imagery perspectives on performance.

Researchers have investigated the PETTLEP model and its elements and provided some support for both (Munroe-Chandler, Hall, & Fishburne, 2008; Ramsey et al., 2010; Smith, Wright, Allsopp, & Westhead, 2007; Smith, Wright, & Cantwell, 2008; Wakefield et al., 2013; Wakefield & Smith, 2009b). For example, Smith et al. (2007) examined the effectiveness of the PETTLEP model by comparing three different imagery intervention styles of hockey players. Those in the first imagery condition (sport-specific imagery group) imagined their performance while wearing the hockey uniform and standing on an actual hockey pitch. Those in the second condition completed the same protocol, but completed their imagery at home instead of on the hockey pitch. Those in the third imagery condition had traditional style imagery training in which participants were seated on a chair at home wearing their normal clothes. Smith et al. found that participants in the sport-specific imagery condition improved their hockey penalty flicks more than those in the second imagery condition, and the second imagery group improved their performance more than those in the traditional imagery condition. Overall, this research has provided key information, including that which concerns additional elements that are able to increase the functional equivalence of imagery. Quinton et al. (2014) applied the PETTLEP model for young futsal players. These players undertook a 5-week layered imagery intervention (adding PETTLEP elements progressively) to improve their imagery ability and the soccer skills of dribbling and passing. The PETTLEP imagery intervention did not significantly affect participants' imagery ability and soccer skills. Quinton et al. proposed that the reason for the lack of change in imagery and performance may be due to children having difficulty with the imagery contents and characteristics. Furthermore, players did not have enough experience of the soccer tasks, which may have been a factor given that creating imagery and an effective mental representation is based on memory (Morris et al., 2005). Finally, researchers suggested that the amount of training in the bi-weekly imagery intervention lasting for five weeks might not have been a sufficient amount of practice to see noticeable improvements in young athletes' performance. Quinton et al. stated that there is limited information about the appropriate amount of imagery that is required to elicit greater effects. Thus, researchers have examined the effect of the PETTLEP model to promote performance outcomes, while there is no systematic experimental research in imagery training regarding the most effective amount of imagery.

Guillot and Collet (2008) introduced the Motor Imagery Integrative Model of Imagery in Sport (MIIMS). MIIMS involves organizing imagery types (Hall et al., 1998) into a multimodal format. Guillot and Collet aimed to represent imagery of specific movements based on integrations from the previous imagery conceptual models of PETTLEP (Holmes & Collins, 2001) and the Imagery Training Program Model (Holmes & Collins, 2001; Morris et al., 2005). Guillot and Collet proposed a number of purposes for which imagery can be utilized, including motor learning and performance, motivation, self-confidence and anxiety, strategies and problem solving, and injury rehabilitation. Furthermore, only a few imagery types are activated simultaneously in order to achieve positive motor imagery in which the imagery perspective is internal or external imagery with kinesthetic, tactile, auditory, or olfactory imagery. Researchers have considered many key components of this model of imagery effects, and it is a guiding framework in motor imagery research (Macintyre & Moran, 2010). Guillot, Moschberger, and Collet (2013) investigated whether coupling motor imagery with actual performance has a positive effect on high jump performance. In this research, they emphasized the aim of motor learning and performance in the MIIMS model. High jumpers performed 10 actual jumps and 10 motor imagery trials of motionless and dynamic imagery (i.e., imitating simple upper-limb movements in actual performance) randomly in a single session. Participants were instructed to use internal visual imagery and kinaesthetic imagery. Guillot et al. found that dynamic imagery positively affected motor imagery quality, temporal congruence between motor imagery and motor performance, and the technical efficacy of the jump. Therefore, it appears that MIIMS has the potential to promote sport performance.

In conclusion, several imagery models have been developed and applied to sport performance. The results of studies testing these modals provide some information on how to deliver imagery training effectively for athletes to facilitate their performance and achieve their goals. For example, the PETTLEP model is often applied in recent sport imagery training studies. Thus, it is important to understand how researchers deliver their imagery training programs using PETTLEP. However, these applied models have not focused on examining effective dosages of imagery, especially three crucial imagery variables of number of imagery repetitions of the task per session, duration of imagery sessions, and frequency of imagery sessions per week. Those imagery variables should be relevant to delivery of imagery training programs because MP reviews and sport imagery studies have reported the effects of dose variables on results (e.g., Cooley, Williams, Burns, & Cumming, 2013; Driskell et al., 1994; Feltz & Landers, 1983; Schuster et al., 2011). Therefore, future imagery models in sport should include information related to how much imagery is enough for enhancing sport performance.

Factors that Affect Imagery Effectiveness

Imagery theories and models have been developed (e.g. Guillot & Collet, 2008; Holmes & Collins, 2001) that have contributed to our understanding of imagery intervention research in sport. In addition, imagery models involve influential factors for imagery effectiveness, which are related to the effective delivery of imagery interventions. However, there is still limited research that addresses imagery effectiveness. In this section, I discuss influential imagery effectiveness factors that have impacts on imagery intervention designs. According to Vealey and Greenleaf (2001), understanding imagery use is important for creating effective imagery interventions. I have separated the factors into three categories, namely characteristics related to imagery aspects, the individual, and those associated with the skill or task being performed. Furthermore, imagery training characteristics are also important when performing imagery in the sport environment, such as frequency of imagery training sessions (e.g. Munroe-Chandler, Hall, Fishburne, & Shannon, 2005), as well as providing instructions for delivering imagery (Guillot & Collet, 2008).

Imagery Characteristics

In individual characteristics, there are specific factors identified in the literature that can influence imagery training programs, including imagery ability, vividness and control of images, imagery perspective, preference of the imager, skill level, age, and gender (Morris et al., 2005; Weinberg & Gould, 2015).

Imagery ability. Imagers have different levels of imagery ability, which is relevant to the effectiveness of imagery. Morris (1997) defined imagery ability as “an individual’s capability of forming vivid, controllable images and retaining them for sufficient time to effect the desired imagery rehearsal” (p. 37). Research has indicated that imagery ability can influence the effectiveness of imagery for performance and learning. For example, Rawlings and Rawlings (1974) reported that imagers who scored above the median performance on measurement of controllability of their imagery attained stronger results in a rotary pursuit tracking task than lower scorers on imagery controllability. Similarly, Marks (1977) investigated the mental practice that is involved in learning a two-handed rotary pursuit tracking skill. He reported that high imagery ability imagers (vivid visual and kinaesthetic imagery) produced superior performance to that of lower imagery ability imagers. Thus, participants should fully understand how their imagery ability is relevant to imagery training effectiveness (Murphy & Martin, 2002).

Imagery ability has measurable components, which are dimensions and modalities. In terms of imagery dimensions, vividness, controllability, duration, ease of generation, and speed of formation have been measured (Watt, Morris, & Andersen, 2004). Vividness and controllability have been studied for many years and have been proposed to be the most influential dimensions (Martin et al., 1999; Rotella, 1998). The definition of vividness is “clarity” and “sharpness,” or “sensory richness” (Moran, 1993, p. 158). Wann (1997) and Cox (1998) defined imagery as being based on the visual sense. Additionally, Denis (1985) stated that vividness “reflects the rate of activity of the mental process underlying the experience of imagery” (p. 8). Hence, researchers have focused on vividness of imagery ability, and they have assessed it by developing questionnaires (Isaac, Marks, & Russell, 1986; Marks, 1973; Marks & Isaac, 1995). For example, Isaac and Marks (1994) investigated athletes’ vividness of imagery of movement by creating the Vividness of Movement Imagery Questionnaire. They reported that elite athletes scored higher on the vividness dimension of imagery ability than lower level athletes.

Controllability is also an influential imagery dimension. Moran (1993) defined it as the “ease and accuracy with which an image can be transformed or manipulated in one’s mind” (p. 158). According to Vealey and Greenleaf (2010), higher-level athletes are able to create more accurate imagery than lower-level athletes. Additionally, Moreau, Clerc, Mansy-Dannay, and Guerrien (2010) found that the expertise variable had a significant effect on controllability. Smith (1987) stated that the higher an athletes’ imagery ability on the controllability dimension, the more beneficial their imagery is likely to be for their skill performance. For example, imagining missing the target or having a lack of control in sport performance is likely to lead to limited benefits during performance. It might even produce decrements in performance. In general, elite athletes have more understanding of their skills and performance, so they are able to imagine a particular skill clearly while maintaining control of their imagery, so the outcome of imagery is likely to be positive, which will lead to a successful performance.

Morris et al. (2005) indicated that imagery ability is independent of the skill level of athletes, and that imagery ability can vary according to the key dimensions of vividness and controllability. Effective imagery is likely to have high levels of vividness and controllability, whereas imagery with high levels of vividness, but low controllability, is likely to be a problematic combination because the imager is creating clear imagery with uncontrolled imagery simultaneously, including possibly imaging unsuccessful, incorrect, or ineffective movement.

Athletes can also vary in their capacity to image in different imagery sense modalities, such as kinesthetic, auditory or tactile imagery, which may be relevant to the imagery training effect. For example, kinaesthetic imagery, that is, feeling the muscles during imagery is like conducting real performance, so athletes cannot imagine the feeling of the performance, if they have a weak kinesthetic sense (Morris et al., 2005). In addition, some researchers have considered the effects of several other imagery ability dimensions (Morris et al., 2005; Murphy, 1990). Duration is another influential dimension. Denis (1985) defined duration as the length of time for which athletes can hold a vivid image from the initial occurrence of the image to the image disappearing. The speed of imagery creation is another dimension of imagery ability. The speed of imagery creation refers to how quickly athletes can create a clear image after the instruction to generate that image (Morris et al., 2005). Another dimension of imagery ability is the ease with which images are generated. This refers to how easy or difficult it is to create images (Hall, Pongrac, & Buckholz, 1985). Emotional senses, such as elation, happiness, and satisfaction, are also dimensions that have been described (Vealey & Greenleaf, 2010). Vealey and Greenleaf explained that athletes should include emotion in their imagery because emotions affect their experiences during performance. Negative emotions are likely to be associated with lower performance than positive emotions because negative emotions disrupt concentration. Weinberg (2008) stated that imagers should include all six sense modalities when creating imagery. Similarly, Pie and Tenenbaum (1996) reported that including more senses in imagery was beneficial in achieving the effective use of imagery. Hence, for instance, basketball players might include the auditory sense when they imagine their dribbling performance because dribbling the ball makes a sound when the ball bounces and this provides useful information for the timing and rhythm of dribbling. On the other hand, swimmers may enhance the imagery of their performance routine in competition by including a sense of the smell of chlorine in the water, which is an environmental condition in swimming pools that can enrich the extent to which the imagery seems real to the swimmers.

Researchers have examined whether high and low imagery ability influences imagery effectiveness and subsequent performance (e.g. Goss, Hall, Buckolz, & Fishburne, 1986; McKenzie & Howe, 1997). Research indicates that high imagery ability athletes tend to experience more positive imagery performance outcomes than low imagery ability athletes (Callow & Waters, 2005; Goss et al., 1986; Gregg, Hall, & Butler, 2010; Isaac, 1992; McKenzie & Howe, 1997). Thus, it appears that athletes with higher imagery ability are able to more effectively create imagery of movement than athletes with lower imagery ability, which allows them to generate imagery that is more relevant to action (Morris et al., 2005). For example, Robin et al. (2007) investigated differences in degree of improvement in tennis service return accuracy of high and low imagery ability tennis players who undertook an imagery training program that required physical practice. Although both high and low imagery ability players improved their performance, participants in the high imagery ability condition experienced greater performance improvement than those in the low imagery ability condition. Hence, screening athletes' imagery ability before starting an imagery training program is important in imagery training as differences in imagery ability may impact on the effectiveness of the imagery. Moreover, systematic imagery training can potentially enhance imagery ability (Evans, Jones, & Mullen, 2004; Weinberg & Gould, 2015), so that testing imagery ability after imagery training periods is helpful for understanding imagery training effects.

The well-established imagery abilities of vividness and controllability (Morris et al., 2005) are important in an imagery training context. Imagery vividness has an effect on performance outcome, with high vividness making the creation or recreation of imagery more effective for athletes' sport performance than low vividness (Murphy, 2005); in other words, image vividness is an important component within the imagery training context (Fournier et al., 2008). For example, Callow et al. (2006) examined whether static and dynamic imagery training influenced downhill ski-slalom time. They found that participants in the dynamic imagery training condition had a significantly higher vividness imagery score than those in the static imagery training condition, as well as achieving significantly greater improvement in downhill ski-slalom time than participants in the control condition. Thus, imagery vividness is an influential component of imagery ability in terms of improvement in sport performance and an element that researchers should consider when designing an imagery training program.

Another vital component of imagery ability in effective imagery training programs is controllability. To enhance imagery effectiveness, athletes' imagery controllability should be at least at a level that enables them to control their performance images. Murphy et al. (2008) stated that imagery controllability has a broad range between uncontrolled spontaneous images and fully manipulated images on a continuum. In early research, Clark (1960) investigated the importance of controllability, in which a participant explained mentally bouncing a basketball in preparation for shooting the basketball; however, the basketball would not bounce, rather it stuck to the floor. This imagery lacked controllability, so that the athlete could not successfully create the imagery of the shooting technique. Hence, Munroe et al. (2000) stated that researchers should consider the extent to which athletes have appropriate imagery abilities of vividness and controllability, and their level is relevant to designing an imagery training program. Vealey and Greenleaf (2010) stated that imagery ability differences are an explanation for equivocal results in the literature. Therefore, researchers need to examine how imagery ability affects imagery training and consider imagery ability in intervention design.

Athletes' imagery ability is an influential factor in enhancing performance (Hall et al., 1998; Weinberg & Gould, 2015). Thus, researchers and trainers should regularly measure athletes' vividness and controllability (Morris et al., 2005). In other words, ensuring that participants are able to create images with appropriate vividness and control should be an important goal of imagery training programs. Furthermore, a systematic imagery training program has the potential to promote imagery ability (Morris et al., 2005). Consequently, researchers should identify athletes with high and low imagery ability prior to the imagery training. This might improve athletes' imagery abilities as part of systematic imagery training, which will ensure that imagery will be effective in enhancing the desired sport performance outcomes.

Watt et al. (2004a) developed a subjective imagery ability measure in sport called the Sport Imagery Ability Measure (SIAM), which is a multimodal and multidimensional measure of sport imagery ability. The SIAM involves five dimensions (vividness, control, duration, ease, and speed of generation images) and six sense modalities (visual, auditory, kinaesthetic, tactile, gustatory, and olfactory). It also includes an emotion subscale. Sport psychologists (e.g., Fazel et al., 2018; Kuan et al., 2018) have used the SIAM to measure imagery ability in their participants, particularly in screening participants' ability to create images during imagery interventions. Watt et al. (2018) conducted a psychometric analysis of the SIAM, in which they examined the reliability, validity, and factor structure of the SIAM. In the analysis, 625 athletes from school, university, and sport clubs across four levels of competition (local, district, state, and national) completed the SIAM. Watt et al. the internal consistency in the SIAM by using Cronbach's alpha. They found adequate results for the vividness (r = .76), control (r = .79), ease (r = 69), speed (r = .68), duration (r = 77), visual (r = .77) auditory (r = 76), kinesthetic (r = .77), olfactory (r = .85), gustatory (r = .87), and tactile (r = .80) subscales. They examined the validity of the SIAM by using Confirmatory Factor Analysis (CFA), and they examined the a priori model with the 12 subscales loading onto three latent factors. Factor 1 is called "generation," which involves the vividness, control, ease, speed, duration and visual subscales. Factor 2 is labelled "feeling senses," which includes the kinesthetic, tactile, and emotion subscales. Factor 3 is labelled "single senses;" its subscales are auditory, olfactory and gustatory. Furthermore, the CFA results showed that chi-square (CMIN/DF: the chi-square degree of freedom) = 3.67, goodness of fit index (GFI) = .96, adjusted goodness of fit index (AGFI) = .93, Tucker-Lewis index (TLI) = .97, Comparative Fit Index (CFI) = .98, and normed fit index (NFI) = .97, reflecting a good fit of the data to the model. In addition, Watt et al. reported a significant difference in imagery ability between respondents according to age, gender, and competition levels in expected ways, which supports the validity of the measure. High-level competitors had higher scores in imagery ability (vividness, kinesthetic, and emotion) than lower level athletes. For the gender comparison, male participants had significantly higher scores than female participants on the ease, speed, olfactory, and gustatory subscales. Moreover, the over-18 participants obtained significantly higher scores on the control, duration, visual, auditory, kinesthetic, olfactory, gustatory, tactile, and emotion subscales than the under-18 participants. These findings also support imagery ability as a mediating variable in the effects of imagery training.

In conclusion, researchers have defined imagery ability, and they have investigated how imagery ability is relevant to sport performance, finding that aspects of imagery ability have noteworthy effects on the impact of imagery training on sport performance. This research is important for understanding the benefits of using imagery in sport, as well as how imagery influences sport performance. Understanding of the role of imagery ability is also important in designing imagery training programs. In addition, athletes can create images of their sport performance freely, so using imagery has various benefits regarding athletes' ability to achieve their desired goals. Hence, imagery ability is an influential factor in the powerful psychological technique of imagery for facilitating athletes' performance. However, there is no information on effective dosages of imagery in sport; in other words, researchers need to examine how the key imagery variables (e.g., repetition, duration, and frequency) are important in terms of sport skill performance. Imagery ability is a key factor for examining imagery dose-response variables because imagery quality is important in terms of examining dose-response of repetitions. Thus, participants with low imagery ability in terms of vividness might not create clear images of sport tasks, so the allocated imagery repetitions would not be effective, despite being adequate for individuals with moderate or high vividness imagery. This could be related to researchers finding inconsistent results from research on imagery training programs. In addition, it is important to determine whether each imagery variable has an individual effect on sport performance, which can be achieved by using the new imagery dose-response protocol under controlled conditions. Thus, screening imagery ability is a key procedure in checking whether all participants have at least moderate imagery ability before selecting them for participation in imagery studies.

Imagery perspectives. For over three decades, researchers have examined the effects of internal and external imagery perspectives as a major imagery research topic. Mahoney and

Avener (1977) defined the imagery perspectives of internal and external imagery. As explained earlier, from an internal perspective, people imagine their performance from a first-person perspective (Cumming & Williams, 2012), whereas, in external imagery people imagine their movement and body from outside, so that it seems like watching oneself on video or TV. This has also been termed the third person perspective (Cumming & Williams, 2012). Mahoney and Avener (1977) investigated the US Olympic gymnastics team and reported that top level gymnasts who used the internal perspective tended to be more successful than those who adopted an external perspective. This led them to conclude that an internal perspective is more effective than an external perspective.

The findings of Mahoney and Avener (1977) prompted further research. Rotella, Gansneder, Ojala, and Billing (1980) reported that an external imagery perspective was employed more by less successful skiers as opposed to more successful skiers. Rotella et al. suggested that less successful skiers do not have the appropriate technical requirements in the skills, which means that they might not use internal perspectives. Other research has also indicated that higher level athletes more frequently use an internal perspective (Paivio, 1971; Salmon, Hall, & Haslam, 1994).

An external perspective might be more beneficial in the early stages of learning as researchers have suggested that imagery from outside of their body (external imagery perspective) may help learners to understand the motor skill, especially the actions of their limbs and relevant visual cues (e.g. Rotella et al., 1980). Montuori et al. (2018) investigated whether the internal and external perspectives of participants of different levels have different functions in terms of learning Pilates exercises (i.e., expert, novice, and no-practice individuals). They used a mental chronometry experimental paradigm, in which they compared physical execution time with the use of the internal imagery perspective and external imagery perspective. The results showed that the expert condition lasted the same time for physical execution and internal perspective imagery; on the other hand, the external perspective imagery lasted for a significantly shorter time than physical execution. For the novice condition, Montuori et al. found the opposite results, which were that their external imagery perspective image had the same time as physical execution, but their internal imagery perspective image was significantly shorter than for physical execution. They concluded that the external imagery perspective function is useful for learning and improving a physical task, whereas using the internal imagery perspective is suitable for experts. Thus, both internal and external imagery have an effect on sport performance improvements, and sport psychologists should advise athletes, so that the performers can decide on the most effective perspective to use to imagine a specific skill or situation, taking into account their level of expertise in performing that skill. However, it is necessary to consider other factors that affect the use of imagery perspectives.

Other factors have been discussed (Annett, 1995; Kearns & Crossman, 1992; McLean & Richardson, 1994; Morris et al., 2005; Spittle, 2001), especially the type of task, such as whether cognitive/visual or motor/kinaesthetic components influence the effective use of imagery perspectives for performance improvements. According to Glisky, Williams, and Kihlstrom (1996), internal imagery is more effective when employed in cognitive/visual tasks, whereas, external imagery is more effective with motor/kinaesthetic tasks. This may be because of kinesthetic sensations experienced in internal imagery, whereas the external perspective may not involve feelings of movement (Jowdy, Murphy, & Durtschi, 1989).

Some of the research findings have indicated that there were no significant differences between internal and external imagery perspectives on performance (e.g. Gordon, Weinberg, &

Jackson, 1994; Harris & Robinson, 1986; Mahoney & Avener, 1977). This could be due to the type of task being practiced. For example, researchers have shown that the external imagery perspective is more effective with performance tasks that are more form-based (rather than performance tasks that are outcome-based), such as karate and gymnastics (Hardy & Callow, 1999; Nordin & Cumming, 2005; White & Hardy, 1995). In recent research, Dana and Gozalzadeh (2017) investigated whether internal and external visual imagery perspectives positively affected novice tennis players' open and closed skills (i.e., serve, forehand, and backhand shots), using a pre-post imagery intervention design. Participants in two imagery conditions (internal and external) and a control condition (mental math exercises) completed a 15-minute intervention three times a week for six weeks. Both internal and external imagery perspective conditions showed performance improvements relative to the control condition. Interestingly, the serve accuracy level was improved by using an internal imagery perspective, whereas an external imagery perspective positively affected forehand performance. Thus, existing evidence supports the contention that internal and external imagery perspectives improve sport performance, but the benefits of perspective depend on the task or part of the task that individuals image. In other words, internal and external perspectives are advantageous for different aspects of sport performance, which helps to explain why one perspective has been found to be superior in certain contexts and tasks and the other perspective has been shown to produce a larger effect in other contexts and tasks.

Regardless of the factors of skill level and type of task, athletes utilize both internal and external perspectives when creating imagery (Dana & Gozalzadeh, 2017; Gordon et al., 1994; Hall, Rodgers, & Barr, 1990; Harris & Robinson, 1986; Weinberg et al., 2003). For example, athletes may use different perspectives for different affective or viewing experiences. Nordin and

Cumming (2005) examined imagery use in dancers and reported that dancers used emotional imagery with an internal imagery perspective, and used an external imagery perspective for their appearance on the dance stage. Furthermore, when athletes imagine themselves from outside their body (external imagery perspective), they are able to see their performance from a variety of angles (Callow & Roberts, 2010; Holmes & Calmels, 2008). In particular, Callow and Roberts (2010) found that athletes reported 10 different viewing angles while utilizing external imagery. Hence, athletes may shift from one perspective to another perspective, in which they decide to use an imagery perspective intuitively or consciously in the most effective way for the task (Guillot et al., 2009; Morris et al., 2005). For example, in serving, tennis players may use an internal perspective as they imagine the feeling of the ball and racquet, and the positioning of the body on the court, while imagining the trajectory of the ball from the racquet, which may work with greater effect when it is done from an external perspective.

Both open and closed skills offer another dimension that is related to imagery effects. Researchers have proposed that different imagery perspectives improve open and closed motor skills (Coelho, De Campos, Da Silva, Okazaki, & Keller, 2007; Hardy & Callow, 1999; McLean & Richardson, 1994). For example, White and Hardy (1995) stated that internal imagery perspective is beneficial for open skills; on the other hand, external imagery perspective is effective for closed skills (Hardy & Callow, 1999). Coelho et al. (2007) examined the effects of imagery on performance of the closed-skill of tennis serve and the open-skill of returning serve. In their results, tennis players in the imagery condition improved their tennis serve more than those in the control condition, while there was no significant difference in the quality of the return of serve between the imagery and control condition. Considering individuals' preferences for use of perspectives is important (Mellalieu, Hanton, & Thomas, 2009). Spittle and Morris

(2011) demonstrated that imagery training makes it possible to increase the degree to which a specific perspective (i.e., internal or external imagery) is used, so that users with a preference for internal imagery can utilise external imagery to a greater degree through the training of their imagery perspectives and individuals who have a preference for external imagery can use internal imagery more, in appropriate circumstances. Hence, individual preferences should be considered when designing effective imagery interventions because some athletes may prefer to use a specific imagery type and perspective, which may lead to difficulties during an imagery intervention. This occurrence is a plausible reason why there are equivocal findings regarding a superior imagery perspective. Individuals' preference for a particular imagery perspective may be identified by interviewing athletes, followed by manipulating their imagery use and ability during a trial period or prior meeting. Morris et al. (2005) recommended that researchers should consider individuals' imagery type preference and match them with the desired imagery type for the performance skill. For example, in the case of basketball players whose imagery preference is external imagery, the imagery training aim is to train their cognitive components (i.e., muscular feeling), so researchers should help them to imagine task-related scenes internally. Therefore, discussion of athletes' imagery preferences prior to conducting an imagery intervention is required, and if the task demands internal or external imagery training, practitioners should develop appropriate guidelines to establish which imagery perspective is superior.

There is a long-running debate about the optimal imagery perspective to promote positive imagery outcomes, especially whether an internal or an external perspective is more effective. Athletes appear to use both perspectives and the efficacious use of imagery perspective probably depends to some extent on individual preference, skill level, and the performance task that is being undertaken (Dana & Gozalzadeh, 2017; Nordin & Cumming, 2005; Spittle &

Morris, 2011). Consequently, sport psychologists should consider the most appropriate imagery perspective when developing an imagery training program and align it with individuals' needs.

Individual Characteristics

Imagery training effects vary depending on individual characteristics, including skill level, age, gender, and task. Each one of these variables is important to consider in terms of designing imagery training programs.

Skill level. Skill level is an individual characteristic that may influence imagery training. Although there is debate about the differences between imagery effects on various performance levels, athletes' expertise level should be considered when developing imagery training (Reed, 2002; Short, Tenute, & Feltz, 2005). For example, Hall et al. (2001) suggested that beginners benefit more from imagery than higher level athletes because beginners' training progress is more cognitive as they are at an early stage of skill acquisition (Fitts & Posner, 1967). However, reviews of imagery have suggested that advanced/skilled athletes achieve a higher level of imagery effectiveness (Morris et al., 2005; Murphy & Martin, 2002) and higher competitive level athletes have higher levels of imagery ability (Roberts, Callow, Hardy, Markland, & Bringer, 2008). In a meta-analytic review of imagery in sport and exercise, Curran and Terry (2010), supported this, reporting larger effect sizes for experienced participants (d = 0.52) than novices (d = 0.44). In line with the Morris et al. (2005) definition of imagery as a technique for creating or recreating an experience based on memory, a higher level of sporting experience is probably conducive to stronger memory representation of a particular skill, resulting in more effective imagery of that skill. For example, Mendes, Marinho, Monteiro, Cid, and Petrica (2019), examined imagery ability in elite, sub-elite, and non-elite swimmers by using the Movement Imagery Questionnaire 3, Portuguese version (Mendes et al., 2016). The results showed that in terms of kinaesthetic and external visual imagery there was no significant difference between elite groups and sub-elite groups, while elite swimmers recorded significantly higher scores than non-elite swimmers for internal visual imagery. Moreover, high-level athletes can create vivid movement images, as well as imagery of sport-related scenes (Roberts et al., 2008; Williams & Cumming, 2011). Barr and Hall (1992) surveyed imagery use among rowers. They indicated that elite and novice rowers had beneficial experiences from imagery use. However, elite rowers created realistic images (i.e., feeling the blade, muscles, parts of the stroke, and the boat and its action in the water), and they had higher imagery ability than lower level rowers. Therefore, skill level is related to imagery training and imagery ability, which means that sport psychologists should be concerned with the differences between athletes' expertise when designing imagery training programs.

Pie and Tenenbaum (1996) stated that skilled athletes had a better understanding of their goals and skills due to more effectively applying imagery to both practice and competition situations. Similarly, Driskell et al. (1994) explained that previous experiences of performance are relevant to MP effectiveness. Olsson, Jonsson, Larsson, and Nyberg (2008) examined whether different brain functions are activated in high jumpers by comparing active jumpers and novice jumpers during motor imagery, using functional magnetic resonance imaging (fMRI) scanning during imagery. The results showed that elite high jumpers had greater activation in motor regions (the pre-motor cortex), whereas novices activated visual and parietal regions to a greater degree. Hence, Olsson et al. concluded that previous experiences and actions are important in neural overlap between imagery and action. In other words, beginner level athletes (i.e., lower physical performance level) may not be able to imagine the motor image clearly, relying instead more on visual representation of the skill. Thus, imagery may be more effective for higher level performers, or at least those with enough experience to generate an appropriate representation of the movement skill in imagery, than those at lower skill levels or with less experience of the skill. In sport psychology contexts, imagery has been shown to be effective for beginners and elite performers alike, if performers have the skill level that is appropriate for the imagery contents (Morris et al., 2005; Weinberg, 2008). Systematic imagery training has been found to be effective for both low-level and high-level athletes' performance (Morris et al., 2005). For example, researchers have found positive effects for both high- and low-level performers (Blair et al., 1993; Perry, Chow, Tenenbaum, & Katz, 2018; Rhodes, May, Andrade, & Kavanagh, 2018; Spindler, Allen, Vella, & Swann, 2018). Therefore, using imagery undoubtedly has effects on athletes of all levels, but athletes should have a systematic imagery training program, so that imagery will enhance their desired sport performance.

Task Characteristics

Researchers have stated that task characteristics are also relevant to imagery effects. In the MP research literature, MP has been shown to be more beneficial for more cognitive tasks than motor or strength-based tasks (Denis, 1985; Driskell et al., 1994; Feltz & Landers, 1983; Ryan & Simons, 1981; Ryan & Simons, 1982). Feltz and Landers (1983) published a seminal meta-analytic review of MP, in which they analysed 60 MP studies involving 1,766 participants, and the number of effect sizes was 146. The overall MP effect size was d = .48 (Cohen, 1988), indicating that MP of a motor skill is more effective in improving performance than not doing any practice. In addition, Feltz and Landers reported the effect sizes of MP for cognitive tasks (M = 1.44), for motor tasks (M = 0.43), and for strength tasks (M = 0.20). This indicated that MP was much more effective for cognitive tasks than for motor tasks, and that MP was least effective for strength tasks.

In a meta-analytic review of MP, Driskell et al. (1994) examined studies that compared mental practice conditions with control conditions (no MP). They reviewed 35 studies with 100 separate hypothesis tests and 3,214 participants. Their results indicated that the mental practice effects leading to enhanced performance ($r = .255$, $d = .527$), were less than those from physical practice ($r = .364$, $d = .782$). Moreover, they identified that there was a significant difference in the effect sizes between cognitive and physical tasks ($z = 4.496$, $p < .001$). Thus, MP is effective in both cognitive and motor tasks, and MP is somewhat more beneficial to the performance of tasks that involve more cognitive elements. In a frequently cited MP study that examined a cognitive task and a motor task, Ryan and Simons (1982) reported that the cognitive task (completion of a maze) improved after the MP, however, there was no improvement in the motor task (balance times on a stabilometer).

For imagery training, imagery task characteristics and task types might influence imagery effectiveness. In their meta-analysis of imagery in sport and exercise, Curran and Terry (2010), reported larger effect sizes for cognitive tasks (e.g., remembering complex routines) ($d = 0.98$) than motor tasks ($d = 0.46$) and strength tasks ($d = 0.36$) . On the other hand, researchers have established that imagery training is effective for most sport tasks, including open and closed skills, motor skills, and high/low cognitive skills ((Morris et al., 2005; Weinberg, 2008)). In PETTLEP research, Smith et al. (2007) found that an imagery intervention had an effect on the motor skill tasks of hockey penalty flicks and the gymnastics beam jump skill. Furthermore, Wright and Smith (2009) improved biceps curls, a strength-based task, by a PETTLEP imagery intervention from pre-test to post-test. In addition, Smith et al. (2019) also found that biceps strength increased with the PETTLEP imagery intervention. Mellalieu et al. (2009) adapted modified MG-A imagery content to accord with athletes' perceptions in their precompetitive experiences. They reported that the intervention had a positive effect on five participants' interpretations of competitive anxiety and their self-confidence. This highlighted that the imagery perspective should be appropriate for both the individuals' psychological response and the imagery task. However, researchers are yet to examine some types of sport skills, for example, gross motor skills (e.g., running and swimming). Overall, however, the research indicates that imagery training can enhance the performance of sport skills.

Imagery Training Characteristics

Examining imagery training characteristics is a major topic in imagery research because it relates to imagery training effectiveness. Morris et al. (2005) and Weinberg (2008) noted that key characteristics, for example, positive and negative imagery and combining physical practice with imagery training have been examined in various studies.

Physical Environment of Imagery Practice

Researchers have reported that athletes use imagery in various environments, such as school, workplace, and practice/competition venue (e.g. Cumming & Hall, 2002; Hall et al., 1990; Quinton et al., 2014). Wakefield et al. (2013) reviewed PETTLEP imagery intervention research that established that athletes should undergo imagery training in a performance environment and emphasized that they should wear the same sport uniforms as they would wear when performing. Furthermore, Wakefield et al. reported that research had supported the PETTLEP proposition that imagery should be facilitated by key physical and spatial elements, for example, standing on the pitch or court, holding any equipment they would hold while performing, feeling kinesthetic sensations while imaging performance of the skill, and feeling the same or similar emotions that they would feel prior to the actual performance (dynamic imagery). Munroe-Chandler et al. (2005) stated that using dynamic imagery instead of static imagery makes it possible to increase the amount of imagery use among young athletes. On the other hand, athletes frequently use static imagery, which is imagery that is performed in a quiet environment or at home. Researchers investigated the degree of improvement that participants made to their ability to perform the bicep curl task by using PETTLEP, in which the participants sat on an actual weight machine and grasped the handles, before creating an image (Smith et al., 2019; Wright & Smith, 2009). The traditional imagery training style does not encourage athletes to adopt a sport performance position. Callow et al. (2006) examined whether dynamic and static imagery of skiing had effects on performance and imagery vividness. Participants in the dynamic imagery condition imagined the downhill ski slalom and wore their equipment. Furthermore, they were instructed to imagine a race position during the imagery session, and they moved their body from side to side (i.e., postures associated with actual skiing technique). Alternatively, participants in the static imagery condition undertook imagery sessions while sitting in a chair. The results showed that the dynamic imagery condition resulted in significantly higher imagery vividness scores than both the static imagery condition and the control condition. However, there were no significant differences between the conditions in a test of skiing performance.

In more recent research, Guillot et al. (2013) reported that imagery with actual movement (dynamic imagery) improved both high jumpers' imagery quality and the technical efficacy of their jump. Hence, conducting imagery training in an actual sport environment should be beneficial to athletes, enabling them to create or recreate images easily by involving the details of their scenes and the associated emotions. In addition, using the environment element of

PETTLEP, sport psychologists can provide information about the environment through videos, photos, and audio for athletes to promote athletes' experience of the real environment when the athletes are not in a position to perform imagery in the actual sport environment (e.g. Holmes & Collins, 2001). Wearing the same clothing that they would wear during competition can facilitate athletes' representation of movements. Thus, researchers have explained that including all of the senses, especially visual, tactile, and kinaesthetic sense modalities, with emotion and environmental information (e.g., sport equipment and performance location) to help create vivid and realistic imagery experiences is expected to be helpful for enhancing performance, so should be included in designing imagery training programs.

Emotion (arousal)

Researchers have addressed the importance of emotion during the creation of imagery in relation to aroused and relaxed states in the process of recreating emotions in imagery training. Some researchers have indicated that relaxing during imagery sessions is important to imagery implementation (Janssen & Sheikh, 1994; Weinberg, 1981). This is because relaxation should reduce distractions while creating images, so that imagers can maintain their concentration, and reduce somatic or bodily tension (Janssen & Sheikh, 1994). Moreover, providing relaxation prior to imagery training facilitates the positive effects of imagery training for imagers (Janssen & Sheikh, 1994; Morris et al., 2005).

In contrast, some researchers recommend that athletes should not maintain a relaxed state during the entire imagery session because arousal level in most sports increases gradually, or even rapidly, and fluctuates during actual physical performance. Smith et al. (2007) argued that involving emotion is more effective than maintaining a relaxed state as in traditional imagery training, so that increasing the arousal level of actual performance is advantageous. However, other researchers still support the benefits of maintaining a relaxed state while using imagery. For example, Ramsey et al. (2010) examined the Emotion element of the PETTLEP model of motor imagery in soccer penalty kicks. They compared two different imagery conditions, as a skill-based imagery script condition and an emotion-based imagery script condition respectively, as well as a stretching condition (they had a series of stretches for improving their flexibility) is included. Their results showed that the post-test performance scores in the both imagery groups were significantly higher than the stretching group. However, there were no significantly beneficial effects of emotional imagery compared with skill-based imagery script condition.

Guillot and Collet (2008) explained that a combination of imagery with relaxation is useful for enhancing motivation and increasing self-confidence, while inappropriate for improving motor performance and learning. Kuan et al. (2018) investigated whether the use of relaxing and arousing music during imagery had any effect on dart-throwing performance. In addition, physiological arousal and competitive state anxiety were measured. Sixty-three novice dart throwers were assigned randomly to unfamiliar relaxing music, unfamiliar arousing music, or no music conditions. Overall, all three conditions improved their dart throwing after the intervention, although there were significant differences between the conditions. For example, participants in the unfamiliar relaxing music condition showed gain scores in dart throwing that were significantly higher than the gain scores of the unfamiliar arousing music and no music conditions. In addition, unfamiliar relaxing music significantly decreased somatic anxiety and cognitive anxiety and increased self-confidence compared to the other two conditions. Hence, Kuan et al. recommended using relaxing music during imagery training because there are benefits for athletes from undertaking effective imagery training with low arousal states. Therefore, relaxation is an influential variable in imagery training. However, there are still limited research findings, which means that researchers should conduct further examination to determine the positive and negative effects of emotion on imagery training.

Time Equivalence

Researchers have addressed the importance of time equivalence in imagery in sport. Based on the timing element of PETTLEP, it is proposed that the imagined speed should be the same as that of actual physical performance (Calmels et al., 2006; Guillot & Collet, 2005; Holmes & Collins, 2001; Moran, 2004; Weinberg & Gould, 2019). Calmels et al. (2006) investigated the time equivalence in elite gymnasts between the duration of the imagined task in both internal and the external imagery perspectives and actual gymnastics vault performance. Their results showed that there was no significant difference between time that was taken for the entire vault performance in the imagined performance and the physical performance. In recent research, Louis, Collet, and Guillot (2011) examined comparisons of accuracy, speed, and vividness in motor imagery between different arousal levels. They identified that motor imagery times in the relaxed condition were longer than in the actual motor task; on the other hand, motor imagery time in both the basal and the aroused conditions was almost the same as actual performance time. Some researchers have stated that imagining motions at a slow speed may elicit dissimilar neural patterns from those created during physical performance, that is, performing imagery in real time, which could lead to errors in actual execution (e.g., Holmes & Collins, 2002; Rushall, 1995).

Imagining tasks undertaken at the actual speed and in the actual time that they are physically performed is more effective than imagery that is slower or faster than the actual time. According to Morris et al. (2005), using an incorrect speed in creating a movement may be disadvantageous when seeking to achieve positive imagery effects. Therefore, researchers and practitioners should consider the speed of imagery in designing imagery training programs for participants because imagining the task at the actual performance speed is beneficial.

Instructions

Imagery training instruction is delivered by way of the description (task details or simple keywords) in a script, so that imagers can create images and modifications of content. Whereas traditional imagery descriptions have used written scripts, recent imagery training programs have employed different methods, such as live or pre-recorded audio, task videos, or virtual reality (VR). For example, the self-modelling video technique, in which individuals watch a video of their own most successful performance, facilitates athletes' creation of clear and vivid images (Ram, Riggs, Skaling, Landers, & McCullagh, 2007; Rymal & Ste-Marie, 2009). Smith and Holmes (2004) compared the effects of using video, audio, and written scripts in imagery training. They found that the videotape condition and the audio condition led to greater improvements in golf putting performance than the written script condition. They concluded that watching and hearing provided very clear cues for facilitating athletes' performance imagery.

Outside of imagery training programs, athletes spontaneously generate imagery all the time, so that sometimes athletes may not have any specific purpose in using imagery, which means that they may not be able to explain the content of their imagery (Hardy, Jones, & Gould, 1996). For example, gymnasts might imagine their release skill performance on the high bar after receiving feedback from their coach. Researchers demonstrated that controlled and systematic imagery training has positive effects on sport skills, learning a skill, and regulation of thoughts, emotions, and arousal levels (Cumming & Williams, 2012; Martin et al., 1999; Murphy, 2005). Furthermore, Vealey and Greenleaf (2010) stated that systematic imagery training is an effective psychological technique in sport. In other words, researchers can provide clear instructions to facilitate athletes' proper use of the imagery function, imagery modality, and imagery contents. For example, Munroe, Hall, Simms, and Weinberg (1998) proposed that imagery function should be consistent with athletes' aims. However, researchers should consider each individual's needs and different requirements when they do imagery training (e.g., Reed, 2002; Short et al., 2005), so that providing clear instructions and involving content that is meaningful to the athletes who perform the imagery are important factors in helping imagers to use imagery appropriately and effectively; otherwise, inappropriate imagery training instructions and contents might discourage athletes, thereby leading to detrimental performance outcomes (Holmes & Collins, 2002).

Well-designed, structured imagery scripts can prevent the occurrence of negative effects on athletes' performance. Researchers can design imagery scripts at the beginning of their planning of the descriptions, that involve meticulous levels of detail, such as competitive or practice situations, and specific performances (Morris et al., 2005; Taylor & Wilson, 2005). Hence, researchers have suggested that an effective imagery description should be very detailed, and include as many sensory modalities as possible to induce emotions, so that imagers can experience realistic executions and actions during the use of imagery (Di Rienzo, Collet, Hoyek, & Guillot, 2012; Morris et al., 2005; Vealey & Greenleaf, 2001). A traditional imagery delivery method is routine imagery (an unchanged scene repeated in every imagery training session). Routine imagery typically includes a wide range of details about the skill to be performed, the sport environment, and even the specific context, for example, the pressure of competition. Nordin and Cumming (2005) stated that elite dancers used an image progressively in that they created a simple image, and after that they included more imagery details. Researchers have found progressive imagery, which is based on the proposition that it provides imagery details progressively from simple to complex, to be an effective imagery delivery method (Calmels, Berthoumieux, & d'Arripe-Longueville, 2004; Williams, Cooley, Newell, Weibull, & Cumming, 2013). Williams et al. reported that progressive imagery can facilitate sport performance more than routine imagery.

