

EFFECT OF PERCEPTUAL-COGNITIVE TRAINING ON IMAGERY ABILITY AMONG ATHLETES

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Abstract

Objective: This study aims to examine the effect of perceptual-cognitive training on imagery ability among athletes.

Methods: The sample comprised athletes (n=10) randomly assigned to experimental (n=5) or control groups (n=5). The Sports Imagery Ability Questionnaire (SIAQ) was used to collect data. The experimental group underwent a 5-week intervention program (30 adaptive training sessions) of perceptual-cognitive training using Neurotracker, while the control group used Quickboard for coordination training (agility, speed, and leg reaction).

Results: Post-intervention assessments using the Sports Imagery Ability Questionnaire (SIAQ) indicated improvements in imagery ability among athletes in the experimental group. Within-group analyses revealed significant improvements in strategy imagery ability ($p = .023$, $d = -1.603$), goal imagery ability ($p = .011$, $d = -1.990$), affect imagery ability ($p = .021$, $d = -1.647$), and the global measure of sport imagery ability ($p = .002$, $d = -3.105$). Between-group comparisons at post-intervention showed significant differences in strategy imagery ability and the global measure of sport imagery ability. Although skill imagery ability and mastery imagery ability did not show statistically significant differences, their effect sizes suggest potential improvements associated with the intervention. The control group demonstrated only minor changes across imagery domains.

Conclusion: The findings provide preliminary evidence that perceptual-cognitive training may positively influence self-reported sport imagery ability among athletes. The strongest effects were observed in strategy imagery ability and the global measure of sport imagery ability, while findings across other imagery domains were mixed. Given the exploratory nature of the study and the small sample size, the results should be interpreted cautiously. Further research with larger samples is needed to better understand the relationship between perceptual-cognitive training and imagery ability.

Keywords: cognitive training, imagery ability, Neurotracker, sports performance, perceptual-cognitive training

I. INTRODUCTION

In the field of competitive sports, imagery serves as a potent mental tool (Hall, 2001), similar to an athlete's silent coach guiding them toward peak performance. Before stepping onto the field or court, athletes often close their eyes and vividly imagine themselves executing flawless performances: the tennis player's powerful serve, the basketball player's perfect jump shot, or the footballer's skillful pass. However, individuals vary in their ability to generate and manipulate mental images, with some demonstrating a remarkable talent for creating rich and detailed internal simulations, while others may struggle to conjure such imagery (Isaac, 1992).

Imagery is widely embraced among athletes and coaches as a valuable strategy for improving performance in different areas. Its significance is evident in the numerous success stories shared by athletes. For instance, Ronaldinho, a midfielder for FC Barcelona and a renowned footballer, vividly expressed his reliance on imagery before the 2006 World Cup in an article featured in the New York Times Sports Magazine.

“When I train, one of my main focuses is to create a mental picture of the best way to pass the ball to a teammate, ideally setting him up alone in front of the opponent's goalkeeper. Before every game, every night and day, I always try to think of plays that no one else has considered, keeping in mind the unique strengths of each teammate I’m passing to. When visualizing these plays, I consider whether a teammate prefers to receive the ball at his feet or ahead of him, if he is good with his head and how he likes to head the ball, and whether he is stronger with his right or left foot. This is my job. This is what I do. I imagine the game." (4 June 2006).” (NYT Sports, 2006)

Imagery plays a crucial role in athletic performance, as exemplified by Ronaldinho's approach to visualizing game scenarios. By mentally rehearsing plays and considering teammates' strengths and preferences, athletes can enhance their decision-making and execution on the field. Ronaldinho's reliance on imagery highlights its importance in optimizing performance by honing strategic thinking and fostering a deep understanding of the game dynamics.

Imagination and Imagery

Individuals often think that imagery and imagination are the same, but the short answer is that imagery has the characteristics that the imagination has not, and the imagery lacks the characteristics that imagination has (White, 1990). Imagery and imagination are the different mental abilities but the boundaries of imagery and imagination are not always clear. From a psychological perspective, imagery and imagination share a same partial underlying of neural structures, while referring to different mental processes, share the underlying ability to create internal representations. Imagery, in particular, has strong cognitive foundations and can be defined as the ability to generate, transform, and manipulate mental representations that involve visual and spatial characteristics, but when it comes to imagination, it

preferentially refers to dream-like processes (Vecchi, 2019) and imagery entails simulating a real-life scenario without experiencing it. It is distinctly different from daydreaming or merely thinking about something. Athletes use imagery to attain various emotional, cognitive, and behavioral benefits. Directly, as well as indirectly, by improving drive, confidence, and focus (Morris et al., 2005)

Imagery involves recreating sensory experiences in the mind without external stimuli. These representations are retrieved from memory and allow individuals to re-experience a modified version of the original stimulus. So, imagery serves as a technique to enhance mental performance by "programming" both the body and mind, aiming to elicit optimal responses in various performance situations (Pearson, 2005). This highlights the importance of imagery in sports.

Imagery in Sport

In sports, imagery involves mentally rehearsing athletic movements, strategies, and scenarios without physical execution. Athletes utilize imagery to prepare for competition, refine skills, boost confidence, and regulate emotions (Blankert & Hamstra, 2016), and imagery has become one of the most prevalent psychological techniques to improve performance in athletes (Hall, 2001). By vividly imagining themselves performing successfully, athletes reinforce the neural pathways linked to performance, thus improving their overall readiness for competition. As the significance of mental imagery in an athlete's performance becomes increasingly evident, Morris et al. (2005) proposed a broader definition of sports imagery. They defined it as the intentional or unintentional recreation of an experience derived from memory, encompassing quasi-affective and quasi-sensorial aspects that can occur without the typical physical stimuli associated with the actual experience. Nowadays, imagery is widely utilized in various sports settings as part of preparation for

competition through imagery training, aiding athletes in enhancing their performance (Corrado et al., 2020). Studies strongly support the idea that imagery can enhance the benefits of training and exercise. However, while certain factors have been identified as moderators of its effectiveness, there remains a limited understanding of the psychological, particularly motivational, factors that may enhance the effectiveness of imagery itself (Sari, 2015). Shedding light on such potential enhancers is practical because understanding changeable conditions like motivation, which influence the effects of imagery, could assist individuals in optimizing their use of imagery techniques and maximizing training and practice outcomes.

Imagery Ability

Imagery is recognized as an important cognitive skill for athletes to develop, with its consistent and structured application being a hallmark of talented performers, distinguishing successful athletes from less successful ones (Cumming & Hall, 2002; Kosslyn et al., 1984; Rees et al., 2016). Moreover, there is a growing understanding that imagery can serve to encourage and sustain physical activity across various demographics, spanning from children and adolescents (Tobin et al., 2017) to older adults (Giacobbi et al., 2014). Regardless of the application or the individual engaging in imagery, a significant factor influencing its efficacy is the individual's ability to generate vivid, controllable mental images and maintain them for a sufficient duration to achieve the intended imagery rehearsal (Morris et al., 2005). Galton (1880) was the first to observe that the "detail and clarity with which individuals experience imagery suggests a spectrum of individual differences in the population. He termed this trait as "vividness," which denotes an individual's capacity to imagine. In specific, imagery ability is a complex cognitive process that involves not just the way individuals generate images but also how they maintain images over time.

The first of these primary processes can be described as follows:

1. Image generation: This process entails producing an image by drawing upon sensory information or stored memories in long-term memory, even in the absence of external perceptual stimuli (Kosslyn et al., 1995).
2. Image inspection: It involves scanning the whole or parts of an image, interpreting its patterns, and extracting information (Kosslyn et al., 2006).
3. Image transformation: It involves changing either the content or characteristics of an image. As explained by Cumming and Williams (2013), imagery content refers to what is being imaged (e.g., skills, strategies, goals), whereas characteristics refer to how the imaged content is experienced (e.g., agency, angle, modality, perspective).
4. Image maintenance: It takes time to generate, inspect, and transform images, and therefore images must be maintained for these processes to be carried out and the desired outcomes achieved.

