The Effects of an Imagery Intervention on Imagery Ability

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Abstract

Athletes commonly use imagery to improve performance by mentally practicing a physical action without explicit physical movement. The ability to image is a trainable skill and a crucial factor influencing the efficacy of an imagery intervention. The purpose of the current study was to determine an appropriate duration of an intervention to improve the ability of generating images. Experienced golfers (n=12) were instructed to practice a personalized imagery script for 15 minutes, three days per week for six weeks. During each weekly visit to the laboratory, participants were evaluated on imagery ability, measured by the Sport Imagery Ability Questionnaire (SIAQ), and putting performance, recorded by successfully made putts and average distance from the hole of missed putts. A one-way repeated-measures ANOVA statistical test comparing the SIAQ scores at seven different times found significant effects, $F(6, 66) = 18.17$, $p < .001$. Follow-up dependent t tests revealed that scores increased significantly from baseline to week 1, $t(11) = -3.38$, $p = .006$, and again from week 2 to week 3, $t(11) = -3.61$, $p = .004$. A secondary purpose of the study was to determine if putting performance improved during the course of an imagery intervention. Two one-way repeated-measures ANOVA's to compare the number of successfully made putts and the average distance of missed putts did not yield significant effects; $F(6,66) = .959$, $p > .05$, and $F(6,66) = 2.08$, $p > .05$, respectfully. Multiple Pearson's correlation coefficients examining the relationship between imagery ability and putting performance did not find any significant ($p > .05$) results. While considering the immense time constraints athletes typically have to devote to mental-skills training, the results of the existing study suggest applying an imagery intervention for a three-week duration to reach optimal imagery performance. Further research is still needed to confirm the trajectory of imagery ability to achieve a peak.

Introduction

Background and Significance

The United States Golf Economy Report released in 2016 states that the game of golf generates $84.1 billion of economic activity annually. Of this considerable amount, it is reported that $5.5 billion is spent on golf equipment and apparel; a vast amount presumably to improve performance (The National Golf Foundation, 2018). Golf is a growing sport with more money-spent year over year (18.2% increase from 2011 to 2016; The National Golf Foundation, 2018) by players trying to find an edge to take strokes off their game. It is well accepted that imagery is a performance enhancing technique extensively used by athletes (Smith & Holmes, 2004) and includes internal mental activity of external information without overt movement or a present stimulus (Cumming & Williams, 2012). Imagery is an easily applicable, beneficial, and, best of all, a free mental skills technique to improve golfing performance.

The applied imagery model suggests an athlete's imagery consists of three main components: situation, type, and outcome and is conducted in one of three settings: training, competition, or rehabilitation (Martin et al., 1999). Athletes frequently use imagery as a means of improving physical skill, enhancing motivation, regulating arousal, or modifying cognitions (Williams et al., 2013). The goal of an imagery intervention is to maximize functional equivalence (Smith et al., 2008), a phenomenon that researchers have identified as similar neurological activity between imagery and physical motor execution (Johnson, 1982). Achieving maximal functional equivalence requires an individual to possess a collection of mental skills that comprise imagery. Previous research suggests that an individual's ability to create and control vivid images with ease may have the greatest impact on the efficacy of an imagery intervention (Hall et al., 1992). An imagery intervention may take many forms, such as an audio recording, visual observation, or layered stimulus response training. Historically, the use of an orally conveyed written script administered by a sport psychologist has been the most popular method of delivery imagery.

The "PETTLEP Approach to Motor Imagery" is an evidence-supported model of constructing imagery in an attempt to maximize functional equivalence. The model is comprised of seven items that sport psychologists should closely consider when delivering imagery training to maximize the efficacy of an intervention; physical, environment, task, timing, learning, emotion, and perspective (Holmes & Collins, 2001). The physical component of the model relates to the individual's physical responses and should include all the senses that would be experienced during actual performance. The environment component refers to the setting the imagery is conducted in and should be as similar as possible to the competition environment (Smith et al., 2008). When it is not possible to replicate the setting, auditory and visual cues may enhance this component (Smith & Holmes, 2004). The task component of the model focuses on aligning thoughts, feelings, and actions of the physical movement with the imagery program. Imaging the correct speed a movement is to be performed is critical to correct skill execution and represented within the model as the timing component. The learning component is a fluid process that refers to constant adaptation of the imagery content in relation to the rate of skill development of an individual. The meaning that an athlete connects with a performance situation is represented by the emotion component (Smith et al., 2008). Attaching positive emotions to the imagery content enhances the memory capabilities and performance outcomes of the athlete (Taylor & Shaw, 2002). The seventh component of the PETTLEP-model is perspective and refers to the way imagery is viewed (Smith et al., 2008). Past research suggests that an internal, or first-person, perspective be used for the acquisition of basic skills and for skills that rely heavily on perception, whereas an external, or third-person, perspective should be applied for form dependent skills and novice athletes (Wright et al., 2015).

Golfing legend Ben Crenshaw once said, “I’m about five inches from being an outstanding golfer. That’s the distance my left ear is from my right” (Breslow, 2006). A successful golfer relies as much on mental skill as physical skill. A vast amount of previous research proposes that practicing imagery can improve performance. In an effort to remain consistent with previous studies exploring the effect of imagery on golfers, the current study seeks to contribute further knowledge to the field of sport psychology by developing a time frame that imagery ability improves.

Hypothesis and Purpose

The purpose of this study was to determine an appropriate duration of an imagery intervention to improve the ability of generating images. The researcher hypothesized that the ease of producing images will significantly improve during the course of the intervention.

Limitations, Delimitations, and Assumptions

Potential limitations of the current study exist that are consistent with previous research. One limitation is the low imagery ability of participants at baseline. Past research has identified that individuals vary in their ability to produce and control vivid imagery with ease (Cumming & Williams, 2012). Additionally, the effectiveness of an imagery program is significantly increased for individuals with a higher ability to image (Williams & Cumming, 2011). In an attempt to control for individual variability between participants, the Sport Imagery Ability Questionnaire (SIAQ) was administered prior to the intervention and participants were excluded from data analysis if considered to have high imagery ability, deemed by a score at baseline of greater than five on the questionnaire (Williams et al., 2013). Another potential limitation of the study was the collection of self-reported data. Manipulation checks were conducted throughout the study to confirm that participants were performing their intervention task as instructed. The researcher instructed participants to avoid using any additional imagery or other mental skills techniques for performance enhancement. To ensure internal validity, the experimental task was performed on a synthetic indoor putting surface. As a result, the imagery script and subsequent findings are limited in their practical application to a golf course where important environmental information is essential for a successful golf putt. A final potential limitation of the current study is the unknown ideal length of an imagery program. Based on previous research (i.e. Smith & Holmes, 2004; Smith et al., 2008), it was predicted by the researcher that imagery ability would improve during the duration of the intervention, yet the capacity to reach peak imagery is unknown.

A delimitation of the study was the sample of convenience from local Edmond, Oklahoma country clubs and golf courses. Participants of the study were older than 18 years of age and had an average golf score between 85 and 105 strokes. Additionally, participants were limited to low-ability imagers at the time of baseline screening determined by the SIAQ.

The researcher assumed that participants would respond to the SIAQ honestly and would perform the putting task to the best of their ability. Due to the nature of self-reported data, the researcher assumed that participants were truthful in reporting the time they spend engaged in the imagery-training task.

Operational Definitions

Below are operational definitions for this study:

- Imagery is a mental skills technique used by athletes to improve physical performance without overt movement by incorporating a variety of senses to create and control images of a desired outcome (Anuar et al., 2016).
- Imagery ability is measured by the Sport Imagery Ability Questionnaire (SIAQ) and is an individual's capability to create and control vivid images with ease (Williams et al., 2011).
- Putting performance is assessed in two ways; the number of putts successfully made and the average distance a missed putt is from the center of the hole in centimeters (Williams et al., 2013).
- Average golf score is the self-reported average strokes per round of 18-holes on a par-72 golf course.
- Functional equivalence is a widely accepted explanation for the performance-enhancing properties of imagery that state that the same neurological processes are utilized in physical movement as in imagery (Smith et al., 2007).

Literature Review

Introduction

Imagery is a well-accepted cognitive strategy that uses all the senses to generate a known or anticipated experience in the mind (Slimani et al., 2016). Athletes frequently use imagery to achieve an identifiable outcome to improve physical skill, enhance motivation, regulate arousal, or modify cognition (Williams et al., 2013). An individual's ease of producing vivid images greatly influences the likeliness of achieving a desired result (Martin et al., 1999). An improved ability of imaging could be an essential benefit to learning a new skill, preparing for competition, or rehabbing from injury for an athlete. The purpose of this literature review was to identify, synthesize, and critically evaluate studies that assess an imagery program's effect on imagery ability and physical performance. A secondary aim is to determine the characteristics of imagery essential to maximizing the efficacy of an intervention. The current literature review, as outlined in the methods section, was systematically conducted by an exhaustive search. The results of the subsequent findings are summarized in two main sub-topics that coincide with the dependent variables of the research question: imagery ability and imagery's effect on physical performance. Major findings, gaps, limitations, and practical applications within sport psychology are summarized in the final section of this literature review.

Methods

A comprehensive search of the literature available was conducted to locate relevant studies from the following databases, Sport Discus Full Text, ScienceDirect, ProQuest Central, PsycInfo and Medline. Searches were primarily conducted using key words such as, *imagery, imagery functions, imagery ability, imagery and sport, imagery and golf, imagery and performance, PETTLEP imagery, functional equivalence,* and *measuring imagery*. Additionally, reference lists of pertinent articles were manually scanned for studies that may be of use. These findings were then located through the previously mentioned databases and analyzed for relevancy.

The outlined search strategy was conducted between September of 2018 and February of 2019. The researcher screened all article titles published between 1985 and 2018. A large time frame of publication was accepted due to the examination of imagery dating back to the early 20th century and in-accord with previous imagery reviews (Driskell et al., 1994). The researcher further evaluated 47 abstracts of studies with relevant titles. A full-text review was warranted if the abstract provided relevant information pertaining to imagery.

All primary sources examining the effectiveness of an imagery intervention on imagery ability or sport performance were included. Both qualitative and quantitative research designs were accepted for inclusion. All included studies were conducted on participants in sport or movement over the age of 18. Studies performed on experienced golfers, novice golfers, and non-golf athletes were included for review. Studies were excluded from the synthesizing process if mental-skills approaches aside from imagery, such as visualization or meditation, were solely examined. All reviews, secondary sources, and non-sport related articles were excluded. Of 26 excluded studies, seven were literature reviews, five tested variables of imagery production besides ability, five examined imagery interventions on special populations, three included non-sport or movement related activities, and six were excluded for miscellaneous reasons. Language restrictions limited only studies published in the English language to be included.

If the outlined inclusion criterion were met, quality standards were assessed. Exceptionally high-quality studies included a PETTLEP-based (Physical, Environmental, Task, Timing, Learning, Emotion, Perspective) imagery intervention assessing imagery's impact on golf-putting performance. Additionally, research of this exceptionally high status also measured imagery ability pre- and post-intervention, using a valid and reliable questionnaire, such as the Sports Imagery Ability Questionnaire (SIAQ), Motivational Imagery Ability Measure for Sport (MIAMS), Movement Imagery Questionnaire-Revised (MIQ-R), or Vividness of Movement Imagery Questionnaire (VMIQ). Studies of high quality measured a PETTLEP-based imagery intervention's effect on athletic performance and imagery ability, measured by one of the aforementioned questionnaires, over-time. A study of moderate quality would assess imagery ability over the course of an intervention, evaluate the validity and/or reliability of imagery assessment questionnaires, or examine the effects of an imagery intervention on imagery ability or physical performance. Low quality studies were literature reviews, tested variables of imagery production besides ability, or examined imagery interventions on special populations. Exceptionally high, high, and moderate quality studies were included in the review.

Full-text articles were critically assessed for providing a comprehensive explanation of research methods, relevant findings, and including suggestions for further implications on the field of sport psychology. Each study was critically examined compared to similar studies selected for inclusion in the review. The results of 21 included studies are reviewed below.

Results

Imagery Ability

In order to quantify imagery ability, several well-established and regularly used questionnaires have been developed to assess an individual's ability to image. The Sport Imagery Ability Questionnaire (SIAQ), developed by Williams and Cumming (2011), allows for the assessment of imagery ability in a sport-related setting, as opposed to imagery of general movements and actions measured in other questionnaires. Five consecutive studies, including a pilot study, were designed to establish a valid and reliable questionnaire specific to sport-related content. All five identified functions of imagery, as outlined below, are reflected in the questionnaire. Williams and Cumming (2011) assessed imagery ability in participants of varying sex, sport, nature of sport, experience, and competitive level. The SIAQ has the ability to distinguish between sexes and individual characteristics, such as competitive level, while displaying good factorial validity and reliability (Williams & Cumming, 2011).

Undoubtedly, the strength of the SIAQ is its ability to assess imagery on the five functions, or purposes, of imagery related to athletics. According to the model presented by Slimani et al. (2016), one of the most frequently employed functions of imagery in athletes is motivational general-mastery (MG-M). MG-M imagery involves imaging a sense of being in control with the purpose of elevating self-confidence (Gregg & Hall, 2006) and is commonly practiced in athletes prior to competition (Williams & Cumming, 2011). The motivational general-arousal (MG-A) function controls emotions and regulates anxiety, while the motivational specific (MS) function is employed to boost self-efficacy and includes images of achieving accomplishments, such as winning. Cognitive specific (CS) imagery encompasses mentally rehearsing movements to be performed and is regularly performed in athletes acquiring a new skill. The cognitive general (CG) function engages the imager in the mental rehearsal of plays, plans, or strategies in competition (Slimani et al., 2016). The SIAQ is unique in its ability to measure all five functions in a sport-related content (Williams & Cumming, 2011).