In more recent research, Fazel et al. (2018) introduced retrogressive imagery. In the retrogressive imagery method, imagers start to use fully detailed imagery scripts (i.e., involving a skill task, environment information, the consideration of a third person/party, such as teammates or opponents, and thoughts and feelings pertinent to the context). Subsequently, the environmental and contextual imagery script elements are excluded one-by-one in each successive phase of the imagery training program. Fazel et al. (2018) examined three different imagery delivery methods, namely routine imagery, progressive imagery, and retrogressive imagery. Their imagery training aim was improving free-throw shooting among limited skill basketball players. In their results, the retrogressive imagery condition led to greater improvement in free-throw shooting scores than the other two imagery conditions and the control condition. Hence, the retrogressive delivery method has potential for improving limited skill players’ performance, although, it is a new delivery method, which means that it should be examined at various levels and different sports. Fazel (2015) repeated the study with higher-level basketball league players. She found that progressive imagery was the most effective delivery method with more skilled players. Fazel explained that, in informal interviews after the study, these players reported that they found the introduction of the audience and high pressure associated with the shots they were imaging to be particularly useful. Fazel noted that these players performed competitively in front of audiences and under high pressure, whereas the limited-skill players did not. This research suggests that skill level moderates the effectiveness of different delivery methods.

Thus, the imagery script is a key factor in obtaining positive imagery training effects for performance improvement. Imagery scripts should be well designed, and tailored to specific athletes' goals. Imagery delivery methods should also be considered as a part of the implementation of imagery training. Using a simple imagery script and a routine is suitable for non-elite athletes because complicated imagery scripts may make it difficult for them to create vivid and controllable imagery of the performance task. However, inclusion of details of the real performance environment should enhance the effectiveness of imagery scripts for higher-level competitive performers, who must perform their skills well under pressure in competition

Dose-response Relationships

A concept that has not been adequately explored in imagery training research is "dose-response" in terms of the duration of sessions, number of trials, and number of sessions per week (Morris, et al. 2012). Dose response research design for investigating "a dose–response relationship requires measurement of responses at different dose levels" (p. 2059) (Holland-Letz & Kopp-Schneider, 2015). This design was introduced in the pharmacological literature. The dose can be defined as the number of treatment/training sessions, whereas the response is defined as the normalized probability of achieving measurable participant improvement (Robinson, Delgadillo, & Kellett, 2019; Stulz, Lutz, Kopta, Minami, & Saunders, 2013). Many researchers have applied the dose-response approach in medicine, psychology, exercise, and education to identify the most effective dosage of medicine and treatment (e.g., Allami, Paulignan, Brovelli, & Boussaoud, 2008; Evangelista, Cacciata, Stromberg, & Dracup, 2017; Howard, Kopta, Krause, & Orlinsky, 1986; Robinson et al., 2019; Sanders, Hortobagyi, la Bastide-van Gemert, van der Zee, & van Heuvelen, 2019; Stulz et al., 2013; Wylie et al., 2013). For example, Howard et al. (1986) first determined the dose-response protocol in psychology and analysed psychotherapy dose-response relationships from 2,431 cases across 15 studies, in which the dose is the number of psychotherapy sessions, and the response is the percentage of patient improvement. In other words, researchers examined how much psychotherapy is enough (Kopta, 2003). Howard et al. identified the relationship between the number of treatment sessions and the outcome by using a log-linear function (curvilinear trend). In addition, they found that most of the therapeutic effects appeared during the earlier sessions of treatment. Finally, they reported that the curvilinear relationship showed reducing treatment effects over time. In reviewing dose-response research, the typical dose-response design uses one control condition with different dose treatment conditions to identify the most effective dosages (Allami et al., 2008; Bond Brill, Perry, Parker, Robinson, & Burnett, 2002; Holland-Letz & Kopp-Schneider, 2015).

Regarding the dose-response relationship in psychology, Robinson et al. (2019) conducted a systematic review of the dose-response effect in routine psychological therapies for adult patient populations with mental health problems. They aimed to examine the relationship between the treatment duration and the outcomes, as well as to identify differences in the optimal length of treatment for different clinical settings or psychotherapies. The results showed that the most effective dosages of psychotherapy in routine settings ranged between 4 and 26 treatment sessions. Kool et al. (2018) introduced a new protocol to establish whether 25 or 50 individual therapy sessions in a year had different effects on patients with comorbid depression and personality disorders. The central research aim was to identify the most effective dosages of treatment in psychotherapy for treatment-effect and cost-effectiveness in the patient population with comorbid depression and personality disorders. Participants took schema therapy and short-term psychodynamic supportive psychotherapy in different dosages of 25 or 50 sessions (e.g., 25 schema therapy and 25 short-term psychodynamic supportive psychotherapy sessions). All research participants had assessments at baseline and at 1, 2, 3, 6, and 9–12 months (end of treatment) as well as at follow-up from 6 to 12 months. The Kool et al. research provides information on the implementation of the most effective dosages of therapy with costs, which is important information for both patients and therapists as part of a practical therapy design. In addition, other researchers can apply the protocol for their research in order to find the most effective dosages of different types of psychotherapy, which means that this implementation can contribute to the research setting in psychology.

In exercise and health contexts, researchers have applied the dose-response design to compare the effects of physical activity on different variables and thereby identify the minimal or optimal amount of physical activity needed to achieve a goal outcome (Bond Brill et al., 2002; Evangelista et al., 2017; Galloway et al., 2019; Jennings et al., 1991; Sanders et al., 2019). In terms of physical activity, Lee and Skerrett (2001) defined a “dose” as being the volume of physical activity (i.e., exercise intensity, repetitions and duration of a session). In other words, the dose-response protocol can provide clear information regarding the most effective exercise volume for athletes, depending on the outcome that is aimed for. For example, practitioners can organize effective exercise programs with an appropriate volume, so that it is beneficial for athletes and coaches in terms of enabling them to minimise overuse and injury. Hence, the dose variables of number of repetitions in an exercise session, duration of exercise sessions, and frequency of sessions per week are relevant to exercise volume. In the research design for identifying the most effective dose in terms of exercise and health effects, researchers have either manipulated one dose variable, but controlled all other variables to identify the most suitable fitness dose for healthy populations (Evangelista et al., 2017; Jennings et al., 1991; Pollock, 1973; Shephard, 1968) or they have manipulated two or more dose variables, while controlling all other variables (Ivey, Stookey, Hafer-Macko, Ryan, & Macko, 2015; Lam et al., 2010; Rimmer, Rauworth, Wang, Nicola, & Hill, 2009). The dose-response studies in exercise and health typically used response variables of aerobic capacity (VO_2 peak), body weight, and blood pressure.

Jennings et al. (1991) examined the dose-response relationship between exercise training and blood pressure. Jennings et al. held intensity (60%–70% of maximum work capacity) and duration (30 minutes) of the bicycling exercise constant, while the frequency was varied. Jennings et al. compared how three-days of sessions or seven-days of sessions per week with a one-month exercise length impacted on participants' blood pressure, with results providing information about how to manipulate exercise frequency in relation to blood pressure.

Bond Brill et al. (2002) examined the dose-response relationship in walking exercise with the outcome variable being weight loss. They manipulated the dose variable of walking exercise duration at 30 minutes or 60 minutes, but held frequency constant at five exercise sessions per week. The exercise duration influenced weight loss with the findings contributing to understanding of how to provide the most effective exercise duration for weight loss. Research such as this can help develop understanding of the most effective volume of exercise when designing exercise programs for specific outcomes. Moreover, by using dose-response study designs researchers can find the minimum and maximum volume of physical activity that will increase the likelihood of attaining the desired outcomes

In a recent study, Evangelista et al. (2017) examined the dose-response relationship related to exercise intensity in terms of psychological response variables, namely mood states and improvements to quality of life. The results showed that improving exercise capacity was correlated with positive psychological outcomes and overall quality of life in patients who had experienced heart failure. Therefore, the identification of exercise benefits can contribute to the research goal of designing the most appropriate exercise program for heart failure patients in order to help them to manage mood disorders and improve their quality of life.

Recently, systematic reviews and meta-analysis studies about the dose-response relationship between exercise and treatment effects have appeared. Based on a systematic meta-analysis, Pandey et al. (2015) examined the quantitative dose-response relationships between physical activity and the risk of heart failure. Pandey et al. included 12 prospective cohort studies with 370,460 participants, and effect size was .70 (.67-.73). Pandey et al. suggested that more doses of physical activity might be required than the current guidelines, which are aimed at reducing the risk of heart failure. In addition, they discussed interventions that involve comparing different dosages of physical activity for heart failure prevention. Galloway et al. (2019) systematically reviewed the relationship between exercise and cardiorespiratory fitness after a stroke, based on nine studies involving 279 participants. They focused on the four most important dose variables, which are frequency, intensity, time (session duration and program length), and type of exercise training. The optimal doses for exercise prescription were not clear, which means that the findings of the effective exercise dose on cardiorespiratory fitness provided clearer guidelines for more effective exercise for trainers. Sanders et al. (2019) conducted a systematic review and meta-analysis in order to examine the dose-response relationship between exercise and cognitive function in the older adult population, who either have or do not have cognitive impairments. The dose variables of training frequency, session and program duration, and intensity were examined, and Sanders et al. reported the effect size for each variable in terms of Cohen's *d*. The results provided information about the most effective volume of exercise that researchers applied and, moreover, contributed to understanding of how specific dose variables have an impact upon treatment results. Thus, systematic examination of the dose-response relationship has generated important protocols for identifying the most effective amounts of physical activity and exercise. Durations (of each session and program), frequency (number of training sessions per week), and intensity of doses are particularly common research topics in physical activity studies, examining both physical outcomes of doing activity and a range of psychological outcomes, including cognitive and affective variables.

Imagery and the Dose-response Relationship

The dose-response concept has provided useful information about physical activity and exercise and the effective implementation of psychotherapies in psychology. However, the dose-response relationship has rarely been examined in sport psychology (Wakefield & Smith, 2009b). This issue should be of interest and value to sport psychology researchers and practitioners, who often lack clear guidelines about the most effective design for the delivery of sport psychology interventions. In interventions that are structured in such a manner that aspects of their delivery can be quantified and in which outcomes of interventions can be clearly measured, it would seem that application of the dose-response approach should be fruitful. Imagery is probably one of the most promising candidates for systematic study using a dose-response protocol because it has been widely studied, the delivery of imagery can be controlled relatively accurately, and responses, in terms of sport skill performance, psychological variables, and injury rehabilitation, can often be measured (Kuan et al., 2018; Monsma, Mensch, & Farroll, 2009; Sordoni, Hall, & Forwell, 2000). In addition, a substantial amount of energy and resources has been invested in examining dose variables, including number of repetitions of imagery of sport tasks, duration of imagery sessions, and frequency of imagery sessions per week. However, imagery studies that include one or more of these variables, as well as reviews and meta-analyses of the research, have produced diverse results that are of limited practical value (Cooley et al., 2013; Paravlic et al., 2018; Slimani, Tod, Chaabene, Miarka, & Chamari, 2016).

The dose-response concept is likely to be important for identifying the most effective amount of imagery for improving sport performance. Moreover, determining imagery training variables can contribute to athletes' understanding of the most effective imagery volume to achieve their goals. Specifically, the number of repetitions, the duration of imagery sessions, and the frequency of imagery sessions per week are key variables in imagery training volume. Nevertheless, there is limited systematic research on the imagery dose-response relationship that provides reliable information from which sport psychology practitioners could identify the most effective volume of imagery training.

The number of repetitions in a session, duration of a session, and frequency of sessions in a week may be defined as "imagery dose variables." The dose variable of repetitions can be defined as how many imagery trials or tasks are performed in an imagery session (e.g., 20 imagery trials of a discrete sport task like golf putting, pistol shooting, or basketball free-throw shooting). Another imagery dose variable is duration, which is the time that is provided to perform imagery during an imagery training session (e.g., a 30-minute session in which to perform imagery of 50 pistol shots). The imagery dose variable of frequency refers to how many sessions of imagery training are performed per week (e.g., imagery sessions are conducted three times per week). The last imagery variable is the imagery training program length, which is the duration of the imagery session during imagery training periods (e.g., a 3-week training program).

Some researchers have compared different numbers of MP repetitions in order to establish their potential for helping athletes to enhance their sport performance. Allami et al. (2008) examined the equivalence between MP and physical learning. They also tested the effective proportions of real execution and imagery rehearsal. Participants performed the task of grasping an object and inserting it into an adapted slot during the course of 240 trials by physical performance or a combination of MP and physical performance. Participants in the physical condition performed 240 trials; whereas, participants in the three MP conditions imagined the performance task for different numbers of trials of the performance task, depending on their research condition. Thus, participants were assigned to imagine 60 trials (25%), 120 trials (50%), and 180 trials (75%), respectively, then they physically performed the remaining trials up to 240 trials. Participants in a Control condition imagined a visual rotation task in 75% of the trials and conducted the same motor task. Results showed that participants in MP conditions showed superior performance than those in the Control condition. In addition, the two highest imagery rate conditions of 120 trials (50%) and 180 trials (75%) produced similar performance to the physical practice condition. In other words, mental rehearsal of 50% or 75% of the trials lead to a similar performance to actual execution of the same amount of trials. These findings indicate that MP is beneficial for partly replacing physical practice in clinical rehabilitation and that the higher numbers of MP trials (120 trials and 180 trials) were more beneficial than 60 MP trials in this study. However, in this study, the researchers only provided one MP session, so that providing more imagery intervention sessions may have different effects on performance.

Kremer et al. (2009) examined different numbers of MP trials using a pre-test and post-test design. They randomly allocated 209 university students into four conditions. Participants in three of the conditions engaged in MP of dart throwing for 25, 50, and 100 trials, respectively. The control condition participants only performed the task of catching a tennis ball. Results showed that the dart-throwing scores for all three MP conditions improved significantly more from pre-test to post-test than the scores for the control condition. There were no significant differences between any of the MP conditions. This study provides some information about the effects of number of MP repetitions in a session; however, this was only investigated for one MP session, whereas most imagery training programs and interventions investigate longer training periods, which means that different effects may become evident (e.g.,Fazel et al., 2018). For example, the effects when using a 4-week imagery training program, where participants' improvements can be tracked week by week, may be different, depending on the number of imagery repetitions.

There have also been reviews of number of imagery repetitions in a session in imagery training research. Paravlic et al. (2018) systematically reviewed the benefits of motor imagery practice on muscle strength facilitation in the healthy adult population. They reported that 25 repetitions per session resulted in the largest improvements in maximal voluntary contraction, based on the effect size, which was 1.18. In a systematic review of motor imagery training research in sport, Schuster et al. (2011) reported that researchers most often utilized around 20 trials in each imagery session, and those repetitions positively affected performance tasks. These imagery training reviews described how successful imagery training typically used around 20 repetitions. However, the number of 20 repetitions should be directly compared with larger and smaller numbers of imager task repetitions in a session (e.g., 15 and 25 repetitions), then researchers should gain greater understanding of whether 20 repetitions would be most beneficial in terms of sport skill performance. Therefore, it is important to experimentally examine whether different numbers of repetitions have different effects on sport tasks in terms of enhancing performance.

In recent imagery training research studies, there have been variations in the number of imagery repetitions that researchers have employed in their imagery training programs. In an example of imagery research in rehabilitation, Lebon, Guillot, and Collet (2012) investigated motor imagery effectiveness in 12 patients following surgery on the anterior cruciate ligament, and they randomly allocated seven participants to a motor imagery condition and five participants to a Control condition. The participants in the motor imagery condition created images in which they perceived muscle contractions and joint tension. In each session, they undertook three blocks of 10 images and had a 10-second rest period between trials with a two-minute break between blocks as they engaged in the 12 imagery intervention sessions. Thus, the total number of imagery repetitions per session was 30 repetitions. Results showed that participants in the Motor imagery condition gained greater muscle activation than the Control condition, which indicated that the imagery had positive effects on their rehabilitation from injury. Smith et al. (2019) examined the effects of a PETTLEP imagery intervention on bicep strength. Participants performed two sets of six to 10 imagery repetitions independently until they failed to create any more images, during the imagery training sessions for three sessions per week. Thus, the number of repetitions that participants performed varied between 12 and 20 imagery repetitions per session. Participants increased their bicep strength after the intervention periods, but the variation in number of imagery repetitions means that this study does not give precise information about number of imagery repetitions. It is acknowledged that imagery repetitions was not the focus of the study. Kuan et al. (2018) found that playing relaxing music during an imagery intervention was beneficial for enhancing dart-throwing performance and controlling mental states (reducing anxiety and increasing self-confidence). However, Kuan et al. did not direct the participants to the optimal number of repetitions of imagining the dart throw, and they suggested that not controlling the repetitions of the dart-throwing image in a session was a limitation of the study. In addition, this inconsistency in the number of imagery repetitions might be an influence (in terms of imagery training effects) on performance. Thus, a broad range of imagery repetitions has been employed or not controlled for in imagery training studies that found positive outcomes of imagery, which means that identifying the most effective number of imagery repetitions in an imagery training program is still an important question in imagery training research. Regarding sport skill tasks, Dana and Gozalzadeh (2017) determined whether internal and external visual imagery perspectives affect the accuracy of serve and forehand and backhand groundstrokes of novice tennis players. Dana and Gozalzadeh instructed the participants to create 20 repetitions of each forehand and backhand shot and 40 serve shots by using an internal perspective during each imagery session. After the imagery intervention, players improved their forehand and backhand shots and serve accuracy. Thus, both 20 and 40 repetitions produced significant performance increases in this study. Recent imagery studies have used different numbers of repetitions, and their imagery interventions have had effects on task performance. Notably, they have used different repetitions from fewer than 10 repetitions to as many as 40 repetitions. Thus, examining the most effective number of repetitions for imagery training in terms of making improvements in sport tasks is important. It can provide a clear plan for the implementation of imagery repetitions for athletes, coaches, and sport psychologists.

Post et al. (2015) determined whether a PETTLEP imagery intervention had positive effects on a standing long jump. They compared four different conditions: physical practice (PP), imagery plus physical practice (IP + PP), imagery practice (IP), and a control condition (CON). They designed the research conditions to provide 10 repetitions of one of the following for participants to follow: conducting standing long jump physically, doing so physically as well as utilizing imagery, or using imagery in a two days a week intervention over four weeks; in other words, the PP group attempted 80 physical jumps, the IP + PP group completed 40 imagined and 40 physical jumps (5 imagery repetitions in a session), the IP group completed 80 imagined jumps (10 imagery repetitions in a session), and the CON group undertook a distraction task. They identified that PP and IP + PP resulted in a significantly higher level of performance than the CON group. Conversely, the IP group maintained their performance from pre-test to post-test. Hence, the use of 5–10 repetitions in an imagery session had positive effects in terms of performance improvements, when combined with physical practice, and maintaining performance level, when participants only performed imagery training. Rozand, Lebon, Stapley, Papaxanthis, and Lepers (2016) determined how number of imagery repetitions affected participants' mental fatigue and imagery duration. Participants completed imagery of 100 point-to-point arm movements combined with actual pointing movements every 10 or 50 imagined movements. They reported that mental fatigue was induced during the course of 100 imagery repetitions. Additionally, participants in the condition for conducting actual performance every 10th image had the lowest mental fatigue out of all the intervention conditions. Rozand et al. concluded that a high number of imagery repetitions may increase mental fatigue. Thus, there are several studies that have compared different imagery repetitions in terms of performance improvements. However, these studies neglected to control the key imagery variables of duration and frequency, so the most effective number of imagery repetitions is still unclear.

In conclusion, research on imagery has been characterized by great diversity in the design of studies, involving substantial variation in the number of imagery repetitions per session, which makes it difficult to determine consistent patterns. In the imagery intervention reviews and studies lasting longer than three weeks, the minimum number of imagery repetitions is most likely over five. Moreover, more than 25 repetitions were employed in several studies. However, it should be noted that a high number of repetitions may cause imagers to experience mental fatigue that may lead to a decrease in their concentration level as they imagine the task. These findings would appear to be inconclusive because they do not examine the imagery dose-response relationship of number of repetitions and sport performance in a consistent and systematic way, although researchers interested in refining the study of imagery repetitions may be able to decide target ranges of repetitions by examining the most effective number of repetitions in the previous research that has the strongest designs.

Furthermore, researchers used different volumes of other key variables (e.g., duration of sessions and frequency of sessions per week), which may make it possible to draw conclusions about the most effective intervention volumes. In other words, imagery intervention research has been characterized by great diversity in the design of studies involving variables, especially imagery repetition, which makes it difficult to determine consistent patterns. Researchers have found that imagery training can enhance sport performance, while also stressing that there is still great potential to increase the effectiveness of imagery delivery. Identifying more precise information can provide useful guidance for enhancing performance in many sports training contexts. For example, there are contributions that athletes and their coaches can utilize as they seek the most effective dosages of imagery repetitions for achieving their goals and avoiding mental fatigue that would otherwise be caused by the excessive use of imagery. Hence, researchers should adopt a systematic approach for comparing the number of repetitions of imagery of a task within a session, and control other key imagery variables, such as the duration of sessions, and the frequency of the sessions, that could influence the outcome of imagery training in terms of performance. In addition, the imagery dose-response protocol can make it possible to examine whether different dosages of repetitions have different performance benefits, which is important information for enabling researchers and sport psychology practitioners to decide on their imagery training program design.

A motor imagery review by Schuster et al. (2011) indicated that around 20 repetitions have been used in successful imagery studies, which means that the use of approximately 20 repetitions should be a viable research option. Therefore, researchers should determine the efficacy of using number of repetitions in a range around 20 repetitions for seeking sport performance enhancements. For example, examining 10, 20, and 30 repetitions would be a suitable design in terms of examining the effects of repetitions on imagery dose-responses.

Duration of Imagery Sessions

Another key imagery dose variable that may influence the effectiveness of imagery training is imagery duration in sessions. As defined earlier, ‘duration’ refers to how long an imagery session lasts. It is important to know the most effective imagery duration that is conducive to achieving the best possible imagery quality, considering factors, such as imagers’ capacity to maintain their concentration and rhythm, which are likely to facilitate the imagery creation process.

Feltz and Landers (1983) reported that an MP duration of less than one minute with an effect size of .9, and a duration of 10–25 minutes with effect sizes ranging from .4 to 1.0, was more effective than a 5-minute imagery duration (effect size = .30) for promoting performance. Hinshaw (1991) reported that meta-analyses of the effectiveness research on durations of MP indicated that durations of one minute or less (effect size = 1.11) and of 10–15 minutes (effect size = 1.05) were more effective than 3–5-minute imagery durations (effect size = .31). On the other hand, Driskell et al. (1994) indicated that there was a negative relationship between MP duration and the intervention effect; in other words, increasing the imagery duration negatively affected MP effects. In addition, Driskell et al. reported that the mean was approximately 20.8 minutes with a very large effect size (Fisher's Z = .261). Use of this regression formula, prompted them to advise athletes, coaches, and sport psychologists that effective imagery interventions should last for approximately 20 minutes for sport skill enhancement. Etnier and Landers (1996) examined whether MP and physical practice and intervention duration had an influence on the performance of basketball shooting at recreational levels. They compared 1-, 3-, 5-, and 7-minute MP with 3-minute physical practice. Participants had three trials of basketball shooting and they engaged in two mental and physical practice sessions between trial 1 and trial 2 and between trial 2 and trial 3. The results showed that the 1-minute MP session duration (effect size = .60) or 3-minute MP (effect size = .59) enhanced performance on the task to a greater degree than longer mental training durations of five minutes or seven minutes. This research provided information about how a shorter MP duration has the effect of improving performance. In addition, Etnier and Landers suggested that future MP studies should examine whether the number of shooting repetitions in an imagery intervention session is a crucial variable. However, they only provided two sessions of MP, which means that their findings may not apply to typical imagery training programs applied in sports. Generally, imagery training studies are conducted with more sessions than MP studies (e.g., total sessions and intervention lengths), which means that the findings in MP research may not be relevant to imagery training programs. In addition, the MP reviews of the effectiveness of different durations of sessions neglected the key variable of imagery repetitions per session, which meant that researchers did not examine whether the 1-minute imagery duration is applicable to different numbers of repetitions. For example, successful imagery training studies have frequently used 20 repetitions in a session (Schuster et al., 2011). Although the MP reviews of imagery session duration may provide some preliminary information on what may be effective in imagery training programs, because of differences in the way MP and imagery are operationalised in research and applied practice, researchers should attempt to establish effective imagery session duration in sessions by using the imagery training design.

Paravlic et al. (2018) systematically reviewed motor imagery training in terms of healthy adults' muscle strength facilitation. They reported that a 15-minute imagery duration in a session was the most frequently used with a large effect size, which resulted in a 1.04 effect size improvement in muscle strength. Furthermore, a more prolonged imagery duration than 15 minutes, such as 20 minutes, was also effective at increasing strength. Another systematic literature review by Schuster et al. (2011) addressed the proposal of a number of leading researchers that successful imagery training in sport involves the use of an average session duration of 10 minutes, whereas in some studies a longer imagery duration, such as a 25 minutes, was employed (i. e.,Guillot et al., 2010). Hence, successful imagery training research employed imagery durations of 10 to 25 minutes, which shows that researchers could examine whether these imagery durations were effective. The imagery session duration is one of the key variables for designing an imagery intervention because examining longer imagery durations than 25 minutes may help to determine the concentration level that is required during the process of imagining the task. For example, when imagining a discrete task (e.g., basketball free-throw shooting), a 30-minute imagery duration may be too long; in other words, each image of free-throw shooting lasts for a short duration, but depending on the number of repetitions per imagery session, imagers could have a long interval between images. This type of imagery training design may have a negative impact on imagery quality and increase mental fatigue. Thus, examining the imagery dose-response relationship between imagery session duration and sports performance is important in the sports imagery literature.

Sport imagery research reviews have primarily reported that successful imagery training programs for sport performance have used different imagery durations in their imagery sessions. For example, Fazel et al. (2018) designed their imagery duration to be from five to 10 minutes in their imagery training program for enhancing limited skill basketball players' free-throw shooting accuracy. Smith et al. (2007) provided a PETTLEP imagery intervention for field hockey players, in which participants imagined penalty flick performance daily for five minutes over a six-week period. Rhodes et al. (2018) provided 15-minute booster sessions for professional soccer players, in which the players undertook the four processes of imagery intervention, which are as follows: engaging in conversation, focusing on an area of improvement, engaging in discussion about change, and planning for development. Anuar, Williams, and Cumming (2018) also used the 15-minute imagery duration in a session to examine the effects of internal and external imagery perspectives on tennis skills. In addition, Dana and Gozalzadeh (2017) found that a 15-minute imagery training program had significant effects in the area of improving tennis strokes and serves.

Sardon, Mazaulan, and Mohamed (2016) provided an imagery intervention for on-court and off-court situations for tennis players, and they used a duration of imagery that lasted from 10 to 15 minutes per imagery session. On the other hand, Kuan et al. (2018) utilized imagery of less than 10 minutes for their imagery intervention. Their imagery intervention lasted approximately nine minutes in each session, and it had positive effects on the performance task of dart throwing. Roure et al. (1999) used a 30-minute duration imagery session for 24 intermediate-level volleyball players to examine four different ways of improving the quality of their volleyball serve. They found that the effects of the imagery training on the imagery conditions' participants were positive and the latter significantly improved the quality of their serve receiving.

In conclusion, according to previous imagery training research, various studies have used quite varied durations, which they found to be effective for the tasks, which were mainly discrete closed skills. Moreover, there are no systematic imagery training studies that have investigated the most effective imagery duration in a session for improving sport performance, whereas successful MP and imagery training studies have used imagery session durations of less than six minutes to 30 minutes. In a review of research on imagery session duration in sport, (i.e., Schuster et al., 2011) reported that an imagery duration of around 10 minutes was employed. One reason for this is that imagery duration in a session may depend on the particular sport tasks. For instance, imagining the discrete task of netball shooting might take a very short time for a single shot, whereas imagining a 100-metre freestyle swim would take a significantly longer time. This could explain why different studies might find a range of imagery durations in a session to have an effective impact on a given sport task. However, examining imagery duration in a session on a discrete task is important in terms of providing guidelines for athletes and coaches about how long sessions should last without fatiguing players or wasting valuable practice time. Moreover, there is no systematic experimental research that examines the most effective imagery duration in a session for improving sport performance because previous studies did not control other key imagery dose variables, namely number of imagery repetitions and frequency of sessions per week, in their research protocols. Thus, it appears that, when examining imagery session duration, the range of around 10 to 20 minutes may be suitable, with the goal of enhancing sport performance.

Frequency of Imagery Sessions

The key imagery variable of frequency of imagery sessions is likely to affect imagery training. Although athletes often use imagery before, during, and after physical practice (Cumming & Hall, 2002; Hall et al., 2001), there is no systematic evidence of the precise number of imagery sessions per week that is the most effective for imagery training. In addition, there are no MP reviews or studies to examine the imagery variable of frequency because MP studies usually involve the use of one or two sessions (Driskell et al., 1994; Feltz & Landers, 1983; Kremer et al., 2009; Morris et al., 2004). However, the frequency of imagery sessions per week may have an effect on MP results. Moreover, researchers have identified the most effective number of repetitions and the most influential duration of MP sessions while neglecting the key imagery variable of frequency of sessions per week. For imagery training, studies in which imagery has been effective have used different numbers of imagery training sessions per week. For example, researchers have used one imagery session per week (Rhodes et al., 2018;

Tenenbaum et al., 1995), two imagery sessions per week (Post et al., 2015; Quinton et al., 2014), three sessions per week (Fazel et al., 2018; Sardon et al., 2016), and four or more imagery sessions per week (Calmels, Holmes, Berthoumieux, & Singer, 2004; Smith et al., 2007; Williams, Cooley, & Cumming, 2013; Yue & Cole, 1992).

Systematic reviews have provided a limited amount of information about effective imagery frequencies in imagery intervention studies, but the frequency of imagery sessions per week that is most effective remains unclear. Paravlic et al. (2018) systematically reviewed the effects of motor imagery training on muscle strength facilitation in healthy adults. They reported that the rate of three imagery training sessions per week resulted in the largest improvements in maximal voluntary contraction (effect size = 1.22). In addition, they reported effect sizes in different frequencies of two sessions per week (effect size = 0.42) and five sessions per week (effect size = 0.72). In another systematic review of imagery training in sport, Schuster et al. (2011) reported the number of imagery sessions per week that has been shown to be the most effective in successful imagery intervention research, indicating that a frequency of three imagery training sessions per week is the most effective shown in research. Thus, these reviews support the hypothesis that three imagery sessions per week may be particularly effective in terms of increasing performance in sport tasks. However, in the sport performance research, on studies have examined more than three sessions per week. It is possible that more than three sessions per week would produce a larger effect than three imagery sessions. Thus, researchers should conduct further studies in the area of the imagery dose-response frequency variable, with particular focus on whether the frequency of three imagery sessions per week is more effective in improving sport performance than more than three imagery sessions per week.

Moving from reviews of imagery to examine studies directly, there are many imagery training studies designed with different numbers of imagery sessions per week. In imagery studies of physical strength, researchers have found that one or more imagery sessions per week can have positive effects on athletes' performance during imagery tasks. For example, Tenenbaum et al. (1995) indicated that one imagery session per week over four weeks improved knee extension strength by 9%. Smith et al. (2008) found that a bi-weekly imagery training program lasting for six weeks enhanced golf bunker shots. Smith et al. (2019) reported that a 3-day PETTLEP imagery intervention had positive effects on participants' bicep strength. Yue and Cole (1992) provided five days of imagery sessions for five weeks to increase muscle strength. The results showed that participants increased their strength by 22%. In examining the effects of imagery training on sports skills, Smith et al. (2007) provided a short PETTLEP imagery intervention daily over six weeks for field hockey players, and the participants improved their penalty flick scores. There is evidence that imagery training involving the use of three days of imagery sessions each week has been effective (e.g., Dana & Gozalzadeh, 2017; Kuan et al., 2018). For example, Fazel et al. (2018) determined whether imagery training improved basketball free-throw shooting accuracy during various mental states in limited-skill basketball players. Fazel et al. provided a systematic imagery training program for three sessions per week over four weeks. They found that there were significant improvements in participants' free-throw shooting performance.

In the studies just reported, each study only examined one level of imagery frequency because imagery frequency per week was not the central variable of those studies. Very few researchers have focused on frequency of imagery sessions, manipulating this variable as a key issue in their study. Wakefield and Smith (2009b) empirically examined the effect of different frequencies of PETTLEP imagery on netball shooting. They recruited 32 female participants, whom they assigned to one of three PETTLEP imagery conditions, which involved one, two, or three sessions per week for four weeks, and compared these to a control condition. They indicated that three imagery sessions per week was a significantly more effective frequency for improving performance than one or two sessions. Wakefield and Smith (2011) determined the effect of frequency of imagery sessions per week on biceps curl performance. Their results also indicated that the use of three imagery sessions per week was significantly more effective than one or two sessions per week. Hence, three days of imagery sessions in a week is most likely a more effective imagery frequency than one or two imagery sessions. However, given that these two studies by Wakefield and Smith are the only two studies in the literature, of which I am aware, to compare different frequencies of imagery sessions per week, there is not yet enough evidence to conclude that three imagery sessions per week is the most effective frequency under all conditions. Certainly, it is of note that one study focused on a discrete sport skill and the other focused on a discrete strength task. Nonetheless, there is a need to refine the research and examine more skills and situations. For example, Wakefield and Smith did not systematically control the imagery variables of number of repetitions and duration of imagery sessions, while varying the frequency of sessions per week. Thus, they only investigated a single imagery dose variable, but other imagery variables were not held constant, which means that this research design might have skewed their imagery training results. Moreover, sport psychologists have not examined whether the use of more than three imagery sessions per week might enhance performance more than three sessions. An increase to the number of imagery sessions may provide scope for promoting sport performance. Thus, there is a need for further research to be conducted to determine whether there is a more effective dose in terms of frequency of imagery sessions.

Consequently, based on a review of sport imagery training research, three days of imagery sessions per week has been shown to be an effective frequency of imagery sessions for increasing performance in a sport task and a strength task. However, there are still limitations in this research because the key imagery dose variables of repetitions and duration of sessions have not been held constant across studies, which could have affected the results. In addition, there is evidence of the effects of three sessions per week in previous studies, but there is no rationale regarding the use of frequencies of four sessions or more per week, with the use of an imagery dose-response protocol. Thus, there is scope for further examining the imagery dose variable of frequency of sessions per week for enhancing sport performance by testing the frequency of three imagery sessions per week against larger imagery frequencies (e.g., four and five sessions per week), which could produce superior results.

Imagery Training Program Length

The fourth important imagery variable is imagery training length, which can be defined as the minimum length of time that is required for imagery training to achieve improved sport performance. In a recent systematic review of the literature on motor imagery training in strength tasks in healthy adults, Paravlic et al. (2018) reported that the total imagery training duration of 300 minutes had a larger effect size (1.07) than shorter total imagery durations, and they also indicated that a 4-week period of imagery training was associated with the largest effect size (.88). Schuster et al. (2011) also explained that successful sport imagery training studies used around a total of 200 minutes of imagery training, that is, imagery duration in a session x total number of imagery training sessions). In addition, a total of around 40 days of imagery training are frequently used.

Although different imagery training program lengths have not really been compared in studies, previous imagery training studies have used imagery training programs ranging from four to 16 weeks (Fazel et al., 2018; Rodgers, Hall, & Buckolz, 1991; Sardon et al., 2016). Results of these studies seem to indicate that studies involving all these different lengths of imagery training have a positive impact on sport performances. For example, a 6-week imagery training design had positive effects on field hockey penalty flicks (Smith et al., 2007), using cognitive general imagery in soccer strategy (Munroe-Chandler et al., 2005), golf bunker shots (Smith et al., 2008), grit in soccer (Rhodes et al., 2018), as well as tennis forehand and backhand strokes and serve (Dana & Gozalzadeh, 2017). Guillot et al. (2010) identified that five weeks of motor imagery positively affected synchronized swimmers' flexibility. On the other hand, a duration of more than seven weeks of imagery training was employed in several published imagery training studies, and researchers found positive effects on sport performance (Cooley et al., 2013; Li-Wei, Qi-Wei, Orlick, & Zitzelsberger, 1992; Rodgers et al., 1991; Sardon et al., 2016; Smith et al., 2001). Nevertheless, the 4-week imagery training design has been shown to enhance sport performance (Fazel et al., 2018; Kuan et al., 2018; Post et al., 2015; Wakefield & Smith, 2009b). However, it is important to understand that controlling the three key imagery dose variables of number of imagery task repetitions, duration of imagery sessions, and frequency of imagery sessions per week is essential to make studies of imagery training length (number of weeks) meaningful. For example, using 6 imagery task repetitions during a 2-minute duration imagery session, and one imagery session per week over 6 weeks is a total of 12 minutes of imagery training, including 36 imagery repetitions in total, which may not have imagery training effects, whereas 20 repetitions in a 10-minute imagery session on four occasions each week for 6 weeks is 240 minutes of imagery, including 4,800 imagery repetitions. Both these programs would be 6 weeks long, but there is a massive difference in the amount of imagery experienced. Studies really need to include all the imagery dose variables reported here to make comparisons really meaningful.

In several imagery training studies, researchers have used the 4-week imagery training duration in their imagery training design. Wakefield and Smith (2009b) used three days of imagery training sessions over four weeks for enhancing netball shooting skills. Their results showed that participants had improved their shooting significantly by the end of the 4-week intervention. More recently, Fazel et al. (2018) invited limited-skill basketball players to take a 4-week imagery training program. They found that the participants significantly improved their shooting accuracy. Kuan et al. (2018) also designed a 4-week imagery training program that incorporated the goal of enhancing dart throwing. They reported a significant increase in dart throwing from pre-test to post-test. This rationale of using a four-week imagery training period is feasible and applicable to examining the imagery dose-response relationship among variables in sport.

In summary, previous studies have used different imagery training lengths effectively, although the 4-week imagery training duration may be an appropriate length for enhancing sport performance, as indicated by several researchers who used this length. Furthermore, the 4-week imagery training duration has greater practical utility than longer imagery training programs. One reason for this is that athletes do not need to have such a high level of commitment. Moreover, shorter imagery intervention periods are beneficial in research settings because they can reduce the likelihood of participants dropping out of the intervention through injury or boredom. Nevertheless, the key imagery dose variable of imagery training duration should be examined more systematically in future research by controlling the number of imagery repetitions of the sport task, the duration of imagery sessions, and the frequency of imagery sessions per week. Such research should contribute knowledge by providing clear guidelines about the most effective length of imagery training programs under different conditions that athletes, coaches, and sport psychologists can apply in practice.

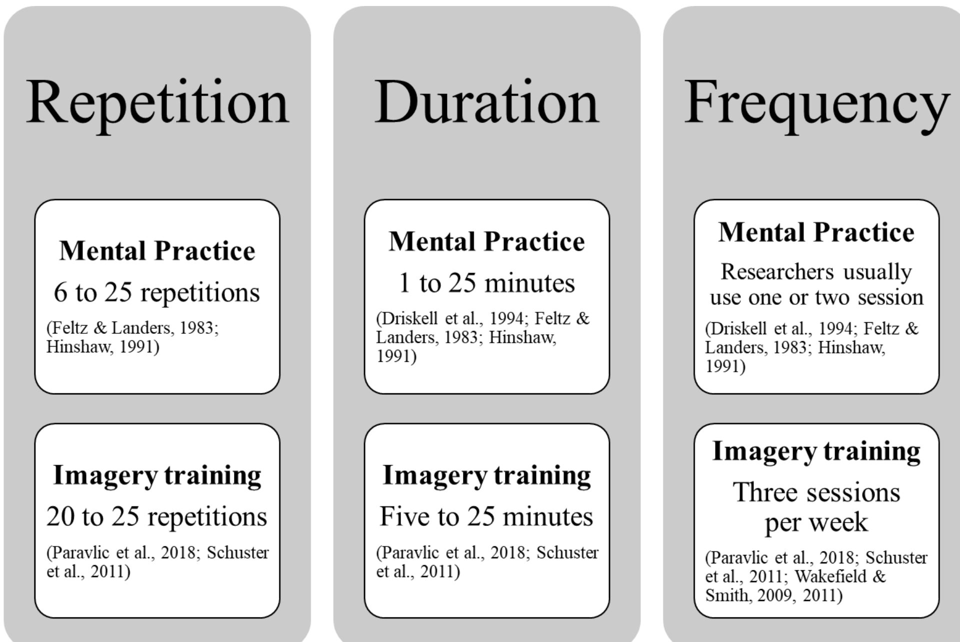
Summary of Dose Response Effects in MP and Imagery Reviews

There are several reviews that indicate the number of imagery repetitions in a session, imagery session duration, and frequency of imagery sessions each week in successful MP and imagery training studies that appear to be more effective. Moreover, the reviews conducted comparisons, examining effect sizes, to compare different numbers of repetitions, durations and frequencies, but in different studies, which varied greatly in a range of factors that might have moderated imagery effects, so they do not provide strong evidence. In this section, I briefly summarise the findings from the reviews of MP and imagery training in order to determine what number of imagery repetitions, imagery session duration, and frequency of imagery sessions have been suggested to be most beneficial for enhancing the performance of sport skills. The conclusions are also presented in a summary in Figure 2.2 where the outcomes for MP are recorded separately from those for imagery training.

In terms of number of imagery task repetitions, the MP and imagery reviews have suggested that the number of repetitions may influence the effective use of imagery by highlighting differences in the effects for different doses. The MP reviews have indicated that less than six repetitions or between 36 and 42 repetitions (Feltz & Landers, 1983) or between 15

Figure 2.2.

Summary of results from reviews and studies of imagery dose response variables of number of imagery task repetitions, duration of imagery sessions, and frequency of imagery sessions per week in MP and imagery training reviews and studies.



and 25 repetitions (Hinshaw, 1991) were most effective. Imagery training reviews have indicated that 20- and 25-repetitions are most effective in the studies conducted in which each study only examined one number of repetitions (Paravlic et al., 2018; Schuster et al., 2011). Thus, it is likely that the most effective dose of repetitions in imagery training may be between 10 to 30 trials. However, there are no studies that have systematically examined whether different numbers of imagery task repetitions have different effects on sport performance under the same conditions than number of imagery repetitions. There is a concern that although imagery is a major topic in sport psychology, it involves diverse characteristics, which means that determining the ideal number of repetitions may be difficult in terms of researching the dose variable of imagery task repetitions. Thus, researchers should seek to identify the most effective number of imagery repetitions in sport performance, especially by comparing numbers of imagery repetitions from 10 to 30 under the same research conditions.