As the importance of imagery in sports explained, it clearly shows that imagery is used in various sports settings as part of preparation for competition through imagery training, aiding athletes in enhancing performance (Carrado et al., 2020). During a game, athletes need to pay attention to the rapidly changing movements of teammates and opponents and quickly perceive the most crucial information, interpret that information, decide on needed actions, and execute these actions to detect optimal choices for their movements and where to pass the ball (Appelbaum & Erickson, 2016; Mangine et al., 2014). Moran and Collet (2013) found that imagery can improve an athlete's ability to perceive, process, and respond to relevant visual and cognitive information, thereby enhancing perceptual-cognitive skills, which signifies the importance of perceptual-cognitive training. Other studies (Moran et al., 2012; Williams et al., 2013; Jackson et al., 2006) also show the importance of imagery and its relation to perceptual-cognitive skills.

Perceptual-Cognitive Training

One of the most challenging tasks for athletes' brains during gameplay is to perceive and process intricate moving patterns while distributing attentional focus across different critical areas of the dynamic scene. This involves integrating information from various visual field areas rather than just focusing on a small portion. Additionally, the speed and unpredictability of players' movements and the game object, such as a ball, pose significant challenges, including abrupt speed changes and unpredictable trajectory paths with frequent occlusions and interruptions; as the athlete progresses to higher levels of competition, the speed and complexity of these mental processes escalate (Faubert & Sidebottom, 2012).

For instance, dynamic team sports like football, hockey, soccer, rugby, and basketball underscore the necessity of monitoring multiple opponents and teammates during crucial phases of play. For instance, when defending against an approaching attacker with the ball, the defender must anticipate the attacker's moves, assess opportunities for teammate support, and predict potential passing or scoring opportunities. At elite levels, such perceptions rely on constant monitoring, especially as attacking strategies often involve deceptive movements to overcome defenders.

Research emphasizes the significance of athletes' perception and reaction to stimuli in high-level competition (Williams et al., 1999). Skilled athletes excel in anticipating opponents' actions and demonstrate superior pattern recognition and strategic understanding, particularly in team sports like soccer (Williams, 2000). This perceptual awareness is considered a fundamental aspect of skill rather than merely a product of experience (Williams & Davids, 1995). Furthermore, studies indicate that playing experience alone may not be the sole determinant of anticipatory abilities when comparing elite and sub-elite players (Vaeyens et

al., 2007). As the importance of perceptual-cognitive training is explained, the effect of perceptual-cognitive training on imagery is also discussed.

Is there any effect of Perceptual-Cognitive Training on Imagery?

Research has shown that perceptual-cognitive training has the potential to influence sport-specific tasks (Moen et al., 2018; Romeas et al., 2016) and that elite athletes have significantly better attentional resources than non-elite, less skilled athletes (Mann et al., 2007). Elite athletes also gain better improvements and have a higher learning rate from perceptual-cognitive training than less skilled athletes (Faubert, 2013; Romeas et al., 2009). Yet, the fundamental concept of perceptual-cognitive training programs is that they aim to enhance the mechanisms governing human perception, cognition, and action dynamics (Miyake & Friedman, 2012). Unfortunately, there is a paucity of studies that have investigated the effect of perceptual-cognitive training on imagery, but there is a connection between these two where visual perception and visual mental imagery, the term where individuals can revisualize a visual item from memory, have been regarded as cognitive functions subserved by common mechanisms (Bartolomeo, 2002). Thus, the leading cognitive model of imagery, the Kosslyn Model (Kosslyn 1980, 1994), holds that visual perception and visual mental imagery involves several mental operations and depends on common neural structures, including the early visual cortices. Vater et al. (2021) support that perceptual-cognitive training has been used in the field that they can examine cognitive abilities using the MOT (3d multiple object tracking) also. Moen et al. (2018) discussed the effects of perceptual-cognitive training on executive brain functioning, such as alerting,

orienting, executive control, inhibition, shifting, and updating, and the study shows that there were significant improvements among the participants in groups on the NT 3D MOT tool.

In conclusion, research highlights the significant impact of perceptual-cognitive training on sport-specific tasks, with elite athletes demonstrating superior attentional resources and learning rates compared to their less skilled counterparts. While studies exploring the direct effects of perceptual-cognitive training on imagery remain scarce, the interconnectedness between visual perception and mental imagery suggests potential cognitive benefits. Moving forward, further investigation into the relationship between perceptual-cognitive training and imagery could offer valuable insights into optimizing athletic performance.

Research Questions

- Would there be any effect of perceptual-cognitive training on imagery ability among athletes?
- Was there be any difference in imagery ability pre-intervention and post-intervention among control and experimental groups?

Significance of the Study

This research aimed to assess the effect of perceptual-cognitive training on imagery ability. Perceptual cognitive training improves the athletes' cognitive skills, and imagery is used as an essential performance-enhancing tool by the athletes. Numerous studies conducted in a wide variety of contexts have also shown that the use of cognitive imagery is conducive to enhancing the learning and performance of motor skills. The study will allow the researcher to know about athletes' imagery ability in order to identify how well they can be utilized by athletes in sports settings. Previous studies have found that imagery has a positive effect on athletes' performance. The study will contribute to the field of how perceptual-cognitive training affects imagery and imagery ability. Thus, the study will research on the perceptual-cognitive training and how it affects imagery ability.

Statement of the Problem

The research aimed to study the effect of perceptual-cognitive training on imagery ability among athletes from various sports. Relevant literature indicates that the topic of the effect of perceptual-cognitive training on imagery ability among athletes has not been explored. Since every sport and athlete requires imagery for optimal performance, the effect of perceptual-cognitive training on imagery ability will be studied in this research.

Objectives of the Study

- To examine the effect of perceptual-cognitive training on imagery ability.

- To measure the effect size of perceptual, cognitive training on imagery ability in experimental group post-intervention.

Hypotheses

- H1: It was assumed that perceptual-cognitive training would have an effect on imagery ability in pre- and post-intervention scores.
- H2: It was expected that there would be a significant difference between the post-intervention scores of the control and experimental groups in terms of imagery ability.
- H3: It was expected that perceptual cognitive training would have a large effect size on the scores of imagery ability.

Definitions and Explanation of Terms

1. Imagery: APA (2018) defines imagery as the cognitive creation of sensory input from the five senses, either individually or collectively, can be recalled from past experiences or generated anew in a form that has not been previously experienced.
2. Imagery Ability: Imagery ability refers to "an individual's capability of forming vivid, controllable imagery and retaining them for sufficient time to effect the desired rehearsal" (Morris et al., 2005).
3. Perceptual, cognitive training: Perceptual-cognitive training is a training program that comprises four components to represent an optimal training environment. These components include distributed attention on multiple dynamic elements, referred to in the literature as multiple object tracking (MOT; Cavanagh & Alvarez, 2005), a wide visual field, speed thresholds, and stereoscopy (binocular depth cues).

II. METHODOLOGY

The chapter methodology deals with detailed information on the methods and processes used in the study which includes explaining the problem statement of the study, detailing the objectives and hypotheses of the study, formulating the research design, subject selection, variables of the study, intervention used, and the statistical analysis used in the study.

Selection of Participants

The participants were taken from athletes of the National Sports University. The sample will comprise 10 athletes within the age range of 18-26 years. The selection of these participants is done using non-probability convenience sampling method because of the duration of research and easiness of participants participation.

Selection of Variables

- Independent variable – Perceptual cognitive training
- Dependent Variables – Imagery Ability

Statistical Tools

- A paired t-test was used to compare the pre-and post-test scores of the experimental and control groups.
- An independent t-test was used to compare the means of two unrelated groups.
- Cohen's d was used to measure the effect size of perceptual-cognitive training on imagery ability among the control group post-intervention. The preference for Cohen's d is because of its versatility and standardized interpretation. When comparing means of two groups, Cohen's d offers a straightforward measure of the magnitude of difference, making it easier to communicate the practical significance of findings.

Tools for Data Collection

- Scores of 'SIAQ' that is Sports Imagery Ability Questionnaire.