The applied model of imagery developed by Martin et al. (1999) suggests that in order to maximize the effectiveness of imagery, the function of the produced image must match the performance outcome. While the SIAQ measures all five functions, the Motivational Imagery Ability Measure for Sport (MIAMS) was developed by Gregg and Hall (2006) to specifically assess the most frequently used function, MG-M, and the closely related function of MG-A. The three-phase process of developing the questionnaire culminated in a study of 315 participants to determine the influence of variables such as sex, competitive level, and sport-type on MG-M and MG-A imagery ability. Significant results indicate that varying levels of competition effect the ability to use the MG-M, $F(2, 305) = 4.82$, $p < 0.01$ and MG-A function, $F(2, 305) = 4.66$, $p < 0.01$. The results do not indicate a significant difference between sexes or team versus individual sport athletes ($p > 0.05$; Gregg & Hall, 2006). Additionally, previous research has determined that athletes displaying a high imagery ability of the two motivational-general functions measured by the MIAMS, predominantly use these two functions of imagery (Gregg et al., 2011).

Gregg et al. (2011) conducted research to further understand the association between imagery use and imagery ability. Athletes (N = 432) from 45 sports with varying skill-level and experience completed the Sport Imagery Ability Questionnaire (SIAQ) to determine an individual's frequency of using one of the five functions of imagery. Additionally, participants completed the MIAMS and Movement Imagery Questionnaire-Revised (MIQ-R) to assess ability of MG-M and MG-A imagery functions and visual and kinesthetic imagery ability, respectively. The results of five hierarchical regression analyses indicated that imagery ability accounts for 20 to 41% of the discrepancy in the use of one of the five functions of imagery (Gregg et al., 2011).

Developed by Hall and Martin (1997), the MIQ-R is the revised edition of the Movement Imagery Questionnaire (MIQ) and is a valid tool with good reliability that uniquely allows participants to physically perform each movement prior to imaging the motor action. Participants are assessed on eight movements and asked to evaluate the ease of which the image was generated on a 7-point Likert-type scale to determine the ability to generate imagery in the visual or kinesthetic imagery modality (Hall & Martin, 1997). The study conducted by Gregg et al. (2011) indicated that visual and kinesthetic imagery predicts the use of the CS imagery function.

Williams et al. (2011) investigated the efficacy of the performed movement prior to subsequent imagery as directed in the MIQ-R. The researchers investigated the ease of generating imagery following four cues: physical movement, external visual observation, internal visual observation, and imagery-only. The results support the use of physical movement, $F(3, 105) = 8.00$, $p < 0.001$, as a prompt to facilitate kinesthetic imagery greater than external visual observation ($p = 0.019$, Cohen's $d = 0.48$), internal visual observation ($p = 0.004$, Cohen's $d = 0.44$), and an image-only condition.

The dissimilarity between visual imagery (VI) and kinesthetic imagery (KI) stems from the general differences in cortical activation stimulated by the two different perspectives (Fery, 2003). Fery (2003) examined the usefulness of each modality in a variety of imagery settings. Pre-test scores on the Vividness of Movement Imagery Questionnaire (VMIQ), a valid and reliable questionnaire to assess the ability to produce vivid images from an internal and external perspective, homogeneously categorized participants into three groups ($n = 8$); visual imagery, kinesthetic imagery, and control. Participants performed their assigned imagery modality prior to reproducing a fine-motor skill task and a gross-motor skill task. The results indicated that the reproduction of tasks requiring a superior motor skill benefit greater using kinesthetic imagery than visual imagery, while tasks requiring peripheral motor skills were better replicated when visual imagery was incorporated. Of greater significance is the fact that both modalities of imagery outperformed the control group in the replication of fine and gross motor skills (Fery, 2003).

Visual motor imagery can further be divided into two perspectives: external visual imagery (EVI) and internal visual imagery (IVI). Yu et al. (2016) investigated the constructs of EVI compared to IVI. The researchers sought to determine the efficacy of each perspective depending on the nature of the participants specialized sport (open vs. closed) and skill level (high vs. low). Participants competed in either closed sports ($n = 27$) or open sports ($n = 45$). The EVI task assessed imagery accuracy by instructing participants through a mental rotation paradigm against superimposed human figure movements. Time taken to complete an action was compared to the time taken to visualize the same movement in the IVI task. Further, participants were classified as high or low-skill athletes. A counterbalanced design was conducted and results significantly indicated, $F(1, 67) = 6.50$, $p = 0.013$, that open sport, high-skill athletes performed the best of the four groups on the EVI task ($\bar{x} = 62.4\% \pm 8.1\%$). Yu et al. (2016) found significant differences in IVI ability, measured in time (ms), between athletes of higher skill level ($\bar{x} = 431 \pm 253$) than lower skill level ($\bar{x} = 702 \pm 338$, $p = 0.001$). Additionally, open-sport athletes performed statistically significantly better ($\bar{x} = 495 \pm 281$) than those that participated in closed-sport athletics ($\bar{x} = 685 \pm 365$, $p = 0.02$; Yu et al., 2016). Therefore, it may be inferred that participants of a high-skill level with a specialization in an open-sport have a greater ability to generate both constructs of visual imagery.

Driskell et al. (1994) conducted a meta-analysis to determine the effects of an imagery intervention on performance and to identify conditions that maximize the effects of imagery. Results of the meta-analysis specified that, while imagery has a significant effect on physical performance, several variables of imagery condition improve performance. Driskell et al. (1994) found imagery to be most effective in tasks requiring cognitive activities ($r = .378$, $z = 4.456$, $p < 0.001$) compared to tasks requiring greater strength ($r = -.358$, $z = 3.856$, $p < 0.001$) and coordination ($r = -.239$, $z = 0.147$, $p < 0.01$). Additionally, a longer span between imagery and physical performance lessens the beneficial effects of imagery on performance ($r = -.216$, $z = 2.453$, $p < 0.01$). Imagery performed on the day of competition is thought to be twice as effective ($z = 0.17$) as imagery performed two weeks prior. If the duration between imagery practice and physical performance expanded to three weeks, imagery's impact on performance was reduced to less than 10% of the effect of imagery performed on the day of competition. In support of the findings by Yu et al. (2016), the results of the meta-analysis indicate that novice participants' do not significantly ($z = 1.246$, $p > 0.1$) experience imagery effects on performance greater than expert participants. Additionally, the results show a lack of significance ($z = 0.019$, $p > 0.1$) between the type of task for experienced participants, suggesting that experts benefit equally well from mental training, regardless of cognitive or physical task type (Driskell et al., 1994).

Research conducted by Goss et al. (1986) suggests that possessing a high ability to image facilitates the learning of new movements. Goss et al. (1986) studied the ease of acquisition of movements between three groups of imagers defined by MIQ results; high visual/high kinesthetic (HH; $n = 22$), low visual/low kinesthetic (LL; $n = 19$), or high visual/low kinesthetic (HL; $n = 11$). Of the 219 participants recruited for the study, it should be noted, only 24% fit into one of these groups by the results of MIQ scores and zero were classified as low visual/high kinesthetic (LH) imagers. An ANOVA statistical test was conducted and indicated a significant difference between imagery groups, $F(2, 27) = 14.54$, $p < 0.05$. While all groups improved over time, the HH imagers acquired the movement pattern with the least number of trials ($\bar{x} = 11.0$). While imagery ability is evidently related to the acquisition of skills, it appears as though kinesthetic imagery facilitates visual imagery as evident by zero participants classifying as LH imagers (Goss et al., 1986).

A three-study design conducted by Hardy and Callow (1999) examined the effectiveness of EVI, IVI, and KI on the performance of form-essential tasks. Cognitive ability is essential in the acquisition and performance of form-based skills to a greater extent than physical ability. Experiment one compared the efficacy of learning a new movement in experienced karateists (n = 25) from an EVI perspective, IVI perspective, or stretching routine. The researchers found that the EVI perspective ($\bar{x}$ = 21.24 ± 1.18) was significantly, $F(2.88, 25.88) = 13.01$, $p < 0.001$, more successful than the IVI perspective ($\bar{x}$ = 20.44 ± 1.29) in learning the new movement. The IVI perspective was more effective than the stretching routine ($\bar{x}$ = 19.31 ± 0.62). The second study conducted by Hardy and Callow (1999) compared the effectiveness of four conditions; EVI without KI, EVI with KI, IVI without KI, and IVI with KI, on novice gymnasts (n = 40) learning a simple floor routine. Study two found significant results, $F(1, 30) = 8.03$, $p < 0.01$, indicating that VI is superior to KI. Further investigation of means reveals that EVI ($\bar{x}$ = 8.47 ± 0.56) is superior to IVI ($\bar{x}$ = 8.26 ± 1.23) in the acquisition of new form-based tasks in novice participants. As revealed in the meta-analysis conducted by Driskell et al. (1994), these results support the use of imagery during the acquisition of cognitive and form-based skills. Results did not reveal a significant improvement in participants using EVI with KI ($\bar{x}$ = 8.68 ± 0.35) compared to participants in the EVI without KI ($\bar{x}$ = 8.47 ± 0.56) group. Experiment three replicated the second study, yet with expert rock climbers (n = 20), and found similar results. However, unlike study two, EVI with KI ($\bar{x}$ = 1.36 ± 0.33) was superior to EVI without KI ($\bar{x}$ = 2.09 ± 0.68, $p < 0.05$; Hardy & Callow, 1999). It is important to note that smaller scores indicate better performance in rock climbing. Hardy and Callow (1999) propose that, dependent of skill level and contrary to Yu et al. (2016), a third-person perspective is superior to a first-person perspective in the acquisition of form-based skills.

Wright et al. (2015) assessed the effectiveness of action observation compared to imagery techniques for improving the imagery ability of club-level golfers (N = 27). Participants were assigned to one of three groups. Imagery group participants ($n = 9$) were instructed to practice their personalized imagery scripts, the action observation group ($n = 9$) viewed a personalized video, and the control group ($n = 9$) engaged in physical practice. Prior to and following the 6-week intervention, participants completed the MIQ-R. Wright et al. (2015) found significant results, $F(4, 48) = 2.77$, $p = .04$, indicating an improvement in ease of visual imagery production in the action observation and imagery groups. Participants of the imagery group significantly improved ease of kinesthetic imagery from pretest to posttest ($p = .005$) as well, yet there was not a significant improvement in kinesthetic imagery ease in the action observation group ($p = .07$). The physical practice performed by the control group did not yield significant improvements ($p > .90$) in imagery ability. The findings are congruent with those of Cumming and Williams (2012) and further support that imagery ability can be improved.

Imagery and Performance

A great amount of previous research has been conducted to determine the effect of imagery on athletic, in particular golf, performance. Bernier and Fournier (2010) conducted a study to examine the use of imagery in expert golfers ($n = 31$). Participants were instructed to apply imagery prior to completing a series of chip shots around a putting green to a target. Following each chip shot, performance was measured by distance to the hole, and participants completed a qualitative questionnaire to assess their choice of content, characteristic, and function of imagery. Chi-square tests were conducted and found results that link the function of imagery use to the characteristics and content of the image produced. Specifically, significant findings link the color, $x^2(5, 243) = 18.29$, $p < 0.05$, speed, $x^2(10, 265) = 33.48$, $p < 0.01$, and vividness, $x^2(10, 282) = 23.16$, $p < 0.01$, characteristics of imagery with the function of imagery. Additionally, significant links were displayed for the perspective, $x^2(10, 275) = 32.91$, $p < 0.001$, and focus, $x^2(15, 289) = 72.24$, $p < 0.01$, variables of content and the function of imagery. Regardless of the purpose of imagery, images from an internal perspective (55%) of a desired outcome (53%) were used most frequently among the 310 performed golf shots (Bernier & Fournier, 2010).

The content of a produced image is an important variable to consider in an imagery intervention. Taylor and Shaw (2002) examined the effects of positive and negative outcome imagery on putting performance compared to a control group. Participants were classified as skilled ($n = 25$) or unskilled ($n = 26$) based on their golf handicap and putting performance was assessed by distance of the ball to the hole. A counterbalance design was adopted in which imagery condition was a repeated factor. Participants in the positive outcome condition were asked to image a successfully made putt immediately prior to performing the task. The negative outcome control instructed golfers to image a missed putt. Participants in the control condition were asked to address the ball and putt as they normally would. Independent of skill level, results indicate a significant difference, $F(1, 46) = 36.3$, $p = 0.001$, in putting error between the positive and negative imagery condition ($p = 0.001$) and the negative imagery and control condition ($p = 0.003$). Significance was not found in putting error between the positive imagery and control condition ($p = 0.99$; Taylor & Shaw, 2002). While the researchers were unable to conclude that imagery could enhance putting performance, results suggest that negative outcome imagery has the ability to considerably decrease performance.

Quinton et al. (2016) also sought to determine the negative effects imagery could have on performance. Similar to Taylor and Shaw (2002) participants were classified as either novice ($n = 40$) or expert golfers ($n = 39$) and completed a standardized putting task to assess performance prior to an imagery intervention. Participants were instructed to practice imagery of a missed golf-putt and then attempt to make a putt. Mean scores indicated that novice golfers ($\bar{x} = 42.84 \pm 12.67$) performed significantly worse than experts ($\bar{x} = 22.38 \pm 5.58$, $p < 0.001$) on the putting performance task pre- and post-intervention. Additionally, participants were assessed on the perceived helpfulness of the imagery intervention. The results of an ANOVA statistical test, $F(1, 75) = 7.88$, $p = 0.006$, indicated that novices ($\bar{x} = 4.00 \pm 1.47$) perceived imagery to be neither helpful nor unhelpful, while expert golfers ($\bar{x} = 3.03 \pm 1.61$, $p = 0.006$) perceived the imagery content to be unhelpful (Quinton et al., 2016). The results suggest that the outcome of the imagery intervention be carefully aligned with the objective of the physical performance.