Reviews have also indicated that another key dose variable may be imagery session duration. MP reviews have indicated that MP session durations from 10 to 25 minutes (Feltz & Landers, 1983) or 10 to 15 minutes of MP (Hinshaw (1991) or 20 minutes (Driskell et al. (1994) had greater effects on performance on other session durations tested in studies that these reviewers examined. Similarly, imagery reviews indicate that durations between 10 minutes and 15 minutes have commonly been employed (Paravlic et al., 2018; Schuster et al., 2011). Hence, according to the reviews, a broad range of imagery durations from 5 to 25-minutes may be effective. Thus, it is important for researchers to identify the most effective imagery session durations for enhancing sport performance, especially by comparing durations of imagery sessions from 5 to 25 minutes, under the same research conditions.

For frequency of imagery sessions per week, MP has often only been investigated across one session of practice (Driskell et al., 1994; Feltz & Landers, 1983; Hinshaw, 1991). Thus, the MP literature provides limited information on frequency. Imagery reviews have reported that successful imagery training studies employed 3 sessions per week (Paravlic et al., 2018; Schuster et al., 2011). Moreover, in the only studies I have found to directly compare different levels of an imagery dose variable, Wakefield and Smith (2009b, 2011) examined differences between the effects of frequencies of one, two, and three sessions per week on sport performance. The results showed that the 3 imagery sessions per week frequency was more effective than the one and two sessions per week frequencies. However, researchers have not determined whether a frequency of more than three sessions per week (e.g., four or five days) gives stronger effects. Further, no studies have yet been conducted in which the other key imagery dose variables of number of repetitions, duration of imagery sessions, and length of imagery training have been held constant. Each of these variables has the potential to change the comparative effectiveness of different frequencies of imagery sessions. Thus, the imagery dose variable of frequency of imagery sessions per week should be examined further, by comparing frequencies of imagery sessions from 1 to 5 or more sessions per week, under the same research conditions.

Overall, the evidence from the reviews and the limited research suggests that the effects of these imagery dose variables have not been examined adequately in imagery training, which means that it is as yet unknown which level of each imagery dose variable is most efficacious. In addition, it is not known whether the effectiveness of different levels of each imagery dose variable is moderated by other factors, including age, gender, and skill level of the athletes, and the nature of the sport task. These reviews have also indicated that a range of repetitions, durations, and frequencies have been used successfully in imagery training programs. These provide some indication of imagery dose requirements; however, researchers have not systematically and empirically compared dose-response variables to support the efficacious use of imagery in improving sport performance. Because existing studies have not systematically addressed key imagery variables together there is no basis for judging the most effective imagery dosages of imagery variables that can in turn lead to the most effective designs of imagery training. Consequently, systematically examining and comparing imagery dose variables, particularly number of imagery task repetitions, duration of imagery sessions, and frequency of imagery session per week, is vital in sport imagery intervention research. It is possible that a small increase in commonly used levels of any of these dose variables might enhance performance further. Conversely, it might be that practitioners are recommending larger doses than are required, thus, wasting athletes' time and effort. Sport imagery researchers have not examined the imagery dose-response relationship by using a systematic approach. Furthermore, the absence of systematic control of key variables appears to have increased confusion among the findings that have been generated by researchers of imagery studies of single dose variables.

The Present Thesis

Imagery training programs can improve performance of athletes at all skill levels (Morris et al., 2005); however, to design optimal sport imagery training programs effective dosages of imagery repetitions in a session, imagery session duration, and frequency of imagery sessions per week need to be determined. The literature generally offers no clear guidance as to what may be the appropriate number of repetitions, duration, and frequency of imagery sessions, with a wide range of different doses being employed in imagery training research to date. Hence, researchers should examine the imagery dose-response relationship between the dose variables of repetitions, duration, and frequency of imagery sessions and the response variable of sport performance. Researchers should also examine the optimal doses for other important response variables, including psychological states and injury rehabilitation. (Morris et al., 2012) proposed a new protocol for examining these dose variables in the context of sport performance and psychological outcome variables, in which one dose variable is systematically manipulated within the range suggested to be most promising by previous research, while the other two dose variables are held at constant levels. The first key imagery dose variable is number of imagery repetitions in a session, that is, how many times an imagery task is repeated during an imagery session. The second key imagery variable is imagery session duration, that is, the length of time that is chosen for one imagery session to be conducted. The third key imagery dose variable is frequency of imagery sessions per week, which is how many sessions of imagery training that are provided for participants in one week.

The length of an imagery training program or imagery intervention, such as a 4-week, 6-week, or 8-week program is another potential imagery variable; however, this is not explored in this thesis. In this thesis, the length of the training program is held constant at four weeks. Previous research on imagery interventions has indicated that interventions of four weeks in length appear to be the most successful (Fazel et al., 2018; Morris et al., 2005; Schuster et al., 2011). The variable of the imagery training program length is not modified in this thesis due to time constraints and resource implications in completing the thesis and because I consider that determining effective levels of the three variables of repetitions, duration, and frequency may be more important than determining the imagery training length for the reason that these are the main components that shape the design of an imagery intervention, so they should precede study of imagery length, which should be studies once number of repetitions, duration of sessions, and frequency of sessions per week have been clarified.

The purpose of the present thesis is to examine whether different dosages of each imagery variable affect sport performance. In three studies, I systematically vary one imagery dose variable, but hold the other two imagery dose variables constant, as I compare the effect on basketball free-throw shooting (FTS) performance of three imagery training conditions and a Control condition. The studies all maintain the same design to maximize the potential for comparison, manipulating just one imagery dose variable. Thus, in each study, one of these imagery dose variables was varied systematically, whereas the other two variables were held constant. In Study 1, I examined the effects of the number of imagery task repetitions in imagery training sessions on FTS performance, while the imagery duration and frequency dose variables were held at a constant level. In Study 2, I tested the effects of different imagery training session durations on FTS performance, while holding repetitions constant at the most effective number of repetitions from Study 1 and keeping the frequency of sessions per week constant. In Study 3, I investigated the effects of different frequencies of imagery training sessions per week, on FTS performance, using the most effective imagery session duration and the most effective number of repetitions of sessions per week from Studies 1 and 2, respectively.

Addressing the length of the training program or intervention is a difficult and potentially less important variable to investigate as imagery is an ongoing practice and development activity. For example, in physical practice, optimally a learner does not stop practicing a skill after four sessions because the development of the skill requires longer practice periods (Baker & Young, 2014; Magill & Anderson, 2017; Spittle, 2013; Thomas, 1994). It would also be expected that athletes would continue to use imagery to practice and refine their skills. Designing and constructing an imagery training program relies on manipulation of the number of repetitions, the duration of a session, and the number of sessions per week. Therefore, further research on understanding the characteristics of the imagery dose-response relationship in imagery training is a critical element in ensuring the effectiveness of imagery training delivery. Hence, I examine those imagery variables to find the most appropriate dosages of imagery for enhancing performance.

Due to the absence of any previous systematic comparison for the most effective numbers of imagery repetitions, session duration, and frequency of sessions per week for improving sport performance, I do not propose specific hypotheses. Hence, I am not able to make any predictions. This does highlight the originality of the present research. However, I set the null hypothesis in each study, depicting the expectation that there would be no significant differences between the three imagery intervention conditions, although I decided the dosages of imagery for examining each variable in accordance with previous imagery training studies and reviews in sport psychology.

Understanding the three imagery dose variables of repetitions, duration, and frequency of imagery sessions should provide useful implications for performance facilitation in sports imagery training contexts. Thus, athletes and coaches should obtain more precise information about the most effective imagery dosages for designing imagery training programs to achieve performance goals. Researchers have reported that athletes frequently use imagery in their sport with limited information and experience (e.g., Hall et al., 1990; Munroe et al., 2000), so it is likely that athletes adopt various misunderstandings in their use of imagery. For example, athletes may believe that a larger number of imagery repetitions of the sport task in sessions of the same duration might be more effective than a small imagery dosage in terms of enhancing their performance. However, researchers have reported that a very large number of imagery repetitions might be counterproductive (Rozand et al., 2016), especially if a high number of repetitions causes physical or mental fatigue, reduced motivation, or boredom. Furthermore, if studies are conducted over a number of imagery sessions, the frequency of sessions is likely to influence outcome variables, such as performance, confidence, or motivation, for the same duration of sessions. This is because elite athletes usually train physically for their sport more than five days per week and they might apply their physical training schedules to their use of imagery. Thus, with new knowledge about how much imagery is enough, sport psychologists should be able to provide practical imagery training programs for athletes in a more efficient way.

The imagery dose-response protocol is a new approach in sport imagery training research, which is highly original in the present thesis. In the results of reviews of meta-analytic MP research, reviewers have reported some promising effect sizes, especially for numbers of imagery task repetitions in sessions and MP duration of sessions (e.g., Driskell et al., 1994; Feltz & Landers, 1983). It has been suggested that researchers and practitioners can apply the results of these reviews for designing their MP programs. However, there are no imagery training studies that have identified the effective volume of imagery in terms enhancing sport performance; in other words, there are no clear guidelines in designing imagery training programs. Nevertheless, the present thesis should support the new protocol, if there are positive results in terms of enhancing sport skills. Moreover, introducing the systematic research design in sports imagery research, should encourage researchers to apply it in further studies, with the aim of understanding the dose-response characteristics of imagery in sport.

I propose that examining the imagery dose-response relationship between the dose variables of number of imagery task repetitions in a session, duration of imagery sessions, and frequency of imagery sessions per week and the response variable of imagery task performance has the potential to make a noteworthy contribution to imagery training research and practice.

The general aim of this thesis is to examine the imagery dose-response relationship between three imagery dose variables, namely number of imagery task repetitions in a session, imagery session duration, and frequency of imagery sessions per week, and basketball FTS performance. This is achieved through three specific aims.

1. The aim of Study 1 is to examine the effect of the number of imagery task repetitions on basketball FTS performance, while holding the imagery session duration and imagery session frequency per week of the imagery training program constant (Study 1).

2. The aim of Study 2 is to examine the effect of different imagery session durations on basketball FTS performance, while holding the number of imagery task repetitions and imagery session frequency per week of the imagery training program constant (Study 2).

3. The aim of Study 3 is to examine the effect of different imagery session frequencies per session on basketball FTS performance, while holding the number of imagery task repetitions and imagery session duration of the imagery training program constant (Study 3).

CHAPTER 3

STUDY 1: Examining the Repetition Component of the Imagery Dose-response Relationship

Introduction

The purpose of Study 1 was to examine whether different numbers of imagery repetitions (10, 20, and 30 repetitions) affect performance of basketball free throw shooting (FTS) to a different extent. The number of repetitions as the dose factor of an imagery task in a session is likely to influence the imagery training effect. In a review of imagery in sport and movement, Feltz and Landers (1983) reported the benefits of MP studies psychologically (e.g., imagery ability) and physically (e.g., increased strength, less performance error). In addition, they indicated that either six or fewer repetitions, or 36 to 42 repetitions had higher effect sizes than other numbers of repetitions. Hinshaw (1991) indicated that 15 to 25 trials were the most effective repetitions to improve performance in MP. Paravlic et al. (2018) reviewed the impact of motor imagery practice on muscle strength. They reported that 25 repetitions per session was the most effective with the largest effect size (1.18). In addition, in a review of sport imagery training research, Schuster et al. (2011) concluded that researchers often used around 20 repetitions in an imagery session for effective outcomes on performance tasks. These research reviews indicated positive numbers of repetitions in both of mental practice and imagery interventions in which researchers used a minimum of 10 repetitions and a maximum of approximately 30 repetitions. Recently, however, imagery training researchers have still used different numbers of repetitions from less than 10 repetitions up to as many as 40 repetitions, and their imagery interventions had significant effects on the performance tasks they studied (e.g., Dana & Gozalzadeh, 2017; Lebon et al., 2012; Smith et al., 2019). Although, these effective numbers of repetitions were not empirically compared because they were not the focus of these studies. Kremer et al. (2009) empirically approached the question of repetitions of MP in a study with a pre-test, intervention, post-test design. They compared three different numbers of MP repetitions of dart-throwing with physical practice for 25, 50, and 100 trials, respectively. Results showed that dart-throwing scores for all three imagery conditions improved significantly more from pre-test to post-test than scores for the control condition. There were no significant differences between any of the imagery conditions. Kremer et al. only gave participants one imagery session, whereas most studies have used multiple imagery sessions over several weeks (Post et al., 2015; Quinton et al., 2014; Smith et al., 2008). In other words, researchers have not identified the most effective number of repetitions in a session during imagery training programs that are similar to programs used in applied settings. Research on imagery has been characterised by great diversity in the design of studies involving variables like number of repetitions, which makes it difficult to determine consistent patterns. Thus, I adopted a systematic approach for comparing the number of repetitions of imagery of a task within a session, while controlling other key imagery dose variables, namely duration and frequency of sessions, that could influence the outcome of imagery training in terms of performance. Moreover, I had no basis in theory or research to propose a formal hypothesis for the most effective number of imagery repetitions because previous research has not controlled other relevant dose variables systematically. Based on previous research, however, I chose to examine number of repetitions in the range between 10 and 30 repetitions, which researchers have previously reported to be effective.

Method

Participants

I invited basketball players from Melbourne, Australia to volunteer to participate in this study via recruitment flyers (Appendix A). A total of 36 male participants with a mean age of 25.17 years (*SD* = 4.26) completed the Imagery intervention or Control condition. The sample size was based on power analysis and previous research. With a significance level of .05, power of 70%, and a large effect size, the G Power analysis software indicated 60 to 80 participants would be appropriate. However, previous research on the effects of imagery dose variables on performance of discrete tasks typically has shown a large effect size with smaller samples. For instance, Wakefield and Smith (2009b) recruited 32 female university students, and divided them into three imagery conditions and a control condition. With that sample size, they found effect sizes for 1-day, 2-day, and 3-day frequency, *d* = .84, .71, and 1.82, which are large and very large effect sizes. Given the duration of intervention studies, I decided to test for significance at a sample size equivalent to previous studies. I only recruited male players because researchers have found significant gender differences in imagery ability and imagery training effects (Burhans, Richman, & Bergey, 1988; Munroe-Chandler, Hall, Fishburne, & Strachan, 2007). I avoided the bias of gender differences in examining imagery dose-response because its influence may affect data analysis and statistical results.

Participants were all basketball players in their local basketball club or university basketball club, or played recreational basketball in their community at least once every week. They reported that they had no previous experience of systematic imagery training to improve their basketball free-throw shooting (FTS) performance. I set eligibility criteria to ensure adequate skill level in FTS and imagery ability. For FTS skill, which had a score range between 0 and 120, I set performance criteria of FTS accuracy for inclusion as participants in this study between a minimum FTS score of 49 (41% FTS accuracy) and a maximum FTS score of 72 (60% FTS accuracy) at pre-test. This range was chosen because participants are likely to benefit more from imagery if they have a moderate level of basketball free-throw shooting skill at pre-test. At the same time, their skill level must not be so high at pre-test that they cannot improve much by post-test due to a ceiling effect (Hall et al., 2001) . For imagery ability, I set eligibility criteria at a minimum imagery ability score of 150 out of 400 on the Sport Imagery Ability Measure (SIAM) key dimension subscales (vividness, control) and sense modality subscales (visual, kinaesthetic, tactile, and auditory), based on the expectation that these modalities are important for basketball FTS performance.

Study Design

The aim of this study was to examine which of three imagery repetition conditions had the greatest effect on FTS performance. Hence, I utilized a pre-test, intervention, post-test experimental design to compare the effectiveness of the three doses of imagery repetitions for improving FTS performance. I manipulated the dose variable of repetitions systematically, while two other key dose aspects, namely duration and frequency, were held constant. In this study, I employed three imagery intervention conditions, 10 repetitions, 20 repetitions, and 30 repetitions, and a control condition, in which participants did no imagery, but performed the FTS tests at the same times as participants in the three imagery conditions. First, I gave participants an Information Statement, describing what they would be expected to do in the study (Appendix B for the Imagery conditions and C for the Control condition). After answering any questions they had, I asked them to sign an Informed Consent Form, if they were willing to volunteer for the study (Appendix D and E). Then, following administration of the SIAM to screen for at least moderate imagery ability, I conducted a FTS pre-test for all four conditions. Then, in the 4-week imagery training period, there were 12 imagery training sessions (three times a week for four weeks), while control participants had no imagery training. I measured FTS of participants in all three Imagery conditions and the Control condition at the end of each week, after participants in the three Imagery conditions had completed the three imagery sessions for that week. I then tested all participants one week later, when Imagery condition participants had no further imagery sessions, to examine retention of any effects of imagery training.

Measures

Demographic Form. This form was used to gather information about age, gender, basketball performance level, years of competition performance, and number of basketball competitions in which participants were participating at the time of the study (Appendix F).

Sport Imagery Ability Measure (SIAM; Watt et al., 2018; Watt, Morris, & Andersen, 2004b). I used the SIAM to screen for at least moderate imagery ability in the visual, kinaesthetic, tactile, and auditory sensory modalities and the vividness and control dimensions. This measure has a three-factor framework, with a general imagery-ability factor leading to image generation, feeling, and single-sense factors that are based on five individual dimensions (vividness, control, ease, speed, and duration of images), six sense modalities (visual, kinaesthetic, auditory, tactile, gustatory, and olfactory senses), and the emotion associated with imagery. Following a practice scene, the SIAM includes four generic sports scenes (Appendix G). Participants decide on a sport, in this case basketball, and generate specific imagery of their own performance that is consistent with the scenes for 60 seconds for each scene. After each scene, they respond by rating items representing each dimension, sense modality, and emotion by placing a cross on a 100-mm analogue scale. Measuring the location of the cross from 0 (*left end of the line, representing no imagery on that subscale*) to 100 (*right end of the line, representing very rich imagery on that subscale*) then adding scores on the four scenes from each subscale produces a score from 0 to 400 for imagery related to each of the five dimensions, six sense modalities, and emotion. In the validation test internal consistency alpha values for the 12 sub-scales were between .66 and .87.

Basketball free-throw shooting (FTS). I measured basketball FTS performance at pre-test, at the end of each of the four weeks of imagery training, and one week after imagery training ended, according to official basketball rules 2014 and the official basketball rules 2014 basketball equipment guidelines (FIBA, 2014a, 2014b). Players shot at the basketball ring from the free-throw line, which was the competition standard 4.225 metres from the basket. The basket was 3.05 metres from the ground and the ring had a diameter of 450 mm to 459 mm. The basketballs were standard men's competition basketballs with a diameter between 749 mm and no more than 780 mm (size 7) and weighing from 567g to no more than 650g. Accuracy of FTS was measured at pre-test and at the end of each week, Weeks 1, 2, and 3, post-test in Week 4, as well as in a retention test at the end of Week 5. Before completing the FTS test, participants had 10 warm-up shots. The FTS test comprised 40 FTS shots with a break of 2 minutes after the first 20 shots to minimize the risk of fatigue. The scoring system I utilized gave a score of 3 points for a clean basket, 2 for the ball going in the basket off the ring, 1 for the ball missing the basket off the ring, and 0 for the ball completely missing the basket. The total score for each test was calculated by summing the scores for the two sets of 20 shots to give a range from 0 to 120

(Appendix H). This scoring system identifies small increases in accuracy over the kind of limited period of time often used by necessity in research, when significant change in the number of baskets scored is unlikely. This system has been used in previous research (De Groot, Balvers, Kouwenhoven, & Janssen, 2012; Fazel, 2015; Neumann & Hohnke, 2018). Participants were instructed to shoot for clean baskets at all times and not to aim to rebound off the backboard.

Imagery log and imagery manipulation check. I gave participants a self-report imagery log (Appendix I), in which I asked them to list the date, time, and duration of all imagery sessions to check whether they competed imagery sessions as instructed. Furthermore, I verified participants' imagery experiences by asking them to fill out a manipulation check form after every FTS imagery session. In the manipulation check form I asked participants how well they imagined FTS, and how well they saw and felt the images, using 5-point Likert scales from 1 (*not at all*) to 5 (*very much*) for the independent questions about visual and kinaesthetic imagery (Appendix J). Moreover, I checked whether participants did any extra imagery training sessions by asking them at the end of each week.

Physical practice log. Participants maintained a physical practice log by recording the date, time, and duration of practice sessions. I also asked participants to make any comments on their basketball free-throw shooting training to verify practice they completed during the imagery intervention period (Appendix K).

Imagery Intervention Conditions

I assigned participants randomly to one of three Imagery interventions, involving 10, 20, or 30 repetitions of imagery of FTS, or a no imagery training control condition. All Imagery condition participants followed the same instructions for imagery, only varying in terms of the number of repetitions. I held duration of imagery sessions constant at 10 minutes in all three Imagery interventions, a duration found to be effective in previous research (Schuster et al., 2011). I held frequency of sessions constant at three sessions per week, a level found to be significantly more effective than one or two sessions per week in previous research (Wakefield & Smith, 2009a; Wakefield & Smith, 2011). To control the number of repetitions participants imaged, I managed imagery training by using MP3 players. Participants completed the imagery sessions on their own, using a MP3 player on which they followed audio instructions to imagine FTS. Participants followed audio instructions to imagine FTS corresponding to the condition to which they were assigned. The three imagery conditions differed in the number of repetitions completed during the 10-minute sessions.

Based on previous research (Schuster et al., 2011), imagery conditions were 10, 20, and 30 repetitions per imagery session. I controlled repetitions of imagining FTS by the use of auditory signals to cue imagery. Participants imagined one FTS after each auditory signal. The auditory signal occurred every 60 seconds, 30 seconds, and 20 seconds in the 10-, 20-, and 30-repetition conditions respectively. After imagining each FTS, participants completed the imagery manipulation check. Participants in the 10 and 20 repetition conditions conducted an additional cognitive interference task, which was designed to prevent them from completing more imagery of FTS during the time between trials until the next auditory signal and planned imagery repetition. The cognitive interference task was presented throughout the duration interval, except for the designated imagery periods. For the cognitive interference task, participants listened to colour words (e.g., red, blue, and green) continuously until the next imagery repetition of FTS. However, I occasionally included words that are not colour names, but had close associations with a colour (e.g., snow, cherry) in the audio list. I instructed participants that when they heard a word that was not a colour name, they were to write the word in the blank box on the imagery experience check sheet. The cognitive interference task was intended to occupy participants' attention, but not be highly cognitively demanding, so that participants would be able to maintain their concentration during the imagery training. I used a bouncing basketball sound as a signal of the end of the cognitive interference task, which indicated to participants that they could prepare for the next repetition of imagery of FTS. Thus, I provided different numbers of repetitions and interval durations in each Imagery condition, and I designed evenly spaced intervals across the duration of each session.

Pilot testing was conducted with four basketball players (recreational and competitive level players) and one basketball coach to identify, refine, and resolve any problems with this imagery delivery method. Participants in pilot testing provided crucial feedback regarding the start timing of the imagery script, auditory signals, and the cognitive interference task on MP3 players in the imagery interventions. Thus, the imagery delivery process in each imagery condition was tested and refined in pilot testing.

The imagery script was based on scripts used by Fazel (2015); Fazel et al. (2018) in a study of FTS with participants of similar skill level to those in the present study. The script described the flow of basketball free-throw shooting, using multiple senses and emotion. I developed the script with the assistance of individuals who were knowledgeable about basketball shooting. The skill level of basketball players in the present study meant that they had competent FTS technique, so, in the imagery script, I was able to instruct participants to imagine FTS, using correct technique and leading them to imagine an outcome of a clean basket with each repetition of the FTS. Additionally, I instructed players to use all the senses as appropriate in imagining the

FTS. The structure of the audio guided the number of repetitions, their timing and frequency, and the duration of the sessions, so that the imagery script was short and simple. I instructed participants to use an internal imagery perspective, also known as a first-person perspective, and to imagine FTS performance consistently. Further, I encouraged participants to include all their senses and emotion as they would when performing the physical FTS activity, in order to have the clearest and richest image of FTS.

Participants first imagined themselves on the basketball court, standing at the free-throw line, and then they imagined checking the basketball ring. They then imagined the feel of the basketball in their hands, using their tactile sense to imagine feeling the dimples on the basketball. After that they imagined seeing the ring, bending their knees to get power in their legs, and having steady body posture. Finally, they took all the power in their legs, up through their body to release the ball properly toward the net and experienced the positive emotion after successfully making a clean basket. I conducted pilot testing before data collection, especially to check whether participants imagined FTS correctly. This script was repeated 10 times for Condition 1, 20 times for Condition 2, and 30 times for Condition 3 in each of 12 imagery sessions in the intervention phase with no changes to the script (Appendix L).

Control Condition

Participants in the Control condition completed all measures, except for the imagery log and manipulation check, at times that corresponded to testing of participants in the three Imagery conditions. However, they did not undertake imagery training sessions.

Procedure

I recruited participants from local basketball teams in Melbourne after receiving approval from Victoria University Human Research Ethics Committee (VUHREC). Before participation, I conducted standard informed consent, and explained what participants were asked to do in the study, the risks of participating, and benefits for participants. I encouraged participants to ask questions and answered them to the best of my ability. After receiving the signed consent form from participants, I conducted the pre-test in which participants completed the Demographic Form, the SIAM, and the FTS test. All participants scored at least 150 in the key imagery variables (vividness, control, visual, kinaesthetic, tactile, and auditory), and achieved FTS points between a minimum of 41% (score = 49) and a maximum of 60% (score = 72). Next, I randomly allocated participants to Imagery training conditions or the Control condition. After all measurements at pre-test, I met each participant in the Imagery conditions individually in a quiet room. I conducted an introduction to imagery, in which I explained what is known about imagery in sport, especially how imagery works, imagery use in basketball, and imagery ability to motivate participants to undertake the imagery training and guide them to utilise their imagery precisely and with more understanding, which is based on the three-stage strategy of Psychological Skill Training (PST) (Weinberg & Gould, 2019). In addition, I asked participants to involve all their senses during imagery and follow the audio instructions carefully to create the most realistic images during the 4-week, imagery-training program. Control condition participants did not have any individual meetings.

Participants in the three imagery conditions undertook the 12 imagery training sessions over four weeks (three times a week), each session lasting around 15 minutes, including preparation for five minutes and actual imagery training for 10 minutes using an audio track on the MP3 player I gave them, which helped them to undertake the imagery training correctly by themselves. At the end of each FTS imagery session, I asked participants to comment on their experience of doing imagery during that session in the imagery logbook, as an imagery manipulation check. Additionally, I asked participants in the imagery conditions to log the date and time of each imagery session. Moreover, I verified the total time of participants' basketball practice during the imagery intervention period from participants' response to the physical practice log. After the 4 weeks imagery training, I asked participants to bring the MP3 players at post-test day. All participants completed the FTS test again at the end of each week of imagery sessions and completed the follow-up FTS test at the end of Week 5, during which there were no instructions to perform imagery. Finally, I had a social validation check with all participants individually on their experience of the whole study by nature of the interview questions (Hrycaiko & Martin, 1996). After Control condition participants completed the study, I offered to give them the imagery-training program.

Analysis

In order to check whether there were any differences in imagery ability at pre-test, I conducted a multivariate analysis of variance (MANOVA) on all 12 SIAM subscales. To determine whether there was any pre-test difference between FTS scores for the four research conditions, I conducted one-way analysis of variance (ANOVA) on pre-test FTS scores.

Prior to undertaking the main analyses, I examined the data from the logbook of total physical practice time during the five weeks of the study, using one-way ANOVA, to check whether there was any systematic difference between the four conditions in the amount of physical practice participants undertook. Further, to ensure that participants in the three imagery conditions did perform the number of imagery repetitions that had been assigned to them, I examined whether there were differences in imagery quality for each imagery condition from Week 1 to Week 4, as well as the differences between conditions, reported in the Likert scales from 1 to 5 used in the manipulation check, by using a mixed design two-way ANOVA. Thus, I tested three imagery conditions (10, 20, and 30 imagery repetitions) and six occasions (repeated measures pre-test, Week 1, 2, 3, and 4, and retention test), as well as the conditions x occasions interaction effect.

I calculated means and standard deviations for the FTS scores in each week for the four research conditions at pre-test, Weeks 1, 2, 3, post-test in Week 4, and retention test in Week 5. I examined whether there were significant differences in the changes in FTS accuracy between the four research conditions at pre-test, Weeks 1, 2, 3, and post-test (Week 4), and retention test (Week 5), by using two-way, mixed-design ANOVA, that is, four conditions (10-, 20-, 30-imagery repetition conditions, and the Control condition) and six occasions (repeated measures at pre-test, and Weeks 1, 2, 3, 4 and retention test), as well as the conditions x occasions interaction effect. In addition, I used a pre-post test mixed design ANOVA to determine whether different imagery repetitions affect basketball FTS enhancements. This was based on previous studies (Kremer et al., 2009; Wakefield & Smith, 2009b). This is because, the extent of variability in the 6-occasion ANOVA reduced significance effects from pre-test to post-test. Thus, I tested the two key occasions, namely pre-test and post-test to examine effects of the research conditions on FTS performance in this study. I examined FTS performance in the four research conditions at pre-test and post-test in Week 4 by using two-way, mixed-design ANOVA, that is, four conditions (10-, 20-, 30-imagery repetition conditions, and the Control condition) and two occasions (repeated measures at pre-test and post-test), as well as the conditions x occasions interaction effect.

I used the Statistical Package for the Social Sciences (SPSS: version 23.0) software to calculate means and standard deviations, and MANOVA and ANOVA for all scales and scores, including *F*-tests, probability (*p*) values, and effect sizes, represented by eta squared (η^2). I followed up significant differences with the Tukey HSD post-hoc test to identify the location of main effects of conditions, main effects of occasions, and interaction effects.

Results

The aim of the present study was to investigate three different levels of imagery repetitions, namely 10 repetitions, 20 repetitions, and 30 repetitions in each imagery session. I compared them to each other, as well as to a Control (no imagery) condition, in terms of improvement in basketball FTS from week to week throughout the study. All participants completed the imagery ability measurement, using SIAM, and the FTS pre-test before four weeks of imagery training, comprising three sessions per week. While imagery repetitions were varied in this way, in this study, I applied a new systematic approach to the examination of the imagery dose-response relationship, in which, while number of repetitions was varied, two more key aspects of the imagery dose, namely the duration and frequency of sessions, were held constant at levels suggested to be optimal by the limited research that has been conducted on these variables. Results of the analyses are presented in this section. First, I present the descriptive results for SIAM and the comparison of SIAM subscales at pre-test, using MANOVA. Second, I report the comparison of total practice time, and the imagery manipulation check for each week by using one-way ANOVA. Finally, I report examination of gain scores, using mixed-design, two-way ANOVA, that I conducted to compare FTS scores between the four conditions, first, on all six occasions from pre-test to retention test, then on two occasions, namely pre-test and post-test.

Imagery Ability

I examined whether all participants had appropriate levels of imagery ability on the imagery ability subscales of SIAM that are considered to be most influential in imagery related to movement, based on theory and research (Fazel et al., 2018; Kuan et al., 2018). These are the auditory, visual, kinaesthetic, tactile, control, and vividness subscales. Additionally, I analysed imagery ability results to check whether there were any significant differences between the four research conditions on the SIAM subscales. Means and standard deviations are presented in Table 3.1. All participants' key imagery ability subscale scores exceeded the requirement of minimum imagery ability scores for participation in this imagery training study of 150 out of 400. I ran a one-way MANOVA for all 12 SIAM subscales between the four research conditions. There was no significant difference in SIAM results between conditions, F (9, 36) = 1.085, p = .38; Wilk's Λ = .527, partial η^2 = .02. Therefore, there were no significantly different SIAM scores between the four research conditions at the start of the study.

Table 3.1

Means and Standard Deviations of Six Key SIAM Subscale Scores

SIAM subscales	CONDITION	*M*	*SD*
AUDITORY	10 repetitions	283.88	44.10
	20 repetitions	310.00	80.59
	30 repetitions	283.22	75.53
	Control	304.33	112.68

VISUAL	10 repetitions	326.50	75.55
	20 repetitions	366.75	62.78
	30 repetitions	337.89	93.24
	Control	343.56	104.53
KINAESTHETIC	10 repetitions	258.00	93.78
	20 repetitions	272.38	57.60
	30 repetitions	293.00	75.27
	Control	320.00	119.60
TACTILE	10 repetitions	290.63	93.78
	20 repetitions	272.38	57.60
	30 repetitions	293.00	74.26
	Control	326.44	103.53
CONTROL	10 repetitions	306.25	87.90
	20 repetitions	343.13	64.33
	30 repetitions	290.56	106.36
	Control	284.89	92.47
VIVIDNESS	10 repetitions	326.75	70.03
	20 repetitions	366.75	62.78
	30 repetitions	306.67	84.38
	Control	322.33	75.11

Total Practice Time

I recorded participants' practice time for each week, using the physical practice log, to examine whether participants in different conditions did equivalent amounts of basketball practice hours during the 5-week study period. For the 10 repetitions condition, the mean was 18.22 (*SD* = 4.05), for 20 repetitions it was 18.00 (*SD* = 7.98), and for 30 repetitions it was 17.89 (*SD* = 7.56), and for the Control condition it was 16.44 (*SD* = 4.00). One-way ANOVA to compare the total practice hours in all conditions during imagery training periods showed no significant differences between conditions F (3, 32) = .153, p = .93 η^2 = .001 with a small effect size, indicating that practice hours were equivalent for all conditions over the study period.

Imagery Manipulation Check

I checked that participants performed the correct number of imagery repetitions, and observed their subjectively perceived quality of imagery, based on rating scale responses on the 5-point Likert scales (Table 3.2). In addition, participants in the 10- and 20-repetitions conditions reported more than 95% of the non-colour words, showing that participants in both conditions did concentrate on the interference task. There was no systematic difference between research conditions in terms of the number of sessions of imagery that participants undertook. Further, all participants reported that, in all sessions, they performed the number of imagery repetitions that they were assigned to do. The mixed design, two-way ANOVA revealed that there was no significant main effect of conditions, F (2, 24) = .383, p > .05, η^2 = .03, with small effect size. On the other hand, there was a main effect of occasions, F (3, 72) = 7.323, p = .001, η^2 = .23, with very large effect size. In addition, I did not find a significant interaction effect between conditions and occasions, F (6, 72) = 1.233, p > .05, η^2 = .09, with large effect size. Hence, participants in all imagery conditions reported improvements in their subjective assessment of the quality of FTS images from Week 1 to Week 4, but there were no significant differences between imagery conditions.

In terms of social validation check, all participants told that they understand all aspects of the study. Thus, all participants took the imagery training program appropriately.

Table 3.2

Means and Standard Deviations in the Imagery Manipulation Check Scores for Imagery Conditions on Weeks 1 to 4

	Week 1		Week2		Week 3		Week 4	
Conditions	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
10 repetitions	3.38	.85	3.17	.83	3.53	.74	3.44	.69
20 repetitions	3.07	.48	3.16	.40	3.51	.59	3.59	.43
30 repetitions	3.13	.41	3.00	.61	3.14	.72	3.39	.52

Performance Outcome

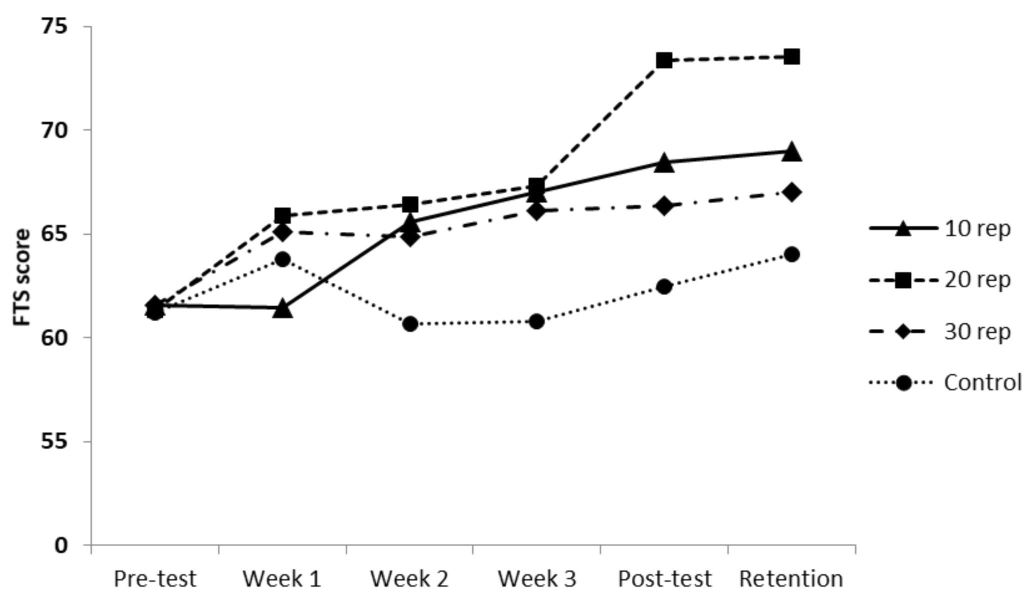
The raw FTS means and standard deviations in all four conditions on six occasions of testing (pre-test, Week 1, 2, 3, post-test, and retention test) are presented in Figure 3.1. All three imagery conditions had higher FTS scores at the post-test than the pre-test, but the Control condition did not improve their FTS scores. The figure shows all conditions' FTS scores in each week. The 20- and 30-repetitions imagery conditions improved their FTS scores gradually week by week, starting in Week 1, whereas the 10 repetitions condition's FTS improvement only started from Week 2.

I utilised one-way ANOVA to test whether there were significant differences between FTS scores for the four research conditions at pre-test. There were no significant differences at pre-test, F (3, 35) = .065, p = .98, η^2 = .01, with small effect size. Therefore, all three Imagery training conditions and the Control condition were equivalent at pre-test.

In terms of the results involving six occasions, two-way, mixed-design ANOVA showed that there was no significant main effect of conditions, F (3, 32) = .741, p > .05, η^2 = .07, with a large effect size. There was a significant main effect of occasions, F (5, 160) = 6.048, p < .001, η^2 = .16, with a very large effect size. There was no significant interaction effect between occasions and conditions, F (15, 160) = 1.196, p > .05, η^2 = .10, with a very large effect size. Tukey post-hoc tests revealed that FTS means at post-test (p = .001) and retention test (p = .001) were significantly higher than at pre-test.

Figure 3.1

Free Throw Shooting Scores of the 10-, 20-, and 30-repetitions and Control Condition on Six Occasions



For the results with two occasions (pre-test and post-test), two-way, mixed-design ANOVA showed that there was no significant main effect of conditions, F (1, 32) = .888, p>.05, η^2 = .08, with a large effect size. There was a significant main effect of occasions, F (1, 32) = 20.996, $p < .001$, η^2 = .40, with a very large effect size. There was a significant interaction effect between occasions and conditions, F (3, 32) = 3.149, $p < .05$, η^2 = .23, with a very large effect size. Hence, I found significant results for the main analysis of effect of number of repetitions on FTS performance with the sample size of 36, so that I stopped recruiting participants at that point.

Tukey post-hoc tests for the ANOVA comparing pre-test with post-test performance revealed that the 20 Imagery repetitions condition had a significantly higher FTS mean than the Control condition (p = .046) at post-test. Additionally, it showed that the 10-repetitions condition significantly improved their FTS score from pre-test to post-test (p = .043) and the 20-repetitions condition showed significant improvement of FTS at post-test (p = .001). However, the 30-repetitions condition and the Control condition did not show significant improvements of FTS between pre-test and post-test.

Discussion

The purpose of Study 1 was to test the effect of different numbers of imagery repetitions in an imagery session on FTS performance among league and recreational basketball players. I compared three different Imagery conditions, namely 10-, 20-, and 30-repetitions, and a no-imagery Control condition in terms of effects on basketball FTS. Study 1 results indicated that participants in the 10- and 20-repetitions Imagery conditions significantly improved their FTS performance from pre-test to post-test (Week 4). In addition, only the 20-repetitions Imagery condition had a significantly higher FTS score than the Control condition at post-test. Hence, 20 imagery repetitions appeared to have the greatest potential of the three numbers of repetitions tested to enhance basketball FTS, in the present study. Consequently, 20 repetitions in a 10-minute session can be recommended as an effective number of imagery repetitions for an imagery training program to enhance basketball FTS.

Researchers have reported that imagery training can improve sport performance (Lindsay et al., 2019; Morris et al., 2005; Schuster et al., 2011). Furthermore, researchers have found imagery training effects in various sports, including basketball (Fazel et al., 2018; Shearer, Mellalieu, Shearer, & Roderique-Davies, 2009), netball (Wakefield & Smith, 2009b), soccer (Ramsey et al., 2010; Rhodes et al., 2018), golf putting (Smith & Holmes, 2004; Taylor & Shaw, 2002), as well as strength tasks (Smith et al., 2019). In the present study, I found that the 10- and 20-imagery repetitions enhanced basketball FTS. Therefore, 10- and 20-repetitions enhanced FTS performance significantly in this study, which has practical implications for use of imagery training in discrete sports tasks.

In the Study 1 findings, the 10- and 20-repetitions imagery conditions significantly improved their FTS after the imagery training. All participants had experience of FTS performance, and their performance reached intermediate level before they participated in this imagery training program. They also maintained their usual basketball training during the imagery training periods. In their meta-analytic review, Curran and Terry (2010) reported that the effect size ($d = 0.52$) for experienced participants was larger than the effect size for novices ($d = 0.44$). Similarly, sport experiences are important for athletes to create images of performance because imagery is often based on memory (Morris et al., 2005). Imagery training effects have been examined in athletes with different skill levels, showing that both lower-level athletes and high-level athletes can improve their performance by undertaking imagery training (e.g., Hall et al., 2001; Murphy & Martin, 2002; Short et al., 2005). It is important that imagery training participants are able to create images (Morris et al., 2005; Rodgers et al., 1991; Weinberg & Gould, 2015), so researchers should monitor imagery ability to ensure it is moderate to high on key imagery ability subscales.

In the present study, participants should have been able to generate appropriate images of FTS because their imagery ability was at least moderate, based on their SIAM results. Hence, all imagery participants had the potential to enhance their FTS performance. Furthermore, based on the bioinformational theory of imagery (Lang, 1977), researchers have shown that imagery enhances performance more if it involves stimulus and response propositions. Stimulus propositions are stimuli that are associated with performance the task, such as the feel of the basketball in their hands and vision of the basketball ring for the task of FTS. Response propositions are movement responses that are integral to performance of the task, such as imagery of the basketball travelling toward the ring for the task of FTS (Bakker et al., 1996; Marshall & Wright, 2016; Smith & Holmes, 2004). To include appropriate stimulus and response propositions like these in the imagery script, I instructed participants to feel positive emotion by generating their ideal FTS image because clear details in the imagery script can facilitate imagery quality (Post et al., 2015; Wakefield et al., 2013). Based on considerable research evidence, gathered since 2001, PETTLEP is now established as the pre-eminent model to guide imagery training programs. Although the PETTLEP model was not explicitly applied in the development of the present study, most of the seven PETTLEP principles are evident in the design. I applied the seven elements to the imagery training program. The imagery script involved the element of physical characteristics (P) in FTS (e.g., ball in hands and actual shooting posture were incorporated in the imagery script). For the environmental element (E), participants recreated imagery of the basketball court environment, such as the FTS line and the basketball ring, as well as imagery of sensations (e.g., sights, and sounds) associated with the environment. In terms of the task element (T), participants imagined actual FTS performance, involving thoughts and feelings that they experienced during the actual physical execution of FTS. For the timing (T) element, I used an mp3 player (audio track) to lead participants to create FTS images, and the speed was actual performance speed. In terms of the learning (L) element, all participants had enough experience of performing FTS with moderate accuracy that the imagery training task matched their basketball skill level and the level. The emotion (E) element was incorporated in the imagery script in which I instructed participants to experience positive emotions after each successful FTS image. In the last element of perspective (P), I asked participants to use the internal perspective during the imagery training, experiencing the FTS task from inside their body.