The SIAQ is designed to measure the ability to image different content athletes frequently use in their sport (i.e., skills, strategies, goals, feelings and emotions, and mastering difficult situations). It can be used to assess an athlete's imagery ability (i.e., ease of imaging) of this sport-specific content as a one-off assessment or monitor how imagery ability may change over time (Cumming & Williams, 2015). In studies conducted to date, the SIAQ has demonstrated good content and factorial validity and correlates well with other measures reflective of imagery ability. Also, the SIAQ has good internal reliability and good temporal stability, with reliability ranging between .78 and .86.

Skill imagery ability:

The skill subscale of the SIAQ (Williams & Cumming, 2011) assessed participants' ability to image positive skill imagery content. The three items include "Refining a particular skill," "Improving on a particular skill," and "making corrections to physical skills." Participants imaged and then rated each of the three items on a 7-point Likert-type scale from 1 (very hard to image) to 7 (very easy to image). The scores were averaged for each subscale to give one skill imagery ability score, with higher scores representing greater ease of imaging.

Strategy Imagery Ability:

The strategy subscale of the SIAQ (Williams & Cumming, 2011) assessed participants' ability to image strategy imagery content. The three items include "making up new plans/strategies in my head," "alternative plans/strategies," and "creating a new event/game plan." The scores were averaged for each subscale to give one strategy imagery ability score, with higher scores representing greater ease of imaging.

Goal Imagery Ability: The goal subscale of the SIAQ (Williams & Cumming, 2011) assessed participants' ability to image goal imagery content. The three items include "myself winning a medal," "being interviewed as a champion," and "myself winning." Participants imaged and

then rated each of the three items on a 7-point Likert-type scale from 1 (very hard to image) to 7 (very easy to image). The scores were averaged for each subscale to give one goal imagery ability score, with higher scores representing greater ease of imaging.

Mastery Imagery Ability: The mastery subscale of the SIAQ (Williams & Cumming, 2011) evaluated participants' ability to visualize positive mastery imagery content. The three items include "maintaining confidence in a challenging situation," "keeping a positive attitude after a setback," and "putting in maximum effort when things are tough." Participants visualized each of the three items and then rated them on a 7-point Likert-type scale ranging from 1 (very hard to image) to 7 (very easy to image). The scores for the subscale were averaged to provide a single mastery imagery ability score, with higher scores indicating greater ease of imaging.

Affect imagery ability: The affect subscale of the SIAQ evaluated participants' ability to visualize positive affective content. The three items are: "the positive emotions I experience while engaging in my sport," "the anticipation and excitement related to my sport," and "the excitement tied to performing". Participants imaged and then rated each of the three items on a 7-point Likert-type scale from 1 (very hard to image) to 7 (very easy to image). The scores were averaged for each subscale to give one skill imagery ability score, with higher scores representing greater ease of imaging.

Global Measure of Sport Imagery Ability: To determine the overall score of each participant, a global score was taken, adding each of the scores from the fifteen items in the survey. To produce the reflective score, all fifteen scores were added together and then averaged.

- NeuroTracker (MOT 3D Multiple Object Tracking)

The MOT task was first presented by Pylyshyn and partners (Pylyshyn, 1994; Pylyshyn & Tempest, 1988) to decide how individuals track numerous components. Generally, MOT is a task where spectators are approached to keep up with the attentional spotlight on a limited

number of preselected subgroups of components in a unique scene where all components cooperate either by bouncing off one another or occluding each other. However, the first work was created on the side of the FINST theory. Studies have demonstrated the way that the vast majority can, by and large, track four to, in some cases, five components depending upon the condition and population (Fougnie & Marois, 2006). Healthy adults can follow the four components, while older adults have all the earmarks of being restricted to three under standard circumstances (Trick et al., 2005). This capacity to follow numerous items in a powerful game's climate has been distinguished as possibly vital to responding quickly and effectively (Willams et al., 2006).

Research Design

The research design for the study is experimental design, in which the independent variable (perceptual-cognitive training) was assessed on the dependent variable (imagery ability) in the experimental group.

Procedure

The intervention of the research was scheduled for 5 weeks. The sample was assessed on imagery using SIAQ. Also, there was perceptual-cognitive training as an intervention using a neuro tracker. After the assessment of imagery (pre-intervention scores), samples are randomly assigned to experimental and control groups. In the 5 weeks (excluding Sunday), the intervention was given five days in a week. During the training period (perceptual-cognitive training) intervention on the experimental group, the control group be given Quick Board training. After the 5-week intervention period, all participants were reassessed on imagery ability using the SIAQ (post-intervention). This assessment was conducted immediately following completion of the intervention.

III. RESULTS AND DISCUSSION

This chapter aims to fulfill the criteria of adding statistical data results and findings of the study to analyze the presented hypotheses. The objective of the current study was to find the effect of Perceptual Cognitive Training on Imagery Ability. This perceptual-cognitive intervention program was administered for 5 weeks on a sample of 5 subjects (experimental group, $n=5$). The study's total sample consisted of 10 athletes ranging in age from 18 to 26 years, which was the study's final sample. The experimental group of the study was given 30 sessions of perceptual-cognitive training in the 5-week intervention program consisting of morning and evening sessions. The control group of the study was given Quickboard Training. After the intervention was completed, the data collected from both groups of samples was analyzed to compute the study result. For purposeful analysis of the study data, IBM SPSS versions 29 and 27 are used to analyze the study data statistically.

After data collection, the initial step involved assessing the normality of the data distribution using the Shapiro–Wilk test. The obtained p -values were greater than .05, indicating no evidence of substantial deviation from normality. Therefore, parametric statistical procedures were considered appropriate for the analysis. After establishing the normality of the data, the necessary parametric tests in the SPSS were used for analysis. Independent samples t -test was used to compare the means between post-intervention scores of experimental and control groups to check whether there were any significant differences among the groups prior to the intervention program to have a baseline understanding of the two groups in the study, followed by execution of paired samples t -test to check the effect of the intervention program on imagery ability among both experimental and control group pre- and post-intervention. Cohen's d value was also noted together with the paired samples' t -test

value to check the effect size and compare between means. Imagery ability has subscales such as skill, strategy, goal, affect, mastery, and global sports imagery.

Table 4.1

Test of normality results of imagery ability subscales and global measure of sport imagery ability for the experimental group

Imagery Ability Subscales	Experimental Pre Shapiro Wilk			Control Pre Shapiro Wilk		
	Statistic	df	<i>P</i>	Statistic	df	<i>P</i>
Skill IA	0.183	5	0.923	0.256	5	0.142
Strategy IA	0.235	5	0.817	0.251	5	0.500
Goal IA	0.292	5	0.432	0.231	5	0.314
Affect IA	0.217	5	0.438	0.277	5	0.473
Mastery IA	0.275	5	0.378	0.322	5	0.132
Global SI	0.241	5	0.507	0.291	5	0.120

Note. Imagery Ability Subscales; Skill IA=Skill Imagery Ability; Strategy IA=Strategy Imagery Ability; Goal IA=Goal Imagery Ability; Affect IA=Affect Imagery Ability; Mastery IA=Mastery Imagery Ability. And Global SI=Global Sport Imagery.

Table 4.2

Descriptive statistics of imagery ability subscales and global measure of sport imagery ability for the experimental and control group

Imagery Ability Subscales	Experimental Pre		Experimental post		Control Pre		Control Post	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Skill IA	4.996	1.130	6.464	0.607	5.264	0.985	5.530	0.902
Strategy IA	4.264	0.759	6.064	0.642	4.198	0.507	4.930	0.760
Goal IA	5.664	0.668	6.398	0.433	5.796	0.556	6.062	0.723
Affect IA	5.386	0.425	6.264	0.496	5.916	0.555	5.998	0.852
Mastery IA	4.924	1.305	5.796	0.731	4.596	1.141	5.062	0.434
Global MSIA	5.026	0.477	6.198	0.317	5.158	0.602	5.516	0.542

Note. Imagery Ability Subscales; Skill IA=Skill Imagery Ability; Strategy IA=Strategy Imagery Ability; Goal IA=Goal Imagery Ability; Affect IA=Affect Imagery Ability; Mastery IA=Mastery Imagery Ability. And Global SI=Global Sport Imagery.