Smith and Holmes (2004) conducted a test to examine the effect of various imagery modalities on golf putting performance. Participants ($n = 40$) were randomly assigned to one of four groups; written imagery script, audio recording, video observation, and control. Participants were assessed on baseline measures of putting performance, determined by number of putts successfully made and an additional performance score. Imagery modalities were all personalized. Participants performed the putting task and practiced their imagery modality twice a week for six weeks. As expected, mean scores indicated that all four interventions elicited improvements in golf putting performance. Results of made putts, $F(3, 36) = 7.95$, $p < 0.001$, and performance score, $F(3, 36) = 11.70$, $p < 0.001$, yielded significant improvements over the six week intervention in the video and audio group participants ($p < 0.01$), but failed to reach significance in the written imagery script and control group scores ($p > 0.05$; Smith & Holmes, 2004). The mode of imagery delivery might impact the effectiveness of an imagery intervention.

Motivational general-mastery (MG-M) imagery, as previously noted (Gregg & Hall, 2006; Slimani et al. 2016), is a function of imagery employed to overcome obstacles in sports with confidence and control. Within the constructs of Martin et al.'s (1999) applied model of imagery, research was conducted to determine the effects of a MG-M imagery intervention on motivational imagery ability and performance among college golfers ($n = 3$; Hammond et al., 2012). Over the course of three weeks, guided imagery sessions were conducted every third day and participants were instructed to practice personalized audio imagery scripts on their own for 10-15 minutes every day. Fifteen rounds of golf were evaluated at baseline and during the intervention phase to assess golf performance. Two participants (66.67%) golf performance, measured by average shots per round, improved, however the results of the independent t-tests failed to reach significance ($p > 0.05$). In support of a vast amount of previous research, all participants (100%) improved their imagery ability from pre-test to post-test.

Similar to past research (Smith & Holmes, 2004; Wright et al., 2015 & Quinton et al., 2016) synthesized in this review, Ashbrook et al., (2018) assessed the effectiveness of an individualized mental skills training program on improving golf scores and mental skills in college golfers ($n = 6$). Using a mixed-design approach, researchers inspected golf and mental skills performance, assessed by the Test of Performance Strategies-2 (TOPS-II) questionnaire, over the course of the fall and spring competition schedule. Results suggest that a one-to-one training program was effective in improving average golf scores in qualifying rounds (50%). Additionally, 78.6% of the TOPS-II subscales improved from baseline to posttest. While the results point to evidence that a mental skills training program, including an imagery intervention, improves physical and mental performance, Ashbrook and colleagues (2018) reported individual differences within participants mental skills performance that are expressed systematically in the research. The results of the one-to-one intervention support the need for personalized imagery scripts.

One method of personalization to improve imagery ability is layered stimulus response training (LSRT). Bioinformational theory suggests that motor images contain stimulus, response, and meaning propositions (Lang, 1979). LSRT is a methodical approach of gradually building images by layers in progressive stages to produce more complex images and is believed to be an effective method of improving imagery ability (Williams et al., 2013). Novice golfers ($n = 24$), low in imagery ability evident by scores less than five on the SIAQ, were randomly assigned to a LSRT, motor imagery (MI), or VI group. The purpose of the study conducted by Williams et al. (2013) was to determine the effects of LSRT training compared to imagery practice on characteristics of imagery ability and golf-putting performance. Over the course of four days, participants of the LSRT and MI groups imaged successfully made golf putts five times per day, while the VI group imaged a golf-ball successfully rolling into the hole. Results yielded significant findings indicating that LSRT imagery is a more effective approach to improving KI ability, $F(1, 21) = 13.23$, $p = 0.002$, imagery of golf-specific skills, $F(3, 42) = 11.23$, $p < 0.001$, and golf-putting performance, $F(2, 21) = 6.41$, $p = 0.007$, than traditional MI or VI. Williams et al. (2013) provided support for Lang's bioinformational theory by demonstrating that LSRT can improve imagery ability when components of stimulus, response, and meaning are systematically included in the personalized image.

Athletes typically use imagery as a supplement to physical practice. Marshall and Wright (2016) conducted a study to determine the efficacy of LSRT when combined with physical practice of a golf-putting skill compared to action observation and motor imagery (AOMI) and a control group. As results by Wright et al. (2015) indicate, action observation and motor imagery can improve imagery ability in participants. Similar to Williams et al. (2013), putting performance and imagery ability of novice golfers ($n = 24$) were assessed over a five-day intervention. In support of the findings by Williams et al. (2013), results indicated that putting performance, $F(2.91, 30.52) = 3.66$, $p = 0.02$, and golf-specific KI skills, $F(1.60, 22.47) = 3.93$, $p = 0.04$, in novice athletes could be improved with the incorporation of LSRT, but not with an AOMI combination. However, significant MI improvements were not found in any group ($p > 0.05$) over the course of the experiment, yet task-specific imagery ability improved in both the LSRT and AOMI groups.

Essential to augmenting the effect of imagery on performance is the principle of functional equivalence. Functional equivalence is the similarity of the neural activity experienced in imagery and actual movement (Johnson, 1982). Holmes and Collins (2001) proposed the “PETTLEP Approach to Motor Imagery” in an attempt to maximize parallels in neural activity between imagery and the preparation and execution of movement. The PETTLEP-model suggests that sport psychologists should closely consider aspects of the athlete’s physical skill when delivering imagery training. The model is comprised of seven items that sport psychologists should use to maximize the efficacy of an imagery intervention; physical, environment, task, timing, learning emotion, and perspective. Holmes and Collins (2001) suggest closely manipulating each component of the model to accurately represent the preparation and execution of the actual movement. A vast amount of research has been conducted to specifically test the implications of the PETTLEP-approach on imagery ability and performance enhancement.

To determine the effect of PETTLEP-based imagery compared to traditional, clinically oriented methods of imagery, Smith et al. (2007) conducted a study involving experienced field hockey players ($n = 48$). Field hockey participants were assigned to one of four groups: sport-specific imagery, clothing imagery, traditional imagery, and a control group. Participants were assessed on the performance of a 6.5m field hockey shot. The sport-specific imagery group was most congruent with PETTLEP recommendations and participants performed individualized imagery on a field hockey pitch while wearing their uniform. The clothing imagery group practiced imagery at home in their uniform. The traditional imagery group performed their imagery at home in regular clothing. All three imagery groups incorporated PETTLEP elements of task, timing, and perspective. Physical and environmental elements were manipulated between groups. Participants performed their assigned imagery daily for six weeks. The results supported the PETTLEP-model guidelines to maximize the efficacy of an imagery intervention. Statistical test's revealed significant, $F(3, 44) = 18.37$, $p < 0.001$, post-intervention improvements in the field hockey skill among all four conditions. Effect size calculations revealed large treatment effects for the sport-specific (Cohen's $d = 1.35$) and clothing imagery groups (Cohen's $d = 0.82$). Results yielded moderate treatment effects for the traditional imagery group (Cohen's $d = 0.50$). All imagery groups significantly ($p < 0.05$) improved greater than the control group (Smith et al., 2007). The physical and environmental elements of the PETTLEP-approach are clearly important variables that must be considered when prescribing an imagery intervention.

As previous research has outlined, supplementing physical practice with an imagery intervention is beneficial to maximizing performance (Marshall & Wright, 2016). Further backing of this narrative are the results found by Smith et al. (2008) that support the effectiveness of PETTLEP-based imagery when combined with physical practice. Experienced golfers (n = 32) were assigned to four groups: PETTLEP imagery, physical practice (PP), PETTLEP imagery and PP, and a control group. During a six-week intervention on performance of a golf-bunker shot, participants of the PETTLEP imagery group practiced an imagery intervention that included the seven components of the model twice a week. Participants of the PP group physically performed the bunker shot twice per week. Participants of the PETTLEP imagery plus PP group were instructed to perform imagery once a week and physical practice once a week. Apart from the control group, the mean scores of shot performance increased for all groups. A 4 x 2 ANOVA statistical test revealed a significant interaction, $F(3, 28) = 7.03$, $p < 0.01$, in bunker-shot performance from pre-test to post-test. Although effect size calculations did not reveal a significant difference in improvement between the isolated PETTLEP (Cohen's d = 0.80) or PP groups (Cohen's d = 1.37, $p > 0.05$), the PETTLEP combined with PP group (Cohen's d = 2.10, $p < 0.05$) significantly improved the magnitude of bunker-shot performance from pre-test to post-test. Therefore, results support the efficacy of sport psychologists implementing an imagery program in conjunction with physical practice (Smith et al., 2008).

A vast amount of research (i.e. Smith et al., 2007, 2008) supports the positive impact of the PETTLEP-model on improving athletic performance; however, limited research with conflicting results has been conducted to determine the effects of a PETTLEP-based imagery intervention on improving imagery ability. Anuar et al. (2016) found in a study that participants (n = 40) ability to generate IVI, $F(2, 38) = 14.90$, $p < 0.001$, and KI, $F(2, 38) = 4.97$, $p = 0.012$, was significantly improved in a PETTLEP-based intervention when compared to traditional practices of imagery. However, the results did not yield significant findings for improvement in

EVI ability, $F(2, 38) = 1.49$, $p = 0.239$, between the two models of prescription (Anuar et al., 2016).

Discussion

The wide-scope of the literature yields results that suggest imagery ability can be improved with an imagery intervention. Additionally, the present review suggests ways of amplifying an imagery intervention to maximize ability and performance.

Imagery Ability

Although all individuals have the ability to image, the level of which images are produced vividly with ease varies between people (Cumming & Williams, 2012). Prior research has identified that imagery training can improve the ability to image. Of 21 reviewed articles, seven examined the ability to improve imagery production. All seven studies found significant results indicating that at least one component of imagery can be generated with greater ease and vividness during the course of an intervention (Anuar et al., 2016; Fery, 2003; Goss et al., 1986; Hammond et al., 2012; Marshall & Wright, 2016; Williams et al., 2013; Wright et al., 2015).

Assessing an individual's imagery ability is critical to determine the efficacy of an imagery intervention. Four validated and reliable assessments are evaluated in the current review: SIAQ, MIAMS, MIQ-R, and the VMIQ. While all four questionnaires serve individual purposes, limitations do exist. One limitation to the SIAQ is its inability to identify between imagery ease and vividness, two vital components of imagery ability (Williams & Cumming, 2011). Similarly, the VMIQ is limited to assessing the vividness of generated images, but not the ease of creating them. A limitation to be considered when assessing imagery ability using the MIAMS assessment is its inability to identify differences in sex or sport-type (Gregg & Hall, 2006). Albeit one of the most popular assessments used in the field of sport psychology, the MIQ-R is not constructed to measure the ability of sport-specific skills (Hall & Martin, 1997).

A few common limitations exist among previous research exploring the effect of practicing imagery on imagery ability. Two studies cited self-reported data as a limitation to their results on the effect of imagery ability (Anuar et al., 2016; Williams et al., 2013). Small sample size, as a result of participant recruitment challenges, were limitations of two separate studies investigating imagery ability (Hammond et al., 2012; Marshall & Wright, 2016). The study conducted by Hammond et al. (2012) reported a sample size of three as a limitation, while the experiment by Marshall and Wright (2016) had a sample size of 24, yet still stated it as a limitation to their research. The studies conducted by Anuar et al. (2016) and Fery (2003) revealed concerns that participants may have engaged in spontaneous psychological techniques beyond the scope of the experiment that may have influenced results. The effect of an individual's imagery ability has on improving performance is also unknown, and therefore, may be a limiting factor to enhancing performance due to a ceiling effect (Goss et al., 1986; Marshall & Wright, 2016). As a result of the need to individualize imagery experiences during an intervention, a lack of homogeneous groups has the potential to occur in a study assessing multiple imagery groups, thus causing a limitation due to the unknown effects of various elements of the image, such as possible EVI versus IVI effects (Wright et al., 2015).

Imagery and Performance

Twelve of the 21 synthesized articles in the present review sought to determine the effect of imagery on performance. Eleven of the 12 articles determined that practicing imagery significantly impacts physical performance (Ashbrook et al., 2018; Bernier & Fournier, 2010; Driskell et al., 1994; Fery, 2003; Marshall & Wright, 2016; Quinton et al., 2016; Smith &

Holmes, 2004; Smith et al., 2007; Smith et al., 2008; Taylor & Shaw, 2002; Williams et al., 2013). Furthermore, eight of the 11 articles finding significance included a golf-specific task (Ashbrook et al., 2018; Bernier & Fournier, 2010; Marshall & Wright, 2016; Quinton et al., 2016; Smith & Holmes, 2004; Smith et al., 2008; Taylor & Shaw, 2002; Williams et al., 2013). The lone study that did not yield significant improvements in physical performance assessed whole rounds of golf, as opposed to specific skills within the game (Hammond et al., 2012); however, while not of significance, the study did indicate positive trends in improving performance. As previously noted, an additional limitation of this research was the small sample size ($n = 3$; Hammond et al., 2012).