In the present study, I designed the imagery training program to clearly instruct participants to create imagery of conducting the movements required to perform basketball FTS. These aspects of the imagery script were the same for participants in all three Imagery conditions. Hence, based on the imagery script, participants in all Imagery conditions had the same opportunity to enhance their performance. Results indicated that participants in the 10- and 20-repetitions imagery conditions did increase their FTS performance from pre-test to post-test and they sustained this improvement at retention test one week later. The only difference between the two Imagery conditions was the number of repetitions in each condition. The most noteworthy finding from the present study was that the 20 Imagery repetitions condition showed the greatest FTS improvement at post-test among the imagery conditions. Further, 10 repetitions showed greater improvement in performance from pre-test to post-test than 30 imagery repetitions. Specifically, the 10 repetitions condition increased their FTS mean from 61.56 (51.2%) at pre-test to 68.44 (57.0 %) at post-test. The increase of the 20-repetitions condition was from 61.33 (51.3%) to 73.67 (61.4%). The FTS mean in the 30-repetitions condition increased from 61.56 (51.1%) to 66.33 (55.3%). The results support previous studies (i.e., Lebon et al., 2012; Schuster et al., 2011; Smith et al., 2019) that 10 repetitions and 20 repetitions are effective in terms of enhancing sport performance. These results can be attributed to the number of imagery repetitions per session because the imagery training instructions and performance conditions were similar in all three imagery-training conditions, except for the number of repetitions. In the retention test (Week 5), participants' FTS performance in all imagery conditions remained their FTS scores from the post-test (Week 4), and the FTS means at retention were considerably higher than they were at pre-test, indicating that clear imagery training effects were sustained over a week with no imagery training. Consequently, it can be concluded that 10- and 20-imagery repetitions can improve FTS performance, while 20 repetitions of imagery performed with 10-minute duration for three sessions a week over four weeks was most beneficial for improving FTS performance.

The main finding of Study 1 indicated that 20 repetitions of imagining FTS improved FTS performance more than 10 or 30 imagery repetitions. Previous research on number of repetitions has been reported in meta-analyses and systematic reviews. Feltz and Landers (1983) conducted a meta-analysis of MP on psychological (e.g., imagery ability) and physical (e.g., increased strength, less performance error) aspects of research results. They reported the effects of repetitions with effect sizes indicating that numbers of 18 repetitions (effect sizes = .20), 24 repetitions (effect sizes = .40), and between 36 and 42 repetitions (effect sizes = 1.0) were all effective. Paravlic et al. (2018) conducted a systematic review and meta-analysis of motor imagery practice on muscle strength facilitation in healthy adults. They reported that 25 repetitions per set and 50 repetitions in a single session had the largest enhancements in maximal voluntary contraction with large effect size (1.18). In addition, Schuster et al. (2011) reviewed a variety of studies, which indicated that around 20 repetitions was employed in successful sport imagery training.

Consistent with the conclusions of Schuster et al., in the Study 1 results, the 20 repetitions Imagery condition was more effective than 10 repetitions and 30 repetitions. On the other hand, the highest number of repetitions examined in the present study, that is, the 30-repetitions Imagery condition did not show a significant difference of FTS performance compared with the Control condition, so that Study 1 did not support previous studies for a larger number of repetitions than 20 (i.e., Feltz & Landers, 1983; Paravlic et al., 2018). Researchers have found positive effects of imagery training, using broad ranges of imagery repetitions (e.g., Dana & Gozalzadeh, 2017; Lebon et al., 2012; Post et al., 2015; Smith et al., 2019). In various studies, numbers of repetitions from less than 10 repetitions to 40 repetitions have been shown to be effective. In another recent imagery training study, Kuan et al. (2018) determined whether relaxing music during an imagery intervention has benefits for dart-throwing performance. Although, Kuan et al. did not instruct participants to use a specific number of imagery repetitions of dart-throwing, results suggested that failure to control the number of imagery repetitions was a limitation of the study, and inconsistency of imagery repetitions might be relevant to the results. Hence, Kuan et al. recommended that researchers should control the number of imagery repetitions in future studies. Furthermore, Kremer et al. (2009) investigated whether 25, 50, and 100 MP repetitions affected a dart throwing task differently. They found that all three numbers of repetitions had an effect on performance. A concern with this study is that Kremer et al. only provided one MP session.

An issue with the existing studies reported here is that researchers often have not controlled other key variables in their imagery training program, when they have examined the effect of number of repetitions on task performance. In other words, researchers have not controlled other imagery dose variables, when studying the effect of different numbers of repetitions in a session. As proposed and undertaken in the present study, it is important to control duration of sessions and frequency of sessions in a week, when focusing on the effect of number of repetitions on performance. In this study, I manipulated the number of imagery repetitions, but I controlled the other two key imagery dose variables of duration and frequency of sessions at levels that have been most effective in previous research on duration of sessions (Paravlic et al., 2018; Schuster et al., 2011) and frequency of sessions per week (Wakefield & Smith, 2009b, 2011). Moreover, I based the range of repetitions from 10 to 30 repetitions on the most frequently used repetitions in previous imagery training studies.

Although, 30 imagery repetitions were not as effective as 20 or 10 repetitions in this study, there are several concerns. First, the 30-repetitions condition had the shortest interval between FTS images of the three imagery conditions. Specifically, 10 repetitions in 10 minutes (600 seconds) is one repetition every 60 seconds (600/10), 20 repetitions in 10 minutes is one repetition every 30 seconds (600/20), and 30 repetitions in 10 minutes is one repetition every 20 seconds (600/30). Once participants in the 30-repetitions condition had imagined performing FTS once, then responded to the manipulation check questions, the 20 seconds they had before the auditory signal for the next imagery repetition might have sounded. Hence, participants in the 30-repetitions condition might have experienced time pressure, leading to increased stress levels that were not experienced in the 10- and 20-repetitions conditions. Further, in use of 30 repetitions in applied imagery programs there would not usually be a manipulation check after every imagery repetition, so 30 repetitions in 10 minutes might be more manageable. In future studies, it would be advisable to find other ways to check that participants are performing imagery repetitions as instructed that do not add pressure to participants to complete all the research demands within the stipulated duration.

Second, participants in the 30-repetitions condition might have experienced more mental fatigue than participants in the 10- and 20-repetitions conditions. Rozand et al. (2016) examined the effects of prolonged sequences of motor imagery to induce mental fatigue or alter motor and mental performance. There were three different imagery experiments with a Control experiment, in which three imagery experiments had 100 imagery repetitions of a pointing movement, while timing and total numbers of actual performance were presented differently. Condition 1 participants only had one actual pointing movement at the beginning and, after 50 images of the task, at the end of the intervention, whereas, Condition 2 participants had the same procedure, but they had three actual pointing movements. Condition 3 participants had the same procedure as participants in Condition 2, but they also performed one actual movement after imagining each 10 pointing tasks. The Control condition participants sat resting at the table for 30 minutes. They made actual pointing movements at the beginning, after 15 minutes, and after 30 minutes. The results showed that participants in Condition 3 had lower fatigue scores than participants in Conditions 1 and 2. In addition, the actual and imagined performance durations in Condition 3 were stable in all testing periods. Rozand et al. concluded that regularly producing actual performance after 10 imagery repetitions may counteract mental fatigue. However, the imagined movement duration in Conditions 1 and 2 was prolonged after 50 repetitions, and after

100 repetitions it was even longer, so that providing a large number of repetitions may have increased mental fatigue and had a negative effect on imagery quality. In the present study, the 30-repetitions condition might have increased participants' mental fatigue more than the 10- and 20-repetitions imagery conditions, which might be related to no significant improvement occurring in the 30-repetitions condition. Thus, the Study 1 results indicated clear information of the effects of different numbers of imagery repetitions on sport performance in sport imagery contexts, but researchers need to conduct further experiments replicating Study 1 to test whether the 20-repetitions condition consistently has the largest effect on performance.

Examining a new protocol for conducting imagery dose-response research was another aim of the present research, that will be applicable in further imagery dose-response research. Similar protocols have been examined in different disciplines, such as psychology (Allami et al., 2008; Howard et al., 1986; Kopta, 2003; Robinson et al., 2019) and physical exercise (Bond Brill et al., 2002; Evangelista et al., 2017; Sanders et al., 2019). Researchers who have conducted such studies have proposed to identify effective dosages by comparing different dose conditions with a control condition, which is a typical research design (Holland-Letz & Kopp-Schneider, 2015). Morris et al. (2012) proposed an imagery dose-response protocol in sport imagery research, arguing that it is necessary to investigate key imagery dose aspects systematically, which means varying one key dose variable, while holding the other key dose variables constant. Imagery is a major topic in sport psychology because it is a widely applied psychological technique (Muir, Chandler, & Loughead, 2018; Spindler et al., 2018).

Sport psychology researchers have investigated the impact of imagery on performance (Coelho et al., 2007; Fazel et al., 2018; Robin et al., 2007) and its impact on important psychological variables like self-efficacy (Shearer et al., 2009), confidence (Munroe-Chandler et al., 2008), attention (Calmels, Berthoumieux, et al., 2004), and flow state (Koehn, Morris, & Watt, 2014; Sardon et al., 2016). However, the most effective amount of imagery remains a controversial issue, and existing research is limited and diverse (i.e., Paravlic et al., 2018; Schuster et al., 2011). For example, Dana and Gozalzadeh (2017) studied tennis players, who imagined 20 repetitions each of forehand and backhand shots, and 40 serve shots in a session. They found that participants improved accuracies of forehand and backhand shots and serve. In an imagery study on rehabilitation, Lebon et al. (2012) examined whether motor imagery facilitates patients' rehabilitation of the anterior cruciate ligament. Lebon et al. provided three blocks of 10 images with 10-second rest periods between trials with two minutes break between blocks, while undertaking imagery training. Participants showed greater muscle activation after the imagery intervention suggesting that motor imagery had positive effects on rehabilitation. Smith et al. (2019) used a PETTLEP imagery intervention, in which participants performed two sets of six to 10 imagery repetitions independently. After the imagery intervention, participants increased their bicep strength. Based on the proposal made by Morris et al. (2012), the imagery dose-response design I have implemented for the first time here should be a useful way to examine different imagery doses to determine, which is the most effective amount of imagery for improving performance of a variety of sport tasks. Thus, the imagery-dose response design should be a useful protocol to identify the effective numbers of imagery repetitions in a session, and it should be applicable for future research that examines the most effective duration of imagery sessions and the most effective frequency of imagery sessions in the same performance context.

In conclusion, the current study contributes to the existing imagery training research literature by examining whether number of imagery repetitions affected athletes' performance of a discrete, self-paced skill, in this case basketball FTS. Overall, the findings indicated that with a constant of three sessions per week for four weeks, for a total of 12 sessions, and with a 10-minute duration of sessions, 20 repetitions of imagery of FTS had a more beneficial effect on performance of the task than 10 or 30 imagery repetitions. Moreover, the new imagery dose-response protocol tested in the present study functioned effectively, so it should be applicable to parallel studies testing the dose variables of duration of sessions and frequency of sessions.

Methodological Issues

This study had a number of limitations, which should be acknowledged. A principal limitation relates to the recruitment of participants. I only invited male basketball players from a limited location. Researchers have found differences in imagery ability and imagery training effects between male and female athletes (Burhans et al., 1988; Munroe-Chandler, Hall, Fishburne, & Strachan, 2007). The reason I chose to include only male basketball players is that I used a new imagery dose-response protocol, so I aimed to avoid complicating the results by possible effects of gender differences. Another limitation related to participants is that some of the participants played in the same basketball club, possibly even for the same team, but were assigned to different conditions. Hence, participants who knew each other could have talked and shared information about their varied imagery training conditions or control condition experiences. For example, control condition participants could have talked to participants in the other conditions and concluded that they were not expected to improve in FTS performance because they did not experience an imagery training intervention. It is less likely, however, that there were risks of demand characteristics or expectancy effects between the imagery training conditions. This is because the imagery conditions had similar instructions and there was no indication that one number of repetitions was expected to produce superior performance to the other repetition conditions.

There was no rationale for determining the most effective number of imagery repetitions that participants could have employed to predict differences in imagery training effects other than that the more repetitions of imagery participants performed, the greater would be the effect on FTS performance. This expectation would have been viable had 30 repetitions been the most effective number I tested. As 20 repetitions was the most effective and 30 repetitions was, in this study, the least effective, it does not appear that this expectation had a major impact in the present study. Another possible issue is that the number of participants was limited, I recruited 36 players in the present study. This number was based on the limited previous research on dose variables (e.g., Wakefield & Smith, 2011), and the G power analysis, which indicated 70 participants would have been appropriate to minimize the risk of finding no significant effect, when there was a real effect. To address the difference between the significant results of previous research with 32 participants and the number of proposed participants derived from the G power analysis, I conducted an analysis when 36 participants had completed the study. At that point, the Study 1 results indicated that there were significant main effects and a significant interaction effect with large effect sizes. Hence, I considered that the sample size of 36 participants, nine in each condition, was sufficient, so I stopped recruiting participants. A reason for stopping once significance was attained is the important ethical principle that researchers should not expose individuals to unnecessary intervention research procedures. This applies either when it is evident that significance will not be achieved by testing additional participants or, as in this case, when significant results have already been established. Thus, recruiting participants is a methodological issue, but it was not a major influence in Study 1.

Another methodological issue was organizing three different imagery conditions. I used three different numbers of repetitions, which were based on reviews of the previous studies on repetitions (e.g., Schuster et al., 2011), which indicated that 10 to 30 repetitions improved the performance of sport skills. However, there was no systematic experimental research on larger or smaller numbers of repetitions, so that less than 10 repetitions and more than 30 repetitions might also have effects on FTS performance. Additionally, I used constants of 10-minute duration for imagery sessions and three times a week for the frequency of sessions over four consecutive weeks. The levels of these imagery variables of duration and frequency are based on limited research, much of which examined one dose variable without holding other dose variables constant. Wakefield and Smith (2011) found three sessions a week was more beneficial than only one or two sessions a week. However, they suggested that researchers need to investigate more imagery sessions per week, such as sessions on 4, 5, 6, or 7 days a week. In other words, higher frequencies of imagery sessions might be more effective for enhancing performance than three sessions a week of imagery training.

In Study 1, I held duration constant at 10 minutes per session and frequency constant at three sessions per week, so I could focus on number of repetitions. It is important for researchers to examine the duration and frequency of imagery sessions per week more thoroughly, using the systematic approach I adopted here. Cooley et al. (2013) conducted a systematic review of movement imagery scripts in sport. They used a Spearman's correlation coefficient to identify the relationships between imagery intervention length (weeks) and total imagery use duration (minutes) and imagery intervention success. There was a positive correlation between the imagery intervention length and intervention success (r = 0.670, p = 0.001), as well as a positive correlation between the total imagery use in a session and intervention success ($r = 0.462$, $p =$

0.021). Furthermore, they stated that examination of the imagery dose-response relationship between these two dose variables (imagery training length and total imagery use) in imagery training is necessary to provide precise information about effective imagery dosages. Thus, there might be a significant effect, if studies include longer imagery training duration than 10 minutes or more frequent sessions than three times per week.

Finally, in considering methodological issues that might have influenced the results, it is necessary to consider the possible impact of interval effects during the imagery training sessions. In the 10- and 20-repetitions conditions, participants had enough time to prepare for the next FTS image during the interval between imagery repetitions. However, in the 30-repetitions condition, participants had limited time until the next FTS image. Potentially, this could have placed participants in the 30-repetitions condition under more pressure than those in the 10- and 20-repetitions conditions. Moreover, participants in the 30-repetitions condition might have experienced greater mental fatigue than those in the 10- and 20-repetitions conditions by being required to create ideal FTS images 30 times in 10 minutes, which demanded maintenance of their concentration (Rozand et al., 2016). On the other hand, the interference task might have introduced biases and effects on participants' imagery training quality. I aimed to use the interference task to minimise the opportunity for participants in the 10- and 20-repetitions conditions to create extra FTS images during the intervals between the planned imagery repetitions. Although I did all I could to develop rapport with participants to ensure that they cooperated with the instructions for the conditions to which I assigned them, participants cannot always control their cognitive processes during involvement in studies like this one. From the imagery manipulation check, participants in the 10- and 20-repetitions conditions found more than 95% of the non-colour words during the interference task. Thus, the interference task provided great control over cognitive processing during the intervals between imagery repetitions, minimising the opportunity for participants to perform extra imagery repetitions. However, I did not include the interference task in the 30-repetitions condition because pilot work indicated that participants had little or no time to perform extra cognitive processing between imagery repetitions, once they had completed the manipulation check. This did introduce a difference in the format of the 30-repetitions condition and the 10- and 20-repetitions conditions, which could have influenced the results. Nevertheless, the Study 1 results indicated that participants in the 10 and 20 imagery repetitions conditions improved their performance more than participants in the 30 imagery repetitions condition, where there was no interference task, which suggests that, while participants did focus on the task in the intervals between imagery repetitions, the interference task did not have a great effect on imagery training quality. Hence, I suggest that the interference task was an effective way to control the amount of imagery that participants performed in those conditions in which there was substantial time with no planned imagery repetitions in the 10-minute duration that I employed in this study.

Future Research

Study 1 has raised a number of issues that warrant further examination. First, there is no previous research that has examined repetitions of imagery in a discrete, self-paced sport skill, using the kind of research design I employed in this study, so the results of Study 1 cannot be confirmed or rejected by previous research. Given the importance of identifying the most effective number of repetitions in imagery training, researchers should replicate this study to determine whether the Study 1 findings are repeated in different samples of basketball players with similar characteristics. It would also be informative to conduct similar studies with female basketball players, players in various age categories, and players at different skill levels. The present research design should also be applied to other discrete, self-paced sport skills, such as rifle and pistol shooting, archery, golf putting, netball shooting, ten-pin bowling, and tennis service. It would be valuable to ascertain whether the results of the present study are transferable to other discrete sports tasks. Further, examining open skills, such as racquet sports and team ball games, would be interested in the future.

In Study 1, the 20 imagery repetitions condition was more effective than the 10 and 30 imagery repetitions conditions, which if replicated, could be applied in research on different participants' characteristics and imagery delivery methods in more ecologically valid contexts than this FTS field study in a controlled environment. Researchers should examine what is the most effective number of repetitions to promote sport performance in participants with different characteristics. For example, determining whether the most effective dose is universal or whether it varies with skill level, as well as female basketball players. The imagery script facilitated FTS performance, but it did not include environmental information, such as competition elements, which would include match conditions, with team-mates and opponents around the players as they shoot, officials managing the FTS performance, supporters and opposition fans in the viewing areas around the court, and the pressure of tight competition. This is because basketball players, performing in leagues at the level of the current sample may not have many experiences of competing in games with large numbers of spectators and the extent of pressure experienced at the highest levels of basketball, so that they might find it difficult to create realistic images of such scenes. Hence, further research should examine the effectiveness of different numbers of imagery repetitions with more complex imagery scripts in the context of ecologically valid competition environments. Therefore, high performance level participants would be more appropriate as participants for this kind of research. Moreover, involving environmental information in imagery scripts introduces the issue of the influence of such contexts on mental states, such as self-confidence, flow state, and anxiety, which adds another dimension to this kind of research. Applying findings about the most effective imagery repetitions from such ecologically valid studies has great potential for this imagery delivery issue.

Applying the imagery dose-response protocol for various imagery training tasks and other key imagery variables is another direction for further research. Examining the imagery dose-response effect associated with number of repetitions on serial and continuous sport tasks could contribute to the effective use of imagery in those sport contexts. For example, artistic gymnastics floor and beam routines require athletes to include a variety of complex skills during a 70-second performance, which could affect the most effective number of imagery repetitions per session. Hence, the Study 1 finding of 20 imagery repetitions being most effective may not apply for serial and continuous sport tasks, especially as such tasks typically involve longer duration performance. On the other hand, researchers can use the same research design by manipulating number of repetitions with other key variables of duration and frequency held constant, which might help to identify the most effective number of imagery repetitions in such serial and continuous sport tasks. The duration and frequency of imagery interventions are key imagery dose variables that should be considered specifically in relation to the length of time that a task typically continues. In other words, with longer duration sport tasks, the number of imagery repetitions in a session might be smaller because each repetition takes much longer. For example, imagining a ski-jump in real time from preparation at the starting gate to landing at the bottom of the hill could take a minute or more. A question for research to examine, related to the most appropriate number of repetitions, is how many ski-jumps would be most effective for experts to imagine in one imagery session. An associated question is how long could experts maintain imagery of ski jumps before concentration lapsed due to fatigue. It might be predicted that figure skaters might manage even fewer repetitions of a free skating routine in one imagery session. Expert skaters would probably only manage one, or at most two, repetitions of the imagery of a complete free skating routine in one session.

Conclusion

To conclude, in Study 1 I examined the imagery dose-response relationship between imagery repetitions and FTS performance. Overall, using 20 repetitions in a session was more effective for FTS performance than 10 and 30 repetitions in a session in this study. This is important information because many published imagery training studies have used broad ranges of imagery repetitions in a session, without testing the number of repetitions to identify effective levels of this variable, because there was no information about effective numbers of repetitions for performance of the breadth and diversity of sports tasks. In addition, in the present study, while examining number of repetitions, I controlled two other important imagery dose variables, namely duration of sessions and frequency of sessions per week. This is an original approach in imagery training research, based on the protocol proposed by Morris et al. (2012). I showed that this research design has potential for identifying the effective number of imagery repetitions at last in a discrete, closed skill like basketball FTS. The Study 1 results contributed to understanding of the role of number of imagery repetitions on FTS performance, however, researchers should examine this issue in further research. With replication, the Study 1 results can help athletes and coaches to use effective numbers of repetitions in their imagery training programs. In this study, the new imagery dose-response protocol has been shown to have promise, which was another research aim. However, there is still great potential to examine dose variables in imagery training in sport. I only examined the key variable of number of repetitions in this study, so the other two key imagery dose variables of duration and frequency warrant systematic study. This is my aim for Study 2 and Study 3 of this thesis.

CHAPTER 4

STUDY 2: EXAMINING THE REPETITION COMPONENT OF THE IMAGERY DOSE-RESPONSE RELATIONSHIP

Introduction

In Study 1, I examined the imagery dose variable of number of repetitions in an imagery session. I determined whether different numbers of repetitions in imagery training helped basketball players to enhance their FTS performance. The main purpose of Study 2 was to determine whether different imagery training durations (8 minutes, 13 minutes, and 18 minutes) affect basketball FTS. I predicted that the key dose factor of imagery duration in a session has an impact on imagery training effects.

Feltz and Landers (1983) reported that MP durations of less than one minute had an effect size of .9, and durations of 10 to 25 minutes had effect sizes ranging between .4 and 1.0. These durations were more effective than a 5-minute imagery duration (effect size = .3) in terms of performance enhancement. Hinshaw (1991) reported the effect sizes of MP durations by using meta-analysis. He found that the effect size for durations of one minute or less was 1.11 and the effect size for durations of 10 to 15 minutes was 1.05. According to the meta-analysis of eligible studies, these durations were more effective than a 3 to 5-minute imagery duration (effect size = .31). Schuster et al. (2011) completed a systematic review of motor imagery in sport, that is, they did not calculate effect sizes. They reported that successful imagery training in sports most frequently utilized duration of 10 minutes, concurring with Morris et al. (2005). In another recent review of the dose-response relationships of motor imagery and muscle strength increase, in terms of healthy adults' muscle strength facilitation, Paravlic et al. (2018) reported that motor imagery training studies frequently used 15-minute imagery duration in a session, with an effect size of 1.04, but they did not compare this effect size with effect sizes for other durations. Similarly, Driskell et al. (1994) reported that MP lasting 20 minutes was more effective for promoting sport skills than shorter interventions. Some imagery training studies have found imagery training effects, using less than 10-minute imagery duration (Fazel et al., 2018; Smith et al., 2007). Several successful imagery training studies in sport skill have also used 15-minute imagery duration in their imagery training, such as a study using imagery to improve soccer skills (Rhodes et al., 2018) and imagery used to enhance performance of tennis groundstrokes and service (Anuar et al., 2018; Dana & Gozalzadeh, 2017). Roure et al. (1999) found that a longer imagery duration of 30 minutes was effective in a study of volleyball skills.

These studies (and reviews of these studies) have all examined only one imagery duration. The researchers have not compared imagery durations or imagery doses. To my knowledge there are no published studies that have directly compared durations in the same study under the same conditions. This makes comparing the influence of duration challenging as factors such as the number of repetitions, frequency of sessions per week, skill level, and type of activity might all vary greatly. Thus, to inform effective imagery training program design, it is important to study how duration influences imagery effectiveness directly. Examining whether different imagery durations in a session has an effect on a discrete task is important for providing guidelines in sport, so that athletes and coaches understand the effectiveness of imagery sessions of different durations. This will allow sport psychologists and coaches to design imagery programs of effective durations without fatiguing athletes or wasting their practice time.

Despite the sometimes highly disparate types of task, characteristics of participants, and levels of other key factors, such as number of repetitions and frequency of sessions, used in previous studies, the research literature does suggest that imagery session durations between 5 and 20 minutes can be effective. Thus, to compare different imagery session durations for a discrete task, in Study 2, I have adopted a systematic approach. I varied session durations within the range that has been suggested by previous imagery studies (8 minutes, 13 minutes and 18 minutes) to address that range.

At the same time as I varied the imagery duration, I kept the other key imagery dose variables of repetitions and frequency of sessions constant in this study. In Study 2, I kept the task the same as in Study 1 and the participants were similar to those in the first study in terms of age and skill level. In addition, based on the results of Study 1 that 20 imagery repetitions was most effective, I used 20 repetitions as the number of repetitions in all three imagery intervention conditions in Study 2. Given that there was no new evidence on frequency of sessions, I continued to use the frequency of three sessions per week, based on research by Wakefield and Smith (2009, 2011). I also included a Control condition to increase confidence that any observed effects in the imagery conditions could be attributed to the imagery training. In Study 2, I did not have any hypothesis because the evidence from previous research and reviews about the most effective imagery duration in a session for improving sport performance is not clear.

Method

Participants

A total of 36 male basketball players from Melbourne, Australia voluntarily participated in Study 2. Their mean age was 25.17 years (*SD* = 4.26). Only male players were recruited in order to avoid gender differences in terms of imagery ability and imagery training effects (Burhans et al., 1988; Munroe-Chandler, Hall, Fishburne, & Strachan, 2007). All participants played basketball for their local basketball club or the university basketball club, or they played recreational basketball in their community at least once every week. They had no previous experience of undertaking systematic imagery training for promoting their FTS. I used the same eligibility criteria as described in Study 1 to screen potential participants for adequate skill level in FTS and imagery ability to be suitable to participate in this study.

Study Design

In Study 2, I examined the most effective imagery durations in a session for improving FTS out of three durations chosen to reflect the range of durations that have been shown to be effective in previous research (Fazel et al., 2018; Guillot et al., 2010; Paravlic et al., 2018; Schuster et al., 2011). Hence, I manipulated the key dose variable of duration systematically, while holding the two other key dose aspects, namely number of repetitions (from Study 1) and frequency, constant. In Study 2, I examined three imagery intervention conditions, which were 8 minutes duration, 13 minutes duration, and 18 minutes duration, and a control condition in which participants performed the FTS performance task only. All participants in the three Imagery conditions performed FTS measurement at pre-test for screening FTS skills, then they undertook the 4-week imagery training, with three imagery sessions each week, an FTS performance test after the third session each week, and a retention test at the end of a no-imagery week (Week 5) to examine whether their FTS improvement was sustained after the intervention was concluded. They undertook a total of 12 imagery training sessions (three times a week for four weeks), while Control condition participants had no imagery training, but performed all the six FTS performance tests (pre-test, imagery Weeks 1 – 4, and Retention test) on a similar schedule to the Imagery condition participants. I utilized a pre-test and post-test experimental design to examine which of the three doses of imagery duration was most effective for improving FTS performance.

Measures

Demographic form. As described in Study 1.

Sport Imagery Ability Measure (Watt et al., 2018; Watt et al., 2004a). As described in Study 1.

Basketball free-throw shooting (FTS). As described in Study 1.

Imagery log and imagery manipulation check. As described in Study 1.

Physical practice log. As described in Study 1.

Research Conditions

Imagery intervention conditions. I randomly allocated participants into three imagery conditions (8 minutes, 13 minutes, and 18 minutes) or the Control condition. I instructed participants in all three imagery conditions to follow the same imagery training instructions, while the conditions only varied in terms of imagery duration. I provided three different durations of imagery sessions at 8, 13, and 18 minutes. This was based on the reviews by Morris et al. (2005) and Schuster et al. (2011). I utilized 20 imagery repetitions from the Study 1 results because I found this number of repetitions to be the most effective in promoting FTS improvement of the three imagery conditions in Study 1. I also employed the same frequency of three imagery sessions per week as in Study 1. Three sessions were shown to be more effective than one or two sessions per week in previous research (Wakefield & Smith, 2009, 2011). As in

Study 1, I presented the audio instructions on a MP3 player to guide participants to imagine FTS as intended. Participants completed the imagery sessions on their own in a quiet place. Because participants in two of the imagery conditions were assigned to imagery training durations (13 and 18 minutes) during which they could have practiced more than the designated 20 repetitions, I controlled cognitive activity during sessions in those conditions with the same interference task that I used in Study 1. During each session, participants completed 20 images of successful FTS by using auditory signals to cue imagery. I instructed participants to imagine one FTS after each auditory signal. The auditory signal occurred every 24 seconds for a duration of 8 minutes, every 39 seconds for a duration of 13 minutes, and every 54 seconds for a duration of 18 minutes, respectively.

After imagining each FTS, participants completed the imagery manipulation check promptly (Appendix J). Only participants in the 13- and 18-minute duration conditions undertook the cognitive interference task, which aimed to prevent participants from imagining extra FTS images. Hence, the cognitive interference task was conducted throughout the time between designated imagery repetitions to minimize the possibility that participants could perform additional FTS imagery repetitions. In the cognitive interference task, players listened to colour words (e.g., yellow, red, and green) continuously until the next imagery session of FTS. However, I randomly included "non-colour words" that had close associations with a colour (e.g., snow, apple, lemon) in the audio list. I instructed participants to write a non-colour word in the blank box on the imagery experience check sheet, when they heard a word that was not a colour. The aim of the cognitive interference task was to control participants' attention. However, it was not highly cognitively demanding, so participants could maintain their concentration for the whole of the imagery training duration. The audio signal was a bouncing basketball sound, which occurred at the end of the cognitive interference task, so that participants could prepare for the next FTS imagery repetition. Therefore, the assigned imagery duration with 20 imagery repetitions was organized to present imagery repetitions at evenly spaced intervals across the duration of each session.

I conducted a pilot test to refine, identify, and resolve any problems with four basketball players (recreational and competitive level players) and a basketball coach prior to Study 1. In the pilot testing, the players and coach provided crucial feedback, for example, on the timing of auditory signals, and on the cognitive interference task on MP3 players during the imagery interventions. Indications in Study 1 were that this procedure was effective. Thus, I had thoroughly tested and refined the imagery delivery process in each Imagery condition before the actual imagery training.

Control Condition. As described in Study 1.

Imagery script. I used the same imagery script in Study 2 that I had used in Study 1. Informal comments from participants in Study 1 indicated that they did not experience any problems with the script and results indicated that the imagery script was effective for enhancing FTS performance in all three imagery conditions in Study 1. All participants in Study 2 were new to the use of imagery, so it was appropriate to use the script that had worked well in Study 1.

Procedure

I recruited basketball players from local basketball teams or communities in Melbourne for Study 2, after receiving approval from Victoria University Human Research Ethics Committee (VUHREC). I mainly used recruitment flyers (Appendix M) for recruiting the participants. Prior to research participation, I conducted a standard informed consent process.

First, I gave each participant an Information Statement that described what they were asked to do if they volunteered to participate in the study (Appendix N and O). I set out the risks and benefits of research participation, and I encouraged participants to ask questions, which I then answered to the best of my ability. After receiving the signed Informed Consent Form (Appendix D and P) from participants, the participants conducted the pre-test measurements, namely the Demographic Form (Appendix F), the SIAM, and the FTS test. I set the eligibility for imagery ability for the SIAM (Appendix G) as a score of at least 150 on the key imagery variables (vividness, control, visual, kinaesthetic, tactile, and auditory) and the FTS points (Appendix H) from a minimum of 41% (score = 49) to a maximum of 60% (score = 72) to ensure that participants had sufficient skill to benefit from the Imagery interventions, but were not such highly-skilled shooters that ceiling effects might occur. Then, I randomly divided participants into Imagery training conditions or the Control condition.

Imagery condition participants undertook the three imagery training sessions each week over four weeks (three times a week for four weeks). In each imagery session, all participants performed their assigned imagery training for 8 minutes, 13 minutes, or 18 minutes, respectively, by using an audio track on the MP3 player, which I gave them at the start of the imagery sessions. I instructed participants to undertake the imagery training by themselves, ensuring they performed a session at each designated time during the week, following the directions on the MP3 player, which I took them through before their first imagery session. In the imagery training session, I asked participants to evaluate their imagery experience after each FTS image (imagery manipulation check) (Appendix J). Additionally, I instructed participants in the imagery conditions to report the date and time in each imagery session. Moreover, I verified the total basketball practice time for each participant during the course of the 5 weeks in the physical practice log (Appendix K). All participants retook the FTS measurement at the end of every week for the 4-week imagery training periods and the retention FTS test at the end of Week 5. After the imagery training, I conducted social validation check for providing general interview questions of participants' experience of the whole study (Hrycaiko & Martin, 1996). After the Control group participants had completed the study, I offered them the opportunity to undertake the imagery training program.

Analysis

I analysed whether there were any differences in imagery ability at pre-test, by using a multivariate analysis of variance (MANOVA) on all 12 SIAM subscales. In addition, I determined whether there were any differences in FTS scores between the four research conditions at pre-test, using one-way analysis of variance (ANOVA) on pre-test FTS scores. In the main analyses, I determined if there were significant differences between the four conditions in the data of total practice time, particularly physical practice, on the physical practice log during the five weeks of the study by using one-way ANOVA. Further, to ensure that participants in the three imagery conditions had undertaken the correct number of 20 imagery repetitions in each imagery training session that participants reported in the imagery log, I calculated the means and standard deviations for imagery repetitions in each week, and I compared the differences between the three conditions by using a two-way, mixed-design ANOVA. I examined FTS accuracy in the four research conditions at pre-test, Weeks 1, 2, 3, and post-test in Week 4, and retention test in Week 5, by using two-way, mixed-design ANOVA, that is, four conditions (8-, 13-, 18-minute imagery conditions and the Control condition) and six occasions (repeated measures at pre-test, Weeks 1, 2, 3, 4, and retention test in Week 5), as well as conditions x occasions interaction effects. In Study 2, I utilized the Statistical Package for the Social Sciences (SPSS: version 24.0) software for calculating means and standard deviations, MANOVA and ANOVA for all scales and scores with F-tests, probability (*p*) values, and effect sizes (eta squared). I employed the Tukey HSD post-hoc test to identify the location of signification conditions, occasions, and interaction effects.

Results

In Study 2, I investigated three different imagery durations (8 minutes, 13 minutes, and 18 minutes) in each imagery session. I compared basketball FTS performance in those three imagery conditions and the Control condition (no imagery training) across six occasions, namely pre-test, Weeks 1, 2, 3, and 4, which was the post-test, and Week 5, which was the retention test. I utilized an imagery dose-response protocol that was new to this thesis to examine duration of imagery sessions. I varied imagery duration, but I also controlled two other imagery dose variables, namely number of repetitions in each session and frequency of sessions in each week, with a suggested effective level of repetitions (20) from Study 1 and the same frequency of sessions as in Study 1 (3 sessions per week), based on previous research. In the present study, the results of the examination of imagery duration in terms of FTS performance are presented in this section. Firstly, I present the SIAM descriptive results and the comparison of SIAM subscales at pre-test, using a one-way MANOVA. Secondly, I report the comparisons of total practice time, and the descriptive imagery manipulation check in each week by using one-way ANOVA. Finally, I report two-way, mixed-design ANOVA on the gain scores for FTS performance, testing whether there are main effects of conditions and occasions, and conditions x occasions interaction effects.

Imagery Ability

I screened participants' imagery ability to ensure that all players accepted as participants reported at least moderate levels on the most important SIAM dimension and sense modality subscales, which are the vividness and control dimension subscales and the auditory, visual, kinaesthetic, and tactile sense modality subscales. Then, I checked that there were no significant differences in imagery ability between the four conditions (three Imagery conditions and the Control condition) at pre-test. Means and standard deviations are presented in Table 4.1. All participants had appropriate SIAM imagery ability subscale scores to meet the criteria for participating in the study. I used a one-way MANOVA to check all 12 SIAM subscales, and there were no significant differences in SIAM results between the four conditions, F (9, 36) = 1.085, p=.22; Wilk's Λ=.475, partial η^2=.22, but there was a large effect size.

Table 4.1
Means and Standard Deviations of Six Key SIAM Subscale Scores

SIAM subscales	CONDITION	*M*	*SD*
AUDITORY	8 minutes	255.22	88.06
	13 minutes	289.38	101.78
	18 minutes	353.25	64.37
	Control	254.89	51.08
VISUAL	8 minutes	322.78	89.32
	13 minutes	379.38	51.24
	18 minutes	402.13	17.64
	Control	297.89	64.76
KINESTHETIC	8 minutes	279.56	81.45
	13 minutes	257.00	96.87

	18 minutes	331.75	85.26
	Control	270.22	50.30
TACTILE	8 minutes	286.00	107.53
	13 minutes	260.00	101.06
	18 minutes	330.38	67.21
	Control	266.33	54.26
CONTROL	8 minutes	288.33	81.73
	13 minutes	314.75	51.71
	18 minutes	349.00	70.51
	Control	288.44	54.02
VIVIDNESS	8 minutes	315.67	73.46
	13 minutes	379.13	61.74
	18 minutes	366.38	32.62
	Control	294.33	54.09

Total Practice Time

I asked participants to report their physical practice time each week by using the physical practice log to ensure that participants in the four conditions did not differ significantly in amount of basketball shooting practice they did during the five weeks of the study. For the 8-minute duration condition, the mean was 11.22 (*SD* = 4.63); for the 13-minute duration condition, the mean was 11.33 (*SD* = 7.79); for the 18-minute duration condition, the mean was 12.22 (*SD* = 4.74); and for the Control condition it was 10.33 (*SD* = 4.03). One-way ANOVA was conducted to compare the total practice hours in all conditions during the imagery training periods. There was no significant difference between conditions F (3, 32) =.178, p = .91, η^2 = .002, with a very small effect size.

Imagery Manipulation Check

To check whether participants followed the correct number of imagery repetitions, I observed their subjectively perceived quality of imagery, based on the 5-point Likert scales (Table 4.2). Overall, participants were asked to imagine 20 repetitions of FTS in all sessions for four weeks. I used a mixed design two-way ANOVA to identify whether there were any significant differences between conditions and occasions from Week 1 to Week 4. There was no significant conditions effect, F (2, 24) = .147, p > .05, η^2 = .01, with small effect size, while, there was a main occasions effect, F (3, 72) = 9.339, p = < .001, η^2 = .28, with very large effect size. There was no significant interaction between conditions and occasions, F (6, 72) = .612, p > .05, η^2 = .05, with a medium effect size. Therefore, all imagery conditions' participants reported that their subjective assessment of the quality of FTS images improved between Week 1 and Week 4, while there were no significant differences between imagery conditions.

For the social validation check, all participants asked that they clearly understood research participation in this study.

Table 4.2

Means and Standard Deviations in the Imagery Manipulation Check Scores for Imagery Conditions on Weeks 1 to 4

	Week 1		Week 2		Week 3		Week 4	
Conditions	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*

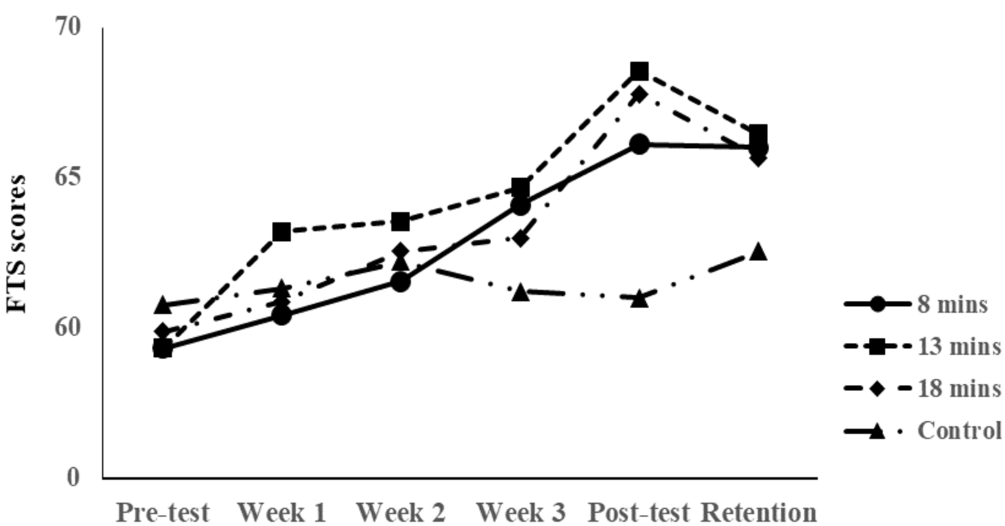
8 minutes	3.17	.69	3.21	.61	3.33	.50	3.72	.47
13 minutes	2.48	.65	3.35	.57	3.54	.41	3.66	.63
18 minutes	3.17	.41	3.21	.43	3.55	.34	3.48	.62

Performance Outcome

The raw FTS means and standard deviations for all four conditions on six occasions of testing (pre-test, Week 1, 2, 3, post-test, and retention test) are presented in Figure 4.1. The FTS means were higher in all imagery conditions at post-test than they were at pre-test, whereas participants in the Control condition did not improve their FTS performance. Figure 4.1 shows FTS improvements from pre-test, as well as from week to week after the imagery training had been introduced. I utilized one-way ANOVA to compare FTS for the four conditions at pre-test. There was no significant difference between the conditions at pre-test, *F* (3, 35) = .077, *p* = .972, η^2 = .01, with a small effect size.