Tables 4.1 and 4.2 represent the results of the test of normality. Since we had a small sample size for the experimental and control group, determining the distribution of the variable subscales under imagery ability (skill, strategy, goal, affect, mastery) and global measure of sport imagery ability was important for choosing an appropriate statistical method. So, a Shapiro-Wilk test was performed and did not show evidence of non-normality (p-value > 0.05). Based on this outcome, we decided to use parametric tests. Also, the means with the standard deviations were used to summarize the variable subscales under imagery ability and global measure of sport imagery ability.

Table 4.3

Paired samples t-test results for pre- and post-intervention sport imagery ability subscales for the experimental group

Imagery Ability	Experimental Pre		Experimental Post		<i>t</i> (4)	<i>p</i>	Cohen's <i>d</i>
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>			
Skill IA	4.996	1.130	6.464	0.607	-2.563	.062	-1.146
Strategy IA	4.264	0.759	6.064	0.642	-3.586	.023*	-1.603
Goal IA	5.664	0.668	6.398	0.433	-4.450	.011*	-1.990
Affect IA	5.386	0.425	6.264	0.496	-3.684	.021*	-1.647
Mastery IA	4.924	1.305	5.796	0.731	-1.813	.144	-0.810
Global MSIA	5.026	0.477	6.198	0.317	-6.944	.002*	-3.105

Note. Imagery Ability Subscales; Skill IA=Skill Imagery Ability; Strategy IA=Strategy Imagery Ability; Goal IA=Goal Imagery Ability; Affect IA=Affect Imagery Ability; Mastery IA=Mastery Imagery Ability; Global MSIA = Global Measure of Sport Imagery Ability.

Along with the descriptive statistics of the subscales of the variable, sports imagery ability, p-value, and Cohen's *d* have been added in order to check the effect size of the significant differences, if any, that have been obtained.

In the case of the Sport Imagery Ability subscale (Skill Imagery Ability) in the experimental group, the scores of the subjects in the post-intervention assessment ($M = 6.464$, $SD = 0.607$) were comparatively higher than their scores in the pre-intervention assessment ($M = 4.996$, $SD = 1.130$), $t(4) = -2.563$, $p = .062$, $d = -1.146$.

For the subscale of Sport Imagery Ability (Strategy Imagery Ability) in the experimental group, an increase in the mean values was observed and it is also observed that there is a significant difference ($p < 0.05$) in the post-intervention assessment ($M = 6.064$, $SD = 0.642$) compared to the pre-intervention assessment scores ($M = 4.264$, $SD = 0.759$), $t(4) = -3.586$, $p = .023^*$, $d = -1.603$.

For the subscale of Sport Imagery Ability (Goal Imagery Ability) a slight increase was observed in the mean scores and a significant difference ($p < 0.05$) for the post-intervention assessment ($M = 6.398$, $SD = 0.433$) compared to the pre-intervention assessment ($M = 5.664$, $SD = 0.668$), $t(4) = -4.450$, $p = .011^*$, $d = -1.990$.

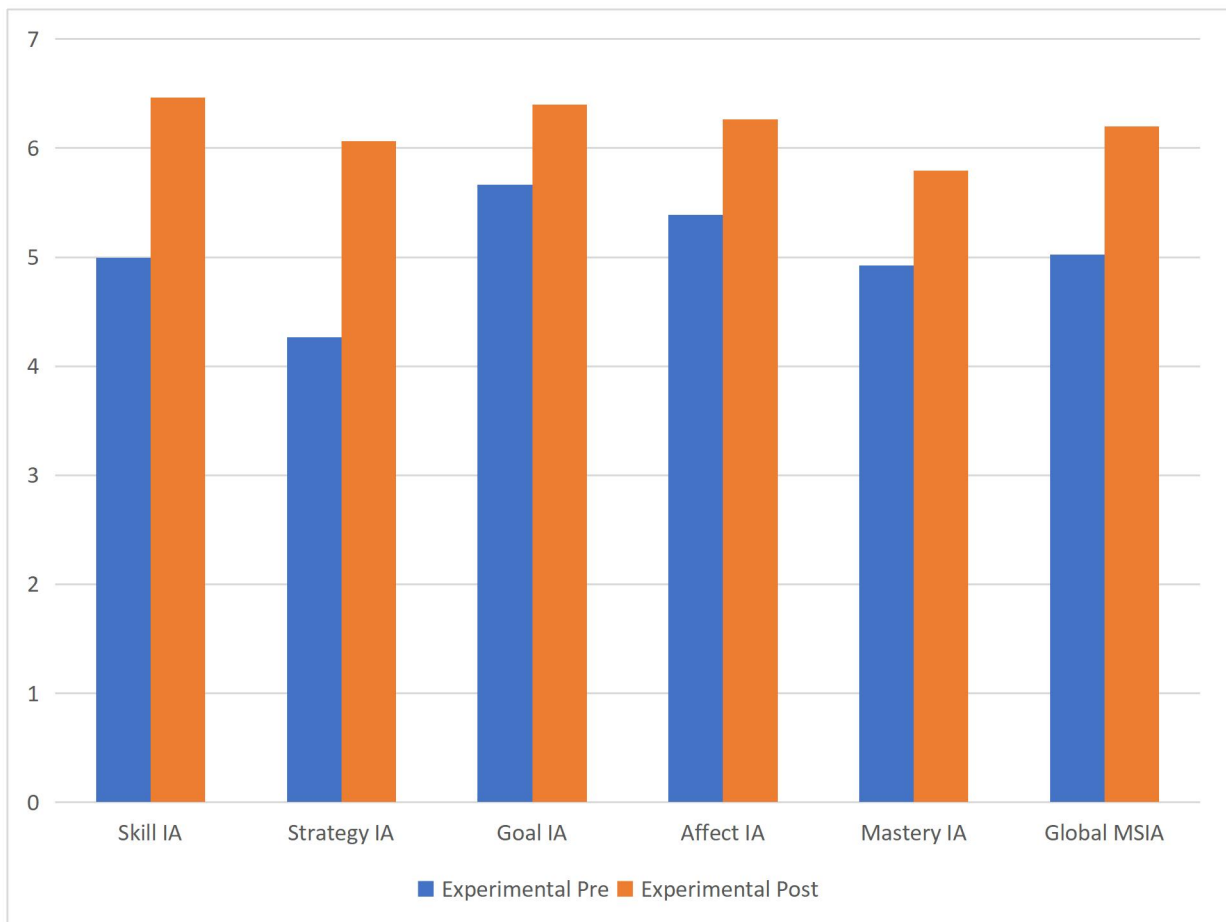
In terms of Sport Imagery Ability (Affect Imagery Ability) a slight increase was observed in the mean scores and showed a significant difference ($p < 0.05$) in the scores of post-intervention assessment ($M = 6.264$, $SD = 0.496$) compared to the pre-intervention assessment ($M = 5.386$, $SD = 0.425$), $t(4) = -3.684$, $p = .021^*$, $d = -1.647$.

For the subscale of Sport Imagery Ability (Mastery Imagery Ability), a slight increase was observed in the mean scores of post-intervention assessment ($M = 5.796$, $SD = 0.731$) compared to the pre-intervention assessment ($M = 4.924$, $SD = 1.305$), $t(4) = -1.813$, $p = .144$, $d = -0.810$.

In the case of the Global Measure of Sport Imagery Ability subscale in the experimental group, the scores of the subjects in the post-intervention assessment ($M = 6.198$, $SD = 0.317$) were comparatively higher than their scores in the pre-intervention assessment ($M = 5.026$, $SD = 0.477$) and found significant difference ($p < 0.05$) between the groups $t(4) = -6.944$, $p = .002^*$, $d = -3.105$.

Figure 4.1

Graph representing mean scores of sport imagery ability subscales for pre- and post-intervention for the experimental group



Note. Imagery Ability Subscales; Skill IA=Skill Imagery Ability; Strategy IA=Strategy Imagery Ability; Goal IA=Goal Imagery Ability; Affect IA=Affect Imagery Ability; Mastery IA=Mastery Imagery Ability.