Similar to the study conducted by Wright et al. (2015), the personalization of an imagery intervention is a limitation in studies that also focus on improving performance (Ashbrook et al., 2018). The need for individualized imagery interventions is confirmed in post-treatment interviews with participants in the Smith et al. (2008) study. As previously noted, Williams et al. (2013) indicated the collection of self-reported data as a possible limitation to their study. However, other studies conducted to determine imagery's impact on physical performance used a self-reported method of collecting data through diaries and manipulation checks, yet did not mention it as a possible limitation to their study (Smith & Holmes, 2004; Smith et al., 2008). The efficacy of collecting self-reported data on participant's use of imagery and practice effects is inconclusive according to the reviewed literature. An additional limitation consistent with golf-putting tasks is caused by the need to perform the task on an indoor, artificial putting surface due to the external variables of weather, turf length, and slope of a realistic putting green. Performing the task in a lab setting on artificial turf (Smith & Holmes, 2004), though necessary to improve internal validity, limits external validity and the practicality of repeating the task outdoors on a real putting green. Another limitation stems from the nature of an artificial putting surface because missed putts may roll off the back and are not valid measures of performance due to changes in surface conditions (Williams et al., 2013). While the research supports using imagery as a performance enhancing technique, two studies also suggest that negatively imaging an outcome can have detrimental effects on performance. However, due to the nature of these studies, participant's motivation to successfully perform the task after negatively imaging an outcome may be a limitation to the results (Quinton et al., 2016; Taylor & Shaw, 2002).

The PETTLEP-based approach to practicing and prescribing imagery is widely accepted and understood. Incorporating the seven elements of the PETTLEP model of imagery is more effective in improving imagery ability than traditional imagery practices (Anuar et al., 2016; Smith et al., 2007; Smith et al., 2008). However, research indicates inconclusive evidence as to the importance of each individual component of the model. Evaluations completed by participants in one study suggest that the physical characteristic of the model is the only component perceived as "more helpful" (Anuar et al., 2016). Previous research has also suggested that the timing element of the PETTLEP-approach is most beneficial to improving performance. Smith and Holmes (2004) suggested that improvement in putting performance was not evident in a written imagery script modality due to the lack of a timing component. Conversely, a timing component was provided by cues in the visual imagery and audio imagery groups, both of which did yield a significant effect on performance. Quinton et al. (2016) propose that the task and learning component of the PETTLEP approach might be the most important characteristics to consider; the image content produced by the athlete must align and continue to develop as skill level improves. Evidently, future research is needed to isolate the seven characteristics of the PETTLEP-approach to determine their variability and importance to improving imagery ability or physical performance in an imagery intervention.

The results of the current review disclose a current gap in the literature that does not specifically examine the ideal duration an imagery intervention must last to achieve peak imagery ability. Additionally, the length an imagery intervention takes to reach maximum effectiveness on physical performance is not presented in the research reviewed here, nor is it a component of the PETTLEP-model.

Conclusion

Martin et al. (1999) proposed that imagery ability is the key cog in the relationship between imagery use and imagery outcome. This idea has since garnered further support in research and suggests that imagers experience greater performance improvements with imagery training (Goss et al., 1986). This literature review aimed to identify, synthesize, and critically evaluate studies that assessed an imagery program's effect on imagery ability and physical performance. A secondary purpose was to determine the characteristics of imagery essential in maximizing the efficacy of an intervention. This review yielded conclusive evidence that imagery ability and physical performance improve with the implementation of an imagery intervention. Sport psychologists should continue to incorporate imagery into an athlete's mental-skills training plan. A successful imagery intervention should be personalized to the athlete's goals and contain as many elements of the PETTLEP-model as possible. However, due to the present gap in the literature, determining a time frame that imagery ability peak's during an intervention is essential for a sport psychologist to suggest an appropriate duration of an imagery program. Future research based on the results of the proposed study can be conducted to determine the value of the seven PETTLEP elements over-time.

Methods

The purpose of the current study was to determine the duration of an imagery intervention to maximize imagery ability. An imagery program focused on the sport-skill of putting in golf was used. The researcher assessed imagery ability through responses to the Sports Imagery Ability Questionnaire (SIAQ). Additionally, putting performance was measured by a putting task. The following chapter outlines the study's participants, instruments, procedures, and statistical design and analysis.

Participants

The Oklahoma City Metro Area offers more than 35 golf courses (The PGA of America, n.d.). Participants were conveniently recruited from Oklahoma City Metro Area country clubs and golf courses upon receiving Institutional Review Board (IRB; Appendix A) approval and permission from golf course managing staff. The researcher garnered permission to recruit participants from Rose Creek Golf Course located at 17031 North May Avenue in Edmond, Oklahoma, KickingBird Golf Club located at 1600 E Danforth Road in Edmond, Oklahoma and Lincoln Park Golf Course located at 4001 Northeast Grand Boulevard in Oklahoma City, Oklahoma (Appendix B). Recruitment was conducted through posted fliers (Appendix C) at participating golf courses providing a brief description of the study and the researcher's contact information. Additionally, a snowball sampling technique was employed by golf course professionals for recruitment of participants due to the need for individuals that are likely to adhere to a prolonged study.

Experienced golfers, male and female, older than 18 years old with an average score between 85 and 105 strokes were eligible to participate. Individuals of this skill level were included as they represent an above-average population of golfers, according to the National

Golf Foundation (Pennington, 2005). Interested individuals meeting the inclusion criteria were presented with an informed consent form (Appendix D) and educated on the purpose of the research, procedures involved, and potential benefits and risks of participating. Participants who agreed to participate in the study and signed the informed consent form were included in the analysis.

The target sample size for the proposed study was a minimum of seven participants. The maximum number of participants accepted for inclusion would have been 20. Similar research investigating improvements in imagery ability during a six-week intervention conducted by Wright et al., (2015), determined an effect size of 1.72 using Cohen's *d*. It is projected by Tran's (1997) estimation of sample size literature that seven participants are needed to achieve statistical power with an alpha level of 0.05 in a repeated-measures analysis of variance (ANOVA) statistical test. A range of 7-20 participants was targeted due to the possibility of an individual's baseline assessment as a high-ability imager and subsequent exclusion from the study.

Instrumentation

Demographic questions (Appendix E) to assess age, biological sex, average golf score, imagery experience, and additional variables were created by the researcher and answered by participants during their initial visit to the laboratory. The SIAQ (Appendix F) was designed to measure an athlete's ability to image different content frequently used in their sport. Participants were asked to image 15 different scenarios and subsequently rate the ease of imaging each item on a 7-point Likert type scale ranging from one (very hard) to seven (very easy). The SIAQ is a valid and reliable tool that may be scored either as a global measure of sport imagery ability or by five separate subscales of imagery ability: skill, strategy, goal, affect, or mastery (Cumming

& Williams, 2015). When compared with the Movement Imagery Questionnaire-3, an assessment of an individual's ability to image specific movements from an external-, internal-, and kinesthetic perspective, the SIAQ is a valid measure of imagery ability with bivariate correlations between .14 and .24 ($p < 0.05$) for each subscale. Additionally, the questionnaire demonstrated good internal reliability for all five subscales ranging from .78 to .86 ($p < 0.05$; Williams & Cumming, 2011).

Putting performance was conducted on a putting surface made from a proprietary aerated polymer material that is ½" thick and has been granted U.S. Patent 8,979,663. The putting surface was 6.1m long and 1.22m wide (BirdieBall Inc.). Consistent with previous research, the putting distance was 3.05m (Marshall & Wright, 2016; Quinton et al., 2016; Smith & Holmes, 2004) from a standard 10.8cm diameter hole.

Participants were instructed to use their own personal putter. This important variable is critical to the nature of the PETTLEP-model of administering imagery and maximizing functional equivalence (Smith & Holmes, 2004). Twenty-four Titleist Pro V1 golf balls, widely accepted as the best ball in the game of golf, were used for the duration of the study. A 72" box level (Empire E75.72) ensured that the putting surface was placed on a level indoor floor. The distance of missed putts from the hole was measured to the nearest quarter-inch from the edge of the ball to the edge of the cup with a Stanley PowerLock 12' Tape Measure. The distance of missed putts was later converted to centimeters for reporting purposes to remain consistent in the use of metric units. Additionally, participants were issued a standard diary to record the date and time they practiced their imagery script, strengths and weaknesses associated with the script, and any additional imagery or putting practice performed during the duration of the study. All instruments were secured with funding from a Research, Creative, and Scholarly Activities (RCSA) Grant from the University of Central Oklahoma.

Procedures

Following Institutional Review Board (IRB; Appendix A) approval, participants visited the laboratory and explained the nature of the experiment. During the initial visit, participants voluntarily signed an Informed Consent Form (Appendix C) and completed a demographics survey. Participants were educated on the purpose of the study (Williams et al., 2011) and screened for imagery ability by completing the SIAQ (Appendix D). Participants with an average score of less than five on the global measure of sport imagery ability scale, representing a “somewhat easy to image” response, were included in the study (Williams et al., 2013). Data of high-ability imagers will not be included in the analysis of the study, yet they were given the opportunity to partake in the imagery program.

During the initial visit to the laboratory, participants completed a golf-putting task. A familiarization period of three practice putts was granted to participants (Marshall & Wright, 2016; Williams et al., 2013) from a distance of 3.05m. Following the practice session, two methods to assess putting performance was used: total number of putts made (Marshall & Wright, 2016) and the distance (cm) of the nearest edge of the ball to the nearest edge of the hole with a higher score indicating worse performance (Quinton et al., 2016). Participants were assessed on 15 putts (Quinton et al., 2016; Smith & Holmes, 2004; Williams et al., 2013) in five blocks of three from the same distance (Marshall & Wright, 2016; Smith & Holmes, 2004).

Following pre-test assessment for imagery ability, participants were introduced to the imagery intervention. The researcher interviewed (Appendix G) each participant to form a personalized imagery program designed to maximize elements of the PETTLEP-approach to imagery. Following reception of the personalized imagery script, participants were instructed to practice their written script for 15 minutes a day, three times a week. The length of the script was dependent on the individual. Participants were asked to read through the script as many times as necessary to achieve 15 minutes of practice. Participants were instructed to not engage in imagery practice outside of the prescribed allotment. Participants were asked to record the amount of time spent practicing imagery during the course of the intervention.

Participants were instructed to meet with the researcher every week for six weeks to assess imagery ability and putting performance. Participants performed the same putting task conducted at baseline upon every visit for the duration of the experiment. The SIAQ was administered to participants during every visit between pre- and post-testing. Manipulation checks were conducted throughout the duration of the study during every visit to the testing center. Personal diaries were reviewed to determine if participants performed any additional putting practice about normal or imagery training other than the allotted 15 minutes, three times a week during the past week. Of particular interest to the researcher was if participants found their personalized imagery script helpful, or if components of the PETTLEP-model needed to be adjusted. Each visit to the testing center with the researcher took the participant between 20 and 30 minutes.

All participants were assessed on putting performance and imagery ability during the seventh week of the study. Upon conclusion of the study, participants were thanked for their time and their personal diaries were collected.

Upon approval of Student Transformative Learning Record (STLR) funding, an undergraduate research assistant (RA) was hired to assist in the aforementioned procedures. The RA was trained to administer the SIAQ, assess putting performance, and review personal diaries.

Additionally, the RA assisted in organizational matters concerning the scheduling of participants to the laboratory for weekly testing. Throughout the course of the intervention, the RA collected data from a predetermined group of participants in an effort to maximize intra-rater reliability. The primary researcher and RA collected data in a consistent matter throughout the course of the study from their assigned participants. The primary researcher was solely responsible for adjusting imagery scripts, when needed, to maximize effectiveness of the imagery intervention based on weekly responses from participants.

Design and Analysis

The null hypothesis stated that there would not be significant improvements in imagery ability during the course of the intervention. The researcher used instructions obtained from the authors to determine the global measure of sport imagery ability from responses to the SIAQ (Appendix D) at baseline and subsequent time points. Statistical tests of descriptive analysis and a one-way repeated-measures ANOVA were conducted using IBM SPSS Statistics Version 24.0. Results of the one-way repeated-measures ANOVA were obtained to compare the means of imagery ability based on repeated observations. In the case of significance, a dependent t-test with a Bonferroni correction was conducted to precisely determine when significant improvements in ability occur over time. Additionally, although not included in the primary research question, the results of putting performance, based on the number of successfully made putts and the average distance of missed putts from the hole, were analyzed using a one-way repeated measures ANOVA. A Pearson correlation coefficient was conducted to analyze if a relationship existed between imagery ability and putting performance at each weekly time point. This analysis was conducted to confirm if an improvement in imagery ability results in enhanced physical performance as indicated in previous literature.

Results

Demographic Data

Upon IRB approval (Appendix A), participants (N = 14) were recruited from participating golf courses. During their initial visit to the laboratory, participants voluntarily signed an Informed Consent Form (Appendix D) and were asked to complete a demographics questionnaire (Appendix E). Responses are displayed in Table H1. Two participants were female (14.3%) and 12 were male (85.7%). One participant was between the ages of 45 and 54 (7.1%), two participants were between the ages of 55 and 64 (14.3%), and the remaining 11 reported an age of greater than 65 (78.6%). Eight participants reported earning a bachelor's degree (57.1%), four earned a graduate or professional degree (28.6%), and two reported completing some college classes without obtaining a degree (14.3%). Additionally, participants reported their annual household income before taxes (7.1% between $25,000-$49,999, 7.1% between $50,000-$74,999, 21.4% between $75,000-$99,999, 21.4% between $100,000-$124,999, and 28.6% greater than $150,000). Two participants (14.3%) elected not to disclose their annual pre-tax household income.

Of particular interest to the primary researcher was the participants' golf experience. Two participants reported playing golf between one and three years (14.3%). One participant responded that they have been playing golf between four and six years (7.1%) and the remaining participants (*n* = 11, 78.6%) indicated that they have been playing golf for greater than ten years. Participants were also asked how many rounds of golf they typically play a year. Two participants reported playing between ten and 19 rounds (14.3%), one reported an average of 20 to 29 rounds (7.1%), four reported between 30 and 39 rounds (28.6%), one reported an average of 40 to 49 rounds (7.1%), and six participants identified that they play an average of greater than 50 rounds of golf per year (42.9%). Participants were asked to identify how many minutes per week they spend practicing golf. Ten participants reported spending between zero and 29 minutes per week (71.4%), three participants practice golf between 30 and 59 minutes (21.4%), and one reported an average between 60 and 119 minutes of practice each week (7.1%).