Figure 4.1

Free Throw Shot Means for the 8-, 13-, and 18-minute Durations and Control Condition on Six Occasions



I conducted two-way, mixed-design ANOVA to examine FTS performance for a main effect of conditions, a main effect of occasions, and a conditions x occasions interaction effect. The results revealed that there was no significant main effect of conditions, F (3, 32) = .404, $p >$ .05 $\eta^2 = .036$, with a small effect size. The ANOVA analysis revealed a significant main effect of occasions, F (5, 160) = 13.533, $p < .001$, $\eta^2 = .30$, with a very large effect size. In addition, there was a significant interaction effect between conditions and occasions, F (15, 160) = 1.926, $p <$ .05, $\eta^2 = .15$, with large effect size.

Tukey post hoc tests indicated the location of significant differences, revealing that all imagery duration conditions showed significant improvements of FTS from pre-test to post-test. These changes were responsible for the main effect of occasions. Tukey post hoc tests showed that the 13-minute imagery duration condition had a significantly higher FTS mean than the Control condition (p = .045) at post-test in Week 4. Additionally, the 18-minute imagery duration condition FTS mean was significantly higher than the Control condition (p = .018) at post-test in Week 4. Moreover, the FTS mean for the 13-minute imagery duration condition in the retention test was significantly higher than the mean at pre-test. Overall, the results indicate that gains in FTS performance occurred gradually, then became significant at post-test in Week 4 and remained significant at the retention test in Week 5. The strongest effects were evident for the 13-minute imagery condition at post-test and retention test, while the 18-minute imagery condition showed a significant effect on FTS performance at post-test.

Discussion

The purpose of the present study was to examine whether different imagery durations in a session (8-minute, 13-minute, 18-minute sessions) have differential effects on basketball players' FTS performance. Overall, I found significant improvements of FTS performance in three imagery training conditions between pre-test and retention test (Week 5), while the Control condition showed no improvement. The 13-minute and 18-minute duration conditions had significantly higher FTS means than the Control condition at post-test, and only the 13-minute imagery duration condition produced higher mean FTS performance at the retention test in Week 5 than the mean at pre-test. Hence, based on this study, the 13-minute and 18-minute imagery durations have the greatest potential for facilitating basketball players' FTS performance. These results supported the capability of applying the imagery dose-response protocol to compare the effectiveness of different imagery durations for enhancing performance. Because dose-response research is new in the psychological field of imagery, the present research design should be replicated in basketball FTS with different samples. Further, researchers should apply the research design to different sport tasks to examine the robustness of findings regarding the effectiveness of different imagery durations. Overall, the results of this study suggest that the 13-minute imagery duration is the recommended imagery duration for designing an imagery training program for basketball FTS because it was the only imagery condition that was significantly higher than the Control condition at post-test and retention test.

In Study 2, I found that participants significantly improved FTS performance in basketball FTS in 13- and 18-minute imagery training sessions delivered three times a week for four weeks. Research reviews in MP and imagery have reported a range of different durations of imagery used in MP and imagery training programs have been effective for enhancing performance and have reported different effect sizes for different imagery durations (Driskell et al., 1994; Etnier & Landers, 1996; Schuster et al., 2011). Previous studies and reviews, however, have not directly compared different durations of imagery training. Thus, this study provides new information on the duration of imagery by comparing different durations, and the results indicate that the 13- and 18-minute durations were effective.

Imagery training effects have been found to enhance performance of athletes with various skill levels and in a range of sports (Hall et al., 2001; Razon, Mandler, Arsal, Tokac, & Tenenbaum, 2014; Turan, Disçeken, & Kaya, 2019). In the present study, all basketball players maintained their usual levels of physical practice that could have had positive effects on their FTS performance, rather than only undertaking imagery training during the 4-week research period (Driskell et al., 1994; Post et al., 2015; Robin et al., 2007). There were no significant differences between the three Imagery training duration conditions in total physical training hours during the imagery intervention period, so that all participants had the same opportunities to improve their FTS performance outside of the imagery training.

All participants had already acquired a moderate level of competence for FTS performance before undertaking one of the imagery-training programs, but their FTS accuracy still left ample room for improvement because the participation criterion for FTS accuracy at the start of the study was from 41% to 60% FTS success at pre-test. Researchers have suggested that skilled players have greater effectiveness of using imagery (Morris et al., 2005; Murphy & Martin, 2002), and experienced athletes typically have higher imagery ability (Mendes et al., 2019; Roberts et al., 2008). In addition, previous sport experiences are related to imagery effectiveness (Driskell et al., 1994; Pie & Tenenbaum, 1996). These studies support the Study 2 results in which all three imagery training conditions showed increases in mean basketball FTS performance from 59.33 (49.4%) at pre-test to 66.11 (55.1 %) at post-test in the 8-minute imagery duration condition, from 59.33 (49.4%) at pre-test to 68.56 (57.1%) at post-test in the 13-minute imagery duration condition, and from 59.89 (49.9%) at pre-test to 67.78 (56.5 %) in the 18-minute imagery duration condition. Coaches and athletes would consider these increases of around 6%, 7.5%, and 6.5% in the 8-, 13-, and 18-minute imagery conditions, respectively, to be valuable improvements in performance, especially if they could be replicated in matches.

In the imagery training program, I instructed participants to use the internal imagery perspective, which is considered to be beneficial in closed skill tasks (Coelho et al., 2007; Dana & Gozalzadeh, 2017; Fogarty & Morris, 2003; Kuan et al., 2018). Moreover, participants had sufficient imagery ability at the start of imagery training (SIAM scores), so that they could create images of FTS performance. In the systematic imagery training program, I controlled two key imagery variables, namely the effective number of 20 repetitions from Study 1, and three sessions per week, the favoured imagery frequency based on previous research (i.e., Wakefield & Smith, 2011). The imagery scripts had a basis in previous research (Fazel, 2015; Fazel et al., 2018; Smith et al., 2007; Wakefield & Smith, 2012), so that stimulus propositions and response propositions were involved. For example, participants saw the free-throw line, felt the basketball, and observed the basketball ring in stimulus propositions, as well as having feelings of body balance, bending their knees, feeling the correct movement of their arms as they projected the basketball toward the ring, and watching the basketball drop through the ring in terms of response propositions. The element of emotion was incorporated in the imagery script, encouraging participants to experience positive feelings after successful FTS performance. As in Study 1, the seven principles of the PETTLEP model were applied without specifically basing the imagery program on PETTLEP. Hence, I contend that, in the current imagery training design, I employed sound criteria to examine the imagery dose variable of duration of imagery sessions.

In the imagery training periods, participants in all imagery conditions improved their shooting accuracy gradually week by week, and all imagery conditions had their highest FTS mean in Week 4. However, the 13-minute and 18-minute imagery duration conditions showed larger improvements at post-test than the 8-minute condition and the Control condition. In addition, the 13- and 18-minute imagery duration conditions had significantly higher post-test means than the 8-minute imagery duration condition and the Control condition. This suggests that the 13-minute and 18-minute imagery duration conditions improved FTS accuracy most in the present study. In other words, participants in these conditions were shooting more successful clean baskets and successful baskets off the ring at post-test than during pre-test FTS performance. This indicates that imagery duration is influential in imagery training effects, which is important for designing imagery training programs. Several previous imagery training studies have used 15-minute imagery training programs (Anuar et al., 2018; Dana & Gozalzadeh, 2017; Sardon et al., 2016) and imagery reviews (e.g., Paravlic et al. (2018) have indicated that durations around 15 minutes can be effective. The current study is the first to directly compare durations to determine effective imagery duration and appears to indicate that, for the basketball FTS skill in the present study, durations around 13 and 18 minutes were effective.

The retention test (Week 5) was conducted after the imagery training period. The aim was to examine whether the imagery training program had positive effects on FTS performance one week after I stopped imagery training with the MP3. The means for the retention test in Week 5 in all imagery conditions decreased from Week 4. Specifically, the means of FTS decreased from post-test to retention test (about 0.1%) for the 8-minute duration condition, (about 1.6%) for the 13-minute duration condition and (about 1.8%) for the 18-minute duration condition. However, the Week 5 means were still higher than the Week 1, 2 and 3 means, and considerably higher than pre-test means, indicating that imagery training did have a noteworthy effect. Further, specifically with respect to the impact of duration, only the 13-minute imagery training duration showed a significantly higher mean than the Control condition on Week 5, suggesting that it was the most effective imagery duration. To summarize, the 13-minute imagery duration, with 20 imagery repetitions in a session for three days a week over four weeks of imagery training, was the most effective dose of the three doses examined for facilitating basketball players' FTS performance in this study.

The main findings of Study 2 provide clear guidelines for effective imagery duration in a session for designing imagery training programs that 13- and 18-minute imagery durations are recommended. The effectiveness of imagery durations in this study enhances the conclusions of previous reviews that indicated that imagery durations over 10 minutes up to between 25 and 30 minutes are beneficial for sport skill performance enhancement (e.g., Hinshaw, 1991; Paravlic et al., 2018, Schuster et al., 2011). Those reviewers drew their conclusions by comparing effect sizes of studies that each applied only one imagery duration. In the present study, I directly compared three imagery durations for the first time, as far as I am aware from searching the literature. Furthermore, Study 2 results indicated that the specific imagery durations of 13 and 18 minutes are effective in terms of facilitation of basketball FTS. In Study 2, the results indicated that the 13-minute imagery duration was most effective, and the 18-minute duration was also more effective than the 8-minute imagery duration condition. However, I did not test durations between 14 and 17 minutes, so it is possible that one or more of these durations would be even more effective than the durations tested in the present study. Similarly, it is possible that a duration between nine and 12 minutes would be more effective than 13 minutes. To my knowledge, the present study was the first to test different imagery durations using a controlled dose-response research protocol. The results are suggestive, but further studies should be conducted with discrete tasks, such as basketball FTS, comparing various durations between nine and 20 minutes, to provide a strong pattern of data from which researchers and practitioners can readily deduce the most effective duration for imagery training programs with discrete tasks.

The Study 2 results contributed new knowledge about how different imagery durations have different effects on performance. The 13-minute imagery duration was the most effective in terms of FTS enhancement and retention in this study, but there are some concerns about its effects. For example, because the design of the present study was original to this thesis, there is no existing evidence from which to draw conclusions about whether participants had an appropriate interval between FTS images. In strength or conditioning research, researchers have examined this issue and provided information about rest interval effects on physical training (e.g., Grgic, Schoenfeld, Skrepnik, Davies, & Mikulic, 2018). Determining the most effective rest interval duration between imagery repetitions would also be important in imagery training because athletes need to apply high levels of concentration to imagery tasks to achieve optimal outcomes. There is, however, a difference between the design of imagery dose-response studies and those in areas like strength and conditioning on which the principle of dose-response relationships is broadly based. In strength and conditioning tasks, researchers can monitor the number of times the task is repeated because participants perform the task physically and rest during intervals in front of the researchers, so they can be sure that participants do not perform the task more times during rest intervals.

In this study, only the 13- and 18-minute Imagery duration conditions included the interference task. As in Study 1, if there are breaks between repeats of imagery of the task, participants could perform extra imagery repetitions of the task without the researchers' knowledge. To control for this, in the present study, I included an interference task that was designed to occupy participants' attention during the intervals between imagery repetitions.

Participants in the 8-minute imagery duration condition created 20 FTS images and they evaluated the quality of each FTS image by answering the manipulation check questions with just 24 seconds for each repetition and manipulation check. Pilot work indicated that in this condition participants only had sufficient time to complete the imagery repetition and manipulation check before the next repetition was prompted by the audio signal. Thus, participants might have experienced the rhythm of creating FTS images and doing the manipulation checks to be too fast, which might have affected their concentration, producing a negative impact on the quality of their imagery during sessions of imagery training. This could explain why the 8-minute imagery repetition condition showed no significant difference from the Control condition. In the comparison between the two longer imagery duration conditions, the 18-minute Imagery duration condition was less effective than the 13-minute Imagery duration condition. This could have been because in the 18-minute Imagery duration condition participants had a longer interference task than participants in the 13-minute Imagery duration condition, which might have caused boredom. It is also possible that the longer intervals between imagery repetitions in the 18-minute imagery duration condition, during which participants had to focus on the interference task, might have had a negative effect on their concentration during imagery training due to mental fatigue. Participants in the 13-minute Imagery duration condition might have experienced the most appropriate rhythm for creating FTS imagery, with an interference task interval between repetitions of FTS imagery that did not disrupt concentration on FTS imagery repetitions as much as was experienced in the shorter and longer Imagery duration conditions. Hence, it appears likely that imagery duration affects imagery training quality, especially given that it may be related to concentration, boredom, and mental fatigue during imagery training. Consequently, the Study 2 results provide new information about the effects of different imagery durations on sport performance in sport imagery contexts. The results of Study 2 should be replicated before strong implications are drawn for the use of different durations of imagery training sessions. However, the present results suggest that sport psychologists should be confident to use imagery durations around 13 minutes in designing imagery training programs.

In conclusion, the Study 2 results contribute to imagery training literature, providing original evidence about imagery duration that researchers should explore further and that practitioners could apply to imagery training programs. Overall, the study suggests that the 13-minute duration of imagery sessions facilitated basketball FTS performance more than the 18-minute duration, which produced greater improvement in performance than the 8-minute session duration. Moreover, the results suggested that the new research protocol for examining imagery dose-response variables could be used to study the dose variable of session duration, comparing the effectiveness of imagery durations within the range of durations previously reported to be effective in studies that applied one duration, while studying other aspects of imagery in sport. The Study 2 findings should contribute to knowledge that can be applied by athletes, coaches, and sport psychologists in practice and competition, enabling athletes to use imagery effectively.

Methodological Issues

In the present study, I identified several limitations related to examining the effectiveness of different imagery duration doses for enhancing FTS performance. I recruited only male basketball players for Study 2 because researchers have found differences between genders in imagery ability and imagery training effects (Burhans et al., 1988; Munroe-Chandler, Hall, Fishburne, & Strachan, 2007). I was concerned that these biases may have affected the results and the focus on examination of a new imagery dose-response protocol in this research, in which I tested the dose variable of duration. Evaluating the usefulness of the protocol was an important element in this study. In addition, through the research in the present thesis, I investigated three imagery dose variables in different studies. These were number of repetitions in a session, duration of sessions, and frequency of sessions per week. To permit comparisons across studies, as well as within studies, I aimed to apply the same research design in all three studies, including controlling characteristics of samples. I chose to examine only male basketball players because gender differences could have confounded the results. In future studies, researchers could study the same variables in female basketball players. Moreover, there is a limited amount of past systematic research into imagery dose-response relationships, which means that it was important to reduce potential confounding variables, including gender differences, for the imagery dose-response research.

Another potential research limitation was the location in which participants were recruited and in which they performed their pre-test and post-test FTS performance. It was a concern that some of the participants might have known other participants who were undergoing testing or doing imagery training at the same venue at similar times. It is possible that players shared their imagery training progress or FTS scores with other members of their team or club. This could have generated expectations among players who participated in different research conditions, particularly those who were assigned to the Control condition. Another concern is that sharing FTS results might have affected participants' self-esteem and confidence in their performance. Participants who achieved lower FTS scores than others might have experienced more negative mental states than those of the higher scoring players. This situation might have been demotivating for lower performing participants.

A further potential limitation in recruiting participants was the total number of participants. This is the limitation associated with recruiting the appropriate number of participants to ensure that a significant result is found, if a real effect exists, as was evident in previous dose-response research (e.g., Wakefield & Smith, 2009b). The sample size in that research and in the present study was lower than that recommended by power analysis software. However, I employed more participants in this study than were employed by Wakefield and Smith. Nonetheless, Wakefield and Smith did find a significant effect associated with different doses of imagery and I found significant effects in the present study. Furthermore, the results showed that there was a significant effect of occasions and a significant interaction effect. In addition to this, I found significant post-hoc test results and large effect sizes. Hence, the number of participants did not appear to be a problem in Study 2.

Examining three imagery durations from 8 minutes to 18 minutes in a session was a more restricted range of durations than have been effective in enhancing performance in previous imagery studies that each employed only one duration (Anuar et al., 2018; Rhodes et al., 2018; Sardon et al., 2016). The restricted range of durations in the present study might be a limitation. Based on reviews, in previous research, researchers employed a broad range of imagery durations in successful imagery training, from around 1 minute to 30 minutes (Etnier & Landers, 1996; Feltz & Landers, 1983; Paravlic et al., 2018; Roure et al., 1999; Schuster et al., 2011), which did not identify a most effective imagery session duration. Again, it must be stressed that these reviews aggregated durations from different studies that each only used one duration and in which duration was not the central issue being examined.

Imagery is a powerful technique, so it is not surprising that different durations, when delivered well, showed positive effects on performance. However, it is not realistic to compare the outcomes of these studies, which varied widely in many respects. Studies included in those review papers showed diverse levels for other important characteristics that could affect the impact of the imagery training programs studied. These variables include age, gender, skill level, and nature of the imagery task. They also include the other key imagery dose variables number of repetitions and frequency of imagery sessions each week, as well as number of weeks of imagery training. All of these variables could play a role in how effective a specific session duration was in a particular study. Nonetheless, I based the durations in the present study on the best information available from previous research and applied work using imagery, which suggested that the most consistent results emerged from studies and practical applications between 10 and 15 minutes in duration (Anuar et al., 2018; Dana & Gozalzadeh, 2017; Fazel et al., 2018; Sardon et al., 2016). Thus, I chose to examine a minimum imagery duration of 8 minutes, which was a little shorter than 10 minutes. Then I added 5 minutes to each of the longer imagery conditions with the maximum imagery duration being 18 minutes, which was longer than 15 minutes. However, I did not examine imagery durations over 18 minutes, which meant that the outcomes of longer imagery durations than those in the current study are unclear, as Driskell et al. (1994) reported positive effects for 20-minute imagery duration in their review.

Results of the present study indicated that the 13-minute imagery duration was more effective than either the shorter 8-minute duration or the longer 18-minute duration. This suggests that imagery durations shorter than 8 minutes and longer than 18 minutes are unlikely to be more effective than the 13-minute duration for enhancing performance of basketball FTS performance. Nonetheless, all imagery durations between 8 and 18 minutes were not tested in the present study. Thus, it would be informative for the 13-minute duration to be tested against durations that are shorter, but not as short as 8 minutes, for example 10 or 12 minutes. It would also be instructive to compare the 13-minute duration with somewhat longer durations, such as 15 minutes or 16 minutes.

To minimize the risk of changes in other influential variables affecting comparisons between the present study and future studies, those studies should examine the same task, basketball FTS, in participants of similar skill level to the basketball players in the present study, that is, with pre-test FTS scores on the 0- to 3-point scoring scheme between 40% and 60%. I suspect that the closer together are the durations studied, the less likely it is that significant differences will be found between their effects of FTS performance. Once a stable pattern of results has been determined for the FTS task with average skill performers, studies should examine the effects of the performance task and performer skill level on the most effective imagery duration.

Interval effects may be involved during imagery training sessions, which may be a limitation in Study 2. I instructed participants in all imagery conditions to take the manipulation check to evaluate their imagery quality. Participants in the 8-minute imagery duration condition might have experienced pressure because time was limited. This is because their imagery training procedures involved imagining FTS and then doing the manipulation check 20 times in the duration of 8 minutes, leaving little time between imagery repetitions. Alternatively, participants in the 13- and 18-minute imagery duration conditions had more time between imagery repetitions, so they might have experienced less pressure during the imagery sessions. Conversely, participants in the 8-minute imagery duration condition could focus on imagery training without the addition cognitive processing of the interference task. That could have been advantageous, especially because they did not have to switch cognitive processing back and forth between imagery and colour name checking.

The interference task was only provided in the 13- and 18-minute imagery duration conditions, in which it might have been a limitation. It was a very simple task that required participants to listen to colour names in English, but they needed to identify non-colour words that had high associations with colours. Although this did not demand a high commitment, the 18-minute imagery duration in particular might have induced boredom in participants. Hence, some of the participants could have been demotivated to focus on another task during the interval between FTS imagery repetitions. In further studies, researchers could use an alternative interference task, and they may be able to examine longer imagery durations than those used in Study 2. Nevertheless, examining the imagery dose-response relationship on durations of less and more than 8 to 18 minutes in a session may be important in further research for contributing to the imagery training literature, but it must be a requirement to create a suitable research design to ensure that participants cannot perform additional imagery repetitions that could distort results.

Future Research

In this subsection, I discuss the research issues raised in Study 2 that could be addressed in further research. First, researchers could replicate this study of the effect of duration of imagery dose on FTS. Examining the imagery dose-response relationship for duration of sessions is a new topic in the sport imagery training literature, and this study is the first to examine different imagery duration effects. Hence, researchers could replicate the study design but explore a range of moderator variables that may influence the effective duration of imagery. For example, researchers could replicate the study, but with different samples of basketball players, such as elite level or novice level players, to determine whether there is an effect of skill level on duration of imagery sessions. In particular, examining whether the effects of the 13-minute imagery duration can promote sport performance in participants with different skill levels addresses the research question of determining if the same duration effect occurs at all skill levels. I used only male basketball players because researchers have reported gender differences in imagery use (Burhans et al., 1988; Munroe-Chandler, Hall, Fishburne, & Strachan, 2007). Therefore, researchers could replicate examination of the effect of the imagery dose variable of duration of sessions in FTS performance in studies with different populations, including female basketball players, then examine both genders to examine further whether male and female players differ in imagery training effects related to imagery dose duration. In such research it would be important to control for the moderating effect of skill level, ensuring that male and female players had equivalent skill levels. This would be best done by using the approach applied in the present study of screening and selecting participants within a limited range of FTS performance because all players who play for the same team or who play in the same division of the same league will not have the same level of FTS shooting skill.

Researchers should also examine the imagery dose variable of duration in athletes of different ages. I only studied basketball players over the age of 18. Researchers have found that younger athletes, as young as or younger than 14 years of age can create imagery and use imagery functions like adult athletes (Hall, Munroe-Chandler, Fishburne, & Hall, 2009; Munroe-Chandler, Hall, Fishburne, O, & Hall, 2007). Moreover, researchers have examined the effects of imagery training on the performance of young athletes (e.g., Atienza et al., 1998; Zhang, Ma, Orlick, & Zitzelsberger, 1992), and found significant effects. On the other hand, Quinton et al. (2014) did not find a significant imagery training effect on younger participants' imagery ability and soccer skills. Providing imagery training programs might be necessary to modify certain aspects of studies involving children and youth to match the language used to what younger athletes will understand (Quinton et al., 2014). Hence, careful imagery training design is necessary for imagery training programs for young athletes. In addition, examining whether 13-minute imagery duration can improve young athletes' performance may contribute to the imagery training literature with young athletes, who might have less capacity to sustain their attention during imagery training. Thus, it is possible that imagery training session durations shorter than 13 minutes might be more effective than 13-minute sessions with younger athletes (Foster, Maynard, Butt, & Hays, 2016).

With reference to athlete characteristics, examination of the imagery dose variable of duration of sessions in elite-level athletes is an important issue for further research. I studied non-elite basketball players because their FTS performance has much greater scope for improvement, which means that imagery training has a greater chance of enhancing their FTS accuracy than it would for elite performers. For future research, researchers should examine whether replicating the Study 2 research design enhances FTS performance in elite-level basketball players. High-level athletes also derive benefits from imagery training, and critical feedback can contribute to refining their skill level and performance accuracy (Morris et al., 2005). Hence, researchers should examine whether more advanced level players can improve their performance in accordance with the Study 2 findings. Consequently, there are many research opportunities for determining whether this new protocol for examining the imagery dose duration variable is applicable to different genders, ages, and skill levels in further research in the area of sports imagery training.

In addition, researchers should further examine whether imagery session durations around the 13-minute duration have different effects on FTS performance. In Study 2, I only compared 8-, 13-, and 18-minute imagery durations, and there was 5 minutes difference between 13-minute imagery duration and the other two imagery conditions. Thus, researchers should compare the effects of 13-minute imagery session duration with duration times that are a little shorter, e.g., 10 or 11minutes, and a little longer, e.g., 15 or 16 minutes because it is possible that imagery durations that are shorter or longer than 13 minutes improve FTS performance more than the 13-minute imagery session duration. It is important to know whether there are more specific imagery duration effects on performance than I examined in the present study. This would permit sport psychologists to provide more specific guidelines to athletes and coaches. For example, researchers could design studies to compare 11-, 13- and 15-minute imagery durations in terms of their effects on FTS performance. I found that the 18-minute imagery duration had an effect on FTS performance, so it is possible that a 15-minute imagery duration may be a more effective duration than 13 or 18 minutes for FTS performance. Conversely, it is uncertain whether a shorter imagery session duration of 11 minutes would have a similar effect on FTS performance to the 13-minute duration imagery sessions because I found the shortest imagery condition (i.e., 8 minutes) in the present study was not as effective as 13- or 18-minute sessions. Therefore, investigating more about 13-minute imagery duration effects might help to determine why I found that the 13-minute imagery session duration was more effective than the other two conditions in Study 2.

It is possible that research examining imagery session durations that are very similar, such as durations that differ by only two or three minutes, will not show significant differences in effectiveness. This would also be valuable information for sport psychologists working with busy athletes, allowing the psychologists to recommend for the athletes with whom they work the shortest imagery training session duration that produces equivalent results. This should produce equally effective imagery training, while allowing the athletes extra time to spend on other aspects of their preparation.

Researchers should examine whether the same results as those in Study 2 emerge when they examine different sport tasks, in which they compare similar session durations to those I studied here. For example, researchers should transfer the Study 2 research design into other closed skill tasks, such as golf putting, netball shooting, and basketball 3-point shooting. A further area of research that could contribute more to the literature is examining this new imagery dose-response protocol in different discrete tasks and on open-skill tasks. I used a simple, closed skill, discrete task in the present study because the imagery dose-response protocol is new, which means that it is important to minimize the possible extraneous variables that could confound results (Morris et al., 2012). The results indicated that there were significant effects of duration of imagery sessions on FTS performance, so the protocol should be applicable to other sport tasks. For example, simple discrete tasks that could be examined include netball shooting, golf putting, dart-throwing, pistol and rifle shooting, and archery. Researchers have reported that imagery training had positive effects on these skills (Kuan et al., 2018; Ramsey, Cumming, & Edwards, 2008; Wakefield & Smith, 2009b), but they chose imagery session durations based on previous research and reviews, in which each study only used one imagery session duration. Using the dose-response research protocol, researchers should compare several session durations in the same study, controlling other dose variables and potential moderators across research conditions.

Examining the effectiveness of different imagery session durations in open skills would extend the new dose-response protocol into more complex tasks. Using a relatively simple open skill may be more researchable because it does not demand as high a degree of information to be processed to test the effect of different imagery session durations on performance as would be required with a complex open skill. For example, tennis serve return may be suitable because researchers have reported that imagery interventions had positive effects on service return (e.g., Coelho et al., 2007; Robin et al., 2007), although, as far as I am aware, there is no published research examining the imagery session duration variable in a simple open skill. After studies are conducted on imagery session duration in several discrete skills, sport psychologists should generate information that would illuminate the question of whether imagery session duration is relevant to the delivery of imagery training in simple open skill tasks. Then, there should be potential to apply effective imager session duration doses to simple open skills.

In the conclusion, there are many further research topics from the Study 3 results. For example, further studies certainly can provide more precisely information of imagery duration in terms of designing imagery training programs for various level athletes. In addition, it is important to have replicate studies, especially examining whether the imagery dose-response protocol can find same imagery training and imagery duration effects on FTS performance. Therefore, replicated research is necessary in this stage, after that researchers can apply the results in more particular study topics.

Conclusion

In Study 2, I examined the imagery dose-response relationship between imagery session duration and FTS performance. The results showed that using 13-minute and 18-minute imagery session durations in a session was more effective for increasing FTS performance than the 8-minute imagery session duration in the present study. In addition, the 13-minute imagery duration condition was likely the best imagery duration in this study because it had significantly higher means than the Control condition at post-test and retention test. Reviews indicated that different imagery durations have been employed in imagery intervention studies, ranging from 1 to 30 minutes (Paravlic et al., 2018; Schuster et al., 2011), thus, there is some inconsistency in the duration of imagery employed in imagery training programs. In addition, there has been no direct comparison to determine which imagery durations may be most effective in imagery training. Hence, I examined three different imagery durations in Study 2. In particular, I manipulated the key variable of duration, while holding two dose variables of number of repetitions and frequency of sessions per week constant. The Study 2 results added to understanding of the effects of different imagery session durations on FTS performance. Although, this issue should be examined further, by repetition with different samples, and in relation to moderator variables, such as skill level, gender, task type, and age, the findings do provide preliminary evidence on the role of imagery session duration in the delivery of imagery training in sport. Findings of this study indicated that imagery duration of 13 minutes was effective in improving FTS performance, which provides guidance for athletes, coaches, and sport psychologists in applying imagery training and in studying imagery in sport.

Examining the new imagery dose-response protocol was another research aim in this study and the thesis as a whole. The dose-response protocol has been used in the disciplines of psychology and physical exercise (Chen & Ringenbach, 2016; Kool et al., 2018; Stulz et al., 2013). (Morris et al., 2012) proposed that the protocol should be applied in sport imagery training research. Sport psychologists have conducted a large amount of research on the effects of imagery training on sport performance (Post et al., 2012; Smith et al., 2008), psychological states in sport (Fazel et al., 2018; Koehn et al., 2014), and sport rehabilitation (Lebon et al., 2012; Sordoni et al., 2000). Although imagery training is delivered in doses, with the aim of changing performance, psychological states, or rehabilitation, imagery training research in sport has not systematically examined the effective delivery of imagery training programs based on dose variables, including duration of imagery sessions. Hence, examining the imagery dose variable of duration of sessions is important to provide clearer implementation of imagery training. The results of this study showed that there were significant effects of imagery session duration on FTS performance between three imagery conditions, 8-, 13-, and 18-minute imagery duration conditions, and the Control condition. This indicates that the imagery dose-response protocol has potential in the examination of effective imagery session duration on sport performance, and this issue should be examined further.

CHAPTER 5

STUDY 3: EXAMINING THE FREQUENCY COMPONENT OF THE IMAGERY DOSE-RESPONSE RELATIONSHIP

Introduction

In Study 3, my focus was on the imagery dose variable of frequency of imagery sessions each week. In Study 2, I examined the imagery dose session duration that was most effective for improving basketball FTS performance. I compared 8-, 13-, and 18-minute imagery sessions, while the imagery dose variables of number of repetitions and frequency of sessions per week were held constant. Based on the Study 1 results, number of repetitions in a session was held constant at 20 repetitions. In Study 2, I continued to employ three imagery frequencies each week, based on the limited previous research on the frequency dose variable. Results indicated that the 13-minute imagery duration had the greatest facilitation effect on FTS.

The key imagery variable of frequency is also an influential factor in sport performance. In a review, Schuster et al. (2011) reported that the most successful imagery intervention research typically employed a frequency of imagery training of three sessions per week. Researchers have examined how frequencies of one, two, or three imagery training sessions per week affected netball shooting performance (Wakefield & Smith, 2009b) , as well as biceps curl performance (Wakefield & Smith, 2011). These researchers found three imagery sessions per week to be more effective than one or two imagery sessions in a week. However, these conclusions were based on limited research and studies that had no systematic manipulation of other key imagery dose variables. Also, these studies did not consider a larger frequency of imagery sessions per week and it might be that four or five sessions would provide greater performance gains than three sessions. Therefore, I used a systematic approach for comparing the frequency of imagery sessions per week by varying frequency systematically, while I controlled the other key imagery variables of number of repetitions and duration of sessions, using the most effective values from Studies 1 and 2, namely 20 repetitions and 13 minutes per session. Because I found no experimental studies of frequency of imagery sessions per week that employed more than three days of imagery training, I had no basis in theory or research to propose a formal hypothesis for the most effective imagery frequency per week.

Method

Participants

Forty Melbourne-based basketball players (mean age 20.92 years, *SD* = 3.01) volunteered to participate in Study 3. They played basketball in their local basketball club, university basketball club, or recreational basketball club in their community at least once every week. Participants were randomly allocated into four conditions (three imagery conditions and a Control condition), so there were 10 participants in each condition. They had no formal imagery training experiences that would have facilitated their basketball free-throw shooting (FTS) performance. I set the eligibility for participating in Study 3 to align with the screening of FTS skill level and imagery ability that I conducted. The FTS score range was from 0 to 120, and I set participation eligibility at FTS accuracy between a minimum FTS score of 49 (41% FTS accuracy) and a maximum FTS score of 72 (60% FTS accuracy) at pre-test. To ensure that all participants had moderate to high imagery ability, I set the imagery ability eligibility criteria at a minimum score of 150 out of 400 on the key Sport Imagery Ability Measure (SIAM) dimension subscales (vividness, control) and sense modality subscales (visual, kinaesthetic, tactile, and auditory), which are relevant to basketball FTS performance. Following these screening tests, I checked that there were no significant patterns of difference in FTS pre-test performance or imagery ability between the four research conditions.

Study Design

In accordance with the aim of Study 3, I examined the effectiveness of frequencies of imagery sessions per week for enhancing the sport skill of basketball FTS. I manipulated the dose variable of frequency systematically, while I held constant the two other key dose variables of number of repetitions per imagery session and duration of imagery sessions. I allocated participants into three different imagery intervention frequency conditions of 3 sessions, 4 sessions, and 5 sessions a week, along with a Control condition. I provided a 4-week imagery training program, but participants took varied numbers of imagery training sessions (three, four, and five times a week for four weeks). The Control participants had no imagery training, but they completed FTS performance tests at corresponding times to the imagery condition participants. I conducted FTS testing at pre-test, then I measured FTS again immediately after the final imagery session each week. In addition, I administered a retention test (no imagery training) one week after the imagery program finished, to check the extent to which participants maintained any improvements in FTS performance. I measured FTS performance of participants in the Control condition at the same six times as the participants in the Imagery conditions, but they did not experience any intervention. Thus, I utilized a pre-test, post-test, and retention design to examine the impact of the three frequencies, namely 3, 4, and 5 imagery sessions per week on FTS performance, compared to the Control condition.

Measures

Demographic form. As described in Study 1.

Sport Imagery Ability Measure (SIAM; Watt et al., 2018; Watt et al., 2004b). As described in Study 1.

Basketball free-throw shooting (FTS). As described in Study 1.

Imagery log and imagery manipulation check. As described in Study 1.

Physical practice log. As described in Study 1.

Research Conditions

Imagery training conditions. I randomly allocated participants into one of the three Imagery intervention conditions, involving frequencies of three, four, or five FTS imagery training sessions per week, or the no imagery training Control condition. Participants in the 3-session per week condition completed imagery training on Saturday, Monday, and Wednesday. Participants in the 4-session per week condition, completed imagery training on Saturday, Monday, Tuesday, and Thursday. Participants in the 5-session condition undertook imagery training on Saturday, Monday, Tuesday, Wednesday, and Thursday.

All participants in the Imagery conditions had the same instructions for imagery training, which only varied in terms of the number of imagery training sessions per week. I kept the two imagery dose variables that I have focused on in the previous studies in this thesis at the constant levels that were most effective in Study 1 (20 FTS imagery repetitions in each session) and Study 2 (13 minutes imagery training duration for each session) for all three Imagery frequency interventions. I used MP3 players for controlling the number of FTS repetitions and the imagery duration in a session. Participants conducted the imagery training sessions independently, which involved them following the MP3 player audio instructions, so that they could imagine the designated FTS number of repetitions and duration in each session. I controlled the number of repetitions of imagining FTS by auditory signals to cue the start of each imagery repetition, so that participants imagined one FTS after each auditory signal. The auditory signal occurred every 39 seconds during the 20 FTS imagery repetitions, with each imagery training session lasting 13 minutes. After imagining each FTS, participants responded to the imagery quality manipulation check on the mp3 (Appendix J).

In all Imagery training conditions, participants conducted the same cognitive interference task as in Studies 1 and 2, following the manipulation check and continuing until the stimulus for the next imagery repetition. The purpose was to minimise the opportunity for participants to imagine extra FTS imagery repetitions beyond the designated 20 repetitions during the time between the FTS image and the next auditory signal. In the cognitive interference task, participants listened to colour words (e.g., yellow, red, green) continuously during the interval, with the exception of the designated imagery periods. However, non-colour words irregularly appeared in the audio list that were closely associated with specific colours (e.g., tomato, banana). I instructed participants to write non-colour words in the blank boxes on the imagery experience check sheet. Participants had to focus on listening during the interfering task, which I considered to involve sufficient cognitive demand to occupy conscious attention, but not to be so demanding that the task would interfere with the concentration needed to perform the designated repetitions of imagery of FTS. Auditory signals of a bouncing basketball sound appeared at the end of the cognitive interference task to prepare participants for the next FTS imagery repetition.

Therefore, 20 repetitions were presented at evenly spaced intervals across the duration of each session. Pilot testing was conducted as in Study 2.

Control condition. As described in Study 1.

Imagery script. As described in Study 1.

Procedure

This study was approved by the Victoria University Human Research Ethics Committee (VUHREC). All participants were volunteers, recruited from local basketball teams in Melbourne. I utilized flyers in order to recruit participants (Appendix Q). I provided standard informed consent for basketball players before participation (Appendix C, D, E, and R), then explained the nature of the study, especially imagery training, the study aims, participation risks, and benefits for participants. I encouraged participants to ask questions about the study, which I subsequently answered to the best of my ability. After the participants had signed the consent form, they completed the screening and pre-test measures, which included the Demographic form (Appendix F), the SIAM (Appendix G), and the FTS performance test (Appendix K). To participate, basketball players were required to score at least 150 on the key imagery variables (vividness and control dimensions; visual, kinaesthetic, tactile, and auditory sense modalities), and they were required to score between a minimum of 41% (score = 49) and a maximum of 60% (score = 72) on the FTS at pre-test. I assigned participants at random to one of the three Imagery training conditions or the Control condition.

Depending on their assigned condition, participants undertook 3, 4, or 5 imagery sessions each week for 4 weeks, or took part in the Control condition in which they completed the SIAM and basketball FTS test at pre-test and the FTS at the end of each week for 5 weeks. For participants in the three imagery conditions, the duration of each imagery session was around 13 minutes and involved the use of an MP3 player. The audio track in their MP3 player presented the Imagery intervention, the within-task manipulation check, and the interference task to participants. After each FTS imagery training session, participants wrote their imagery experience and the date and time on the post-task imagery manipulation check sheet (Appendix J). In addition, I checked the participants' total physical basketball practice time during the imagery intervention period from the physical practice log (Appendix K) that each participant completed when they were involved in basketball practice sessions. In the FTS tests, I tested participants in all four conditions at the end of each week of imagery sessions and completed the retention test at the end of Week 5, during which there was no imagery training of participants in the imagery conditions. After they had completed all the imagery training sessions and FTS tests, I had a social validation check with all participants in the imagery conditions about their experiences of the imagery training in the study, using interview questions to elicit their reflections on their experience of the study (Hrycaiko & Martin, 1996). At the end of their involvement in the study, I offered Control condition participants the opportunity of participating in the imagery-training program.

Analysis

I examined whether there were any significant differences in imagery ability between conditions for the 12 SIAM subscales at pre-test screening by using a multivariate analysis of variance (MANOVA). For the physical practice log, I calculated the total basketball practice time from the logbook during the five weeks of the study. Then I used one-way ANOVA to examine whether there was any significant difference on the total practice time between the four conditions. To test for any differences between conditions in the imagery manipulation check, I calculated means for all imagery conditions in each week from the imagery manipulation check sheet. Then I tested for differences between conditions by using two-way, mixed-design ANOVA, for the three Imagery conditions (3-, 4-, 5- imagery sessions per week) x four occasions (Weeks 1, 2, 3, 4). To test for differences between FTS scores for the four conditions at pre-test, I used one-way ANOVA. Finally, I tested FTS means in all four conditions, at pre-test, at the end of Weeks 1, 2, 3, at post-test at the end of Week 4, and at retention test at the end of Week 5, using two-way, mixed-design ANOVA, with four conditions (3, 4, 5 Imagery sessions per week conditions, and the Control condition) x six occasions (repeated measures at pre-test, and Weeks 1, 2, 3, 4, and 5). I followed up any significant main effects of conditions or occasions, and any significant conditions x occasions interaction effects, using Tukey post hoc tests. I used the Statistical Package for the Social Sciences (SPSS: version 25.0) software for all statistical analyses, including F-tests, probability (p) values, and effect sizes (eta squared).

Results

The aim of Study 3 was to compare the effects of three different imagery frequencies of 3 sessions, 4 sessions, and 5 sessions per week, and the Control (no imagery) condition on performance of basketball FTS. I applied a new systematic approach to examine the imagery dose-response relationship in the context of FTS performance, in which I investigated a three different doses of imagery frequency, in terms of sessions per week. However, two key aspects of the imagery dose, number of repetitions and duration of sessions, were held constant at the most effective levels from Study 1 and 2, respectively. Results of the analyses are presented in this section. First, I explain the descriptive results for imagery ability, assessed using SIAM, and I compare the four research conditions on key imagery ability subscales, using MANOVA.

Second, I compare the four research conditions on total practice time, using one-way ANOVA. Third, I present the means and standard deviations of the imagery manipulation check. Finally, I examine FTS scores in two ways. I use one-way ANOVA to compare FTS performance in the three imagery frequency conditions and the Control condition at pre-test. Then, I use two-way, mixed design ANOVA that I conducted to compare FTS performance among the four conditions on the five occasions following the pre-test.

Imagery Ability

All players had at least moderate levels on the imagery ability subscales of SIAM, which I considered to be the vividness and controllability imagery dimensions and the visual, kinaesthetic, auditory, and tactile sensory modalities. This was a criterion for inclusion in the study, ensuring that participants possessed sufficient imagery ability to benefit from imagery training. I examined whether there were significant imagery ability differences between the four research conditions. Means and standard deviations are presented in Table 5.1. Visual inspection of the table indicates differences between the means for the four conditions on each subscale, but there is no systematic pattern of differences. Different research conditions showed the highest and lowest means on different imagery ability subscales. I used a one-way MANOVA to test for SIAM subscale differences between the four research conditions. I found no significant differences in SIAM subscale means between the conditions, F (9, 36) = .646, p = .85; Wilk's Λ = .704, partial η^2 = .11, with a large effect size. Thus, I concluded that there were no differences between imagery ability for the four research conditions.