Figure 4.1 portrays the graphical representation of the mean scores of pre and post-intervention the experimental group of all the subscales of sport imagery ability i.e., Skill imagery ability, strategy imagery ability, goal imagery ability, affect imagery ability and mastery imagery ability. The graph represents clear evidence that post-intervention experimental group mean scores are higher than pre-intervention scores in all subscales

Table 4.4

Paired samples t-test results for pre- and post-intervention sport imagery ability subscales for the control group

Imagery Ability	Control Pre		Control Post		<i>t</i> (4)	<i>p</i>	Cohen's <i>d</i>
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>			
Skill IA	5.264	0.985	5.530	0.902	-0.500	.642	-0.223
Strategy IA	4.198	0.507	4.930	0.760	-2.051	.109	-0.917
Goal IA	5.796	0.556	6.062	0.723	-0.925	.407	-0.413
Affect IA	5.916	0.555	5.998	0.852	-0.261	.806	-0.116
Mastery IA	4.596	1.141	5.062	0.434	0.810	.463	-0.362
Global MSIA	5.158	0.602	5.516	0.542	-1.04	.233	-0.626

Note. Imagery Ability Subscales; Skill IA=Skill Imagery Ability; Strategy IA=Strategy Imagery Ability; Goal IA=Goal Imagery Ability; Affect IA=Affect Imagery Ability; Mastery IA=Mastery Imagery Ability; Global MSIA = Global Measure of Sport Imagery Ability.

In the case of the Sport Imagery Ability subscale (Skill Imagery Ability) in the control group, the scores of the subjects in the post-intervention assessment ($M = 5.530$, $SD = 0.902$) were slightly higher than their scores in the pre-intervention assessment ($M = 5.264$, $SD = 0.985$), $t(4) = -0.500$, $p = .642$, $d = -0.223$.

For the subscale of Sport Imagery Ability (Strategy Imagery Ability), a slight increase in the mean values was observed in the post-intervention assessment ($M = 4.930$, $SD = 0.760$) compared to the pre-intervention assessment scores ($M = 4.198$, $SD = 0.507$), $t(4) = -2.051$, $p = .109$, $d = -0.917$.

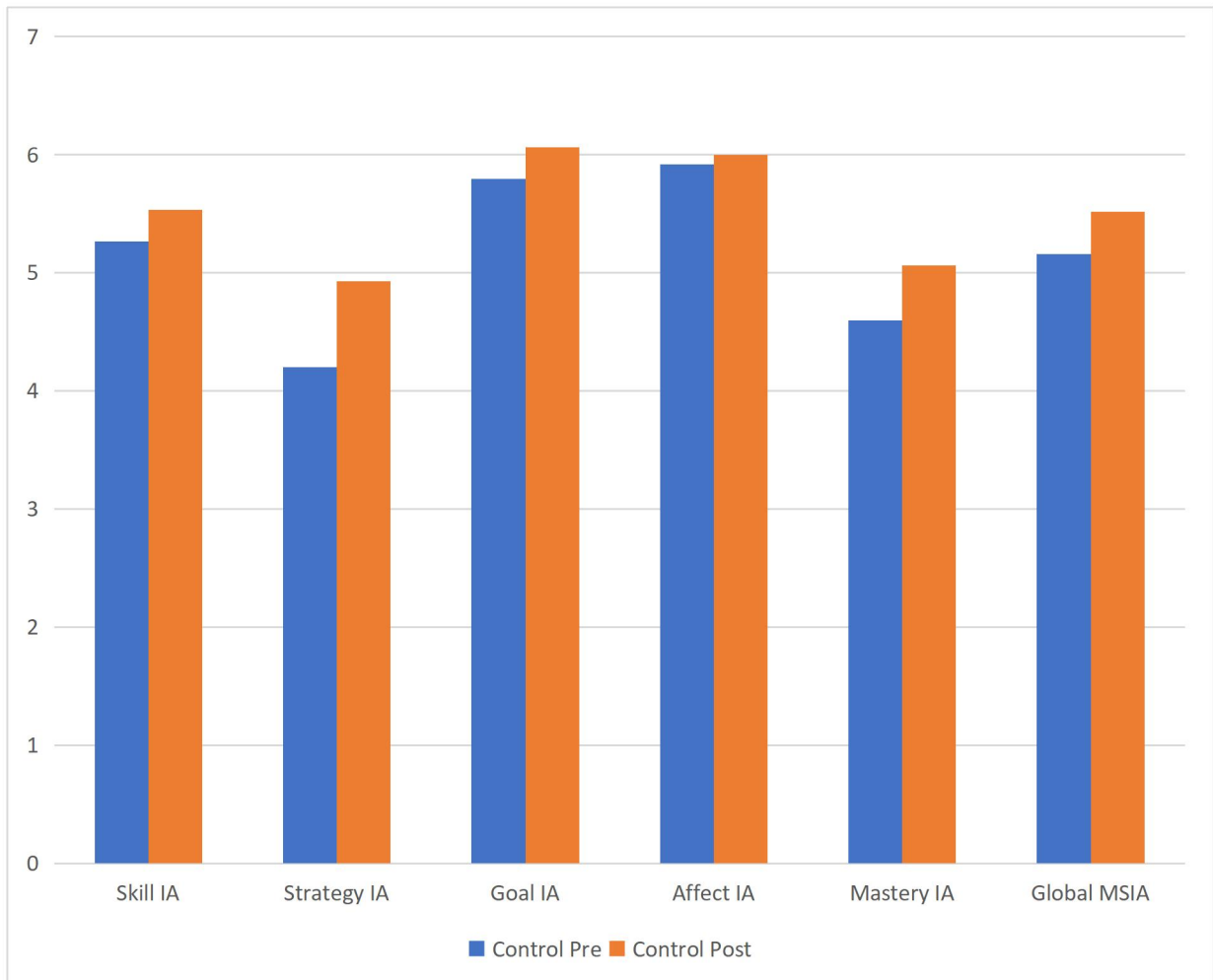
In terms of Sport Imagery Ability (Goal Imagery Ability) an increase was observed in the scores for the post-intervention assessment ($M = 6.062$, $SD = 0.723$) compared to the pre-intervention assessment ($M = 5.796$, $SD = 0.556$), $t(4) = -0.925$, $p = .407$, $d = -0.413$.

For the subscale of Sport Imagery Ability (Affect Imagery Ability), a slight increase was observed in the scores for the post-intervention assessment ($M = 5.998$, $SD = 0.852$) compared to the pre-intervention assessment ($M = 5.916$, $SD = 0.555$), $t(4) = -0.261$, $p = .806$, $d = -0.116$.

For the subscale of Sport Imagery Ability (Mastery Imagery Ability), an increase was observed in the scores for the post-intervention assessment ($M = 5.062$, $SD = 0.434$) compared to the pre-intervention assessment ($M = 4.596$, $SD = 1.141$), $t(4) = -0.810$, $p = .463$, $d = -0.362$.

Figure 4.2

Graph representing mean scores of sport imagery ability subscales for pre- and post-intervention for the control group



Note. Imagery Ability Subscales; Skill IA=Skill Imagery Ability; Strategy IA=Strategy Imagery Ability; Goal IA=Goal Imagery Ability; Affect IA=Affect Imagery Ability; Mastery IA=Mastery Imagery Ability.

Figure 4.2 portrays the graphical representation of the mean scores of pre and post-intervention of control group of all the subscales of sport imagery ability i.e., skill imagery ability, strategy imagery ability, goal imagery ability, affect imagery ability and mastery

imagery ability. The graph represents clear evidence of post-intervention control group mean scores are higher in all subscales.

Table 4.5

Independent samples t-test results for imagery ability subscales in the experimental group and control group post-intervention

Imagery Ability Subscales	Experimental Post		Control Post		<i>t</i> (8)	<i>p</i>	Cohen's <i>d</i>
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>			
Skill IA	6.464	0.607	5.530	0.902	1.920	.091	1.214
Strategy IA	6.064	0.642	4.930	0.760	2.545	.034	1.610
Goal IA	6.398	0.433	6.062	0.723	0.890	.399	0.563
Affect IA	6.264	0.496	5.998	0.852	0.603	.563	0.381
Mastery IA	5.796	0.731	5.062	0.434	1.929	.089	1.220
Global MSIA	6.198	0.317	5.516	0.542	2.424	.041*	1.533

Note. Imagery Ability Subscales; Skill IA=Skill Imagery Ability; Strategy IA=Strategy Imagery Ability; Goal IA=Goal Imagery Ability; Affect IA=Affect Imagery Ability; Mastery IA=Mastery Imagery Ability; Global MSIA = Global Measure of Sport Imagery Ability.