Participants were required to have an average golf score per round between 85 and 105 strokes on a par-72 golf course. All 14 participants reported an average golf score ($\bar{x} = 90.75 \pm 4.13$) within the acceptable range. An additional requirement for inclusion in the study was to never have participated in an imagery program as a performance enhancing technique in the past. All participants ($n = 14$) reported never having practiced imagery before and were further progressed.

Baseline

Following completion of the demographic questionnaire, participants were asked to perform a putting assessment consisting of three practice putts followed by 15 putts that were recorded as either successfully made or a missed putts distance (cm) from the hole. Participants ranged from making zero to 11 putts with an average of 5.21 (± 2.97) putts successfully made. The average distance of a missed putt from the hole was 27.61 (± 11.31).

During the initial visit to the laboratory, participants completed the Sport Imagery Ability Questionnaire (SIAQ; Appendix F) to determine their baseline ability to create and control vivid images with ease. The average score of participants' imagery ability at baseline ($\bar{x} = 4.26 \pm .71$) was calculated by the global measure scale and indicated a collective "neutral" to "somewhat easy" ability to image. Two (21.4%) participants were classified with a high ability to image, indicated by an initial SIAQ score greater than 5.00, and will subsequently be excluded from the following data. The average imagery ability at baseline of participants that were included in the study was 4.04 (± .13).

Two Pearson correlation statistical tests were conducted to examine the correlation between SIAQ score and putting performance. At baseline, imagery ability was found to have a weak relationship that was not significant with putting performance assessed by number of made putts, $r(10) = .226$, $p > .05$, and by the distance of a missed putt from the hole, $r(10) = .245$, $p > .05$.

Imagery Ability

The primary purpose of this study was to determine an appropriate duration of an imagery intervention to improve the ability of generating images. A descriptive statistical test to analyze scores of the SIAQ, as an indicator of imagery ability, was conducted. As seen in Table H2, the participants ($n = 12$) mean imagery ability was greater at the conclusion of the study ($\bar{x} = 5.38 \pm .91$) than at the baseline assessment ($\bar{x} = 4.04 \pm .455$), suggesting an overall improvement in the ability to create and control vivid images with ease.

The researcher hypothesized (H_1) that the ease of producing images will significantly improve during the course of the intervention. The researcher stated a null hypothesis (H_0) that imagery ability would not improve during the intervention. A level of significance ($a = .05$) was set that is consistent with social science standards. A one-way repeated-measures ANOVA statistical test was calculated comparing the SIAQ scores of participants at seven different times; baseline, week one, week two, week three, week four, week five, and week six. A significant effect was found, $F(6, 66) = 18.17$, $p < .001$. Follow-up dependent *t* tests with a Bonferroni correction ($a = .008$) were conducted to determine precisely when significant improvements in imagery ability occurred. The statistical test revealed that scores increased significantly from baseline ($\bar{x}$ = 4.04 ± .45) to week 1 ($\bar{x}$ = 4.53 ± .58), $t(11) = -3.38$, $p = .006$, and again from week 2 ($\bar{x}$ = 4.74 ± .87) to week 3 ($\bar{x}$ = 5.11 ± .77), $t(11) = -3.61$, $p = .004$. Results of the dependent *t* tests are displayed in Table H3. As seen in Figure I1, imagery ability improved during the course of the intervention, with significant improvements occurring following the first and third week of practicing imagery. The researcher rejected the null hypothesis. During the statistically significant time points, imagery ability improved 12% and 7.8% from baseline to week one and week two to week three, respectively. Despite a lack of significance, imagery ability improved from week one to week two (4.6%), week four to week five (3.0%), and week five to week six (4.5%). Although not significant, imagery ability peaked at the post-test assessment ($\bar{x}$ = 5.38 ± .91).

Putting Performance

Previous research has suggested that practicing imagery can have significant improvements on a physical skill. Therefore, a secondary purpose of the study was to determine if putting performance improved during the course of an imagery intervention, despite the absence of additional putting practice. The researcher analyzed descriptive statistics and two independent one-way repeated-measures ANOVA statistical tests to determine if improvements in putting performance, measured by successfully made putts and average distance of missed putts from the hole, improved.

Made Putts

A descriptive statistical test was conducted to analyze if putting performance, measured by successfully made putts, improved during the course of the intervention. At baseline, participants averaged 5.42 (± 3.18) successfully made putts, the lowest amount during the course of the study. Participants averaged 7.25 (± 3.22) successfully made putts during the final week of the intervention. As seen in Table H4, successfully made putts by participants reached a peak during the fourth week of the program ($\bar{x}$ = 7.67 ± 2.54).

A trend of improved putting performance is evident in Figure I2; however, a one-way repeated-measures ANOVA to compare the number of successfully made putts at seven different times did not yield a significant effect, $F(6,66) = .959$, $p > .05$. No significant difference in number of putts made, as an indicator for putting performance, exists among the means of the different time points.

Missed Putts

Putting performance was also assessed by the average distance of a missed putt to the hole, in centimeters. A descriptive statistical test was conducted to analyze if the average distance of missed putts improved during the course of the intervention, indicated by a lower value. At baseline, participants averaged a miss of 28.57 (± 11.9) centimeters from the hole; the lowest amount during the course of the study, indicating the greatest performance. Participants averaged a miss of 33.55 (± 14.27) centimeters from the hole during the final week of the intervention. As seen in Table H5, putting performance, measured by the average distance of missed putts, was at its worse during the third week of the program ($\bar{x}$ = 42.28 ± 11.57).

A one-way repeated-measures ANOVA to compare the average distance of missed putts at seven different times did not yield a significant effect, $F(6,66) = 2.08$, $p > .05$. No significant difference in the average distance of missed putts, as an indicator for putting performance, exists among the means of the different time points. Figure I2 represents the means of the distance from the hole of missed putts, as well as, the association between successfully made putts and the average distance of missed putts to the hole.

A Pearson correlation coefficient was calculated for the relationship between participants' total number of successfully made putts and average distance of missed putts from the hole. A significant, moderate, positive correlation was found at baseline, $r(10) = .660$, $p < .05$, and week four, $r(10) = .598$, $p < .05$, of the study. A non-significant, weak, positive correlation was found at week one, $r(10) = .222$, $p > .05$, and week two, $r(10) = .219$, $p > .05$. A non-significant, weak, negative correlation was found at week three, $r(10) = -.177$, $p > .05$. A non-significant, moderate, positive correlation was found at week five, $r(10) = .488$, $p > .05$. A non-significant, moderate, negative correlation was found at week six, $r(10) = -.355$, $p > .05$. The association between the two variables of putting performance is displayed in Table H6 and Figure I2.

Imagery Ability and Putting Performance

Although not a primary research question, the researcher sought to understand if a relationship existed between imagery ability and putting performance. Multiple Pearson correlation coefficients were conducted for each weekly time point to analyze if an association exists.

A Pearson correlation was calculated examining the relationship between participants' imagery ability and putting performance. A weak correlation that was not significant was found for imagery ability and successfully made putts, $r(10) = .226$, $p > .05$, and for imagery ability and average distance of missed putts, $r(10) = .245$, $p > .05$, at the baseline visit. Imagery ability was not related to putting performance at the baseline visit. At the week one visit to the laboratory, a weak correlation that was not significant was found, $r(10) = .061$, $p > .05$, for imagery ability and successfully made putts. Furthermore, a weak negative correlation that was not significant was found, $r(10) = -.246$, $p > .05$, for imagery ability and average distance of missed putts during the same week. A weak correlation that was not significant was found, $r(10) = .067$, $p > .05$, for imagery ability and successfully made putts at week two. A moderate correlation that was not significant was found, $r(10) = .350$, $p > .05$, for imagery ability and average distance of missed putts at the same time point. Following the third week of the intervention, a weak negative, insignificant, correlation was found, $r(10) = -.253$, $p > .05$, between imagery ability and successfully made putts. Additionally, a weak correlation that was not significant was found, $r(10) = .234$, $p > .05$, between imagery ability and average distance from the hole of missed putts. The relationship between imagery ability and total number of made putts during the fourth week of the study was weak and not significant, $r(10) = .190$, $p > .05$. The association between imagery ability and distance to the hole of missed putts was moderate and insignificant, $r(10) = .343$, $p > .05$, at the same time point. A weak correlation that was not significant was found, $r(10) = .265$, $p > .05$, for imagery ability and successfully made putts during the fifth week. Additionally, a moderate correlation that was not significant was found, $r(10) = .383$, $p > .05$, for imagery ability and average distance of missed putts at the same time point. A moderate correlation that was not significant was found, $r(10) = .322$, $p > .05$, for imagery ability and successfully made putts following six weeks of practicing imagery. Additionally, a weak negative correlation that was not significant was found, $r(10) = -.142$, $p > .05$, for imagery ability and average distance of missed putts at the same time point. As seen in Table H6, there was not a significant relationship between imagery ability and either measure of putting performance at any of the seven time points; baseline, week one, week two, week three, week four, week five, week six, or week seven.

Changes from baseline to post-test in imagery ability and the two measures of putting performance were computed by subtracting the absolute value of the baseline assessment from the absolute value of the post-test assessment for each participant. A positive change in imagery ability and successfully made putts indicated improved performance. Whereas, a negative change in the average distance of missed putts represented an improvement in putting skill. As seen in Table H7, all of the participants (100%) improved their imagery ability from baseline to the conclusion of the intervention. Seven participants (58%) improved their putting performance, as measured by successfully made putts, between the first and final attempt. Conversely, five participants (42%) improved their average distance of missed putts from the hole as determined by the change in value from the final week of the study compared to the baseline visit. A moderate, not significant, relationship was found between the changes of imagery ability and successfully made putts, $r(10) = .520$, $p > .05$, as seen in Figure I3. A weak, negative relationship found to be not significant between imagery ability and the average distance of missed putts, $r(10) = -.033$, $p > .05$, from the hole existed, as seen in Figure I4. A weak, not significant, relationship between successfully made putts and the average distance of missed putts from the hole, $r(10) = .065$, $p > .05$, was found, as seen in Figure I5. The preceding relationships are displayed in Table H8.

Additionally, it should be noted that all participants (100%) reported full compliance to the requests of the researcher. In the provided diaries, all participants recorded that they practiced imagery three times a week for fifteen minutes each time for the duration of the study. Participants reported that they did not practice any additional mental skills performance enhancing techniques or practice any putting above weekly norms. All participants completed the intervention with full compliance and adherence.

Discussion

Participants (N = 14) were recruited to complete an imagery intervention to determine a timeframe of peak imagery ability. Participating individuals reported an average golf score between 85 and 105 strokes on an 18-hole, par-72 golf course. All participants stated that they had never formally practiced imagery as a performance enhancing technique. Although all individuals have the ability to image, the level of which images are produced vividly with ease varies between people (Cumming & Williams, 2012). Additionally, the efficacy of an imagery intervention is significantly increased for individuals with a higher ability to image (Williams & Cumming, 2011). Therefore, in an effort to be consistent with previous literature and eliminate a potential ceiling effect (Williams et al., 2013), two participants were deemed to have a high ability to image at baseline and were excluded from the study. The included participants of the study (n = 12) displayed a collective "somewhat hard" to "neutral" ability to image indicated by a mean SIAQ score of 4.04 (± .13) at baseline.

Imagery Ability

The primary purpose of the study was to determine an appropriate duration of an intervention to improve the ability of generating images. Imagery ability, as proposed by Martin et al. (1999), is the key cog in the relationship between imagery use and imagery outcome. Average scores of imagery ability improved throughout the course of the intervention, with improvements occurring at all time points except from week three to four. As evident by investigating changes from baseline to post-test, 100% (n = 12) of participants improved their ability to create and control vivid images with ease. The results of a one-way repeated-measures ANOVA statistical test and follow-up dependent t tests with a Bonferroni correction indicate that significant improvements in the ability to create and control vivid images with ease occurred during the first and third week of practice. The results of the current study support the findings of previous research indicating that imagery can be generated with greater ease and vividness by participating in an intervention (Anuar et al., 2016; Fery, 2003; Goss et al., 1986; Hammond et al., 2012; Marshall & Wright, 2016; Williams et al., 2013; Wright et al., 2015).

Despite the findings of significant improvements in imagery ability, the mean SIAQ scores displayed in Table H2 suggest that imagery ability may not have obtained a peak. This is evident by an average SIAQ score ($\bar{x} = 5.38 \pm .91$) observed during the final week of the study; the greatest reported value of imagery ability among the seven time points. Although not statistically significant, imagery ability continued to increase through the conclusion of the study. The average SIAQ score for the sample size increased 0.23 points (4.5%) during the final week of imagery practice. A plateau in imagery ability would more confidently indicate a time frame to acquire peak skill; however, a leveling off is not observed in the results of the current study. Further research with a longer intervention timeframe is needed to determine if imagery ability continues to improve after six weeks.

Putting Performance

While imagery ability is a trainable skill, it is more useful if it improves actual performance. A successful golfer relies as much on mental skill as physical skill. Imagery, as an easily applicable and beneficial mental skills technique, may bridge that gap and be a means to improving golf performance. A secondary purpose of the study was to determine if putting performance, despite the absence of additional physical practice, improved during the course of an imagery intervention.