Table 5.1

Means and Standard Deviations for all Conditions in the Sport Imagery Ability Measure

SIAM subscales	CONDITION	*M*	*SD*
AUDITORY	3 days	301.25	78.75
	4 days	313.63	80.49
	5 days	339.56	88.38
	Control	272.90	109.71
VISUAL	3 days	393.63	58.36
	4 days	392.63	86.78
	5 days	368.89	97.81
	Control	358.80	94.99
KINESTATIC	3 days	324.50	94.55
	4 days	277.88	122.22
	5 days	314.33	95.34
	Control	314.10	78.29
TACTILE	3 days	312.38	124.76
	4 days	291.50	124.01
	5 days	314.44	91.06
	Control	327.00	105.97
CONTROL	3 days	357.63	59.74
	4 days	332.50	83.47
	5 days	339.00	82.71
	Control	327.30	92.17
VIVIDNESS	3 days	378.00	53.45
	4 days	369.63	65.46

5 days	368.78	84.81
Control	347.30	110.06

Total Practice Time

Participants reported their practice time during the four weeks of imagery training of Study 3 in the Physical Practice Log. I examined whether participants in the four conditions showed any systematic difference in the extent of their basketball practice hours. For the 3 imagery sessions per week condition, the mean was 15.90 (*SD* = 7.46), for the 4 imagery sessions per week condition, it was 17.50 (*SD* = 7.01), for the 5 imagery sessions per week condition it was 16.30 (*SD* = 4.85), and for the Control condition it was 12.40 (*SD* = 3.98). Amount of practice in the Control condition was notably lower than in the three imagery conditions. However, one-way ANOVA, which was used to compare the total practice hours in all four conditions during the imagery training periods, showed no significant differences between the conditions F (3, 36) = 1.33, p = .28, η^2 = .01, with a small effect size, indicating that the practice hours were equivalent for all the conditions over the study period.

Imagery Manipulation Check

The aims of the imagery manipulation check were, first, to screen participants to examine whether they completed the required 20 imagery repetitions appropriately, and, second, to elicit a rating of participants' imagery quality, based on rating scale responses, which are displayed in Table 5.2. Participants reported their imagery quality in all of the imagery sessions. I averaged ratings for the 3, 4, or 5 sessions each week to produce a weekly mean for each participant. Next, I calculated a condition mean and *SD* for each condition, based on the participants' weekly mean, so I could examine whether there were any significant effects of conditions, occasions, or the interaction between conditions and occasions. I used a mixed-design, two-way ANOVA. There was no significant main effect of conditions, F (2, 27) = 1.666, p > .05, η^2 = .21, with a very large effect size, while there was a significant main effect of occasions, F (3, 81) = 22.879, p < .001, η^2 = .15, with very large effect size. There was no significant interaction between conditions and occasions, F (6, 81) = .597, p >.05, η^2 = .04, with a small effect size. Therefore, all imagery conditions' participants increased their subjective assessment of the quality of FTS images between Week 1 and Week 4.

All participants told whether they fully understood the aspects in this study during the social validation check.

Table 5.2

Means and Standard Deviations for Imagery Conditions in Weeks 1 to 4 in the Imagery Manipulation Check

	Week 1		Week 2		Week 3		Week 4	
Conditions	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
3 days	3.30	.59	3.52	.44	3.65	.28	4.06	.24
4 days	3.00	.38	3.27	.57	3.51	.43	3.72	.46
5 days	3.37	.75	3.43	.70	3.91	.40	3.94	.39

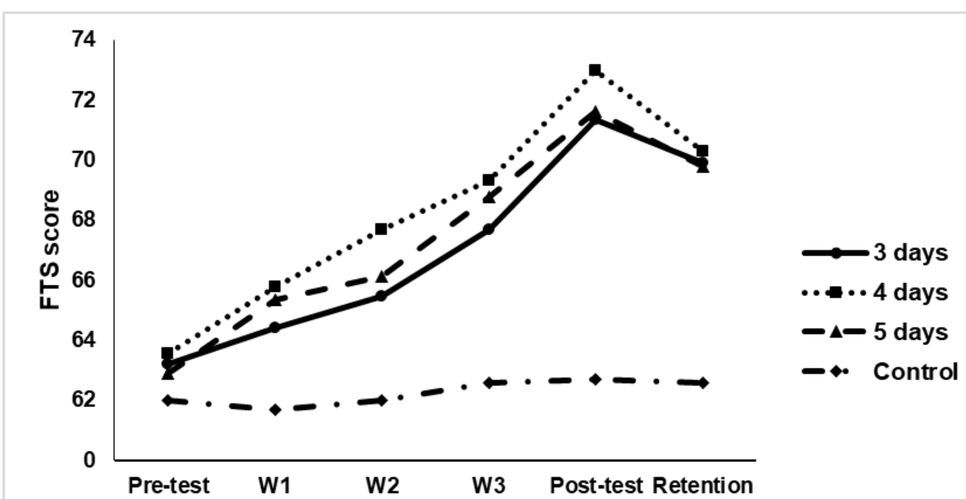
Performance Outcome

The means for the four research conditions across the six weeks of the study (pre-test. Weeks 1, 2, 3, and 4, and the retention test at the end of Week 5) are presented graphically in Figure 5.1. Overall, Figure 5.1 shows that basketball FTS means increased monotonically in all three imagery intervention conditions from pre-test to post-test at the end of Week 4. Means for all three research conditions declined a little from Week 4 to the retention test at the end of Week 5, but they were still higher than in Week 3. There was virtually no change in basketball FTS means for the Control condition across all six measurement occasions. All three imagery intervention condition means were notably higher at post-test (Week 4) than the Control condition mean. They also increased substantially from pre-test to post-test. However, the mean in the 4 imagery sessions per week condition was noticeably higher than the means in the 3 and 5 imagery sessions per week conditions at post-test.

I checked whether there were significant differences between the FTS scores for the four research conditions at pre-test, using one-way ANOVA. Results showed that there was no significant difference at pre-test, F (3, 36) = .082, p > .05, $\eta^2 = .01$, with a small effect size. Consequently, the Imagery training conditions and the Control condition were not significantly different in FTS levels at pre-test.

Figure 5.1

Free Throw Shooting Scores of the 3-, 4-, and 5-Imagery sessions per week condition week and Control Condition on Six Occasions



To test for any significant effects of conditions, occasions, or the interaction between conditions and occasions, I conducted a two-way, mixed-design ANOVA. This showed that there was a significant main effect of conditions, F (3, 36) = 3.215, $p < .05$, $\eta^2 = .21$, with a very large effect size. There was also a significant main effect of occasions, F (5, 180) = 20.746, $p < .001$, $\eta^2 = .37$, with a very large effect size. There was a significant interaction between conditions and occasions, F (15, 180) = 1.886, $p < .05$, $\eta^2 = .14$, with a very large effect size.

Tukey post-hoc tests revealed that, at post-test in Week 4, the 3 Imagery sessions per week condition was significantly higher than the Control condition (p = .004), the 4 Imagery sessions per week condition was significantly higher than the Control condition (p = .005), and the 5 Imagery sessions per week condition was significantly higher than the Control condition (p = .035). At retention test, only the 4 Imagery sessions per week condition was significantly higher than the Control condition (p = .005). However, there were no significant differences between the imagery conditions. Tukey post-hoc tests showed that all the Imagery conditions' post-test FTS means were significantly higher than the corresponding pre-test means. In addition, the 4 Imagery sessions per week condition and the 5 Imagery sessions per week condition had significantly higher retention test means than their pre-test FTS means. The absence of a significant difference between the imagery conditions and the Control condition at pre-test, combined with the significant differences observed at post-test and retention test indicate that all three Imagery conditions had a noteworthy impact of FTS performance, that was sustained after a week with no imagery training, when participants in the 4 and 5 Imagery session per week conditions retained their increased performance a little more strongly than participants in the 3 Imagery sessions per week condition.

Discussion

The purpose of Study 3 was to examine whether different frequencies of imagery training sessions per week lead to different levels of increase in basketball FTS performance. I examined three imagery conditions, 3, 4, and 5 sessions per week, and a Control condition in terms of the extent to which they facilitated basketball FTS, in a design equivalent to the one I used in Studies 1 and 2. However, in the present study, I employed the number of repetitions (20) that I found to be most effective of the three imagery intervention conditions in Study 1 and the duration (13 minutes) that I found to be most effective of the three imagery intervention conditions in Study 2. The overall results showed that basketball FTS performance at post-test improved substantially in all three imagery intervention conditions, compared to pre-test. There was a small decrease in basketball FTS from post-test to retention test, but performance was still substantially higher than at pre-test and was higher than in Weeks 1, 2, and 3. In addition, FTS performance in all imagery conditions was significantly higher than performance in the Control condition, which did not change from pre-test through Weeks 1, 2, 3, 4, and 5. Basketball FTS performance in the 4 and 5 sessions per week imagery intervention conditions was significantly higher than performance in the control condition at post-test, in Week 4. Only the 4 sessions per week imagery intervention frequency condition displayed significantly higher basketball FTS performance than the Control condition at retention test, in Week 5. Interestingly, all three imagery training conditions had almost the same trends of improvement in basketball FTS performance between pre-test and post-test in that their FTS scores improved monotonically week by week, whereas the results showed that increases in basketball FTS performance varied somewhat from week to week. The results indicated that, although all three frequencies of imagery training were effective, the 4 sessions per week imagery intervention condition was the most effective frequency in this study.

The Study 3 findings indicated that 3, 4, and 5 sessions of imagery training per week can facilitate basketball FTS performance. Imagery training effects have been reported by researchers in a large number of studies (Calmels, Berthoumieux, et al., 2004; Fortes et al., 2018; Olsson, Jonsson, & Nyberg, 2008; Rhodes et al., 2018), and I also found positive imagery training effects on basketball FTS performance for all three imagery frequency conditions in this 4-week imagery training program. In addition, all the participants maintained their usual physical practice during imagery training periods, which might have facilitated imagery training effects (Driskell et al., 1994; Fazel et al., 2018; Post, Wrisberg, & Mullins, 2010). However, it should be noted that there was no increase in performance in the Control condition, in which participants' physical practice did not differ significantly from that in the three imagery conditions. Moreover, I used the most effective numbers of imagery repetitions and durations in a session that I determined in Study 1 and 2, and I kept these two variables constant across all three imagery intervention conditions. This meant that two key imagery dose variables had appropriate levels in all three imagery conditions. The FTS performance increase in the 3 imagery sessions per week condition supported previous research that found 3 sessions of imagery training per week was more effective than 1 or 2 sessions per week (Schuster et al., 2011; Wakefield & Smith, 2009b, 2011). However, the findings that both 4 and 5 imagery training sessions per week were more effective than 3 sessions per week are new findings in sport imagery research. Although visual inspection of the results in Figure 5.1 indicates that the effects of the three imagery intervention conditions were similar, I drew this conclusion because both the 4 and 5 imagery sessions per week conditions showed significantly higher performance at post-test than the Control condition, but the 3 imagery sessions per week condition was not significantly different to the Control condition at post-test. All the participants already had skill in FTS before participating in this imagery training program, but their skill level was not advanced, as evidenced by their FTS accuracy, which was between 41% and 60%. Hence, these participants had potential to increase their skill by participating in the imagery training program. This is supported by the results, which showed that mean basketball FTS performance in all three imagery intervention conditions increased from 63.2 (52.6%) at pre-test to 71.70 (59.8 %) in the 3 imagery sessions per week condition, 63.1 (52.7%) at pre-test to 73.00 (60.8%) at post-test in the 4 imagery sessions per week condition, and 62.9 (52.6%) at pre-test to 71.60 (59.7%) at post-test in the 5 imagery sessions per week condition at post-test.

Basketball FTS means for all the imagery training conditions decreased from post-test to retention test, when there was no-imagery training for a week. This result was expected for several reasons. First, there is a long history of research on motor skills that has used retention tests to examine how effectively various interventions, including imagery, were sustained during periods when the interventions were removed (Diane, Kelly, Amanda, & Rose, 2011; Park & Sternad, 2015). The vast majority of such studies show decreases in performance of the skill during the retention period (Spittle & Kremer, 2010). This is also the case in imagery research (Wright & Smith, 2007). In imagery research, decrements during retention periods vary with the length of the retention period; the longer the retention period the greater the decrement from post-test (Arnaud et al., 2013; Dunsky, Dickstein, Marcovitz, Levy, & Deutsch, 2008; O, Ely, & Magalas, 2019). However, for 1-week retention periods, percentage decrements typically vary from 1.5% to 2.3% (Ram et al., 2007). The percentage decrements from post-test to retention test for the three imagery intervention conditions in the present study were (about 1.5%) for the 3 imagery sessions per week condition (about 2.3%) for the 4 imagery sessions per week condition and (about 1.5%) for the 5 imagery sessions per week condition. Thus, the 3 and 5 imagery sessions per week showed smaller reductions at retention test than the 4 imagery sessions per week condition. By comparison with previous imagery research that has included a retention period, this represents relatively strong retention in all three imagery intervention conditions in the present study.

Another reason why participants might be expected to have reduced their basketball FTS performance from post-test to retention test is that participants' FTS accuracy level was not at the elite level after the imagery training program. This means that they still had potential to improve or refine their FTS performance. Percentage of maximum score on basketball FTS (120) at post-test was still only 59.8% for the 3 imagery sessions per week condition, 60.8% for the 4 imagery sessions per week condition, and 59.7% for the 5 imagery sessions per week condition. Finally, participants in the imagery intervention conditions only performed physical training during the retention test week, which means that their performance at the end of the week was based on their physical training that week and residual effects of the four previous weeks of imagery training. Researchers have reported that physical training alone is less effective than the combination of imagery training and physical training (Darling, 2008; Gould et al., 2002). Hence, the present study provides further information about the most effective imagery training periods and other key imagery variables in imagery training effects that researchers should examine in further research. Consequently, designing 20 repetitions and 13 minutes imagery duration in a session for 3, 4, and 5 imagery sessions per week frequencies did facilitate basketball FTS performance, and in the present study, the 4 imagery sessions per week frequency had the strongest effect in terms of post-test and retention test FTS performance.

The Study 3 results showed that the 4 imagery sessions per week condition was the most effective imagery frequency for improving basketball FTS performance among the three imagery frequency conditions selected for the present study. Researchers have found that imagery training is one of the most effective psychological techniques, and it is possible to utilize for enhancing performances in many sports (Olsson, Jonsson, & Nyberg, 2008; Smith et al., 2001; Smith et al., 2008). Researchers have used a variety of frequencies in imagery training programs. For example, in a study of muscle strength, Tenenbaum et al. (1995) used an imagery training program that involved 1 imagery session per week and found a significant effect of imagery training. In another muscle strength study, Yue and Cole (1992) used 5 imagery sessions per week and found that this frequency enhanced performance. Thus, these different frequencies both increased muscle strength, but we have no understanding about which frequency is more effective because the researchers did not compare different frequencies of imagery training sessions per week in the same study, under the same conditions. Wakefield and Smith (2009, 2011) have compared the impact of different frequencies on sport performance in netball (Wakefield & Smith, 2009b) and strength performance in the biceps curl activity (Wakefield & Smith, 2011). In both studies, they found that 3 imagery sessions per week were more effective than 1 or 2 imagery sessions per week. However, there is still limited research regarding the most effective weekly frequencies of imagery training in terms of sport performance facilitation, which is why I examined the effects of 3, 4, and 5 imagery training sessions each week. Results of the present study revealed that the 4 imagery sessions per week condition produced higher means at post-test and retention test than the other two imagery conditions, as well as a significantly higher mean than the Control condition at post-test and retention test. Therefore, I concluded that 4 imagery sessions per week was the most effective imagery session frequency in this study.

There are several reasons why the 4 imagery sessions frequency could have been more effective than the 3 and 5 imagery sessions per week conditions. For example, because 4 imagery sessions per week participants undertook imagery training for 16 sessions, which was more than 3 imagery sessions per week (12 sessions), they had more experience of imagery overall, which has the potential to lead to a greater increase in their FTS performance. However, 5 imagery sessions per week gives even more experience, so it might be expected that this would produce an even greater increase in performance, but it was not as effective as 4 imagery sessions per week in this study. It is possible that 5 imagery sessions per week was less effective because the number of imagery sessions per week (20 sessions) was too demanding for the skill and commitment levels of the participants in the present study. The participants in the imagery training conditions had not undergone systematic imagery training before, so they were not familiar with using imagery. Hence, 4 imagery sessions per week may be a more appropriate imagery dosage for participants of this type. This imagery training condition was designed for 20 repetitions with a duration of 13 minutes in a session for 4 sessions per week over 4 weeks, which was manageable with the participants' physical training schedules. In addition, participants could select their preferred time and location for conducting the imagery training sessions. These findings are important for designing imagery training programs. This is because adding 1 or 2 imagery training sessions in a week affects athletes' schedules, creating extra demands that they have to fit into their schedules with their physical practice and other commitments, including work and study (Farrow & Robertson, 2017). An implication of the effects of the extra demand of additional imagery sessions per week, postulated as an explanation for the 5 imagery sessions per week condition not being as effective as the 4 sessions per week condition, is that the most effective frequency of sessions per week might vary with skill level, as well as athletes' level of commitment to their sport. Thus, elite or professional athletes might perform more effectively with a higher frequency of sessions per week because of their high level of skill and commitment to sport, whereas novices might find even 4 sessions per week to be highly demanding. This is an issue that should be addressed in future research on frequency of imagery sessions.

The imagery dose-response protocol used in the present study was based on the proposition made by Morris et al. (2012). This protocol can be applied to imagery training research in order to examine effective imagery frequency dosages. Previous imagery training research used different combinations of imagery dose variables, because most researchers did not control other key imagery variables, when examining frequency of imagery sessions, particularly not systematically controlling the number of imagery repetitions in a session and the duration of each session (Paravlic et al., 2018; Schuster et al., 2011; Wakefield & Smith, 2009b, 2011). Thus, in future research, it is important to control imagery dose variables systematically, so, while one key dose variable is manipulated to test the options that are considered most likely to be effective, other key dose variables are held constant (Morris et al., 2012). In the present study, I examined whether this imagery-dose response design can identify effective imagery frequency. Following the specific results of Study 3, the 4 imagery sessions per week frequency was more effective than an imagery frequency with fewer sessions per week (3 sessions) and an imagery frequency with more imagery sessions per week (5 sessions).

In conclusion, the Study 3 findings contribute new knowledge to the imagery training literature, thus, enabling researchers to apply them when designing imagery training program research in future. The general conclusion is that doing more than 3 imagery sessions per week can facilitate performance in a discrete task, such as basketball FTS. In addition, I found that 4 imagery sessions per week was more effective for promoting sport performance than 3 and 5 imagery sessions per week, so that I conclude that the frequency of the 4-day imagery sessions had a more beneficial effect on basketball players' FTS than 3 or 5 imagery sessions per week, in the present study. Moreover, the imagery dose-response protocol (Morris et al., 2012) was applied effectively in the present study. These findings contribute to practice, helping athletes, coaches, and sport psychologists to use imagery training more appropriately and apply the most effective imagery frequency in their imagery training programs.

Methodological Issues

I identified several limitations in Study 3, as well as methodological strengths. One of the delimitations was in the profile of participants recruited. I made a decision that I would invite only male basketball players to participate in this study because there are differences in imagery ability and imagery training effects between male and female athletes (Burhans et al., 1988; Munroe-Chandler, Hall, Fishburne, & Strachan, 2007). Considering gender differences is important for applying a new protocol that examines the frequency dose variable in imagery training. I used similar research methods in the previous two studies in this thesis, so I followed the same research design as that in Studies 1 and 2 to maximize the opportunity to compare the three studies. Replicating the present study with female participants is important, as well as comparing male and female participants in the same study. However, this will require a larger sample size.

The location for recruiting participants could also have affected outcomes. I asked all participants not to share their FTS scores and imagery training experiences with anybody during their participation in the present study. Some participants came from the same basketball team or club, which increased the potential that those participants might have shared information about their imagery training protocol, experiences, and FTS results. For example, I was concerned that sharing FTS results might have been an influential motivating factor, in which players with lower scores in early weeks of the study compared themselves with players who had higher scores, and as a consequence might have been disappointed by their lower performance level, lowering their motivation. Additionally, Control condition participants' performance might have been affected by expectations. That is, they might have intentionally maintained their FTS scores throughout the study, rather than improving, because of their expectation that the aim for the Control group in research is not to change behaviour because they have not been given an active intervention.

The total number of participants was also a limitation in this study. I recruited 40 basketball players for Study 3, basing the number of recruited participants partly on previous research (e.g., Wakefield & Smith, 2011) and partly on a power analysis. I decided to conclude data collection when I found that that the results showed significant differences with appropriate effect sizes. If I had continued collecting data until I had a sample closer to the sample size identified by power analysis, it is possible that the differences between the three imagery intervention conditions would have been more clear-cut. However, this was a demanding study to conduct, especially in the 4 and 5 imagery sessions per week conditions, which required participants to commit a substantial amount of time and effort to the study over six weeks (pre-test, Weeks 1 to 4, and the retention test). I considered that to ask additional participants to undertake this demanding schedule, when I already had significant results, was not appropriate on ethical grounds or in terms of the time-limited nature of doctoral research.

Another methodological issue was that I used only a limited range of imagery frequencies in this study. I examined whether 3, 4, and 5 imagery sessions per week and the Control condition had different effects in terms of improving basketball FTS. The results indicated that the 4 imagery training sessions per week condition provided the highest FTS scores at post-test after 4 weeks and at retention test after another week with no imagery sessions. The 5 imagery sessions per week condition showed similar patterns of FTS results to the 4 imagery sessions condition at post-test and retention test. Like the 4 imagery sessions condition, the 5 imagery sessions per week condition had a significantly higher mean than the Control condition at post-test, but unlike the 4 sessions per week condition, the 5 sessions per week condition was not significantly different from the Control condition at retention test. However, I did not examine 6 or more imagery sessions per week. It is possible that 6 or 7 imagery sessions per week might have produced greater imagery training effects than the 4 imagery sessions per week condition over a 4-week imagery training program. Cumming and Ramsey (2009) found that high-level athletes used imagery every day. Orlick and Partington (1988) reported that Canadian Olympic athletes used imagery daily in their preparation for training and competition. Hence, there is some scope to examine the effect of 6 or more imagery training sessions per week on sport performance. However, there are concerns that providing an imagery training program that involves 6 sessions per week or more might raise some drawbacks for athletes. Outside their sport practice and competition commitments, club athletes who are non-elite, like the basketball players in the present study, have limited time to devote to practice and competition in their sport because they are also working or studying, as well as undertaking domestic activities (Farrow & Robertson, 2017). Thus, asking non-elite players to perform imagery on 6 or 7 days per week might create stress or pressure for these athletes, leading to a loss of motivation. They might even drop out of the imagery program. I found that the participants in the present study, who were assigned to the 5 imagery sessions per week condition needed to be encouraged more than those in the 3 and 4 imagery sessions conditions to maintain their imagery training schedule. They reported that undertaking sessions five times a week was highly demanding. Elite or professional athletes have greater potential to include in their schedule an imagery training program comprising 6 or 7 sessions per week, as their priority is their sport training and they spend most of their time on activities related to enhancing sport performance. Adding 15 minutes of imagery to their daily schedule should not be too difficult.

Another point that is pertinent here is that there is no value in undertaking additional imagery sessions per week, if they do not lead to further benefits, especially in terms of performance enhancement. In the present study, 4 imagery sessions per week was found to be more effective than 5 imagery sessions per week. Thus, it is possible that 6 or 7 imagery sessions per week would be less effective. However, the differences between 3, 4, and 5 imagery sessions that I found in the present study cannot be claimed to be conclusive. Further studies should be conducted with similar skill level performers in the same sport task, with similar skill level performers in different discrete sport tasks, and with elite level performers in various discrete tasks to determine whether the present result is replicated.

In this study, I also found that undertaking 4 imagery sessions per week was a more effective approach than performing 3 or 5 imagery sessions per week. This suggests that 6 or 7 imagery training sessions per week may not be more effective than a frequency of 4 imagery sessions per week. However, the present study is the first to examine imagery frequencies of more than 3 sessions per week, using a protocol that involves systematic control of other imagery dose variables and the differences between 4 and 5 imagery sessions per week were not clear-cut at post-test or retention test. Thus, further studies with these frequencies are warranted, using the systematic approach applied in the present thesis, which involves manipulating one imagery dose variable, while controlling the other imagery dose variables at the same levels across research conditions, as well as over different studies, as exemplified in the three studies in this thesis. In addition, distributing imagery training sessions per week may also be a crucial consideration in terms of replicating imagery dose-response frequency studies. I asked participants to undertake imagery training on Saturday, Monday, and Wednesday for the 3 imagery sessions per week condition, Saturday, Monday, Tuesday, and Thursday for the 4 imagery sessions per week condition, and Saturday, Monday, Tuesday, Wednesday, and Thursday for the 5 imagery sessions per week condition. However, if researchers organised 3 imagery training sessions consecutively during weekdays (e.g., Monday, Tuesday, and Wednesday), so that participants had a long break from Thursday to Monday, the participants might not have an adequate opportunity for each imagery training session to be consolidated in memory before the next session. Hence, the way in which imagery training sessions are distributed during the week could be an important influence that needs to be considered in the design of frequency studies of the imagery dose-response relationship. Further, trends in research on imagery variables, including frequency of sessions per week, do not consistently demonstrate a monotonic relationship between the imagery dose variable and outcome measures, such as performance in sports tasks (Duncan, Hall, Wilson, & Wilsons, 2012; Fazel, 2015). Thus, it is premature to assume that higher frequencies of imagery sessions would not be associated with larger performance increases. This suggests that examining the imagery dose-response variable of frequency for 6 imagery sessions per week or more could be informative. Research conditions involving 6 or 7 imagery sessions per week alongside 4 and 5 imagery session conditions could be an effective way to explore this issue in further research, in order to contribute to the imagery training literature.

Future Research

The results of Study 3 are promising. However, this is the first study to examine the imagery frequency dose variable, using the protocol proposed by Morris et al. (2012), in which one imagery dose variable is manipulated, while the other two main dose variables are held constant at levels previously shown to be effective. Although the present study showed substantial increases for all three imagery frequency conditions compared to the Control condition, differences between the three imagery frequency conditions were small. Thus, researchers should replicate this study design, including different samples of basketball players to determine whether the results are robust and whether they might be more clear-cut in further studies. In addition, applying the same design to other types of discrete sport task should be informative, because investigation in a range of tasks should indicate whether the result favouring the 4 imagery sessions per week condition in the present study is transferable to other discrete sports tasks. For example, replicating the present research design, using 3, 4, and 5 imagery sessions per week conditions with simple closed skills, such as golf putting, pistol shooting, archery, netball shooting, and basketball three-point shooting could build a pattern of results.

In the present study, the 4-session per week imagery frequency condition had the highest FTS score after the 4-week imagery training program compared to the 3-session and 5-

session per week imagery conditions and the Control condition. Researchers can apply the results to imagery delivery. I used a relatively simple imagery script in this study that excluded factors like environmental information, audience impact, and match pressure. However, by incorporating more information in the imagery script it may become possible to improve performance in competitive situations. For example, the progressive imagery delivery method or retrogressive imagery delivery method (Fazel et al., 2018) can be applied, using a design similar to the one employed in the present study. Practising the same imagery training program for 4 sessions per week over a 4-week period might lead athletes to lose motivation. Using imagery scripts with different content every week, but with the three key imagery dose variables used in the present study kept constant, has the potential to create stronger imagery training effects. Fazel et al. (2018) examined three imagery delivery methods, routine imagery, which had the same content in every session, comprising the core technical aspects of the task, as well as environmental, audience, and pressure content, progressive imagery, which started with core technical aspects of the task, then progressively added environmental, audience and pressure content to end with the equivalent of routine imagery content, and retrogressive imagery, which started with the full routine imagery content and removed pressure, audience, and environmental content in turn to end with the core technical task.

Another area in which further research could help to clarify the role of imagery frequency is applying the Study 3 results to athletes at various skill and competition levels and with characteristics that might influence the number of sessions per week that is most appropriate and effective. In the present study, I employed moderate-skill level, adult basketball players, and all the imagery training conditions led to significant FTS improvements. Participants had a strong probability of promoting their FTS performance because they started with moderate FTS performance accuracy before undertaking the imagery training. However, researchers should also examine whether replicating the Study 3 design imagery training can improve elite basketball players' FTS performance. Elite athletes often use cognitive imagery functions for their performance improvement (Arvinen-Barrow, Weigand, Thomas, Hemmings, & Walley, 2007), which means that replicable imagery training research has the potential to refine the shooting performance accuracy of elite basketball players, even though they would have less potential to improve, given that their starting performance levels would be much higher. Perhaps more important is that elite performers are often more dedicated to training, so they might be more comfortable adding 5, or even 6, sessions of imagery of FTS to their schedules, than were the participants in the present study. For example, examining the effects on performance of adding 6 days and 7 days per week of imagery training to their schedule may be important for designing appropriate imagery training programs for performers at the elite level. On the other hand, novice and developing basketballers might find 4 or 5 imagery sessions per week to be rather demanding, so they might produce superior performance with 3 sessions per week. Replicating the present study with developing and elite basketball players would help to determine the role of skill and competition level in the most effective frequency of imagery training per week.

With reference to the influence of personal characteristics on the most effective frequency of imagery sessions per week, it must be noted that the present study was conducted exclusively with male basketball players to minimise extraneous variability between participants. In previous studies, researchers found gender differences in imagery training effects and imagery ability (Burhans et al., 1988; Munroe-Chandler, Hall, Fishburne, & Strachan, 2007). Hence, there is the potential to conduct further research in order to explore whether replicating the present study design would facilitate female basketball players' FTS performance in a similar way to the findings with male basketball players. Another characteristic that might affect the most effective weekly frequency of imagery training is age. The present study was conducted with adult basketball players. Given that there are developmental changes in cognitive function that mean that children and adolescents might not have the same cognitive capacity as adults to concentrate on imagery training (Morris et al., 2005; Munroe-Chandler, Hall, Fishburne, O, et al., 2007; Simonsmeier & Buecker, 2017), it is possible that, independent of skill level, younger basketball players would not benefit from a high frequency of imagery sessions per week. Replication of the present study design with children and adolescents would help to determine whether 4 imagery sessions per week is more effective than other frequencies at all ages or whether the most effective frequency varies with age. Study 3 identified imagery training effects of the imagery-dose response variable of frequency on FTS performance, but researchers can conduct further research in relation to athletes of different performance levels and personal characteristics.

Motivating participants to remain committed to imagery training programs is important for improving imagery training effects. A possible limitation in the present study was that participants potentially could have become bored by repeating the same imagery training content over 4 weeks. Specifically, the 5-day imagery condition had 20 similar imagery sessions during the 4-week training period, a number, that might lead to a greater reduction in concentration levels among participants than 3 imagery sessions per week, which is a total of 12 sessions. In future studies, researchers could make changes to the imagery script week by week. Nordin and Cumming (2005) interviewed dancers regarding imagery use, asking the dancers “How” they used imagery. High-level dancers explained that they used layers of images, in which they started by using a simple image, and after a period of imagining the simple image they included additional imagery details. Cooley et al. (2013) conducted a systematic examination of movement imagery script delivery. They examined a progressive approach to imagery delivery, which they termed "layered" imagery, compared to imagery in which they gave participants the same content in every session. They stated that the first imagery script they provided to participants in the layered imagery condition involved very basic technical details of the task. Then, they added more details to the script in subsequent imagery sessions. Cooley et al. found this progression proved to be a beneficial method. In a recent imagery training study, Fazel et al. (2018) reported that basketball players, who had limited FTS skill, made great improvements in this task from pre-test to post-test by using the retrogressive imagery method. This is the reverse of progressive imagery, so, in retrogressive imagery, participants start with an elaborate script and less central aspects are removed step by step to leave imagery of basic technical aspects of the task by the end of the imagery training period. For example, researchers could present participants with fully detailed imagery scripts (e.g., involving the technical skills associated with a task, environmental information related to who else is present, and imagery designed to increase the experience of pressure) for them to use in the first week, then they could use more basic imagery training scripts week by week, first removing the pressure imagery, then removing imagery of the environmental aspects. In this way, researchers might better maintain participants motivation during the imagery training period.

Examining the frequency variable in the new imagery dose-response protocol in other discrete tasks is another direction for future research. In this study, I used the simple discrete task of basketball FTS because, although moderate-skill level players have experience with the skill of basketball FTS, the fact that they are still developing the skill means that there is potential for improvement with imagery training. However, in further research, researchers should examine whether the imagery dose-response protocol frequency variable can be applied to advanced-level discrete tasks, such as golf putting and archery. In terms of examining a discrete open-skills, basketball 3-point shooting or jump shooting from different angles may be suitable tasks. Basketball 3-point shooting is the most difficult shooting skill in basketball, which means that researchers can investigate a broad range of levels of athletes. Studying the imagery-dose response frequency variable in serial and continuous sport tasks is also a further research topic. For example, freestyle swimming, artistic gymnastics (e.g., floor and beam routines), rowing, cycling, and athletics are serial and continuous tasks that are performed for a variety of durations. Researchers will need to take into account the different features of serial and continuous tasks, compared to discrete tasks, when designing studies to examine imagery frequency in that context. Thus, researchers can apply the results of Study 3 to other discrete closed and open tasks, and to serial tasks, to examine whether the most effective imagery frequency dosage is the same across a variety of tasks or whether it differs depending on characteristics of the task.

Conclusion

In Study 3, I examined the imagery dose-response relationship between imagery frequency and FTS performance improvements. Examining the imagery dose-response protocol for the frequency dose variable is a key issue for imagery training research to provide clearer implementations of imagery training. Specifically, in the present study, I examined whether different frequencies have different effects on FTS performance, with the other two effective imagery dose variables of number of imagery repetitions and duration of imagery sessions held constant. I found that there were effective results in terms of FTS performance enhancement in all three imagery training conditions at post-test compared to the Control condition. Although differences were not large, 4 imagery sessions per week was the most effective frequency in this study because it was the only condition that showed significantly higher means than the Control condition at post-test and retention test. In the previous imagery training studies examining frequency of sessions per week, Wakefield and Smith (2009b, 2011) found that 3 sessions per week was more effective in terms of imagery training effects than 1 and 2 sessions per week. In the present study, I provided a new finding that 4 sessions per week was more effective than 3 or 5 sessions per week. Results of the present study indicated that all three imagery conditions were effective compared to the Control condition, so sport psychologists can advise athletes and coaches that they can use 3, 4, or 5 imagery sessions per week effectively to enhance basketball FTS shooting in club level players. Qualified support can be given to the 4 imagery sessions per week frequency for effectively improving FTS performance, so that athletes and coaches, and sport psychologists can apply the Study 3 results in their imagery training programs. From this study, I conclude that, for the conditions studied here, the most effective imagery training design is 20 repetitions and 13-minutes in a session for 4-day sessions per week over 4 weeks. Nonetheless, further research examining the frequency dose variable is warranted with refined elements of the design to further tease out the imagery dose-response relationship.

CHAPTER 6

GENERAL DISCUSSION

Introduction

This chapter consists of four sections. First, I present a summary of the conclusions from the three studies in the thesis. Second, I discuss findings of the present thesis in relation to existing theory and research. Third, I consider directions for future research, based on findings of the three studies in the thesis, and expanding to address potential new research directions. Finally, I discuss implications of the imagery dose-response research reported in the thesis in terms of sport performance enhancement, primarily through the role of sport psychologists.

Conclusions

In the present thesis, I ~~have~~ examined the impact of three major imagery dose variables, repetitions, duration, and frequency, on performance. I adopted a new approach to the examination of these variables that involved systematically varying one imagery dose variable in each study, while keeping the other two imagery dose variables constant at levels identified in previous research (Morris et al., 2012). Similar protocols have been used in other research areas, such as pharmacodynamics, psychology, exercise, and education, for identifying the most effective dosage of medicine, exercise, or treatment (Allami et al., 2008; Howard et al., 1986; Stulz et al., 2013; Wylie et al., 2013). Reviews revealed the ideal duration and number of repetitions in a session and the frequency of imagery sessions per week in terms of successful MP and imagery training studies (Figure 2.1). However, the effects of the three imagery dose variables have not been systematically examined in imagery training. Thus, my aim in this thesis was to systematically examine each dose variable in a different study, while keeping the other two dose variables constant and recruiting similar participants to perform the same task in each study. In all three studies, I used a dose-response study design in which I compared three different imagery dosages and one control condition, as well as using the simple discrete task of FTS. I systematically manipulated one imagery variable while holding the other two imagery variables constant. However, I did not have a hypothesis for each study because there were no previous systematic comparisons of the effects of each of these imagery variables on sport performance. By "systematic" here I mean studies in which other key variables are held constant while researchers examine the effect of one imagery dose variable. For example, because different studies of the number of repetitions did not hold duration and frequency constant, differences between the results of these studies could be explained by the variations in duration and frequency (Kuan et al., 2018; Rodgers et al., 1991).

The overall findings in the present thesis provide evidence of the positive effects of imagery training on FTS by identifying clearer improvements in FTS in all the imagery training conditions between pre-test and post-test across three studies than I observed in the Control condition, which showed no increases of FTS means across all occasions in any of the three studies. I examined whether there were differences between participants' usual physical practice times during the imagery training periods. In addition, I assessed imagery ability in participants by using the SIAM at pre-test. There were no significant differences in either physical practice time or imagery ability between all four research conditions in any study. Sport psychologists have indicated how imagery training has a positive effect on sport performance (Kuan et al., 2018; Morris et al., 2005; Turan et al., 2019; Weinberg & Gould, 2019). Hence, it was expected that all the imagery training conditions would produce increases in participants' FTS scores by the end of the imagery training. while it was noteworthy that imagery training was effective in all imagery conditions in all three studies, the primary aim of each study was to examine how different imagery dosages affected the imagery training results. Notably, the findings confirmed that the varying dosages of imagery variables lead to different FTS results at post-test and retention test in each study. For example, 20 repetitions in a session was the most effective number of imagery task repetitions in terms of increasing FTS performance in Study 1. In terms of duration of imagery sessions in Study 2, the 13-minute duration was more effective than the 8-minute and 18-minute durations. In Study 3, it can be concluded that four imagery sessions per week was the most effective of the three frequencies that I examined. Therefore, I conclude from the thesis results across all three studies for the facilitation of basketball FTS that the most effective dosages of imagery of the three alternatives tested in each study were 20 imagery task repetitions, imagery session duration of 13 minutes, and an imagery session frequency of 4 imagery sessions per week.

The results of the three studies that I conducted in this thesis suggest that the imagery dose-response protocol that I followed (Morris et al., 2012) is likely to be a useful research design for examining the most effective imagery dosages in terms of enhancing FTS performance. Examining the imagery dose variables systematically is a new approach, which means that there is no previous evidence of the most effective imagery dosages for improving sport performance in imagery training-based research. There are several findings that provided evidence of the feasibility of imagery dose-response research designs in the present thesis. First, there were significant differences among the FTS scores in the comparisons between the imagery conditions and the Control condition after the imagery training periods in all the studies. Second, I identified the most effective number of repetitions and duration in a session, as well as the most effective number of imagery training sessions per week, of the three conditions I selected in each study. These results may be enough to make it possible to see how this imagery dose-response protocol works in the examination of effective doses of imagery for enhancing sports performance. For the research design, using a simple discrete task was appropriate for comparing the difference between the effect of imagery on physical performance. However, given that the imagery dose-response protocol is a new approach, researchers should examine further whether the same results are found with different samples and in the same discrete task. Thus, researchers should replicate the present research design, controlling participants' skill level, and involving male basketball players from the same age range.

Relationship to Theory and Research

In the present thesis, the findings provide conceptual and theoretical understanding about imagery training effects on sport performance. The following areas are addressed: knowledge of imagery training effects, the functional relationship between imagery and physical performance, the imagery training content, and imagery ability. In addition, the main findings of the thesis provide information about methodological designs in order to examine the imagery dose-response relationship and how to organize the three key imagery variables together in the imagery training program.

The thesis findings support theoretical explanations of imagery and imagery training applications in sport psychology (Ahsen, 1984; Cooley et al., 2013; Holmes & Collins, 2002; Korn, 1994; Morris et al., 2005). In previous imagery training studies, sport psychologists identified how systematic imagery training programs have an effect on sport-specific skills in various sports (Dana & Gozalzadeh, 2017; Fazel et al., 2018; Lindsay et al., 2019). Participants in all the imagery conditions in the present thesis improved their FTS performance substantially from pre-test to post-test and much of the improvement was sustained at retention test a week later, which means that the results support previous imagery training studies. In addition, all the participants were experienced basketball players who had already achieved a relatively high level of FTS performance, so their FTS performance increases support the meta-analytic study of Curran and Terry (2010), which reported a large effect size in imagery training for experienced participants (d = 0.52). Hence, involving experienced athletes as participants in imagery training research might be an effective approach for identifying imagery training effects. Nonetheless, research comparing imagery training effects across skill levels from novice to elite performers should be informative because the most effective levels of all three dose variables examined in this thesis might vary with skill level. The simple discrete task has been used in previous imagery training studies, such as the basketball shooting task, which is a task that has been commonly used in imagery research (e.g., Fazel et al., 2018; Kearns & Crossman, 1992; Post et al., 2010). Based on the thesis results, it is clear that FTS is likely to be a suitable task for examining physical performance in comparisons of effective imagery dosages. This is because there were significantly higher FTS means after the imagery training program in all three studies in this thesis. Thus, the present thesis supports previous imagery training studies, and the thesis results provide more information about how imagery training is beneficial in relation to enhancing FTS performance.

This thesis contributes to knowledge about the potential functional equivalence between imagery and FTS performance. In functional equivalence theory, researchers have proposed that there is a similar process in the brain when individuals use mental imagery to rehearse a task and when they perform the same task physically (Finke, 1980; Jeannerod, 1995). In all the studies in the present thesis, participants created images of their own FTS performance, and they improved their FTS performance during the imagery training periods. For certain performance improvements, participants' brains could follow the same process as in the actual

FTS performance, when they imagined FTS, thus, providing evidence of equivalence. The results showed some similarities that suggest there might be functional equivalence, but studies in the present thesis did not directly test this. In future research, studies need to be specifically targeted on testing functional equivalence between imagery and actual movement. Thus, the thesis results support crucial points in functional equivalence theory.