Each of the analyses is shown for the Experimental Group post-intervention ($n = 5$) and Control Group post-intervention ($n = 5$), as well as the results of *t*-tests (assuming equal variance) comparing the parameter estimates between the two groups.

Table 4.5 demonstrates the result attained from calculating the independent sample *t*-test that was conducted to compare the means between experimental and control groups with the respective variable subscales used for evaluation for the study purpose. This table presents the post-intervention comparison between the experimental and control groups across imagery ability subscales and the global measure of sport imagery ability.

In terms of the Imagery Ability (Skill Imagery Ability) subscale, the data obtained shows a slight increase in the mean scores between the experimental group ($M = 6.464$, $SD =$

0.607) and the control group ($M = 5.530$, $SD = 0.902$). The p-value obtained was not significant ($p > 0.05$), $t(8) = 1.920$, $p = .091$, $d = 1.214$.

There is a slight difference in the mean scores between the experimental group ($M = 6.064$, $SD = 0.642$) and the control group ($M = 4.930$, $SD = 0.760$) among the subscale of Imagery Ability (Strategy Imagery Ability). The p-value obtained was significant ($p < 0.05$), $p = .034$, $t(8) = 2.545$, $d = 1.610$.

In the case of the Imagery Ability (Goal Imagery Ability) subscale, a slight increase was observed between the experimental group ($M = 6.398$, $SD = 0.433$) and the control group ($M = 6.062$, $SD = 0.723$). The p-value obtained was not significant ($p > 0.05$), $t(8) = 0.890$, $p = .399$, $d = 0.563$.

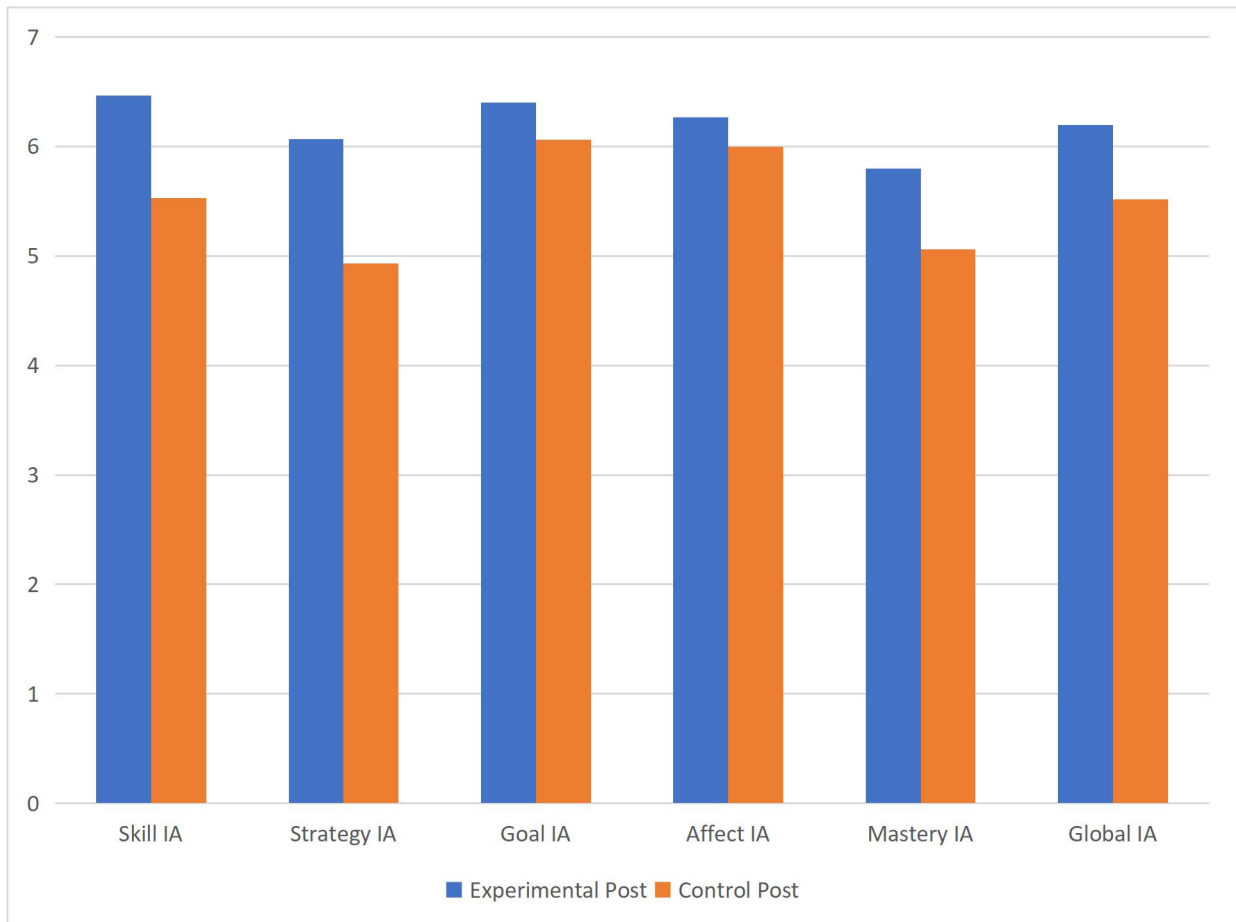
For the subscale of Imagery Ability (Affect Imagery Ability), comparing the means between the experimental group ($M = 6.264$, $SD = 0.496$) and control group ($M = 5.998$, $SD = 0.852$), no difference was found. The p-value obtained was not significant ($p > 0.05$) $t(8) = 0.603$, $p = .563$, $d = 0.381$.

There is a slight difference between the mean score of the experimental group ($M = 5.796$, $SD = 0.731$) and the control group ($M = 5.062$, $SD = 0.434$). The p-value obtained was not significant ($p > 0.05$), $t(8) = 1.929$, $p = .089$, $d = 1.220$ among the subscale of Imagery Ability (Mastery Imagery Ability).

Lastly, comparing means between the experimental group ($M = 6.198$, $SD = 0.317$) and control group ($M = 5.542$, $SD = 0.542$), there was an increase in the mean scores in global MSIA, and the p-value obtained was significant ($p < 0.05$), $p = .041^*$, $t(8) = 2.424$, $d = 1.533$.

Figure 4.3

Graph representing post-intervention mean values of sport imagery ability subscales for the experimental and control groups.



Note. Imagery Ability Subscales; Skill IA=Skill Imagery Ability; Strategy IA=Strategy Imagery Ability; Goal IA=Goal Imagery Ability; Affect IA=Affect Imagery Ability; Mastery IA=Mastery Imagery Ability.

Figure 4.3 portrays the graphical representation of the post-intervention mean scores of the experimental and control groups across all subscales of sport imagery ability and the global measure of sport imagery ability, i.e., Sports Imagery Ability (skill, strategy, goal, affect, mastery) and global measure of sport imagery ability. Following the intervention

program, the graph represents differences in the mean scores of the experimental and control groups across the imagery ability subscales and the global measure of sport imagery ability.

Discussion of Hypotheses

This section of the chapter is primarily focused on the discussions of the results obtained in the earlier sections. The hypothesis proposed in the first chapter of this research study will be discussed here, with respect to the results that were obtained through statistical analysis of the data. In the subsequent subsections, the hypotheses proposed earlier in this study have been stated, and under the statements, the discussion

based on findings is presented.

The assumed hypotheses for this study were:

- H1: It was assumed that perceptual-cognitive training would have an effect on imagery ability in pre- and post-intervention scores.
- H2: It was assumed that there would be a significant difference between the post-intervention scores of the control and experimental groups in terms of imagery ability.
- H3: It was expected that perceptual-cognitive training would have a significant effect size on the scores of imagery ability.