As expected, the average amount of successfully made putts, as an indicator of putting performance, was lowest at the time of the participants' initial visit to the laboratory. This may be a result of the absence of the implementation of an imagery intervention and/or the lack of familiarization with the putting surface. The collective average of successfully made putts peaked during the fourth week of the study. Despite the lack of statistically significant improvements in successfully made putts, there is a clear trend of performance improvement, as observed by analyzing the means in Table H4 and line graph in Figure I2. Investigating changes from baseline to post-test showed 58% (n = 7) of participants improved their ability to make putts.

Conversely, putting performance, measured by the average distance of missed putts, did not improve from baseline to post-test. The average distance of missed putts, indicated by a lower measurement from the ball to the hole, was smallest during the baseline visit. At the time that performance measured by made putts was at its worst, performance measured by missed putts was at its best. Furthermore, the average distance of missed putts from the hole continued to increase, indicating poorer performance, until week four. However, from week four through the end of the intervention, the average distance of missed putts from the hole decreased in value, indicating improvement in performance. Although not statistically significant, these results are seen in Table H5 and Figure I2. By evaluating changes from baseline to post-test, an improvement in the distance of missed putts was observed in 42% (n = 5) of participants.

Interestingly, a lack of a relationship exists between the two measures of putting performance. It may be assumed that as an individual successfully makes more putts, the distance from the hole of a missed putt would decrease. This assumption is not supported by the current study and may be due to a number of factors. One factor may be that the average distance of missed putts from the hole is highly intertwined with the number of successfully made putts. As a participant improves their ability to make putts, the number of missed putts decreases resulting in a smaller sample size. Further research assigning a value of '0' to successfully made putts would need to be conducted to determine if the average distance of all putt attempts decreased from their distance to the hole.

Imagery Ability and Putting Performance

In contrast to previous research that suggests imagers experience greater performance improvements with imagery training (Goss et al., 1986), the current study did not yield any significant relationship between imagery ability and either measure of putting performance at any of the seven time points. Despite all participants improving their ability to image, there is no evidence suggesting a relationship in the changes from baseline to post-test between imagery ability and made putts, imagery ability and missed putts, and made and missed putts; as seen in Figure I3, I4, and I5, respectively.

Despite previous research that concluded practicing imagery significantly improved physical performance (Ashbrook et al., 2018; Bernier & Fournier, 2010; Driskell et al., 1994; Fery, 2003; Marshall & Wright, 2016; Quinton et al., 2016; Smith & Holmes, 2004; Smith et al., 2007; Smith et al., 2008; Taylor & Shaw, 2002; Williams et al., 2013), the current study did not find significant results that support this theory. Although a statistically significant association between imagery ability and successfully made putts fails to exist, it may be due to properties of improvements in imagery. The data showed that significant improvement in imagery ability peaks at week three. Interestingly, putting performance, measured by successfully made putts, peaks just one week later, at week four. By investigating the means of imagery ability and successfully made putts, it is observed that the only decrease in mean imagery ability occurred from week three to week four. If there is a delay in the performance enhancing effects of imagery practice on physical skill, it would reason that a decrease in successfully made putts would be seen one week later; week four to week five. The results support this hypothesis; mean putting performance measured by successfully made putts decreases from week four to week five. Further research is needed to determine if the performance enhancing effects of imagery practice are delayed in the outcome of physical skills.

Although not statistically significant, there is evidence that imagery ability had simultaneous positive and negative effects of ability to successfully make putts and average distance of missed putts, respectively. As previously explained, a possible reason for a lack in relationship between the two putting performance measures, is that as a participant improves their ability to make putts, the number of missed putts decreases, resulting in a smaller sample size. This reasoning also applies to the association of imagery ability and the average distance of missed putts from the hole. Additionally, participants anecdotally expressed that their self-confidence in putting performance improved. As a result, they may have stroked the ball with more force, resulting in a greater distance the ball traveled past the hole. An additional reason for a lack of a relationship between the imagery ability and the average distance of missed putts from the hole may be the imagery script itself. The personalized imagery scripts were distinctly designed to image successfully made putts. However, it is common in golf to have an outcome goal of missing putts near the hole in an attempt to set up an easier follow-up shot. This is common for golfers with a low level of confidence in their ability to make a given putt. It is conceivable that results may have been different if the content of the imagery script was designed for this outcome goal in mind (Taylor & Shaw, 2002).

As previously stated, the game of golf generates approximately $5.5 billion in annual revenue on golf equipment and apparel; a vast amount presumably to improve performance (The National Golf Foundation, 2018). The performance enhancing technique of imagery is free and widely available. Imagery training is very generalizable to the many skills required in golf, such as a tee-shot, approach-shot, and putt. Additionally, all participants, independent of skill-level or age, may obtain improved performance from imagery practice; however, further research is needed to understand the effects of imagery training on the outcome of physical skills.

Limitations

Although the current study was successful in rejecting the null hypothesis and finding significant improvements in imagery ability, some limitations do exist that are consistent with previous literature. The current study demonstrated strength in delivering a personalized script for each participant (Smith et al., 2008) that implemented the PETTLEP-based approach to imagery (Smith et al., 2007); however, the use of a written script, as opposed to an audio recording, visual observation, or layered stimulus response training, does not maximize the timing component of the PETTLEP-model. Smith and Holmes (2004) suggested that improvements in performance were not evident in a written imagery script modality due to the lack of a timing component. Consistent with previous literature investigating imagery ability, the current study is limited by the use of self-reported data (Anuar et al., 2016; Williams et al., 2013) despite incorporating manipulation checks in an effort to mitigate this weakness (Smith & Holmes, 2004; Smith et al., 2008). Participants were instructed to report time spent practicing imagery, additional mental performance enhancing techniques used, and putting practice above weekly norms. All participants reported full compliance; practicing imagery as requested fifteen minutes for three times each week, and nothing greater. Additionally, participants reported an avoidance of any additional putting practice above their normal routine. An additional limitation to the current study is the measuring tool used to assess imagery. Despite the SIAQ being a reliable and valid measure to assess sport-specific imagery ability, a limitation is its inability to identify between ease and vividness, two vital components of the ability to image (Williams & Cumming, 2011). Furthermore, the present research is limited by performing the putting task in a lab setting on an artificial surface (Smith & Holmes, 2004). Although necessary to improve internal validity, performing the task on an indoor imitated green limits external validity and the practicality of repeating the task outdoors on a real golf course. Additionally, assessing performance on an artificial putting surface limits the distance that significantly missed putts roll past the hole. As suggested by previous literature (Williams et al., 2013), putts that contacted the back border of the putting green were subsequently eliminated from the data.

Future Research

As previously suggested, future research is needed to better understand an appropriate timeframe needed for an imagery intervention to maximize imagery ability. The results of the current study suggest that imagery ability was still peaking at the conclusion of the final week. A study with a longer duration and multiple assessments of imagery ability throughout a week is needed. Although the researcher did not require how imagery was practiced, full compliance and adherence to the procedures by all participants throughout the course of the intervention supports the current studies internal validity. Future research with observed imagery training may enhance the efficacy of an imagery intervention by facilitating an environment conducive to maximizing the elements of the PETTLEP-approach. Further investigation into the relationship between the two measures of putting performance is needed to understand how imagery affects physical performance of a putting task. As suggested, assigning a value of ‘0’ to successfully made putts would allow further research to potentially determine if the average distance of all putt attempts decreased in their distance to the hole. The current study proposes the hypothesis that the performance enhancing effects of imagery practice are delayed in the outcome of physical skills. Future study is needed to explore this further. A significant limitation of the current study was the use of a written script as the delivery method for imagery. The appropriate duration of an intervention may differ depending on the method the sport psychologist delivers imagery to the athlete. Further research is needed to understand an appropriate timeframe for each delivery system. Additionally, proceeding studies should incorporate more participant groups. Similar to the study conducted by Smith et al. (2008), future research with an imagery only group, physical practice group, physical practice and imagery group, and control group would allow for data analysis to differentiate between effects of physical practice and imagery on outcomes of imagery ability and skill performance. Supplementing physical practice with an imagery intervention is beneficial to maximizing performance (Marshall & Wright, 2016) and should be included in all further research.

Conclusion

The present data suggests evidence that sport psychologists should continue to incorporate imagery into an athlete's mental-skills training plan. A successful imagery intervention should be personalized to the athlete's goals and maximize functional equivalence by including as many elements of the PETTLEP-model as possible. The current research aimed to determine a time frame that imagery ability peaked during an intervention. This knowledge is essential for the field of sports psychology to facilitate practitioners in suggesting an appropriate duration of an imagery program. While considering the immense time constraints athletes typically have to devote to mental-skills training, the results of the current study suggest a three-week imagery intervention to reach optimal imagery performance.

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Appendix A

Institutional Review Board (IRB) Approval

UNIVERSITY OF Central Oklahoma

November 26, 2019 IRB Application #: 2019-153

Proposal Title: The Effects of an Imagery Intervention on Imagery Ability

Type of Review: Initial Review-Expedited

Investigator(s):

Alexander

London
Melissa Powers, Ph.D.

Dear Mr. London and Dr. Powers:

Re: Application for IRB Review of Research Involving Human Subjects

We have received your materials for your application. The UCO IRB has determined that the above named application is APPROVED BY EXPEDITED REVIEW. The Board has provided expedited review under 45 CFR
46.110, for research involving no more that minimal risk and research Category

7. Date of Approval: November 26, 2019

If applicable, informed consent (and HIPAA authorization) must be obtained from subjects or their legally authorized representatives and documented prior to research involvement. A stamped, approved copy of the informed consent form will be made available to you. The IRB-approved consent form and process must be used, where applicable. Any modification to the procedures and/or consent form must be approved prior to incorporation into the study. At the completion of the study, please submit a closure request form to close your file.

It is the responsibility of the investigators to promptly report to the IRB any serious or unexpected adverse events or unanticipated problems that may be a risk to the subjects.

Please let us know if the IRB or Office of Research Integrity and Compliance can be of any further assistance to your research efforts. Never hesitate to contact us.

Sincerely,

Jaime L. Burns

Jaime Burns, Ph.D.
Assistant Chair, Institutional Review Board

Appendix B

Permission to Recruit

Permission to Recruit for UCO Thesis

Alexander London <alondon3@uco.edu> 11:54 AM (0 minutes ago)
to skimmel, jsandell

Good Morning Mr. Kimmel and Mr. Sandell,

My name is Alex London and I am a UCO graduate student pursuing a M.S. degree in Exercise Science. I am in the process of researching the effect of an imagery intervention on golf-putting performance for my thesis. With your permission, I would like to recruit participants for my study. I believe that members of your country club would benefit greatly from participating in the study by being introduced to imagery as a performance enhancing technique.

I look forward to hearing from you and would love to have further discussion in greater detail.

Thank you,

Alex London

Graduate Teaching Assistant, Kinesiology & Health Studies
M.S. in Exercise Science Candidate
University of Central Oklahoma
(781)264-2451

Permission from Rose Creek Golf Club:

rprice@tour18inc.com 1:02 PM (41 minutes ago)
to me

Alex,

Feel free to use our golfers, and our facilities. If we can do anything, please let us know.

Ron Price

405.330.8220

Permission from KickingBird Golf Club:

Brian Soerensen <Brian.Soerensen@edmondok.com> Sat, Apr 27, 12:49 PM
to me

Yes that would be fine we would just need to set up a day and time for you to come out and recruit.

Brian Soerensen
Head Golf Professional
KickingBird Golf Club
405-341-5350

STAY CONNECTED:

Oral permission granted from Aaron Kristopeit, PGA Professional, at Lincoln Park Golf Course.

Appendix C

Recruitment Flyer

Free Imagery Training for Golfers

An IRB Approved Research Study

Recruiting

-Graduate student study exploring changes in imagery ability and putting performance in response to imagery training

-Golfers older than 18 years old with an average score between 85 and 105

Participation

-Complementary six-week personalized imagery program

-Weekly visits with research team to analyze imagery ability and putting performance

Benefits for Participating

-Introduction to imagery training for the purpose of optimizing performance

-Ability to use mental skills technique to maximize performance in other aspects of golf, sport, and life

For more information or to enroll contact:

Alex London
alondon3@uco.edu
(781) 264-2451

DEPARTMENT OF
Kinesiology and Health Studies

Appendix D

Informed Consent Form

UNIVERSITY OF CENTRAL OKLAHOMA

INFORMED CONSENT FORM

Research Project Title: The Effects of an Imagery Intervention on Imagery Ability and Putting Performance

Researcher (s): Alex London, Primary Investigator

A. Purpose of this Research: The purpose of this study is to determine an appropriate duration of an imagery intervention to improve the ability of generating images.

B. Procedures Involved: Upon voluntarily signing the Informed Consent Form, you will be asked to complete a putting performance task and imagery ability survey. Imagery ability will be measured by completing the Sport Imagery Ability Questionnaire (SIAQ). If you have a high score on this survey, you may not be able to participate in the study. Your putting performance will be assessed from 15 putts as the number of putts successfully made and the distance of missed putts from the hole. You can use your own putter for this test. We will also ask you about your age, biological sex, golf performance, and imagery experience. Then you will be individually interviewed to personalize your imagery training script. You will be asked to train using this script 3 times per week for 15 minutes over the next 6 weeks. During this time, we will ask you to keep a journal of your training. Each week, we will ask you to return to the lab and complete the imagery survey and putting performance task. At this meeting, we will also review your journal and discuss it with you. At the end of six weeks, you will complete the imagery survey and the putting performance task one more time. We will collect your journal at this time.

C. Expected Length of Participation: The expected length of participation is six weeks. You will be expected to individually practice imagery for 15 minutes, three times a week.

You are also expected to meet with the researcher once a week, every week, for approximately 20-30 minutes.