To provide further information about the imagery training content, I used a traditional imagery training design in all three studies by following key components in the imagery training program (Morris et al., 2005). For example, I asked the participants to do the imagery training program in a quiet place, as well as allowing them to decide the most convenient time of day to perform imagery training and the most comfortable body postures during the imagery sessions. Furthermore, I included a short relaxation time prior to the imagery training session because a relaxed state is beneficial for reducing somatic tension and calming the mind (Janssen & Sheikh, 1994; Morris et al., 2005; Weinberg & Gould, 2019). In terms of imagery perspectives, I asked the participants to use the internal perspective in the imagery training program. This was because the internal perspective is more likely to have a beneficial effect on FTS performance than the external perspective in terms of increasing shooting accuracy (Dana & Gozalzadeh, 2017; Mahoney & Avener, 1977; Montuori et al., 2018). One reason for this is that internal perspective imagery usually involves greater involvement of the kinaesthetic sensations associated with performance of tasks (Dana & Gozalzadeh, 2017; Olsson, Jonsson, & Nyberg, 2008). The imagery script in the present thesis had a very simple design, in which participants could focus on the basic process of performing FTS, including elements of technique, as well as a positive outcome. The imagery script is one of the key components in the imagery training design, with its specific descriptions of sport skills. Its usefulness is likely to depend on participants' skill level (Morris et al., 2005; Weinberg & Gould, 2019). Furthermore, the design of the imagery script was based on bioinformational theory (Lang, 1977) with the aim of involving both stimulus and response propositions that are relevant to imagery training effects (Bakker et al., 1996; Marshall & Wright, 2016; Smith & Holmes, 2004). In terms of the imagery script applied in the three studies in the present thesis, participants were encouraged to image the sensations of the basketball in their hands and a vision of the basketball environment (e.g., free throw line and ring), which are stimulus propositions. In addition, they experienced integral FTS performance in which they felt the appropriate body balance and postures (e.g., bending their knees) and the correct movements associated with FTS, as well as seeing the basketball arc up then drop into the ring, which are all response propositions. In the imagery script, experiencing a positive emotion after creating the ideal FTS image was also associated with facilitating imagery quality (Post et al., 2015; Wakefield et al., 2013). Overall, I aimed to enhance participants' FTS, which was based mainly on CS imagery (Hall et al., 1998; Munroe et al., 2000). It likely that CS imagery function had an effect on the target performance in this thesis, which was FTS, because FTS scores at post-test in all imagery training conditions in all three studies were higher than pre-test FTS scores. It would be interesting to examine whether imagery scripts that aim to use the other four imagery functions (e.g., CG, MG-A, MG-M, and MS) in imagery dose-response research would show significant effects on the target outcome variable. Immediately after imaging FTS on each repetition, participants were asked to subjectively rate the quality of the imagery during the imagery manipulation check. This helped to ensure that I fully evaluated participants in all three imagery conditions on the process associated with their FTS images, so that they performed the imagery task as instructed. Participants in all imagery conditions showed clear improvements in FTS after the imagery training program. Thus, the research findings support the importance of the key components in imagery training.

There is an additional concern, which is that imagery training effects could be related to imagery ability. Sport psychologists have explained that imagery ability can influence imagery effectiveness in sport performance (Isaac & Marks, 1994; Martin et al., 1999; Moran, 1993; Moreau et al., 2010; Rotella, 1998; Watt et al., 2018), and that screening imagery ability in participants is a prerequisite for undertaking imagery training studies. For example, there is the possibility that low-imagery ability participants may not be able to create a clear image of a sport task, meaning that they have a limited chance of achieving the required imagery effectiveness. The SIAM is a subjective imagery ability measure, reliability and validity of which have been examined (Watt et al., 2018; Watt et al., 2004a). Recent imagery training studies have used SIAM for screening whether participants have enough imagery ability to create images, as well as for checking differences in terms of imagery ability between research conditions. In order to reduce the chances of obtaining inconsistent results from the imagery training program, it is necessary to screen imagery ability at pre-test to ensure that all the participants can create effective images of the task and that there are no noteworthy imagery ability differences between the research conditions (e.g., Fazel et al., 2018; Koehn et al., 2014; Kuan et al., 2018). For the present thesis, I also screened participants' imagery ability at pre-test by using the SIAM in all three studies. The results showed that the participants in all three studies had sufficient scores of at least 150 on the key subscales of auditory, visual, kinaesthetic, tactile, control, and vividness. These SIAM subscales represent key factors related to imagery effectiveness in the FTS imagery script in the present thesis. Hence, I could estimate whether all the imagery condition participants would be able to create FTS images in their allocated research conditions. For example, the participants had to create 10, 20, or 30 FTS images in Study 1, and it was necessary to create 20 FTS images in Study 2 and Study 3. Therefore, the SIAM provided useful information about the probable imagery training effectiveness and there were no noteworthy differences of imagery ability between the research conditions in the present thesis.

Finally, the most important research aim of the present thesis concerns the imagery dose-response relationship. In order to examine the new imagery dose-response protocol, I focused on the three key imagery variables of number of imagery task repetitions, duration of imagery sessions, and frequency of imagery sessions per week, which are important in terms of imagery training effectiveness. Morris et al. (2012) introduced this imagery dose-response protocol. They proposed several elements of the research design that are important to examine key imagery dose variables effectively. However, there are no previous imagery training studies that have used the imagery dose-response protocol and examined its feasibility. Thus, the present thesis incorporates a high level of originality in applying key elements of the protocol, and the overall thesis findings contribute knowledge about the most effective imagery dosages within the framework of the systematic approach to examining imagery dose-response relationships.

For delivering the imagery dose-response research design in this thesis, I followed a typical dose-response research design. This involved three research conditions and a Control condition (e.g., Allami et al., 2008; Evangelista et al., 2017; Howard et al., 1986; Robinson et al., 2019; Sanders et al., 2019; Stulz et al., 2013; Wylie et al., 2013). Because there is no previous imagery dose-response research that has adopted the protocol applied in the current thesis, it is important to clearly compare differences between imagery training conditions and a full control condition, that is a condition in which participants are tested on the outcome variable at equivalent points in time to those in imagery conditions, but do nothing else in the study. Hence, I employed a full control condition, rather than an active control condition because using an active control condition may have placebo effects that affect the results. The findings of the present thesis support the position that the research design should consist of three different imagery conditions with the Control group. This design was superior to other designs because I was able to find the effective imagery dosages in each study. In addition, examining four conditions is manageable for observing imagery training and measurement of FTS in each condition. Some imagery researchers might argue that the design of the imagery scripts in the present thesis did not follow the common practice of basing the design of scripts on the PETTLEP model. I consider that the PETTLEP model has great merit. However, I did not think it was advisable to use the PETTLEP approach in the present research. An important reason for this is that PETTLEP is individually-based on or customised to each participant's personal characteristics and experience, an approach that would have disrupted the careful manipulations of one variable and the constant levels of the other two variables in the imagery conditions in each study. Nonetheless, within the constraints of the design of the three studies in this thesis, PETTLEP recommendations were observed. Further, it is recommended that, once parameters are established for the most effective doses in a specific context, studies should be conducted to explore the effects of applying PETTLEP in its individually-based form. Throughout all three studies, I clarified several points of feasibility and limitation, such as an acceptable number of participants, a suitable level of supervision of the imagery intervention, and the type and frequency of measurement of performance, which have implications for future imagery dose-response research. I obtained significant results in Study 1 and Study 2 by including 36 basketball players (9 participants in each condition), as well as in Study 3, in which I included 40 basketball players (10 participants in each condition). It is important to know how to accurately estimate an appropriate number of participants for obtaining significant results. This is because recruiting a larger number of participants takes more time to process given the necessity of organising imagery training and measurement. This is particularly relevant at the PhD level, where time and resources are limited. For example, I tracked whether all the participants took the full imagery training course for four weeks across all the studies. Moreover, I tested FTS 216 times in Study 1 and Study 2 (36 participants x 6 FTS) and 240 times in Study 3 (40 participants x 6 FTS), which meant that testing FTS performance took a long time. Thus, if researchers choose to organize a larger number of participants, then it is possible that they will require the assistance of a research team, in other words, allocating research staff to a specific role. For example, members of staff could be divided into those who test the physical task, those who supervise the imagery training, and others whose role remains confidential. Thus, overall, the imagery dose-response research in the present thesis contributed to knowledge of an imagery dose-response study design.

Organizing the three variables of number of imagery task repetitions, duration of imagery sessions, and frequency of imagery sessions per week together in the imagery training program is another original contribution of the present thesis. In previous MP and imagery training studies (Driskell et al., 1994; Feltz & Landers, 1983; Hinshaw, 1991; Kremer et al., 2009; Paravlic et al., 2018; Schuster et al., 2011; Wakefield & Smith, 2009b, 2011), researchers stated that the imagery dose variables were crucial in ensuring imagery effectiveness. In addition, researchers and reviewers have suggested that the three dose variables are probably independent, but each interacts with other variables, so that the variables are likely to be key components for constructing imagery training programs to enhance sport skills. Hence, researchers should examine the dose variables to determine whether they have independent effects on the imagery dose-response relationship (Morris et al., 2012). For example, because it is important to know how a different amount of an imagery variable will influence sport performance, researchers may further examine the interactions of the dose variables. In terms of imagery variables in imagery dose-response study, Morris et al. (2012) recommended manipulating one imagery variable, but holding the other two variables constant. I applied this approach in the present thesis. To provide further details about organizing the three variables together in the imagery program, I used an audio track on an MP 3 player because it is a useful way of guiding participants to undertake the imagery training program (Fazel et al., 2018; Morris et al., 2005). It also facilitated my control over the number of repetitions and the duration in sessions. Furthermore, I was able to check whether participants followed a sufficient number of repetitions by using the imagery manipulation check. I also kept a record of the frequency of imagery training sessions by utilising the imagery training log. Moreover, I used the interference task between FTS images to minimise participants' opportunity to perform extra imagery of the FTS task during the intervals between intended imagery trials. All these procedures, which have been discussed in the present thesis might have been sufficient to ensure that the research design was sound, because participants fully engaged in the imagery training and the key imagery variables were controlled. In addition, there were clear improvements in FTS performance from pre-test to post-test in all the imagery conditions in all three studies, which led to the imagery training programs being confirmed to be effective. Thus, the contribution of the present thesis is to reveal how to organize three key imagery variables together and provide practical implementations, so that researchers can apply these research procedures.

In conclusion, I undertook a systematic experimental research design to examine the imagery dose-response relationship in the thesis, with particular emphasis on investigating whether the key imagery dose variables influence FTS performance. The present thesis is the first study of the imagery dose-response relationship, to manage all three imagery dose variables in a systematic way. I found positive results related to FTS performance in all the studies, and the research procedure appears to have been appropriate. Moreover, the findings of the present thesis provide guidelines for implementation that shows how to organize the three imagery dose variables together in imagery training programs. However, the fact that the imagery dose-response protocol is new means that research is necessary that replicates the studies in this thesis.

Future Research

Findings from the present thesis are promising, yet they raise more questions that should be addressed in future imagery dose-response research related to sport performance, as well as other outcome variables. Replicating studies is necessary because the imagery dose-response protocol is new, which means that it should be examined further in the context of discrete sport tasks, like Basketball FTS. For example, researchers should replicate the research design of this thesis, such as by using male participants who have a similar performance level, using the physical task of FTS. Further research topics regarding imagery dose-response relationships should also be examined, for example, examining another imagery variables and personal factors, as well as applying the thesis results in terms of psychological states and imagery delivery methods. Examination of these research topics could provide more knowledge and applications of imagery dose-response relationships that could contribute to successful outcomes in sporting contexts.

In the present thesis, I concluded that the number of 20 repetitions and a duration of 13 minutes in a session and four sessions per week may be appropriate for designing imagery training programs. It is important to know how many doses of imagery are enough in terms of enhancing FTS performance. In addition, there is no direct evidence about imagery dose-response relationships in imagery training studies, which means that researchers should replicate studies regardless of whether the results are similar across the studies when the samples are different. Researchers should also organize the task, skill level, interference task, and other variables so they remain the same. This is because the imagery dose-response protocol is still a new design, meaning that it requires a greater number of studies for it to be possible to draw firm conclusions about its effects. In replicated studies, researchers might find the same pattern that was revealed in the thesis results; in other words, the participants in imagery conditions may improve their FTS from pre-test to post-test. Moreover, researchers may find the same effects of specific imagery doses of imagery task repetitions, imagery session duration, and imagery session frequency in terms of FTS performance. In this case, it would be possible to confirm that the imagery dose-response protocol is an effective approach to examine imagery dosages. Thus, replicated studies of key imagery dose variables are important for providing more evidence of the usefulness of this imagery response protocol.

Examining a little above and below imagery dosages of the most effective number of imagery task repetitions and imagery session durations employed in the present thesis is important to provide a clear guideline of effective imagery dosages in terms of effects on sport performance. It is important to determine whether the 20 imagery task repetitions and 13-minute session duration are the most effective of all possible doses. For example, researchers should compare 15 repetitions and 25 repetitions with 20 imagery task repetitions. If 20 repetitions is found to be more effective for enhancing performance than 15 and 25 repetitions, researchers could further examine whether 20 repetitions is also more effective than 17 repetitions and 23 repetitions. Should there be no difference between 17 and 20 repetitions, or between 20 and 23 repetitions, then researchers and practitioners could use the range of imagery dosages from 17 to 20 repetitions or from 20 to 23 repetitions. This would be valuable information in terms of designing imagery training programs. Researchers should also compare 10-minute and 15-minute imagery session durations with the most effective duration in Study 2, which was the 13-minute duration. If the imagery session duration that is lower than 13 minutes is superior then this would be recommended as the most effective duration, whereas, if the duration that is slightly higher than 13 minutes is more effective, that would be identified as the preferred duration, at least for that type of performance task. If the three different imagery duration conditions have the same effect on performance tasks, then researchers can indicate that imagery session durations from 10 minutes to 15 minutes are equally effective. Consequently, further comparing 20 imagery task repetitions and the 13-minute imagery session duration with similar doses, each in a substantial number of studies, could provide more specific information for the effective implementation of imagery training programs. For the frequency of imagery sessions per week, considering the studies by Wakefield and Smith (2009, 2011), alongside the results from Study 3 here, it seems likely that further study of 1 and 2 sessions per week is not necessary for simple, discrete tasks. However, there might be specific circumstances where these frequencies could be useful. An example might be in the use of imagery with novices, who could benefit from a less demanding imagery program. On the other hand, examining more frequent imagery sessions, such as 5, 6, or 7 sessions, compared to 4 sessions, the most effective frequency in the present thesis, might be appropriate, particularly with elite performers who should be motivated and prepared to spend more time undertaking imagery training.

I used a simple discrete task in the present study because the imagery dose-response protocol is new, and this requires the research design to be relatively simple (Morris et al., 2012).

The results indicated that there were significant effects on FTS performance, so the protocol can be applied to other sport tasks. The research design can also be applied in different discrete tasks. Examples of discrete sport tasks in which imagery interventions have been studied successfully, include golf shots (Smith & Holmes, 2004), netball shooting (Wakefield & Smith, 2009b), and tennis serves (Coelho et al., 2007). Applying the imagery dose-response protocol could provide more precise information about the most effective doses of imagery for performance enhancement. Such research will be important when considering the 'unit' of the task, as well as how we measure the response in a quantifiable way that allows examination of dose-response relationships. By applying results of the present thesis in relatively simple discrete tasks, researchers can examine the three imagery dose variables in different advanced discrete tasks. For example, the basketball 3-point shot is an advanced skill for which many basketball players are likely to have greater limitations in terms of their skill performance than for a simpler task like FTS. Researchers have examined 3-point shooting experimentally in field studies (e.g., Waraphongthanachot, Morris, & Watt, 2017, 2018, 2019). However, there is a consideration that task difficulty may influence the ideal imagery dose. For example, players of a non-elite level might need to apply greater concentration than skilled performers, when performing a simple discrete skill. In addition, they might need to spend more time imaging their routine during the conduct of a difficult skill, thus, making the duration longer (Morris et al., 2005). Thus, researchers should examine the interaction between task difficulty and duration in the future study of imagery dose-response. The skill level that the 3-point shot requires may make it particularly suitable for examining imagery dose-response variables among elite compared to average basketball players.

Determining the imagery-dose response relationship for imagery dose variables in serial and continuous sport tasks is also a further research topic. For example, freestyle swimming, artistic gymnastics (e.g., floor and beam routines), and athletics are performed over a considerably longer duration than discrete tasks like basketball shooting and golf putting. Researchers can apply the present thesis approach, but the number of imagery repetitions and the duration of a session may need to be revised as each imagery repetition of the task has a longer duration. This is an important consideration because there are both psychological factors, such as physical and mental fatigue and boredom, and logistical factors, such as the amount of time individuals can devote to imagery sessions, that limit the maximum duration of imagery sessions. Thus, it might only be acceptable to repeat a task that lasts five minutes two or three times in one imagery sessions. Researchers can apply the same research design as a way of manipulating the three imagery dose variables systematically. Researchers can vary one imagery-dose variable, while holding the other two imagery variables constant to examine the way in which the duration of one repetition of serial and continuous tasks affects the effectiveness of the three imagery dose variables. Thus, sport tasks that involve serial and continuous performance components should be examined with the effective imagery dose variables with a view to promoting performance.

To give an example of a serial sport task, a gymnastics floor routine typically involves gymnasts performing multi-faceted skills in quick succession. Imagery can either focus on the performance of a skill (or a combination of skills) or it can focus on performance of the entire task. In other words, if a gymnast focuses on the difficult skill of performing front double pike somersaults, it is possible to have an imagery program that focuses on performing that skill. The imagery training program could be designed to use 10, 20, and 30 repetitions of the somersaults in one imagery session. It is also possible to develop an imagery program that involves imagining a whole floor routine as the task. One session might then involve imaging the whole routine once or twice because a gymnastics floor routine lasts for around 60 seconds. Moreover, gymnasts usually include 10 floor skills in their routine, which means that the imagery of the routine is complex. Hence, researchers need to reflect on how the thesis results of the key imagery dose variables of repetition and duration can best be applied in imagery of a whole floor routine. Nevertheless, researchers can apply the imagery dose-response protocol, which means controlling all three imagery variables in their study.

As an example of a continuous sport task, swimming involves four styles, and all these styles are performed repeatedly in a whole event. Freestyle swimming is the fastest and most efficient of the swimming strokes. When performing freestyle, swimmers move their arms and legs alternately, while they are in a prone position in the water. The elements of accelerated swimming are the flutter kick and moving each arm backward in the water from an overhead position. However, repeating these specific movements requires coordination and awareness in the water. For this reason, using imagery training programs may facilitate athletes' freestyle swimming technique. However, there is a limitation, which is that it is necessary to examine what imagery duration is applicable to an imagery training program in swimming, which is dependent on distance. Hence, initially, researchers might examine the imagery dose-response research design in middle distance swimming events, such as 200 metres freestyle, which lasts around 2 minutes, to identify the most effective imagery duration. Thus, for different types of sport task, researchers need to determine the most suitable way to apply the imagery dose-response protocol to identify the most effective imagery repetitions, duration, and frequency in longer duration serial and continuous sport tasks.

In terms of open skills, researchers can also examine whether the imagery dose-response protocol could be applied to open skill sports, such as racquet sports and team ball games. The effectiveness of imagery interventions has been examined in several open skill tasks. For example, researchers have commonly used the tennis service return or forehand and backhand groundstroke shots in imagery training studies (Coelho et al., 2007; Dana & Gozalzadeh, 2017; Fogarty & Morris, 2003). In terms of applying the imagery dose-response protocol to the tennis service return, researchers would be able to apply the thesis results. Researchers can manipulate the number of imagery task repetitions (e.g., 10-, 20-, and 30-repetitions of the service return), but control other imagery variables, so that they remain constant. For example, if the research aim is to improve forehand return or backhand return then 20 repetitions of the specific return could be used. An open skill involves more tactical decision making than is the case for discrete, self-paced or closed skill tasks because the opponents and the sport environment are influential in the performance of open skills. Hence, a more complex open skill may affect the dose of imagery variables that is most effective. For example, if participants imagine getting a particular score in a tennis match, in which they create an image to perform seven tennis strokes and win the match point by means of a drop shot in their imagery session, it is possible that the participants would use a different skill for every stroke and the position on the tennis court where the ball is returned will depend on where their opponent directs the previous shot, so the number of repetitions of each skill shot within an imagery session duration may vary. In this case, the imagery script would lead players to create the imagery scenario of winning the match point by playing seven strokes, which may be to count one repetition for which researchers could use the imagery dose-response protocol in terms of examining the effective repetitions of open skills. In addition, it is possible to include other open skill elements (e.g., tactics) in the imagery script, as well as stimulus and response propositions, and PETTLEP elements, as they were applied within the imagery scripts in the present thesis. There is potential that the number of 20 repetitions of the imagery scenario would take more time than discrete task imagery, but researchers and practitioners could examine the 13-minute duration, perhaps without the interference task. Thus, open skill imagery is more complex than discrete skill imagery, but examining imagery of open skills by applying the imagery dose-response protocol is necessary, in order to provide precise information for athletes and coaches.

In the present thesis, I examined three imagery dose variables, based on the proposition Morris et al. (2012) made, in proposing the imagery dose-response protocol applied in the three studies in this thesis. Although it is a variable that affects the overall scale of imagery programs, Morris et al. did not include the length of time for which imagery programs should be conducted, as a variable to be considered. Imagery program length should be defined as duration of sessions multiplied by total number of sessions, which itself is comprised of frequency of sessions per week multiplied by number of weeks for which the program runs. One reason why Morris et al. excluded imagery program length was that it would make the protocol very complex, with four dose variables to consider (T. Morris, personal communication, 19th January, 2020). Nevertheless, the imagery dose variable of imagery training program length should be examined because there has been no systematic study of the optimal length of imagery training programs in terms of the number of weeks for which athletes should undertake imagery training in order to improve their performance. In a systematic literature review of the effect of motor imagery training on strength tasks in healthy adults, Paravlic et al. (2018) reported that an imagery training duration total of some 300 minutes resulted in the largest effect size (1.07) in comparison with shorter total imagery durations, and the period of four weeks of training produced the largest effect size (.88). Schuster et al. (2011) explained that in successful sport imagery training studies a total of approximately 200 minutes for the imagery training time (imagery duration in a session x total number of imagery training sessions) and around 40 days of imagery training are the most often used durations in successful imagery training. However, different imagery training program lengths have resulted in positive improvements to sport performance being made (Cooley et al., 2013; Dana & Gozalzadeh, 2017; Fazel et al., 2018; Rhodes et al., 2018; Sardon et al., 2016), but these studies are not comparable because they used different values of other imagery dose variables, different tasks, and participants at different skill levels. Thus, it is clear that imagery training continues to enhance performance of strength and skill tasks up to a length of imagery training of several weeks, but it is not clear when, or even if, the effects of imagery training plateau or what effects different structures of imagery programs have on the impact of imagery. To take an extreme, hypothetical example, if participants undertook one imagery session per week of three minutes' duration for four weeks, they would have a total of 12 minutes of imagery training time for the whole program. This may be an insufficient amount of imagery training to produce increases in sport performance with participants having too few opportunities to use imagery. Providing seven imagery sessions per week, each one with a duration of 15 minutes, also for a period of four weeks, equates to 420 minutes of imagery training time, which is 35 times as much imagery as was used in the first program. However, both imagery training programs were organized for a 4-week period and it could well be that the use of imagery training during this period resulted in significant improvements in FTS performance in both studies. Further, from the current literature, there is no way to know what effect different numbers of imagery repetitions of tasks, durations of sessions, and frequencies of imagery sessions per week have on the efficacy of imagery training.

For example, it cannot be assumed that the effect of a small number of very long duration sessions is the same as the same total imagery time made up of a large number of short duration sessions. For this reason, it is important to understand the key dose variables for imagery duration in sessions and frequency of sessions per week to make meaningful and informative statements for total imagery training time. Although I found that the participants in all the imagery training conditions in Study 2 and Study 3, in the present thesis, showed decreases in their FTS performance from post-test to retention test, there is the potential that the participants might have retained their performance level if they had undertaken a longer total period of imagery training. Thus, there is scope for researchers to examine different total imagery training time conditions to find the most effective total imagery training time. In other words, researchers can apply the procedure described in this thesis, organising four imagery sessions per week of 13 minutes duration with 20 repetitions in a session. However, the total number of imagery training weeks could be manipulated, so that each condition has a different total imagery training time, but the three imagery dose variables examined in this thesis remained constant. In addition, researchers could select participants with similar characteristics to those in the present thesis (e.g., skill level, age) and the same FTS imagery task that I studied in this thesis. However, it is possible that with a longer total period of imagery training participants may reach a plateau, meaning that their FTS performance will cease to improve further. Thus, researchers should examine the effects of the total period of imagery training on sport performance, using the imagery dose-response protocol applied in the studies in this thesis to control the number of imagery task repetitions, duration, and frequency of imagery sessions.

Imagery training that continues for more than the four weeks employed in the present thesis might be more beneficial because participants would experience a larger number of imagery training sessions and, with the same levels of imagery task repetitions, session durations, and session frequencies employed in this thesis, that would mean a larger total amount of imagery training. Researchers have reported that imagery training programs ranging from 7 to 16 weeks were more successful in obtaining the desired outcomes than shorter or longer programs (e.g., Cooley et al., 2013; Li-Wei et al., 1992; Rhodes et al., 2018; Rodgers et al., 1991). Hence, imagery training longer than the 4-week period employed in the present thesis should be examined with reference to the research design employed in this thesis in order to help clarify the most appropriate imagery training periods. The number of weeks of imagery training might be considered to represent a fourth dose variable that should be systematically examined while holding the number of imagery task repetitions, duration of sessions, and frequency of sessions per week of imagery training constant. In particular, it is important to note that even if repetitions and duration are held constant, the frequency of sessions per week. The total number of imagery sessions in imagery training programs depends on the frequency of sessions per week multiplied by the number of weeks that the program lasts. For example, five sessions per week for four weeks produces a total of 20 sessions. Two sessions per week would require 10 weeks to produce the same total number of sessions. Examining the interaction between the frequency of sessions per week and the number of weeks of imagery training, while holding the number of repetitions and the duration of sessions constant is an important direction for future research on the dose-response relationship. If the effects of imagery training take some time to consolidate after each imagery training session, fewer sessions per week over a larger number of weeks might be more effective. On the other hand, if massed practice of imagery is more effective because each consecutive session occurs when memory of the previous session is still fresh in the mind, then a larger number of sessions per week for a shorter period of time might be more effective. Study 3 shed a little light on this issue, showing that a moderate number of sessions of 4 per week, was more effective than a shorter number, 3 sessions, or a larger number, 5 sessions, per week. However, the differences were not substantial, and all three imagery session frequencies produced noteworthy increases in FTS performance. Further study of frequency of sessions per week, along with number of weeks of imagery training, would be valuable.

Examination of the influence of personal factors on imagery dose variables constitutes another research topic to which the imagery dose-response approach should be applied. In this thesis, I only studied basketball players who were male, non-elite level, and over the age of 18. Hence, it is important to examine the imagery dose-response protocol with different samples varying in characteristics, including gender, age, imagery ability, and skill level. Examining female players in further studies should be informative. I only recruited male basketball players for the studies in this thesis because there are potentially different imagery training effects for females and males, as well as noting that there are likely to be differences individuals performance with varying imagery doses in terms of imagery ability (Campos, Pérez-Fabello, & Gómez-Juncal, 2004; Curran & Terry, 2010; Munroe-Chandler, Hall, Fishburne, & Strachan, 2007). Hence, researchers should examine whether results are replicated or different when the participants are female basketball players. In examining imagery dose-response relationships, another relevant personal characteristic is skill level. The participants in the three studies in the present thesis were limited-level players who had experience with the skill of basketball FTS, but were not experienced in the use of imagery. However, they were still learning the skill, which means that participants in the imagery intervention conditions in each study had potential for improvement in FTS, based on the imagery training. However, it is important to know whether future research using the imagery dose-response protocol would replicate the effects in studies with novices or elite-level performers. Most elite-level athletes use imagery in a regular and organized way, as part of their preparation, whereas novice athletes performing at lower levels do not (Arvinen-Barrow et al., 2007; Watt, Spittle, Jaakkola, & Morris, 2008), so more imagery doses (i.e., total imagery training duration per week, that is, imagery duration in a session x frequency) might have a greater impact than the number of doses that were used in obtaining the results in this thesis. Hence, the use of an increased number of imagery sessions per week might be more effective in elite athletes than the four sessions per week, which produced the most effective FTS performance in the present thesis. Researchers should also examine imagery dose-response relationships in young athletes. There is still only a limited number of studies that explore the effects of imagery training on young athletes. However, it is important to find the most effective imagery dosages for enhancing sport performance in younger athletes. These potentially differ depending on the age of the younger athletes. For example, Munroe-Chandler et al. (2007) reported that male and female children from 11 to 14 years old can use imagery in a similar manner to adult athletes, but 7-10 year-old children may not use imagery effectively. This is important to consider when researchers and practitioners are considering whether to provide imagery training programs to young athletes. Hence, the use of fewer imagery doses may be more effective for young athletes because they can only maintain their concentration for a limited period of time, which means that they cannot sustain the imagery quality for many repetitions. For example, it may be appropriate to design an imagery training program in which young athletes use 10 repetitions during five-minute sessions with three sessions per week.

In most of the discussion in this chapter, I have focused on imagery dose variables in relation to sports performance response variables. However, there are other outcome variables that are of importance to those involved in sport. Two categories of outcome variables that have potential for examination with reference to applying the present thesis findings are whether the imagery dose variables studied here facilitate mental states or rehabilitation from injury or illness in sport. Researchers have identified positive imagery training effects on mental states (e.g., Cumming et al., 2007; Guillot & Collet, 2008) and rehabilitation (e.g., Driediger et al., 2006; Mulder, 2007). However, examination of these studies indicates that the researchers did not control the three imagery dose variables systematically. Hence, applying the imagery dose-response protocol in their imagery training programs might have generated different results, perhaps adding precision to the outcome and consistency across studies, in terms of the dose variables. For example, in recent imagery training studies, researchers have investigated the effect of imagery training on psychological states in the context of sport, including self-efficacy (Fazel et al., 2018), self-confidence (Callow & Waters, 2005), flow state (Koehn et al., 2014; Sardon et al., 2016), and anxiety (Kuan et al., 2018). Those researchers identified positive outcomes on psychological states stemming from imagery training programs, so it may be the case that researchers will find clearer results, in terms of imagery dose variables, if they apply the systematic approach to repetitions, duration, and frequency of imagery sessions that I have examined in the present thesis. If the characteristics of participants and sport tasks were to be similar to those employed in the sport performance research, an issue that would be addressed by this research is whether the most effective levels of imagery dose variables are relatively constant across as diverse a range of response variables as different sport tasks, and mental state variables, such as anxiety and flow state.

Applying the imagery dose-response protocol in an examination of imagery training effects on rehabilitation is another research topic that has potential benefits. Researchers have found positive effects of imagery training on injury rehabilitation among athletes (Lebon et al., 2012; Mulder, 2007; Sordoni et al., 2000). The systematic approach to repetitions, duration, and frequency of imagery sessions that I have examined in the present thesis might also be beneficial in studies of injury rehabilitation. Identifying the most effective number of imagery repetitions, the ideal duration of a session, as well as the imagery session frequency per week should help athletes to maximise their use of rehabilitation time, in terms of employing a combination of physical recovery techniques and the use of imagery. Moreover, there is also potential for applying the thesis results to motor disorder research. For example, researchers have examined whether imagery training can facilitate the development of motor abilities in individuals with a motor disorder (Adams, Steenbergen, Lust, & Smits-Engelsman, 2016; Dijkerman, Ietswaart, Johnston, & MacWalter, 2004; Fang et al., 2018). Hence, researchers and practitioners could apply the results of the three studies in this thesis for designing imagery training therapy in the context of physical rehabilitation. As shown in the findings of this thesis (i.e., 13-minute imagery training duration on four days per week), the design of imagery training does not require high commitment in terms of participation, making this a practical design that might be suitable for athletes in periods of injury and rehabilitation. Once again, research with response variables related to rehabilitation would also provide a test of the generality of imagery dose-response variable research.

The systematic dose-response approach employed in this thesis could also be applied to the examination of imagery delivery methods. I designed simple imagery scripts for the imagery training, while actual sport situations include more environmental elements, such as opponents, officials, audiences, venues, and the pressure of competition. Involving more information on these issues in the imagery script might be a more effective approach than using the current imagery scripts, when athletes undertake imagery training to promote performance in competition. Fazel et al. (2018) examined whether the three different imagery delivery methods of routine imagery, progressive imagery, and retrogressive imagery improved FTS performance and self-efficacy in the case of limited-skill level basketball players. The research findings indicated that the retrogressive imagery condition showed the largest increase in FTS performance among the imagery conditions, as well as producing a greater increase in self-efficacy. However, in a parallel study with skilled players, Fazel (2015) found that progressive imagery was superior to routine and retrogressive imagery. Thus, it is important to consider skill level in determining the most effective delivery method. Whether progressive or retrogressive imagery delivery is preferred, it is important for researchers to consider how they should organize the imagery dose-response protocol in conjunction with the imagery delivery method in further research. There is a challenge of organising the same imagery repetitions and duration in a session as in the research design of the present thesis. This is because both the progressive imagery and the retrogressive imagery necessitate changes to the imagery script each week. For example, retrogressive imagery is supposed to exclude elements from the more detailed imagery scripts every week (e.g., a skill task, presence of teammates and opponents, presence of an audience, pressure related to game context), so the imagery script is very basic, focusing on the technique of task performance, by the time of the last imagery training week. For progressive imagery the pattern is reversed, with a basic, technique-focused initial script that becomes more complex from phase to phase. Thus, participants take a longer time with the more detailed imagery scripts than they do when using the basic imagery script, which could affect the number of repetitions that can be included in a session, as well as the duration of sessions. Hence, researchers may need to consider solutions, such as organising the imagery scripts by adding more details to the basic imagery script that focuses on performance technique only. For example, researchers can add more details about how to perform the task (e.g., body parts and key skill points) in the basic imagery scripts. By doing so it might then be possible for researchers to control the number of imagery repetitions and duration in a session for all the imagery training sessions. Nevertheless, study of the combination of the imagery dose-response protocol with imagery delivery methods could be beneficial in terms of improving imagery training effects. For example, imagers can take small and gradual steps in the progressive imagery method, thereby enabling them to focus on key elements of the imagery task week by week. Furthermore, repeating the same imagery script over an entire imagery training program could demotivate participants by creating boredom. Using different imagery scripts after a number of sessions might positively affect participants' motivation because providing new imagery scripts can provide freshness for participants, reducing boredom. Hence, researchers can use both the present thesis results and Fazel's research findings for their future research in order to determine imagery training effects that consider both imagery dose-response relationships and imagery delivery methods. Moreover, in seeking to identify a more effective imagery training program design, researchers should incorporate clear guidelines that are applicable to a range of athletes. Consequently, applying the imagery dose-response approach used in this thesis makes it possible to examine mental states, rehabilitation, and imagery delivery methods in future imagery training research in a more systematically focused manner.

In the present thesis, I followed the imagery dose-response protocol presented by Morris et al. (2012), who proposed that each dose variable should be examined independently, while the other two dose variables are held constant. Thus, in each study, I varied one imagery dose variable, but I kept the other two dose variables constant, based on the prediction that each imagery variable had independent effects. However, Morris et al. proposed this as the first stage in study of the imagery dose-response relationship, which should provide baselines for the three imagery dose variables. In fact, it is likely that the three imagery dose variables interact in ways that have yet to be tested. In other words, the most effective number of imagery task repetitions might have an interaction with the duration of imagery sessions, so that as imagery session duration changes the most effective number of repetitions also changes. Similarly, as frequency of sessions per week changes, the most effective duration might change. Hence, building on the baseline research in this thesis and replication studies, researchers should examine whether manipulating two imagery dose variables in the same study or even manipulating all three imagery dose variables affects sport performance in different ways. However, there are no studies examining imagery dose-response systematically, so that it is currently necessary to apply research from different research fields to demonstrate the potential for dose-response research on imagery in sport. For example, in exercise and health studies, researchers have already examined how to manipulate two or more dose variables, while controlling other relevant variables (Ivey et al., 2015; Lam et al., 2010; Rimmer et al., 2009). For example, Lam et al. (2010) manipulated the two dose variables of intensity and exercise length (week) together in terms of improving cardiorespiratory fitness. Lam et al. organized two exercise conditions, a high-intensity condition (80% heart rate reserve) that lasted for 12 weeks and a low-intensity condition (60% heart rate reserve) that lasted for 24 weeks. Other dose variables were held constant. Lam et al. organized three sessions per week (frequency) and 40-minute duration in each exercise session. The high-intensity for 12 weeks condition showed superior results compared with the low-intensity for 24 weeks condition. Luft et al. (2008) manipulated the dose variable of program length (12-week and 24-week), but intensity (60% heart rate reserve), frequency (three sessions per week) and the 40-minute duration in an exercise session were held constant. Results showed that exercise gains continued when program length was increased. Hence, it is possible that there will be different results, if two dose variables are manipulated in the same study (Galloway et al., 2019). Despite these findings, which indicate that changing the level of one dose variable might affect the effectiveness of other dose variables, researchers have not discussed whether manipulating two variables together may produce an interaction effect. Sport and exercise psychology researchers are also able to manipulate two or more imagery dose variables in the same study to examine their interaction. Based on the outcome of such studies, researchers should be able to provide more precise implementation guidelines for imagery training dose variables to athletes and coaches. For example, examining different numbers of repetitions and durations in a session, but with frequency of imagery sessions per week and length of the imagery training program held constant, should refine the most effective repetitions and duration conditions for a particular type of task. Moreover, researchers can determine more complex study designs to manipulate three imagery dose variables. However, it is important to note that the research design of imagery dose-response studies that manipulate two or three imagery dose variables at the same time will be complex. In the case of a standard research design to examine interactions between the three dose variables examined in the present thesis, there would need to be three levels of each of the three dose variables. This would produce a design with nine conditions (3 dose variables x 3 levels of each variable), plus a Control condition. Each condition would need 10 participants based on Study 3, so researchers would have to recruit 10 participants for nine imagery conditions and a Control condition. That is, they would need 100 participants for such a study. This is a very large sample in terms of research examining imagery training interventions that last for several weeks. Specifically, testing a physical task and collecting the data would take a long time, if the researchers tested the participants every week over a 4-week period, for example. In addition, analysing the results is more complicated than examining one imagery dose variable. Thus, examining the interactions between imagery dose variables is a valuable research direction, but researchers need to consider that examining two or three imagery dose variables is more complicated than examining one imagery variable and would have substantial resource implications. It should be noted that the findings from the present thesis would be valuable researchers who wish to embark on imagery dose variable interaction studies because they provide guidelines for the kinds of levels of each imagery dose variable that would be useful to examine, at least in the first instance.

Implications for Practice

The findings that I have reported in this thesis provide practical information that can help athletes, coaches, and sport psychologists to use imagery training effectively in terms of enhancing performance of discrete closed skill tasks. Imagery training has been identified to have a positive effect on performance in various sports situations (Morris et al., 2005; Weinberg, 2008; Weinberg & Gould, 2015). Nonetheless, there is still potential to refine aspects of the delivery of imagery training to increase its effectiveness. In this respect, increasing understanding of the imagery dose-response relationship has great potential. I propose that the approach I employed in the present thesis to examine three key imagery dose variables in the context of sport performance has produced interesting findings. The results of the three studies in this thesis should be replicated in a range of discrete sport tasks to consolidate the conclusions derived from the three studies I conducted. However, it is possible to draw out some implications with a note of caution that further study should be conducted. In particular, I have taken the first steps in identifying effective imagery doses for enhancing sports performance in terms of number of imagery repetitions in a session, duration of sessions, and number of sessions per week for enhancing FTS. In Study 1, the results indicated that all three imagery conditions showed a substantial increase in FTS performance, but the 20-repetition condition was more effective in promoting FTS performance than 10 or 30 repetitions. This represents key information for sport psychology practitioners in the design of imagery training programs for basketball FTS that is likely to transfer to similar discrete sport tasks. It is possible that a high number of imagery repetitions is a trigger for mental fatigue (Rozand et al., 2016). For practical purposes, it is also important to note that performing larger numbers of repetitions could mean spending more time doing imagery without extra benefit. The additional time could be valuable to be used for other aspects of athletes' training. The information on whether different numbers of imagery repetitions have varying effects on performance could contribute in coaching. For example, elite athletes use imagery more frequently than novice athletes (Arvinen-Barrow et al., 2007; Watt et al., 2008); in other words, elite athletes potentially use a relatively high number of imagery repetitions, either as part of their formal training schedule or informally. This could lead elite athletes to experience mental fatigue. Hence, it would be useful to determine the most appropriate dose in terms of number of repetitions of discrete sport tasks, so that a suitable number of imagery repetitions could be included in athletes' formal training programs, and athletes could be assured that no additional benefits would accrue from doing more imagery training informally. In terms of the duration of sessions, in Study 2, I found that the 13-minute imagery duration was more effective compared to 8- and 18-minute durations. It appears that a longer imagery duration than the 8-minute imagery sessions had a significantly greater effect on FTS performance. This could be related to the time needed to become focused on the imagery. The 13-minute imagery duration sessions were also more effective than the 18-minute imagery duration sessions. Again, it is possible that 18 minutes is too long because most athletes find it difficult to maintain their attention on an intensive imagery task for this long, so mental fatigue increases during the final minutes. For practical purposes, once more, longer durations use up more of athletes' valuable training time, so it is helpful for sport psychologists and coaches to know that the athletes they advise not likely to gain much from doing imagery sessions of extended duration. In Study 3, my aim was to determine whether three imagery frequencies (i.e., 3, 4, and 5 sessions per week) had different effects in terms of FTS performance. All imagery frequencies had significant effects on FTS performance compared to the Control condition. I concluded that the 4 sessions per week imagery frequency was more effective than 3 or 5 sessions because it was the only frequency that showed significantly higher FTS performance at retention test. Previous studies reported that 3 sessions per week was more effective than 1 and 2 sessions (Wakefield & Smith, 2009b, 2011), but no studies focusing on number of sessions per week had tested more than 3 sessions. The Study 3 results provided information that should be informative to sport psychologists, coaches and athletes, indicating that 3, 4 or 5 sessions per week are all effective. Although there was little difference between them, 4 sessions per week was more effective at retention test, so might be the preferred choice in practice at this stage. This is key information for sport psychologists and coaches to organize imagery training programs for their athletes. Overall, the thesis findings across three studies indicated that using 20 repetitions with 13-minute imagery duration for four sessions a week over four weeks should have the greatest probability to enhance FTS performance. The results of the studies in this thesis present practical information about minimum and maximum imagery dosages for basketball players to enhance their FTS. For example, athletes frequently use imagery (Arvinen-Barrow et al., 2007; Ribeiro et al., 2015; Watt et al., 2008), but the present thesis findings provide guidelines for athletes to prevent overuse of imagery that could lead to negative psychological outcomes, such as mental fatigue (Rozand et al., 2016). In addition, the results suggest that it is not necessary for coaches and sport psychologists to design imagery training sessions for athletes that are longer than needed to use imagery effectively for improving performance of sport tasks. Knowledge gained from the studies in this thesis and research that replicates and extends on these studies should enable sport psychologists to be in a more informed position to coordinate effective practical imagery training programs for athletes.