Effect of Perceptual Cognitive Training on Extent Subscales of Imagery Ability in Experimental and Control Groups Prior to and Post Intervention:

The aim of the present study was to examine the effect of perceptual-cognitive training on the imagery ability of athletes. Thus, this first section of the discussion of results will present the effect of perceptual-cognitive training on the extent of subscales of imagery ability and the global measure of sports imagery ability. The assessment was carried out using Neurotracker.

The extent to which various subscales of imagery ability are used in this study will give an understanding of the effect of perceptual-cognitive training in athletes. The subscales in imagery ability are:

1. Skill Imagery Ability
2. Strategy Imagery Ability
3. Goal Imagery Ability
4. Affect Imagery Ability
5. Mastery Imagery Ability

For each of these subscales, data was obtained using SIAQ on two separate occasions. For both the experimental and control group, the first assessment was taken before the start of the 5-week intervention plan for the experimental group. The data has been analyzed for baseline scores of all variables under consideration in this study to assess the scores prior to administering the intervention of both the control and experimental group. This course of action allowed for a better understanding of the effectiveness of the intervention program.

H1: It was expected that perceptual-cognitive training would have an effect on the imagery ability of athletes.

Based on the results that were obtained through the statistical analysis of the data, it was observed that a significant difference was indeed obtained for the imagery ability subscales Strategy IA (Strategy Imagery Ability), Goal IA (Goal Imagery Ability), Affect IA (Affect Imagery Ability) and also observed a significant difference in Global MSIA (Global Measure of Sport Imagery Ability) in the experimental group (refer table 4.3). However, there was no significant difference in the mean score for subscales Skill IA (Skill Imagery Ability) and Mastery IA (Mastery Imagery Ability) for the experimental group ($p > 0.05$). The obtained p-value is greater than 0.05 for these subscales which implies that the results obtained were not

statistically significant (refer table 4.3). However, it would be incorrect to say that the intervention plan was ineffective because a statistically significant result was not obtained in the study for some of the subscales. Since significant improvements were observed in strategy imagery ability, goal imagery ability, affect imagery ability, and the global measure of sport imagery ability within the experimental group, the first hypothesis was partially supported.

Effect of Perceptual Cognitive Training on Imagery Ability in Experimental and Control Group

Prior and Post Intervention:

Paired t-test was used to statistically calculate the data that were obtained from Sports Imagery Ability Questionnaire scores for the experimental and control group pre and post-intervention.

H2: It was expected that there would be a significant difference between the experimental and control group post-intervention on imagery ability.

Based on the post-intervention comparison between groups, significant differences were observed for Strategy Imagery Ability and the Global Measure of Sport Imagery Ability. No statistically significant between-group differences were observed for Skill Imagery Ability, Goal Imagery Ability, Affect Imagery Ability, or Mastery Imagery Ability. Therefore, the second hypothesis was partially supported. However, there was no significant difference in the mean score for subscales Skill IA (Skill Imagery Ability), Mastery IA (Mastery Imagery Ability), Goal IA (Goal Imagery Ability), and Affect IA (Affect Imagery Ability) for the experimental group and control group ($p > 0.05$). The obtained p-value is greater than 0.05 for these subscales which implies that the results obtained were not statistically significant (refer table 4.5). However, it would be incorrect to say that the intervention plan was ineffective

because a statistically significant result was not obtained in the study for some of the subscales. Since two of the subscales showed significant differences, the alternate hypothesis has been partially accepted.

H3: It was expected that cognitive training would have a large effect size on the scores of imagery ability.

Based on the results obtained (refer to Table 4.3) for the subscales of Strategy IA (Strategy Imagery Ability), Goal IA (Goal Imagery Ability), Affect IA (Affect Imagery Ability), and Global MSIA (Global Measure of Sport Imagery Ability) in the experimental group pre- and post-intervention, significant differences were found. Thus, the effect size was statistically analyzed using Cohen's d for the subscales, Strategy IA ($d = -1.603$), Goal IA ($d = -1.990$), Affect IA ($d = -1.647$) and Global MSIA ($d = -3.105$). Since $d > 0.8$ for the subscales, this indicates that there was a large effect size for the Perceptual Cognitive Training intervention. There was a large effect size for the subscales, Skill IA ($d = -1.146$) and Mastery IA ($d = -0.810$) even though there was no significant difference for these subscales. This result can be attributed to the small sample size of the study and the short duration of the intervention.

The third hypothesis has been partially accepted as there have been large effect sizes for the subscales of Strategy IA, Goal IA, Affect IA, and Global MSIA for experimental group pre and post-intervention.

Discussion of Findings

This study set out to find out how perceptual-cognitive training affected the imagery ability of athletes. The study had ten athletes who were randomized into experimental ($n = 5$) and control ($n = 5$) groups. While the experimental group received NeuroTracker-based perceptual-cognitive training, the control group participated in Quickboard training.

Imagery Ability:

- **Skill Imagery Ability:** There was an increase in skill imagery ability within the experimental group following the intervention. Although the improvement did not reach statistical significance, the observed effect size suggests the possibility of a meaningful practical change, indicating the impact of the perceptual cognitive training. After the intervention, participants in the experimental groups demonstrated notable improvements in their ability. This suggests that perceptual-cognitive training effectively enhances imagery skills.
- **Strategy Imagery Ability:** Following the intervention, the experimental group exhibited a significant difference in strategy skill imagery. The results show that participants in the experimental group improved their capacity to visualize and plan strategic actions more effectively than those in the control group. This significant difference underscores the beneficial impact of perceptual-cognitive training on enhancing strategy-related imagery skills.
- **Goal Imagery Ability:** After the intervention, a notable mean difference in goal imagery ability emerged among the experimental groups. This suggests that the perceptual-cognitive training effectively enhanced participants' capacity to mentally visualize and focus on achieving specific goals. Specifically, participants in the experimental group demonstrated significant improvements from pre- to post-intervention. However, post-intervention differences between the experimental and control groups were not statistically significant.
- **Affect Imagery Ability:** The intervention demonstrated a significant difference in affect imagery ability among the experimental groups. This highlights the impact of perceptual-cognitive training on enhancing participants' ability to vividly imagine and emotionally engage with scenarios related to their performance. The results indicate that the experimental group experienced notable improvements in affective imagery following the intervention, underscoring the potential value of perceptual-cognitive training in fostering emotional visualization skills.
- **Mastery Imagery Ability:** There was a slight increase in the mean mastery imagery ability observed among the experimental groups after the intervention. This suggests that participants in the experimental group showed some improvement in their ability to mentally visualize and achieve mastery in their performance domains. Although the increase was modest, it indicates a positive trend in enhancing mastery-oriented imagery skills through perceptual-cognitive training.

Global Measure of Sport Imagery Ability:

- The global measure of sport imagery ability showed a significant difference among the experimental groups following the intervention. This indicates that perceptual-cognitive training had a substantial impact on enhancing participants' overall ability to visualize and mentally simulate sport-related scenarios. The findings suggest that participants in the experimental group experienced marked improvements in their sport imagery skills compared to those in the control group, highlighting the effectiveness of the training program.

In summary, this study investigated the effects of a 5-week perceptual-cognitive training intervention on the imagery abilities of athletes. The results indicate significant improvements across various facets of imagery ability among participants in the experimental group compared to the control group. Specifically, perceptual-cognitive training was associated with improvements across several imagery domains, with significant improvements observed in strategy imagery ability, goal imagery ability, affect imagery ability, and the global measure of sport imagery ability within the experimental group. However, findings across subscales were mixed, and not all domains demonstrated statistically significant differences. Moreover, the global measure of sport imagery ability showed substantial improvement in the experimental group, underscoring the effectiveness of the training in enhancing overall visualization and mental simulation skills related to sports performance.

This conclusion summarizes the significant findings related to imagery ability following perceptual-cognitive training in athletes, highlighting the broad impact across different dimensions of mental imagery

Based on the research findings and discussions, it can be stated that:

- The first hypothesis was partially supported, as significant pre- to post-intervention improvements were observed in Strategy Imagery Ability, Goal Imagery Ability, Affect Imagery Ability, and the Global Measure of Sport Imagery Ability within the experimental group.