D. Potential Benefits: By engaging in the study, you will be introduced to an imagery intervention for the purpose of improving athletic performance. Following participation in the study, you will be able to practice imagery on your own to enhance aspects of golfing performance. Additionally, the research will aim to contribute further knowledge to the field of sport psychology by establishing a time frame that imagery ability improves during an intervention.

E. Potential Risks or Discomforts: There is no more than the assumed, minimal risk of putting to physical and/or mental harm by participating in the study.

F. Contact Information for Researchers:

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G. Contact Information for UCO IRB:

Office of Research Compliance, Academic Affairs
UCO-IRB Office
100 N University Dr. NUC 341, Box 132
Edmond, OK 73034
(405) 974-5497
(405) 974-3818 (fax)

H. Explanation of Confidentiality and Privacy: Your data will be kept confidential and completely private. The Informed Consent Forms and the master code sheet with participant's names will be kept in a locked file cabinet in a locked closet separate from the printed data. After data collection is completed, the master code sheet will be shredded to prevent any breach in confidentiality or privacy. The Informed Consent Forms will be kept in the secure location for three years to comply with federal regulations. Electronic data will be de-identified by coding participants and securely stored on the primary researcher's personal and protected computer.

I. Assurance of Voluntary Participation: Your participation is voluntary and you may withdraw from the study at any time without penalty. If you withdraw, your data will not be included in the study.

Affirmation by Research Participant:

I hereby voluntarily agree to participate in the above listed research project and further understand the above listed explanations and descriptions of the research project. I also understand that there is no penalty for refusal to participate, and that I am free to withdraw my consent and participation in this project at any time without penalty. I acknowledge that I am at least 18 years old. I have read and fully understand this Informed Consent Form. I sign it freely and voluntarily. I acknowledge that a copy of this Informed Consent Form is available upon request for me to keep.

Participant's Printed Name: __________________________________

Signature: _________________________________ Date: ______________

Appendix E

Demographics Questionnaire

The Effects of an Imagery Intervention on Imagery Ability

Demographics Questionnaire

Please circle your gender.

Male

Female

Please circle the category that includes your age.

Under 18

18-24

25-34

35-44

45-54

55-64

65 or Above

Please identify your education level.

Some High School

High School Graduate or Equivalent

Some College

Associate Degree

Bachelor Degree

Graduate or Professional Degree

Prefer Not to Answer

What best describes your total yearly household income before taxes?

Less than $25,000

$25,000-$49,999

$50,000-$74,999

$75,000-$99,999

$100,000-$124,999

$125,000-$150,000

$150,000 or Greater

Prefer Not to Answer

Please indicate how long you have been playing golf.

Less than 1 year

1-3 years

4-6 years

7-9 years

10 years or Greater

How many rounds of golf do you play each year?

Less than 10	30-39
10-19	40-49
20-29	50 or More

How many minutes do you spend practicing golf per week?

0-29	60-119
30-59	120 or More

Please indicate your average 18-hole golf score on a par-72 course.

____

What is your United States Golf Association handicap?

Less than 0.0	20.0-24.9
0.0-4.9	25.0-29.9
5.0-9.9	30.0 or Greater
10.0-14.9	Unknown
15.0-19.9	

Have you ever formally practiced imagery as a performance enhancing technique?

Yes	No

If yes, please explain.

____

____

____

Appendix F

Sport Imagery Ability Questionnaire (SIAQ)

Sport Imagery Ability Questionnaire

Instructions:
The purpose of this questionnaire is to obtain information about your ability to generate a number of images athletes use in relation to their sport.

For each item, bring the image to your mind with your eyes CLOSED. Then rate how easy it is for you to form this image (1 = very hard, 4 = not easy or hard to 7 = very easy). Circle the appropriate rating based on the scale provided. For example, some athletes may find imaging themselves kicking a football neither easy nor hard and therefore select 4.

Please be as accurate as possible and take as long as you feel necessary to arrive at the proper ratings for each image. There are no right or wrong answers, because we are simply interested in your response.

In relation to my sport, how easy is it for me to image…	**Very hard to image**	**Hard to image**	**Somewhat hard to image**	**Neutral (not easy or hard)**	**Somewhat easy to image**	**Easy to image**	**Very easy to image**
1. Making up new plans/strategies in my head	1	2	3	4	5	6	7
2. Giving 100% effort even when things are not going well	1	2	3	4	5	6	7
3. Refining a particular skill	1	2	3	4	5	6	7
4. The positive emotions I feel while doing my sport	1	2	3	4	5	6	7
5. Myself winning a medal	1	2	3	4	5	6	7
6. Alternative plans/strategies	1	2	3	4	5	6	7
7. The anticipation and excitement associated with my sport	1	2	3	4	5	6	7
8. Improving a particular skill	1	2	3	4	5	6	7
9. Being interviewed as a champion	1	2	3	4	5	6	7
10. Staying positive after a setback.	1	2	3	4	5	6	7
11. The excitement associated with performing	1	2	3	4	5	6	7
12. Making corrections to physical skills	1	2	3	4	5	6	7
13. Creating a new event/game plan	1	2	3	4	5	6	7
14. Myself winning	1	2	3	4	5	6	7
15. Remaining confident in a difficult situation	1	2	3	4	5	6	7

Appendix G

Personalized Imagery Script Interview

PERSONALIZED IMAGERY SCRIPT INTERVIEW

Do you putt with a golf glove on your hand? If so, what hand?

Are you a right- or left-handed putter?

In detail, describe your pre-putt routine.

What is your objective when attempting a ten-foot putt? Make the putt? Leave it close to the hole?

What emotions do you experience when attempting a ten-foot putt? (i.e. nervous, excited, confident, pessimistic, etc.)

Is there any other content that you think may be important to include in an imagery script?

Appendix H

Tables

Table 1

Demographic Statistics

Factor	Response	*n*
Biological Sex		
	Male	12
	Female	2
Age		
	Under 18	0
	18-24	0
	25-34	0
	35-44	0
	45-54	1
	55-64	2
	65 or Above	11
Education Level		
	Some High School	0
	High School Graduate or Equivalent	0
	Some College	2
	Associate Degree	0
	Bachelor Degree	8
	Graduate or Professional Degree	4
	Prefer Not to Answer	0
Income		
	Less than $25,000	0
	$25,000-$49,999	1
	$50,000-$74,999	3
	$75,000-$99,999	1
	$100,000-$124,999	3
	$125,000-$150,000	0
	$150,000 or Greater	4
	Prefer Not to Answer	2
Golf Experience		
	Less than 1 Year	0
	1-3 Years	2
	4-6 Years	1
	7-9 Years	0
	10 Years or Greater	11
Rounds of Golf		
	Less than 10	0
	10-19 Rounds	2
	20-29 Rounds	1
	30-39 Rounds	4
	40-49 Rounds	1
	50 or More Rounds	6
Golf Practice		
	0-29 Minutes	10
	30-59 Minutes	3

	60-119 Minutes	1
	120 or More Minutes	0
Golf Score		
	Minimum	85.00
	Maximum	95.00
	Mean	90.75
	Standard Deviation	4.13
Imagery Experience		
	Yes	0
	No	14

Note. N = 14. Age reported in chronological years lived. Education level is a representative of the highest level of education achieved. Income is a total yearly household income before taxes. Golf experience is the number of years playing golf. Rounds of golf are the number of rounds of golf played per year. Golf practice is the amount of minutes spent practicing golf per week. Golf score is an average, self-reported, 18-hole golf score on a par-72 course. Responses to imagery experience indicate if a participant has ever formally practiced imagery as a performance enhancing technique.

Table 2

Descriptive Statistics of Imagery Ability

	Minimum	Maximum	Mean	Standard Deviation
Baseline	3.40	4.73	4.04	0.45
Week 1	3.60	5.46	4.53	0.58
Week 2	3.30	6.00	4.74	0.87
Week 3	3.80	6.46	5.11	0.77
Week 4	3.40	6.67	5.00	1.00
Week 5	4.00	6.80	5.15	0.95
Week 6	4.20	7.00	5.38	0.90

Note. The SIAQ measures imagery ability on a scale of one to seven with a higher number indicating a better ability to create and control vivid images with ease.

Table 3

Dependent t Test to Identify Improvements in Imagery Ability

				95% Confidence Interval of the Difference				
	Mean	*SD*	Std. Error Mean	Lower	Upper	t	dF	Sig. (2-tailed)
Baseline – Week 1	-0.49	0.50	0.15	-0.81	-0.17	-3.38	11	0.006
Week 1 – Week 2	-0.22	0.43	0.12	-0.49	0.06	-1.74	11	0.110
Week 2 – Week 3	-.037	0.35	0.10	-0.59	-0.14	-3.61	11	0.004
Week 3 – Week 4	0.12	0.41	0.12	-0.15	0.38	0.96	11	0.356
Week 4 – Week 5	-.016	0.25	0.07	-0.32	-0.01	-2.22	11	0.049
Week 5 – Week 6	-0.23	0.26	0.08	-0.39	-0.06	-2.98	11	0.013

Note. Significance level set at $a = 0.008$.

Table 4

Descriptive Statistics of Successfully Made Putts

	Minimum	Maximum	Mean	Standard Deviation
Baseline	0.00	11.00	5.42	3.18
Week 1	1.00	14.00	6.25	3.82
Week 2	1.00	12.00	7.58	4.10
Week 3	3.00	12.00	7.50	2.71
Week 4	4.00	12.00	7.67	2.54
Week 5	0.00	11.00	6.83	3.90
Week 6	4.00	14.00	7.25	3.22

Table 5

Descriptive Statistics of Average Distance of Missed Putts

	Minimum	Maximum	Mean	Standard Deviation
Baseline	16.57	56.09	28.57	11.90
Week 1	24.40	59.93	37.95	10.55
Week 2	17.98	64.98	39.21	13.52
Week 3	24.45	58.91	42.28	11.57
Week 4	19.26	60.64	38.75	12.72
Week 5	22.07	67.56	37.88	15.40
Week 6	4.87	53.34	33.55	14.27

Note. Distance of missed putts from the hole is an average measurement (cm) of missed putts during the course of a laboratory visit. Better putting performance is represented by a lower value.

Table 6

Pearson Correlations between Imagery Ability and Putting Performance

Week			Imagery Ability	Missed Putts	Made Putts
Baseline	Imagery Ability	Pearson Correlation	1.00	0.25	0.23
		Sig. (2-tailed)		0.44	0.48
		N	12.00	12.00	12.00
	Missed Putts	Pearson Correlation		1.00	0.66
		Sig. (2-tailed)			0.02
		N			12.00
	Made Putts	Pearson Correlation			1.00
		Sig. (2-tailed)			
		N			12.00
1	Imagery Ability	Pearson Correlation	1.00	-0.25	0.06
		Sig. (2-tailed)		0.44	0.85
		N	12.00	12.00	12.00
	Missed Putts	Pearson Correlation		1.00	0.22
		Sig. (2-tailed)			0.49
		N			12.00
	Made Putts	Pearson Correlation			1.00
		Sig. (2-tailed)			
		N			12.00
2	Imagery Ability	Pearson Correlation	1.00	0.35	0.07
		Sig. (2-tailed)		0.27	0.84
		N	12.00	12.00	12.00
	Missed Putts	Pearson Correlation		1.00	0.22
		Sig. (2-tailed)			0.50
		N			12.00
	Made Putts	Pearson Correlation			1.00
		Sig. (2-tailed)			
		N			12.00
3	Imagery Ability	Pearson Correlation	1.00	0.23	-0.25
		Sig. (2-tailed)		0.46	0.43
		N	12.00	12.00	12.00
	Missed Putts	Pearson Correlation		1.00	-0.18
		Sig. (2-tailed)			0.58
		N			12.00
	Made Putts	Pearson Correlation			1.00
		Sig. (2-tailed)			
		N			12.00
4	Imagery Ability	Pearson Correlation	1.00	0.34	0.19
		Sig. (2-tailed)		0.28	0.55
		N	12.00	12.00	12.00
	Missed Putts	Pearson Correlation		1.00	0.60
		Sig. (2-tailed)			0.04
		N			12.00
	Made Putts	Pearson Correlation			1.00
		Sig. (2-tailed)			
		N			12.00

5	Imagery Ability	Pearson Correlation	1.00	0.38	0.27
		Sig. (2-tailed)		0.22	0.41
		N	12.00	12.00	12.00
	Missed Putts	Pearson Correlation		1.00	0.49
		Sig. (2-tailed)			0.11
		N			12.00
	Made Putts	Pearson Correlation			1.00
		Sig. (2-tailed)			
		N			12.00
6	Imagery Ability	Pearson Correlation	1.00	-0.14	0.32
		Sig. (2-tailed)		0.66	0.31
		N	12.00	12.00	12.00
	Missed Putts	Pearson Correlation		1.00	-0.36
		Sig. (2-tailed)			0.26
		N			12.00
	Made Putts	Pearson Correlation			1.00
		Sig. (2-tailed)			
		N			12.00

Note. Significance level set at $a = 0.05$. Imagery ability was measured by the SIAQ. Missed putts are the average distance (cm) of missed putts from the hole.

Table 7

Change from Baseline to Post-test for Imagery Ability and Putting Performance by Participant

Participant	Imagery Ability Change	Missed Putts Change	Made Putts Change
1	0.80	10.76	-1.00
2	1.87	34.29	4.00
3	1.14	12.90	4.00
4	0.94	-8.82	-2.00
5	0.34	-8.57	-4.00
6	2.20	1.41	1.00
7	1.40	25.56	2.00
8	0.74	11.83	-3.00
9	3.27	-11.70	8.00
10	1.03	-5.00	4.00
11	1.33	-4.29	-2.00
12	1.07	1.32	11.00

Note. Change was computed by subtracting the absolute value of the baseline assessment from the absolute value of the post-test assessment. Imagery ability was calculated by the SIAQ. Missed putts are the average distance (cm) of missed putts from the hole.