The new imagery dose-response protocol proposed by Morris et al. (2012) and employed to study repetitions, duration, and frequency dose variables in this thesis is likely to have practical benefits that will help sport psychologists and coaches to determine effective imagery dosages to enhance athletes' sport performance. The dose-response approach has a basis in research design ideas discussed in previous studies in different disciplines, including exercise (Ashor et al., 2015), psychology (Kool et al., 2018), and physiology (Wylie et al., 2013), as well as sport psychology (Morris et al., 2012). Specifically, Morris et al. (2012) stated that researchers should examine the effectiveness of key imagery dose-response variables empirically because there are limited studies (Kremer et al., 2009; Wakefield & Smith, 2009b, 2011). In addition, they also proposed that a systematic way to do this is by manipulating one dose variable, while holding the other two variables constant in a consistent way across studies, which has not been a feature of the substantial quantity of previous research on imagery in sport. Hence, in this thesis, I generated new knowledge in sport psychology, regarding the effectiveness of different numbers of repetitions, durations in a session and frequency of imagery sessions per week. In addition, the research findings of the studies in this thesis support the new protocol, including the introduction of a systematic research design in sports imagery research, so that researchers can apply it in further studies of discrete sport skills, as well as serial and continuous closed skills, and open skills in sport to increase understanding of the dose-response characteristics of imagery in across the breadth of sports.

Concluding Remarks

In the present thesis, I aimed to examine the effectiveness of varying amounts of imagery in terms of performance enhancement, using a proposed new protocol of imagery dose-response. In each of three studies, I varied one imagery dose variable, while I kept the other two dose variables constant, which is an original approach to the examination of the number of repetitions, duration of sessions, and frequency of sessions per week variables in sport imagery research. In each study, I found that all three imagery doses showed a substantial increase in. FTS performance over 4 weeks, largely retained after a week with no imagery. Importantly, I distinguished effective numbers of repetitions, duration in a session, and frequency of imagery sessions per week. A major conclusion of the thesis is that it would be fruitful for researchers to examine the imagery dose-response relationship more extensively. Specifically, further studies should be conducted employing the kind of design employed in this thesis to examine the imagery dose-response relationship in a range of discrete sport tasks, as well as serial and continuous tasks, and open skill sport tasks. In addition, the protocol can be applied to examine the impact of key personal and situational variables on the imagery dose-response relationship, including gender, age, skill level, and intensity of competition. Then, researchers should be able to apply the findings in a wide range of sports. Therefore, I hope that researchers will continue to examine the imagery dose-response relationship in sport performance, as well as for the enhancement of psychological variables important to the performance and enjoyment of sport at all levels.

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APPENDIX A-Flyer (Study 1)

VICTORIA UNIVERSITY
MELBOURNE AUSTRALIA

ISEAL
VICTORIA UNIVERSITY

WANT TO IMPROVE SHOOTING SKILL WITH IMAGERY ABILITY??

VOLUNTEERS NEED

<u>Effect of imagery dose variables on performance in sport</u>

In this project, we aim to examine the best number of repetitions of imagery of the skill among the levels we use in this study for improving basketball free-throw shooting. This project has potential of providing more precise guidance about what is enough repetitions of imagery for athletes and coaches.

You may be eligible to participate in this study

Male and female (aged 18-40) players have played basketball competitively from grassroots level to high level

- Understand imagery effects in sport: why and how top athletes utilize imagery?
- Free participation, imagery training, 3 x per week for 4 weeks
- Each training session will take approximately 20 minutes
- You can take the training by yourself, decide the most suitable time to do the imagery training.
- Measure shooting accuracy, 1 x per week for 5 weeks

FOR FURTHER INFORMATION
PLEASE CONTACT
Sho Itoh
[redacted]

APPENDIX B-Information for participation (Study 1)

INFORMATION TO PARTICIPANTS INVOLVED IN RESEARCH

You are invited to participate

You are invited to participate in a research project entitled 'Effect of number of repetitions of imagery on performance in sport'.

This project is being conducted by a student researcher Sho Itoh as part of a PhD study at Victoria University under the supervision of Professor Tony Morris and Associate Professor Michael Spittle from the College of Sport and Exercise Science.

Project explanation

In this project, we aim to examine the best number of repetitions of imagery of the skill among the levels we use in this study for improving basketball free-throw shooting. This project has potential of providing more precise guidance about what is enough repetitions of imagery for athletes and coaches.

What will I be asked to do?

If you volunteer to participate in this project, first, you will complete one measure of imagery ability (15-20 minutes) and a free-throw shooting task (15 minutes). After these measures, you will undertake the imagery intervention, which involves imagining perfect free-throw shooting. You will complete the intervention on 3 days each week over four weeks. It will take approximately 20min in each imagery intervention. You also will complete the same free-throw shooting task at the end of each week and the end of the week after the imagery intervention. At the end of the study, Sho will talk to you briefly about your experiences during it.

What will I gain from participating?

You will learn about how to utilize imagery effectively for your performance aims in sport. Moreover, the imagery intervention might positively affect your free-throw shooting and this could be transferred to your game performances.

How will the information I give be used?

Research findings will be published in academic journals and/or presented at academic conferences and they will be in an unpublished PhD thesis. We will only present group data, so your results will not be identifiable (Listed below).

What are the potential risks of participating in this project?

Our research has low psychological risk. First, you might feel anxious or stressed prior to the imagery intervention because you have never tried imagery training before, and you are advised that it is important to follow the imagery script carefully. In addition, you may have poor imagery experiences that also relate to increasing stress. Second, the Sport Imagery Ability Measure (SIAM), which assesses imagery ability, will be used to measure your imagery ability and you might be worried about your answers and scores. Finally, you could feel anxious while performing the free-throw shooting task. It must be emphasized that while any of these experiences are possible, it is quite likely you will not experience any of them.

Confidentiality is an important issue in this research. All data will be de-identified and access to the data will only be allowed by members of the research team. We will replace your names by code numbers that will keep your personal scores confidential. Only data for the whole group will be reported in papers and presentations.

How will this project be conducted?

If you volunteer to participate in this research, you will sign a consent form, after we check that you understand what you will be asked to do. Then you will complete the measures of imagery ability and free-throw shooting. You will then undertake the imagery intervention three times a week over four weeks. Your free-throw shooting will be examined again at the end of each week of the intervention and at the end of the first no-imagery week. After the final measure of FTS performance, you will participate in an interview with one of the investigators.

Who is conducting the study?

Any queries about your participation in this project may be directed to the Chief Investigator, Professor Tony Morris (Tel: 0430 511 543), the Co-investigator, Michael Spittle (Tel: 99199512) or the student investigator, Sho Itoh (Tel: 0479 066 444).
Any queries about your participation in this project may be directed to the Chief Investigator listed above.
If you have any queries or complaints about the way you have been treated, you may contact the Ethics Secretary, Victoria University Human Research Ethics Committee, Office for Research, Victoria University, PO Box 14428, Melbourne, VIC, 8001, email researchethics@vu.edu.au or phone (03) 9919 4781 or 4461.

APPENDIX C-Consent form in imagery training conditions (Study 1-3)

VICTORIA UNIVERSITY
MELBOURNE AUSTRALIA

CONSENT FORM FOR PARTICIPANTS INVOLVED IN RESEARCH

INFORMATION TO PARTICIPANTS:

We would like to invite you to be a part of a study into the effect of an imagery intervention on basketball shooting performance. Our central aim is to identify the most effective level of the crucial variable of duration of imagery sessions during imagery training. In other words, how long athletes should utilize imagery for in each session for it to be effective and efficient.

CERTIFICATION BY PARTICIPANT

I, of

certify that I am at least 18 years old* and that I am voluntarily giving my consent to participate in the study entitled: "Effect of duration of imagery sessions on performance in sport", being conducted at Victoria University by PhD student Sho Itoh under supervision by Professor Tony Morris and Associate Professor Michael Spittle. I certify that the objectives of the study, together with any risks and safeguards associated with the procedures listed hereunder to be carried out in the research, have been fully explained to me by Sho Itoh and that I freely consent to participation involving the below mentioned procedures:

- To complete a measure of imagery ability and a free-throw shooting task
- Then to undertake the imagery intervention over 4 weeks
- To complete free-throw shooting tasks at the end of each week
- To complete the final free-throw shooting task a week after the imagery intervention ends
- To talk with Sho Itoh about my experiences during the study

I certify that I have had the opportunity to have any questions answered and that I understand that I can withdraw from this study at any time and that this withdrawal will not jeopardise me in any way.

I have been informed that the information I provide will be kept confidential.

Signed:

Date:

Any queries about your participation in this project may be directed to the researcher
Professor Tony Morris
ph. 0430 511 543; Email: Tony.Morris@vu.edu.au

If you have any queries or complaints about the way you have been treated, you may contact the Ethics Secretary, Victoria University Human Research Ethics Committee, Office for Research, Victoria University, PO Box 14428, Melbourne, VIC, 8001, email Researchethics@vu.edu.au or phone (03) 9919 4781 or 4461.

APPENDIX D-Consent form in imagery training conditions (Study 1-3)

VICTORIA UNIVERSITY
MELBOURNE AUSTRALIA

CONSENT FORM FOR PARTICIPANTS INVOLVED IN RESEARCH

INFORMATION TO PARTICIPANTS:

We would like to invite you to be a part of a study into the effect of an imagery intervention on basketball shooting performance. Our central aim is to identify the most effective level of the crucial variable of duration of imagery sessions during imagery training. In other words, how long athletes should utilize imagery for in each session for it to be effective and efficient.

CERTIFICATION BY PARTICIPANT

I, of

certify that I am at least 18 years old* and that I am voluntarily giving my consent to participate in the study entitled: "Effect of duration of imagery sessions on performance in sport", being conducted at Victoria University by PhD student Sho Itoh under supervision by Professor Tony Morris and Associate Professor Michael Spittle. I certify that the objectives of the study, together with any risks and safeguards associated with the procedures listed hereunder to be carried out in the research, have been fully explained to me by Sho Itoh and that I freely consent to participation involving the below mentioned procedures:

- To complete a measure of imagery ability and a free-throw shooting task
- Then to undertake the imagery intervention over 4 weeks
- To complete free-throw shooting tasks at the end of each week
- To complete the final free-throw shooting task a week after the imagery intervention ends
- To talk with Sho Itoh about my experiences during the study

I certify that I have had the opportunity to have any questions answered and that I understand that I can withdraw from this study at any time and that this withdrawal will not jeopardise me in any way.

I have been informed that the information I provide will be kept confidential.

Signed:

Date:

Any queries about your participation in this project may be directed to the researcher
Professor Tony Morris
ph. 0430 511 543; Email: Tony.Morris@vu.edu.au

If you have any queries or complaints about the way you have been treated, you may contact the Ethics Secretary, Victoria University Human Research Ethics Committee, Office for Research, Victoria University, PO Box 14428, Melbourne, VIC, 8001, email Researchethics@vu.edu.au or phone (03) 9919 4781 or 4461.

APPENDIX E-Consent form in Control condition (Study 1-3)

VICTORIA UNIVERSITY
MELBOURNE AUSTRALIA

CONSENT FORM FOR PARTICIPANTS INVOLVED IN RESEARCH

INFORMATION TO PARTICIPANTS:
We would like to invite you to be a part of a study into the effect of an imagery intervention on basketball shooting performance. Our central aim is to identify the most effective level of the crucial variable of number of repetitions of imagery of the task during imagery training. In other words, how much imagery athletes should utilize for it to be effective and efficient.

CERTIFICATION BY PARTICIPANT

I, of
certify that I am at least 18 years old* and that I am voluntarily giving my consent to participate in the study entitled: "Effect of number of repetitions of imagery on performance in sport", being conducted at Victoria University by PhD student Sho Itoh under supervision by Professor Tony Morris and Associate Professor Michael Spittle. I certify that the objectives of the study, together with any risks and safeguards associated with the procedures listed hereunder to be carried out in the research, have been fully explained to me by Sho Itoh and that I freely consent to participation involving the below mentioned procedures:

- To complete a measure of imagery ability and a free-throw shooting task
- To complete free-throw shooting tasks on weekend over 5 weeks
- To talk with Sho Itoh who will offer you to take the imagery training

I certify that I have had the opportunity to have any questions answered and that I understand that I can withdraw from this study at any time and that this withdrawal will not jeopardise me in any way.

I have been informed that the information I provide will be kept confidential.

Signed:

Date:
Any queries about your participation in this project may be directed to the researcher
Professor Tony Morris
ph. 0430 511 543; Email: Tony.Morris@vu.edu.au

If you have any queries or complaints about the way you have been treated, you may contact the Ethics Secretary, Victoria University Human Research Ethics Committee, Office for Research, Victoria University, PO Box 14428, Melbourne, VIC, 8001, email Researchethics@vu.edu.au or phone (03) 9919 4781 or 4461.

APPENDIX F-Demographic Questionnaire

Code:

Demographic Information

Instructions: Please provide information about yourself. Please CIRCLE or WRITE CLEARLY where appropriate.

1. **Gender** Male Female
2. **Age_____________years**
3. **Current basketball competition level**

- Domestic Basketball Competitions (local basketball around the state) this season

  Division C Division D Division E

- Representative Competitions (players selected by associations)
- National Leagues (Elite players)
- International Tournaments (At the highest level, Australian national teams compete in World Championships, Olympic Games and other international events).
- Other (specify) ____

4. How long have you played competitive basketball in years? ____________years
5. How many times per week do you compete? ______________________times
6. How many hours per week do you train? __________________________hours

APPENDIX G- Sport Imagery Ability Measure (SIAM)

Sport Imagery Ability Measure (SIAM)

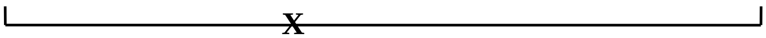
Code:_________________

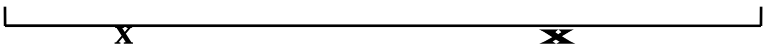
Date:_________________

Sport Imagery Activities Form

Introduction

This questionnaire involves creating images of four situations in sport. After you image each scene, you will rate the imagery on twelve scales. For each rating, place a cross on the line at the point you feel best represents the image you produced. The left end of the line represents no image or sensation or feeling at all and the right end represents a very clear or strong image or feeling or sensation.
Ensure the ***intersection*** of the cross is on the line as shown in the examples below.

Correct 

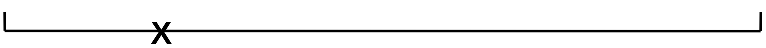
Incorrect 

An **example** of the style of scene to be created is as follows:

You are at a carnival, holding a bright yellow, brand new tennis ball in your right hand. You are about to throw it at a pyramid of six blue and red painted cans. A hit will send the cans flying and win you a prize. You grip the ball with both hands to help release the tension, raise the ball to your lips and kiss it for luck, noticing its soft new wool texture and rubber smell. You loosen your throwing arm with a shake and, with one more look at the cans, you throw the ball. Down they all go with a loud "crash" and you feel great.

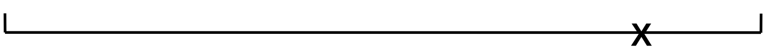
Below are some possible ratings and what they represent to give you the idea.

1. How **clear** was the image ?

no image  perfectly clear image

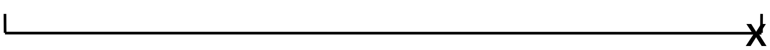
This example shows an image was experienced but was quite unclear

6. How well did you **feel the muscular movements** within the image?

no feeling  very strong feeling

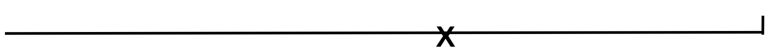
This example indicates very strong imagery of the feel of muscular movements

7. How well did you **hear** the image?

no hearing  very clear hearing

This example reflects the strongest possible image, like hearing the real sound

12. How strong was your **experience of the emotions** generated by the image?

no emotion  very strong emotion

This example reflects a degree of emotion which is moderate

Do you have any questions regarding the imagery activity or the way you should respond using the rating scales? Please feel free to ask now.

DO NOT TURN THE PAGE UNTIL YOU ARE ASKED TO DO SO.

Please complete the following practice question. Listen carefully to all the instructions. Note that this question does not count. It is here to help you get used to imaging and rating your experience

Fitness Activity

Imagine yourself doing an activity to improve your fitness for your sport. Get a clear picture of what you are doing, where you are, and who you are with. Take notice of what you can see around you, the sounds you hear, and the feel of any muscles moving. Do you get the sensation of any smells or tastes? Can you feel the equipment and surfaces you are using? Do you get an emotional feeling from this activity? Now you have 60 seconds to create and experience your image of the scene. When the 60 seconds is up, complete **all** 12 scales below. Don't spend too much time on each; your first reaction is best. Remember to place a cross with its **intersection** on the line.

1. How well did you get the sensation of **taste** within the image?

no taste ________________________________ very clear taste

2. How **long** was the image held?

image held for a very short time ________________________________ image held for the whole time

3. How well did you **feel the texture** of objects within the image?

no feeling ________________________________ very clear feeling

4. How **clear** was the image?

no image ________________________________ perfectly clear

5. How well did you **hear** the image?

no hearing ________________________________ very clear hearing

6. How **easily** was an image created?

image difficult to create ________________________________ image easy to create

7. How well did you **see** the image?

no seeing ________________________________ very clear seeing

8. How **quickly** was an image created?

image slow to create ________________________________ image created quickly

9. How strong was your **experience of the emotions** generated by the image?

no emotion ________________________________ very strong emotion

10. How well did you **feel** the muscular movements within the image?

no feeling ________________________________ very strong feeling

11. How well could you **control** the image?

unable to control image ________________________________ completely able to control image

12. How well did you get the sensation of **smell** within the image?

no smell ________________________________ very clear smell

Check that you have placed a cross on all 12 lines.

DO NOT TURN OVER UNTIL YOU ARE ASKED TO DO SO.

Your "Home" Venue

Imagine that you have just got changed and made your final preparations for a competition at your "home" venue, where you usually practice and compete. You move out into the playing area and loosen up while you look around and tune in to the familiar place. Take notice of what you can see around you, the sounds you hear, and the feel of any muscles moving. Do you get the sensation of any smells or tastes? Can you feel the equipment and surfaces you are using? Do you get an emotional feeling from this activity? Now you have 60 seconds to create and experience your image of the scene. When the 60 seconds is up, complete **all** 12 scales below. Don't spend too much time on each; your first reaction is best. Remember to place a cross with its **intersection** on the line.

1. How well did you **feel the texture** of objects within the image?

no feeling ________________________________ very clear feeling

2. How **clear** was the image?

no image ________________________________ perfectly clear

3. How well did you get the sensation of **taste** within the image?

no taste ________________________________ very clear taste

4. How **long** was the image held?

image held for a very short time ________________________________ image held for the whole time

5. How well did you **hear** the image?

no hearing ________________________________ very clear hearing

6. How **easily** was an image created?

image difficult to create ________________________________ image easy to create

7. How strong was your **experience of the emotions** generated by the image?

no emotion ________________________________ very strong emotion

8. How well did you **see** the image?

no seeing ________________________________ very clear seeing

9. How well did you **feel** the muscular movements within the image?

no feeling ________________________________ very strong feeling

10. How well could you **control** the image?

unable to control image ________________________________ completely able to control image

11. How well did you get the sensation of **smell** within the image?

no smell ________________________________ very clear smell

12. How **quickly** was an image created?

image slow to create ________________________________ image created quickly

Check that you have placed a cross on all 12 lines.

DO NOT TURN OVER UNTIL YOU ARE ASKED TO DO SO.

Successful Competition

Imagine you are competing in a specific event or match for your sport. Imagine that you are at the very end of the competition and the result is going to be close. You pull out a sensational move, shot, or effort to win the competition. Take notice of what you can see around you, the sounds you hear, and the feel of any muscles moving. Do you get the sensation of any smells or tastes? Can you feel the equipment and surfaces you are using? Do you get an emotional feeling from this activity? Now you have 60 seconds to create and experience your image of the scene. When the 60 seconds is up, complete **all** 12 scales below. Don't spend too much time on each; your first reaction is best. Remember to place a cross with its **intersection** on the line.

1. How well did you **see** the image?

no seeing ________________________________ very clear seeing

2. How **quickly** was an image created?

image slow to create ________________________________ image created quickly

3. How strong was your **experience of the emotions** generated by the image?

no emotion ________________________________ very strong emotion

4. How **clear** was the image?

no image ________________________________ perfectly clear

5. How well did you get the sensation of **taste** within the image?

no taste ________________________________ very clear taste

6. How well could you **control** the image?

unable to control image ________________________________ completely able to control image

7. How well did you get the sensation of **smell** within the image?

no smell ________________________________ very clear smell

8. How **easily** was an image created?

image difficult to create ________________________________ image easy to create

9. How well did you **feel the texture** of objects within the image?

no feeling ________________________________ very clear feeling

10. How **long** was the image held?

image held for a very short time ________________________________ image held for the whole time

11. How well did you **feel** the muscular movements within the image?

no feeling ________________________________ very strong feeling

12. How well did you **hear** the image?

no hearing ________________________________ very clear hearing

Check that you have placed a cross on all 12 lines.

DO NOT TURN OVER UNTIL YOU ARE ASKED TO DO SO.

A Slow Start

Imagine that the competition has been under way for a few minutes. You are having difficulty concentrating and have made some errors. You want to get back on track before it shows on the scoreboard. During a break in play, you take several deep breaths and really focus on a spot just in front of you. Now you switch back to the game much more alert and tuned in. Take notice of what you can see around you, the sounds you hear, and the feel of any muscles moving. Do you get the sensation of any smells or tastes? Can you feel the equipment and surfaces you are using? Do you get an emotional feeling from this activity? Now you have 60 seconds to create and experience your image of the scene. When the 60 seconds is up, complete **all** 12 scales below. Don't spend too much time on each; your first reaction is best. Remember to place a cross with its **intersection** on the line.

1. How strong was your **experience of the emotions** generated by the image?

no emotion ____ very strong emotion

2. How **easily** was an image created?

image difficult to create ____ image easy to create

3. How well did you **feel the texture** of objects within the image?

no feeling ____ very clear feeling

4. How well could you **control** the image?

unable to control image ____ completely able to control image

5. How well did you get the sensation of **smell** within the image?

no smell ____ very clear smell

6. How **clear** was the image?

no image ____ perfectly clear

7. How well did you **hear** the image?

no hearing ____ very clear hearing

8. How **quickly** was an image created?

image slow to create ____ image created quickly

9. How well did you get the sensation of **taste** within the image?

no taste ____ very clear taste

10. How **long** was the image held?

image held for a very short time ____ image held for the whole time

11. How well did you **see** the image?

no seeing ____ very clear seeing

12. How well did you **feel** the muscular movements within the image?

no feeling ____ very strong feeling

Check that you have placed a cross on all 12 lines.

DO NOT TURN OVER UNTIL YOU ARE ASKED TO DO SO.

Training Session

Think of a drill you do in training that is really tough. Now imagine yourself doing the drill. As you get a picture of yourself performing the skill in practice, try to complete an entire routine or drill. Take notice of what you can see around you, the sounds you hear, and the feel of any muscles moving. Do you get the sensation of any smells or tastes? Can you feel the equipment and surfaces you are using? Do you get an emotional feeling from this activity? Now you have 60 seconds to create and experience your image of the scene. When the 60 seconds is up, complete **all** 12 scales below. Don't spend too much time on each; your first reaction is best. Remember to place a cross with its **intersection** on the line.

1. How well did you **feel** the muscular movements within the image?

no feeling ______________________________ very strong feeling

2. How well could you **control** the image?

unable to control image ______________________________ completely able to control image

3. How well did you **hear** the image?

no hearing ______________________________ very clear hearing

4. How **long** was the image held?

image held for a very short time ______________________________ image held for the whole time

5. How well did you get the sensation of **taste** within the image?

no taste ______________________________ very clear taste

6. How well did you **see** the image?

no seeing ______________________________ very clear seeing

7. How **easily** was an image created?

image difficult to create ______________________________ image easy to create

8. How strong was your **experience of the emotions** generated by the image?

no emotion ______________________________ very strong emotion

9. How **quickly** was an image created?

image slow to create ______________________________ image created quickly

10. How well did you get the sensation of **smell** within the image?

no smell ______________________________ very clear smell

11. How **clear** was the image?

no image ______________________________ perfectly clear

12. How well did you **feel the texture** of objects within the image?

no feeling ______________________________ very clear feeling

Check that you have placed a cross on all 12 lines.

DO NOT TURN OVER UNTIL YOU ARE ASKED TO DO SO.

APPENDIX H-FTS test sheet

FTS test sheet

Code: P1

Date:

Pre	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
suc/unsuc																				
Score																				
	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
suc/unsuc																				
Score																				

Date:

Week 1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
suc/unsuc																				
Score																				
	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
suc/unsuc																				
Score																				

Date;

Week 2	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
suc/unsuc																				
Score																				
	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
suc/unsuc																				
Score																				

Date:

Week 3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
suc/unsuc																				
Score																				
	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
suc/unsuc																				
Score																				

Date:

Week 4	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
suc/unsuc																				
Score																				
	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
suc/unsuc																				
Score																				

Date:

Week 5	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
suc/unsuc																				
Score																				
	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
suc/unsuc																				
Score																				

APPENDIX I-Imagery log

VICTORIA UNIVERSITY
MELBOURNE AUSTRALIA

Imagery log

Please complete the Imagery Log after each imagery session you do. Note the date, time you started and time you finished. Then write any comments about your experience of that session, including things that worked well for you and anything that was not so good, such as distractions.

Date	Start time	End time	Comment

APPENDIX J-Imagery manipulation check sheet

Imagery experience check

		Not at all				Very much			Not at all				Very much
1	how well you imagined motion.	1	2	3	4	5	11	how well you imagined motion.	1	2	3	4	5
2	how well you imagined motion.	1	2	3	4	5	12	how well you imagined motion.	1	2	3	4	5
3	how well you imagined motion.	1	2	3	4	5	13	how well you imagined motion.	1	2	3	4	5
4	how well you imagined motion.	1	2	3	4	5	14	how well you imagined motion.	1	2	3	4	5
5	how well you imagined motion.	1	2	3	4	5	15	how well you imagined motion.	1	2	3	4	5
6	how well you imagined motion.	1	2	3	4	5	16	how well you imagined motion.	1	2	3	4	5
7	how well you imagined motion.	1	2	3	4	5	17	how well you imagined motion.	1	2	3	4	5
8	how well you imagined motion.	1	2	3	4	5	18	how well you imagined motion.	1	2	3	4	5
9	how well you imagined motion.	1	2	3	4	5	19	how well you imagined motion.	1	2	3	4	5
10	how well you imagined motion.	1	2	3	4	5	20	how well you imagined motion.	1	2	3	4	5

APPENDIX K-Physical practice log

Please complete the physical practeice/trainig log after each physical practice you do. Note the date, time started and time you finished. Then write any comments about your free-throw shooting.

Date	Start time	End time	Comments on your free-throw shooting

Date	Start time	End time	Comments on your free-throw shooting

APPENDIX L-Imagery training explanation

VICTORIA UNIVERSITY
MELBOURNE AUSTRALIA

Imagery Training

General Instructions

Imagery is a mental process used to create or recreate experiences, including all the senses (sounds, sights, smell, touch, and the muscular feelings), which are based on memory. For instance, before performance athletes can create mental images of specific skills or routines using these senses. Imagery training is a tool that can be used for improving sport performance, which enables athletes to rehearse/practice specific situations or events. So when you imagine the free-throw shooting (FTS), try to experience all the senses associated with FTS, such as the sounds, sights, smell, touch, and the feelings in your muscles. Moreover, please try to imagine FTS as vividly, clearly, and realistically as possible.

Imagery Training

- During this study you are asked to perform three imagery sessions per week for a period of four consecutive weeks.
- Each imagery training session will take approximately 20 minutes (including preparation and brief comments on your experience of the session)
- Each day you can choose the most suitable time to do the imagery training. Please write the date and time you start and finish in your imagery log.

Instructions for Imagery Training

- Follow the imagery script on the MP3 player; it will guide you to imagine FTS correctly
- The FTS imagery training should be performed in a quiet and comfortable environment, where it is easy to concentrate on audio cues
- Wear comfortable clothing. You can sit or lie down. You should relax, but please do not get so comfortable that you might fall asleep
- Your eyes can be open or closed
- It is important that you do not pause your listening device during the imagery training
- After completion of each FTS imagery session, you will ask “how well you imagined FTS” by 5-point Likert scale from 1 (*not at all*) to 5 (*very much*) on the imagery experience check sheet.
- After responding the imagery experience check, you will undertake the concentration task until the next imagery of FTS is presented.

- You will repeat the imagery of shooting the FTS 10/20/30 times.

1. Preparation (relaxation)

Take four deep breaths for approximately 1 minute. Breathe in through your nose (5 sec), hold it (2 sec) and then let it go slowly through your mouth (8 sec). Concentrate on your breathing, feel the movement of your stomach (e.g. abdomen rises pulling the diaphragm down and drawing the breathe down to the bottom of their lungs) as you breathe in and out, and let your mind and muscles become relaxed. Let any distracting thoughts or sounds enter and exit your mind freely. You can listen to this guide to relaxation on the listening device.

Imagine that you are standing behind the free-throw line. Take a breath. In a moment, imagine you are doing your regular routine before you perform each free-throw shot. Notice how the surface of the basketball feels against your fingers. Imagine yourself hearing the sound of every bounce of the ball. You recognize the feeling in the muscles of your hands and arms when you release the ball for a bounce and when you catch it again. Take some time now to experience this with all of your senses. Now you are ready to imagine shooting.

2. Imagery Script

Imagine looking down to check that your feet are behind the free-throw line, check that your knees are bent and your body is well-balanced. Imagine focusing on the ring, then shoot and feel the ball release from your fingers. Watch the ball arc up and then drop down cleanly through the ring. Feel the satisfaction of a successful shot.

3. Concentration task

Concentration is an important skill in basketball shooting. Hence, we want to check how well you can concentrate between doing imagery of free throw shooting. After finishing each check of your imagery experience, you will do the concentration task in which you will listen to color words (e.g., red, blue, green) continuously until the next imagery session of FTS. However, we have mixed words that are not color names (e.g. snow, cherry) in the audio list. When you hear a word that is NOT a color name write these the word in the blank box on imagery experience check sheet. The sound of a bouncing basketball is a signal of the end of the concentration task, so you should prepare for the next imagery of FTS.

APPENDIX M-Flyer (Study 2)

VICTORIA UNIVERSITY MELBOURNE AUSTRALIA

ISEAL VICTORIA UNIVERSITY

WANT TO IMPROVE SHOOTING SKILL WITH IMAGERY ABILITY??

VOLUNTEERS NEED

Effect of imagery dose variables on performance in sport

In this project, we aim to examine the best duration of imagery sessions of the skill among the levels we use in this study for improving basketball free-throw shooting. This project has potential of providing more precise guidance of what is a long enough duration of imagery sessions for imagery to be effective for athletes.

You may be eligible to participate in this study

Male and female (aged 18-40) players have played basketball competitively from grassroots level to high level

- Understand imagery effects in sport: why and how top athletes utilize imagery?
- Free participation, imagery training, 3 x per week for 4 weeks
- Each training session will take approximately 20 minutes
- You can take the training by yourself, decide the most suitable time to do the imagery training.
- Measure shooting accuracy, 1 x per week for 5 weeks

FOR FURTHER INFORMATION
PLEASE CONTACT
Sho Itoh
[redacted]

APPENDIX N-Information for participation (Study 2)

VICTORIA UNIVERSITY
MELBOURNE AUSTRALIA

INFORMATION TO PARTICIPANTS INVOLVED IN RESEARCH

You are invited to participate

You are invited to participate in a research project entitled 'Effect of duration of imagery sessions on performance in sport'.

This project is being conducted by a student researcher Sho Itoh as part of a PhD study at Victoria University under the supervision of Professor Tony Morris and Associate Professor Michael Spittle from College of Sport and Exercise Science.

Project explanation

In this project, we aim to examine the best duration of imagery sessions of the skill among the levels we use in this study for improving basketball free-throw shooting. This project has potential of providing more precise guidance of what is a long enough duration of imagery sessions for imagery to be effective for athletes.

What will I be asked to do?

If you volunteer participate in this project, first, you will complete one measure of imagery ability (15-20 minutes) and a free-throw shooting test (15 minutes). After these measures, you will undertake the imagery intervention, which is imagining perfect free-throw shooting within 3 days each week over four weeks, and you will take approximately 20min in each imagery intervention. You also will complete free-throw shooting tests at the end of each week and the end of the week after the imagery intervention. At the end of the imagery intervention, Sho will talk to you briefly about your experiences during the study.

What will I gain from participating?

You will learn more about how to utilize imagery correctly for your performance aims in sport. Moreover, the imagery intervention might positively affect your free-throw shooting and this could be transferred to your game performances.

How will the information I give be used?

Research findings will be published in academic journals and/or presented at academic conferences and they will be in an unpublished PhD thesis. We will only present group data, so your results will not be identifiable (Listed below).

What are the potential risks of participating in this project?

Our research has low psychological risk. First, you might feel anxious or stressed prior to the imagery intervention because you have never tried imagery training before, and you are advised that it is important to follow the imagery script correctly. In addition, you may have poor imagery experiences that also relate to increasing stress. Second, the Sport Imagery Ability Measure (SIAM) which assesses imagery ability) will be used to measure your imagery ability and you might be worried about your answers and scores. Finally, you could feel anxious while performing the free-throw shooting test.

Confidentiality is another issue in this research. All data will be de-identified and access will only be allowed by members of the research team. We will replace your names by code numbers which will keep your personal scores confidential. Only data for the whole group will be reported in papers and presentations.

How will this project be conducted?

You will volunteer to participate in this research by signing a consent form, after we check that you understand what you will be asked to do. Then you will take the measures of imagery ability and free-throw shooting. You will then undertake the imagery intervention three times a week over four weeks. Your free-throw shooting will be examined again at the end of each week of the intervention and at the end of the first no-imagery week. After the final measure of FTS performance, you will participate in an interview with one of the investigators.

Who is conducting the study?

Any queries about your participation in this project may be directed to the Chief Investigator, Professor Tony Morris (Tel: 0430 511 543), the Co-investigator, Michael Spittle (Tel: 99199512) or the student investigator, Sho Itoh (Tel: 0479 066 444).
Any queries about your participation in this project may be directed to the Chief Investigator listed above.

APPENDIX O-Information for participation in a control condition (Study 2)

VICTORIA UNIVERSITY
MELBOURNE AUSTRALIA

INFORMATION TO PARTICIPANTS INVOLVED IN RESEARCH

You are invited to participate

You are invited to participate in a research project entitled 'Effect of duration of imagery sessions on performance in sport'.

This project is being conducted by a student researcher Sho Itoh as part of a PhD study at Victoria University under the supervision of Professor Tony Morris and Associate Professor Michael Spittle from the College of Sport and Exercise Science.

Project explanation

In this project, we aim to examine the best number of repetitions of imagery of the skill among the levels we use in this study for improving basketball free-throw shooting. This project has potential of providing more precise guidance about what is enough repetitions of imagery for athletes and coaches.

What will I be asked to do?

If you volunteer to participate in this project, first, you will complete one measure of imagery ability (15-20 minutes) and a free-throw shooting task (15 minutes). You also will complete the same free-throw shooting task on Thursday, Friday or weekend (optional) over 5 weeks.

What will I gain from participating?

We will offer you to take imagery training after the study. If you will take imagery training, you will learn about how to utilize imagery effectively for your performance aims in sport. Moreover, the imagery intervention might positively affect your free-throw shooting and this could be transferred to your game performances.

How will the information I give be used?

Research findings will be published in academic journals and/or presented at academic conferences and they will be in an unpublished PhD thesis. We will only present group data, so your results will not be identifiable (Listed below).

What are the potential risks of participating in this project?

Our research has low psychological risk. First, the Sport Imagery Ability Measure (SIAM), which assesses imagery ability, will be used to measure your imagery ability and you might be worried about your answers and scores. Second, you could feel anxious while performing the free-throw shooting task. It must be emphasized that while any of these experiences are possible, it is quite likely you will not experience any of them.

Confidentiality is an important issue in this research. All data will be de-identified and access to the data will only be allowed by members of the research team. We will replace your names by code numbers that will keep your personal scores confidential. Only data for the whole group will be reported in papers and presentations.

How will this project be conducted?

If you volunteer to participate in this research, you will sign a consent form, after we check that you understand what you will be asked to do. Then you will complete the measures of imagery ability and free-throw shooting. You will then undertake the free-throw shooting will be examined again on Thursday, Friday or weekend (optional) over 5 weeks. After the final measure of FTS performance, we will offer you to take the imagery training.

Who is conducting the study?

Any queries about your participation in this project may be directed to the Chief Investigator, Professor Tony Morris (Tel: 0430 511 543), the Co-investigator, Michael Spittle (Tel: 99199512) or the student investigator, Sho Itoh (Tel: 0479 066 444).

Any queries about your participation in this project may be directed to the Chief Investigator listed above.

If you have any queries or complaints about the way you have been treated, you may contact the Ethics Secretary, Victoria University Human Research Ethics Committee, Office for Research, Victoria University, PO Box 14428, Melbourne, VIC, 8001, email researchethics@vu.edu.au or phone (03) 9919 4781 or 4461.

APPENDIX P-Consent form in Control condition (Study 1-3)

VICTORIA UNIVERSITY
MELBOURNE AUSTRALIA

CONSENT FORM FOR PARTICIPANTS INVOLVED IN RESEARCH

INFORMATION TO PARTICIPANTS:

We would like to invite you to be a part of a study into the effect of an imagery intervention on basketball shooting performance. Our central aim is to identify the most effective level of the crucial variable of number of repetitions of imagery of the task during imagery training. In other words, how much imagery athletes should utilize for it to be effective and efficient.

CERTIFICATION BY PARTICIPANT

I, of

certify that I am at least 18 years old* and that I am voluntarily giving my consent to participate in the study entitled: "Effect of number of repetitions of imagery on performance in sport", being conducted at Victoria University by PhD student Sho Itoh under supervision by Professor Tony Morris and Associate Professor Michael Spittle. I certify that the objectives of the study, together with any risks and safeguards associated with the procedures listed hereunder to be carried out in the research, have been fully explained to me by Sho Itoh and that I freely consent to participation involving the below mentioned procedures:

- To complete a measure of imagery ability and a free-throw shooting task
- To complete free-throw shooting tasks on weekend over 5 weeks
- To talk with Sho Itoh who will offer you to take the imagery training

I certify that I have had the opportunity to have any questions answered and that I understand that I can withdraw from this study at any time and that this withdrawal will not jeopardise me in any way.

I have been informed that the information I provide will be kept confidential.

Signed:

Date:

Any queries about your participation in this project may be directed to the researcher
Professor Tony Morris
ph. 0430 511 543; Email: Tony.Morris@vu.edu.au

If you have any queries or complaints about the way you have been treated, you may contact the Ethics Secretary, Victoria University Human Research Ethics Committee, Office for Research, Victoria University, PO Box 14428, Melbourne, VIC, 8001, email Researchethics@vu.edu.au or phone (03) 9919 4781 or 4461.

APPENDIX Q-Flyer (Study 3)

VICTORIA UNIVERSITY
MELBOURNE AUSTRALIA

ISEAL
VICTORIA UNIVERSITY

WANT TO IMPROVE SHOOTING SKILL WITH IMAGERY ABILITY??

VOLUNTEERS NEED

<u>Effect of imagery dose variables on performance in sport</u>

In this project, we aim to examine the best frequency of sessions per week of imagery of the skill among the levels we use in this study for improving basketball free-throw shooting. This project has potential of providing more precise guidance of what is enough sessions of imagery per week to provide benefits for athletes.

You may be eligible to participate in this study

Male and female (aged 18-40) players have played basketball competitively from grassroots level to high level

- Understand imagery effects in sport: why and how top athletes utilize imagery?
- Free participation, imagery training, 3-5 x per week for 4 weeks
- Each training session will take approximately 15 minutes
- You can take the training by yourself, decide the most suitable time to do the imagery training.
- Measure shooting accuracy, 1 x per week for 5 weeks

FOR FURTHER INFORMATION
PLEASE CONTACT
Sho Itoh
[redacted]

APPENDIX R-Information for participation (Study 3)

VICTORIA UNIVERSITY
MELBOURNE AUSTRALIA

INFORMATION TO PARTICIPANTS INVOLVED IN RESEARCH

You are invited to participate

You are invited to participate in a research project entitled 'Effect of frequency of sessions of imagery on performance in sport'.

This project is being conducted by a student researcher Sho Itoh as part of a PhD study at Victoria University under the supervision of Professor Tony Morris and Associate Professor Michael Spittle from College of Sport and Exercise Science.

Project explanation

In this project, we aim to examine the best frequency of sessions per week of imagery of the skill among the levels we use in this study for improving basketball free-throw shooting. This project has potential of providing more precise guidance of what is enough sessions of imagery per week to provide benefits for athletes.

What will I be asked to do?

If you volunteer participate in this project, first, you will complete one measure of imagery ability (15-20 minutes) and a free-throw shooting test (15 minutes). After these measures, you will undertake the imagery intervention, which is imagining perfect free-throw shooting within 3/4/5 days each week over four weeks, and you will take approximately 20min in each imagery intervention. You also will complete free-throw shooting tests at the end of each week and the end of the week after the imagery intervention. At the end of the imagery intervention, Sho will talk to you briefly about your experiences during the study.

What will I gain from participating?

You will learn more about how to utilize imagery correctly for your performance aims in sport. Moreover, the imagery intervention might positively affect your free-throw shooting and this could be transferred to your game performances.

How will the information I give be used?

Research findings will be published in academic journals and/or presented at academic conferences and they will be in an unpublished PhD thesis. We will only present group data, so your results will not be identifiable (Listed below).

What are the potential risks of participating in this project?

Our research has low psychological risk. First, you might feel anxious or stressed prior to the imagery intervention because you have never tried imagery training before, and you are advised that it is important to follow the imagery script correctly. In addition, you may have poor imagery experiences that also relate to increasing stress. Second, the Sport Imagery Ability Measure (SIAM) which assesses imagery ability) will be used to measure your imagery ability and you might be worried about your answers and scores. Finally, you could feel anxious while performing the free-throw shooting test.

Confidentiality is another issue in this research. All data will be de-identified and access will only be allowed by members of the research team. We will replace your names by code numbers which will keep your personal scores confidential. Only data for the whole group will be reported in papers and presentations.

How will this project be conducted?

You will volunteer to participate in this research by signing a consent form, after we check that you understand what you will be asked to do. Then you will take the measures of imagery ability and free-throw shooting. You will then undertake the imagery intervention three times a week over four weeks. Your free-throw shooting will be examined again at the end of each week of the intervention and at the end of the first no-imagery week. After the final measure of FTS performance, you will participate in an interview with one of the investigators.

Who is conducting the study?

Any queries about your participation in this project may be directed to the Chief Investigator, Professor Tony Morris (Tel: 0430 511 543), the Co-investigator, Michael Spittle (Tel: 99199512) or the student investigator, Sho Itoh (Tel: 0479 066 444).
Any queries about your participation in this project may be directed to the Chief Investigator listed above.
If you have any queries or complaints about the way you have been treated, you may contact the Ethics Secretary, Victoria University Human Research Ethics Committee, Office for Research, Victoria University, PO Box 14428, Melbourne, VIC, 8001, email researchethics@vu.edu.au or phone (03) 9919 4781 or 4461.