Table 8

Pearson Correlations between Change Score of Imagery Ability and Putting Performance

		SIAQ Change	Missed Putts Change	Made Putts Change
SIAQ Change	Pearson Correlation	1.00	-0.03	0.52
	Sig. (2-Tailed)		0.92	0.08
	N	12	12	12
Missed Putts Change	Pearson Correlation		1.00	0.07
	Sig. (2-Tailed)			0.84
	N	12	12	12
Made Putts Change	Pearson Correlation			1.00
	Sig. (2-Tailed)			
	N			12.00

Appendix I

Figures

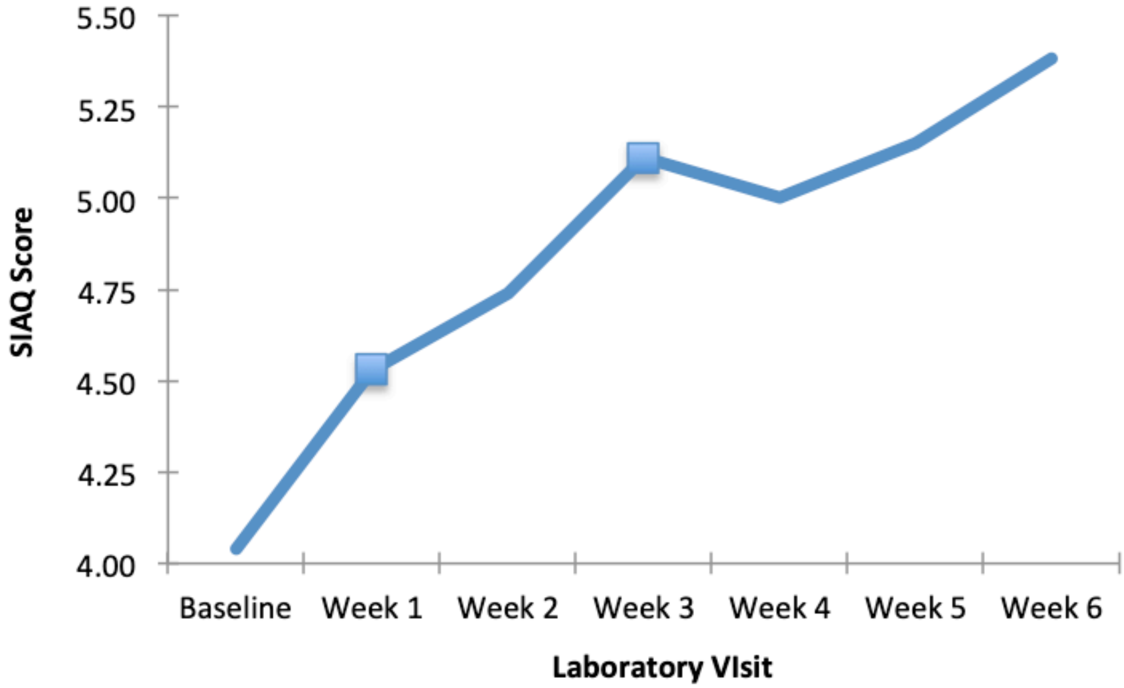

Figure 1. Imagery ability improvements throughout the duration of the study. Marked points represent significant improvements in imagery ability after the first ($p = 0.006$) and third ($p = 0.004$) week of practicing imagery.

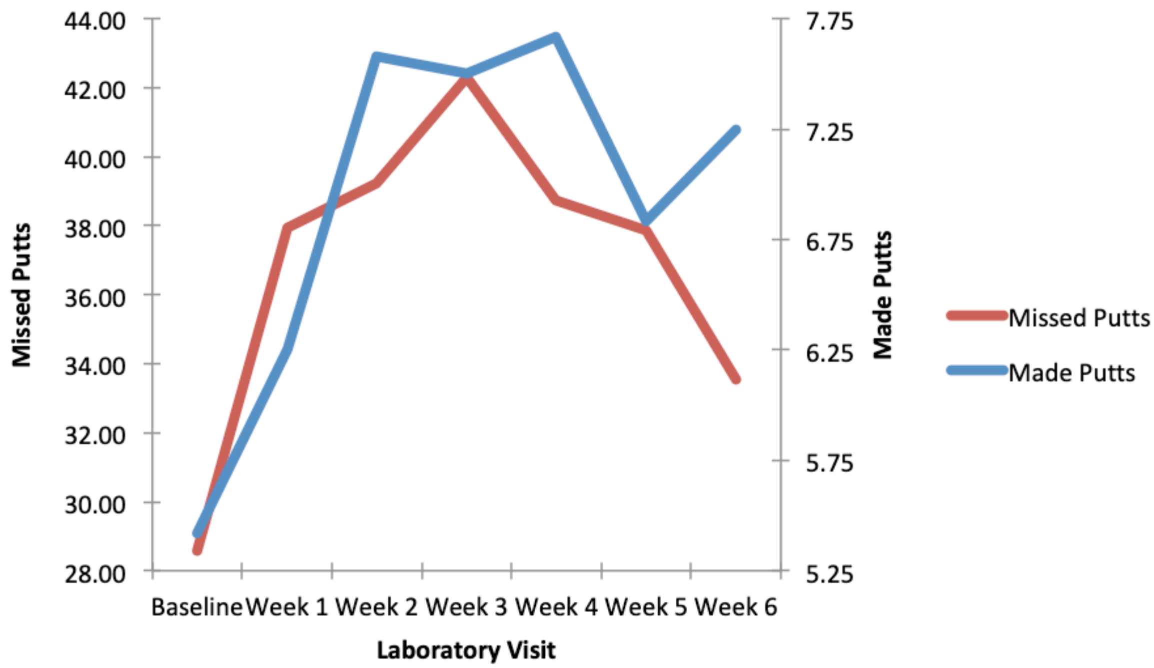

Figure 2. Putting performance, as measured by successfully made putts and the average distance of missed putts from the hole, throughout the course of the imagery program. The distance of missed putts from the hole is an average and better performance in indicated by a lower number.

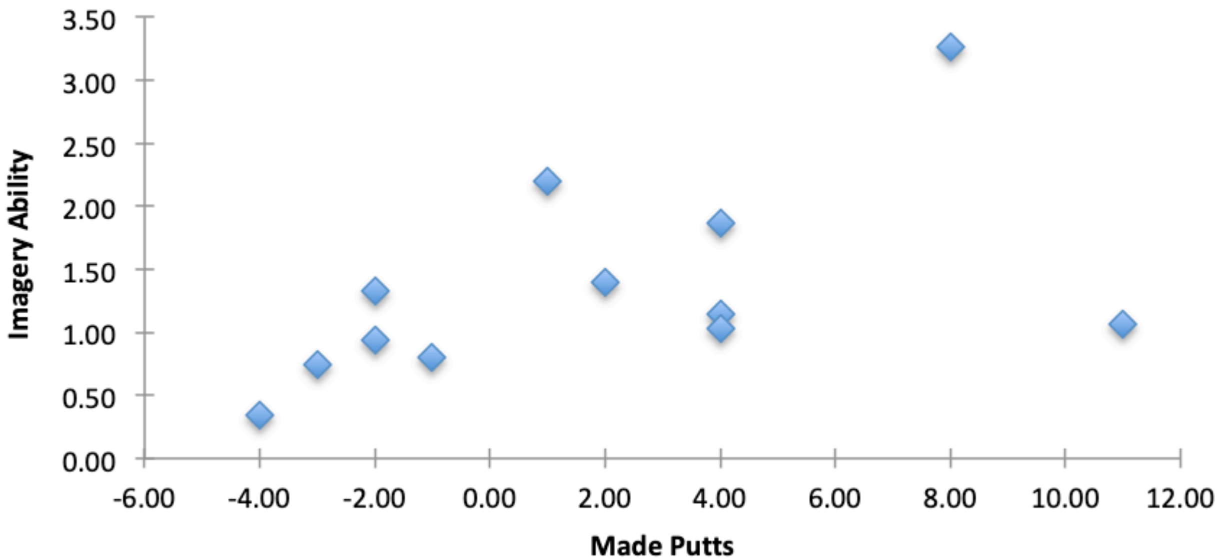

Figure 3. Scatterplot representing the relationship between the change in imagery ability and change in successfully made putts from baseline measures to post-test assessment. Imagery ability was measured by the SIAQ.

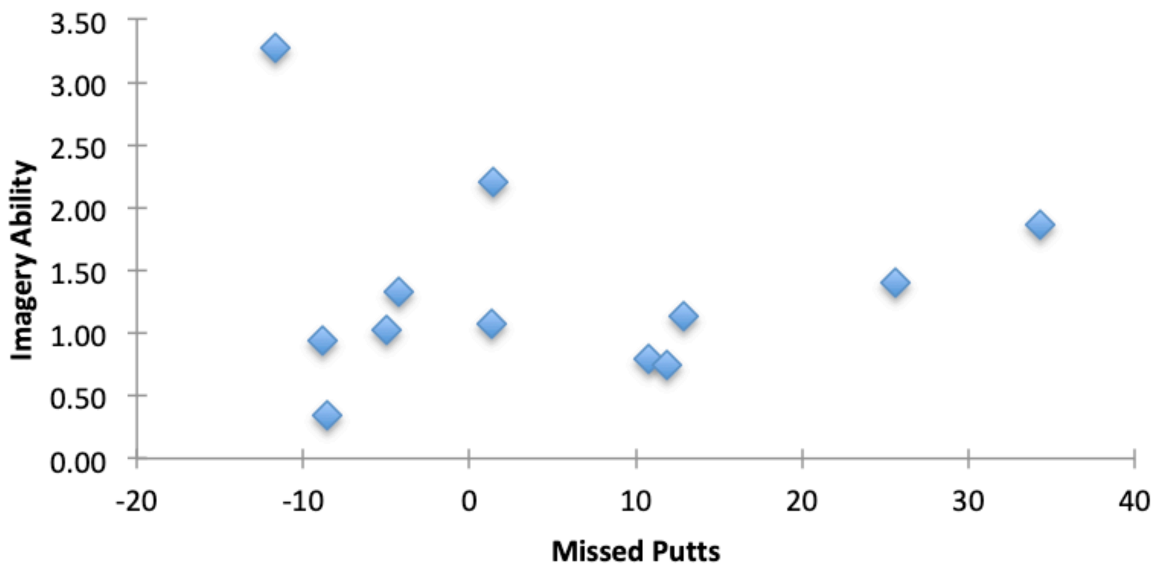

Figure 4. Scatterplot representing the relationship between the change in imagery ability and change in missed putts from baseline measures to post-test assessment. Imagery ability was measured by the SIAQ. Missed putts are the average distance (cm) of missed putts from the hole.

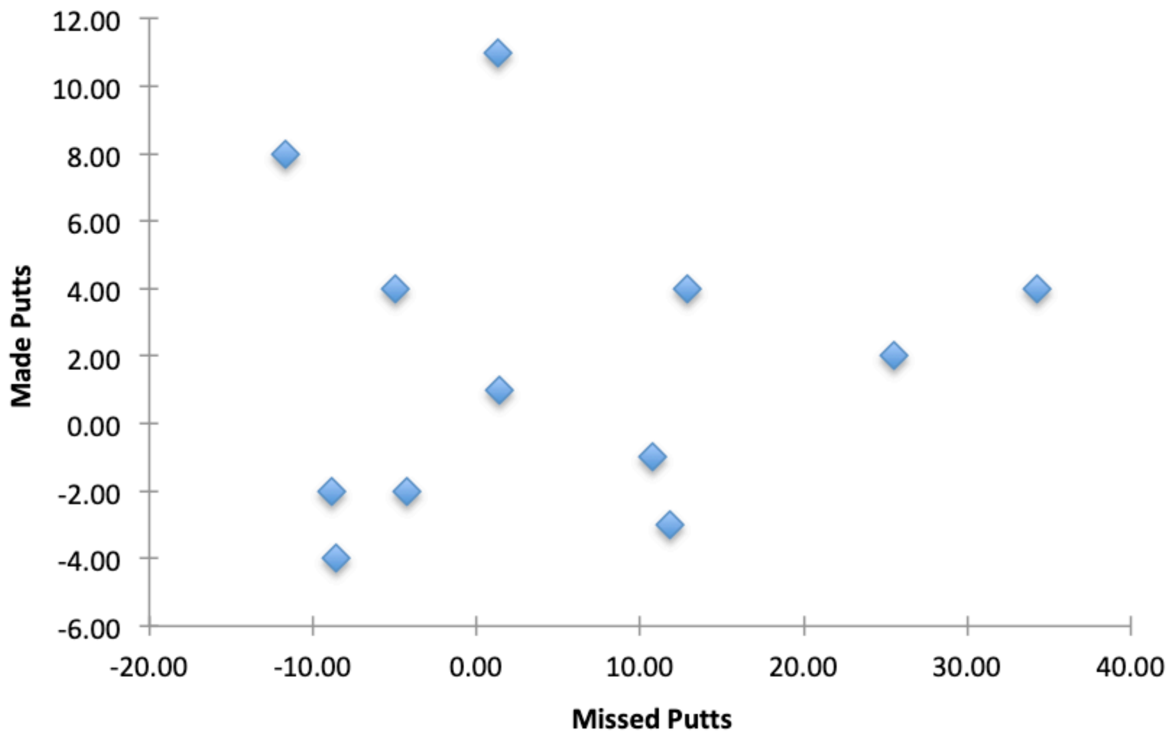

Figure 5. Scatterplot representing the relationship between the changes in successfully made putts and missed putts from baseline measures to post-test assessment. The average distance of missed putts from the hole, measured in centimeters, represents missed putts.