- The second hypothesis was partially supported, as significant post-intervention differences between the experimental and control groups were observed for Strategy Imagery Ability and the Global Measure of Sport Imagery Ability.
- The third hypothesis has been partially accepted as there have been large effect sizes for some of the subscales (Strategy IA, Goal IA, Affect IA, and Global MSIA) for the experimental group pre and post-intervention.

IV. CONCLUSION

The present study explored the effect of a 5-week NeuroTracker-based perceptual-cognitive training intervention on imagery ability among athletes. The findings provide preliminary evidence that perceptual-cognitive training may positively influence self-reported imagery ability, particularly strategy imagery ability and the global measure of sport imagery ability.

Significant improvements were observed in several imagery domains within the experimental group, although the pattern of findings was not consistent across all subscales. Skill imagery ability and mastery imagery ability did not demonstrate statistically significant changes, suggesting that the effects of the intervention may vary across different aspects of imagery ability.

Given the small sample size and exploratory nature of the study, the results should be interpreted with caution. Nevertheless, the findings suggest that perceptual-cognitive training may represent a promising approach for supporting imagery-related processes in athletes. Future research involving larger samples, longer intervention periods, and diverse athletic populations is recommended to further examine the relationship between perceptual-cognitive training and imagery ability.

Recommendations

In the light of the results, the following recommendations were made:

- The study may be taken further with a longer duration of the intervention program and a higher number of sessions to test whether significant results can be obtained with other subscales.
- Future studies may further examine the effects of perceptual-cognitive training on athletes' imagery ability.
- The current study has approached the use of Neurotracker, adaptive training program was used from the different programs offered. However, it is recommended that for future purposes, the use of core programs offered, which have more sessions and sections of perceptual-cognitive training, may be employed in the study to better understand the outcome of Imagery Abilities.
- The study may be conducted in the future with another set of Imagery ability variables that are expected to have a related relationship with the objectives of the different programs in Neurotracker.
- For future purposes, the study may be applied to samples from elite athletes for better understanding.

Abbreviations

Skill IA=Skill Imagery Ability; Strategy IA=Strategy Imagery Ability; Goal IA=Goal Imagery Ability; Affect IA=Affect Imagery Ability; Mastery IA=Mastery Imagery Ability.

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REFERENCES

- Alves, H., Voss, M. W., Boot, W. R., Deslandes, A., Cossich, V., Salles, J. I., & Kramer, A. F. (2013). Perceptual-cognitive expertise in elite volleyball players. *Frontiers in Psychology*, 4. <https://doi.org/10.3389/fpsyg.2013.00036>
- Bartolomeo, P. (2002). The relationship between visual perception and visual mental imagery: A Reappraisal of the Neuropsychological Evidence. *Cortex*, 38(3), 357–378. [https://doi.org/10.1016/S0010-9452\(08\)70665-8](https://doi.org/10.1016/S0010-9452(08)70665-8)
- Bartolomeo, P., Bachoud-Lévi, A.-C., De Gelder, B., Denes, G., Barba, G. D., Brugières, P., & Degos, J.-D. (1998). Multiple-domain dissociation between impaired visual perception and preserved mental imagery in a patient with bilateral extrastriate lesions. *Neuropsychologia*, 36(3), 239–249. [https://doi.org/10.1016/S0028-3932\(97\)00103-6](https://doi.org/10.1016/S0028-3932(97)00103-6)
- Blankert, T., & Hamstra, M. R. W. (2016). Imagining success: Multiple achievement goals and the effectiveness of imagery. *Basic and Applied Social Psychology*, 39(1), 60–67. <https://doi.org/10.1080/01973533.2016.1255947>
- Cavanagh, P., & Alvarez, G.A. (2005). Tracking multiple targets with multifocal attention. *Trends in Cognitive Sciences*, 9(7), 349–354. <https://doi.org/10.1016/j.tics.2005.05.009>
- Cumming, J., & Williams, S. E. (2015). The sport imagery ability questionnaire manual: *Journal of Sport and Exercise Psychology*, 33(3), 416–440. <https://doi.org/10.1123/jsep.33.3.416>
- Cumming, J., & Williams, S. E. (2013). Introducing the revised applied model of deliberate imagery use for sport, dance, exercise, and rehabilitation. *Movement & Sport Sciences*, 4, 69–81. <https://doi.org/10.1051/sm/2013098>
- Cumming, J., Hall, C., Harwood, C., & Gammage, K. (2002). Motivational orientations and imagery use: A goal profiling analysis. *Journal of Sports Sciences*, 20, 127–136. <https://doi.org/10.1080/026404102317200837>
- Di Corrado, D., Guarnera, M., Vitali, F., Quartiroli, A., and Coco, M. (2019). Imagery ability of elite level athletes from an individual vs. team and contact vs. non-contact sports. *PeerJ*. <https://doi.org/10.7717/peerj.6940>

- Farah, M. J. (1984). The neurological basis of mental imagery: A componential analysis. *Cognition*, 18(1-3), pp. 245–272. [https://doi.org/10.1016/0166-2236\(89\)90079-9](https://doi.org/10.1016/0166-2236(89)90079-9)
- Faubert, J. (2013). Professional athletes have extraordinary skills for rapidly learning complex and neutral dynamic visual scenes. *Scientific Reports*, 3(1), 1154. <https://doi.org/10.1038/srep01154>
- Faubert, J., & Sidebottom, L. (2012). Perceptual-cognitive training of athletes. *Journal of Clinical Sport Psychology*, 6(1), 85–102. <https://doi.org/10.1123/jcsp.6.1.85>
- Fougnie, D., & Marois, R. (2006). Distinct capacity limits for attention and working memory: Evidence from attentive tracking and visual working memory paradigms. *Psychological Science*, 17(6), 526–534. <https://doi.org/10.1111/j.1467-9280.2006.01739.x>
- Galton, F. (1880). Statistics of mental imagery. *Mind*, pp. 5, 301–318. <https://www.jstor.org/stable/2246391>
- Giacobbi, P. R. Jr., Buman, M. P., Dzierzewski, J. M., Aiken-Morgan, A. T., Roberts, B. L., Marsiske, M., ... McCrae, C. S. (2014). Content and perceived utility of mental Cumming and Eaves 15 imagery by older adults in a peer-delivered physical activity intervention. *Journal of Applied Sport Psychology*, 26, 129–143. <https://doi.org/10.1080/10413200.2013.803502>
- Hall, C. (2001). Imagery in sport and exercise. In R. Singer, H. Hausenblas, & C. Janelle (Eds.), *Handbook of sport psychology* (pp. 529–549). Wiley.
- Isaac, A. R. (1992). Mental practice: Does it work in the field? *The Sport Psychologist*, 6, pp. 192–198. <https://doi.org/10.1123/tsp.6.2.192>
- Jackson, R. C., Farrow, D., & Abernethy, B. (2006). Visual perception and action in sport. *International Journal of Sport and Exercise Psychology*, 4(2), 219–240.
- Komarudin, H., Yusuf & Novian, Geraldi & Foster, Nelson. (2021). Neurotracker training to improve shooting performance of archery athletes. *International journal of human movement and sports sciences*. 9. 66–70. doi:[10.13189/saj.2021.091311](https://doi.org/10.13189/saj.2021.091311)
- Kosslyn, S. M. (1980). *Image and mind*. Harvard University Press.
- Kosslyn, S. M. (1994). *Image and brain: The resolution of the imagery debate*. MIT Press.
- Kosslyn, S. M., Behrmann, M., & Jeannerod, M. (1995). The cognitive neuroscience of mental imagery. *Neuropsychologia*, 33, 1335–1344. [https://doi.org/10.1016/0028-3932\(95\)00067-D](https://doi.org/10.1016/0028-3932(95)00067-D)
- Kosslyn, S. M., Brunn, J., Cave, K. R., & Wallach, R. W. (1984). Individual differences in mental imagery ability: A computational analysis. *Cognition*, pp. 18, 195–243. [https://doi.org/10.1016/0010-0277\(84\)90025-8](https://doi.org/10.1016/0010-0277(84)90025-8)
- Kosslyn, S. M., Thompson, W. L., & Ganis, G. (2006). *The case for mental imagery*: Oxford University Press.

- Leopold, C., & Mayer, R. E. (2015). An imagination effect in learning from scientific text. *Journal of Educational Psychology*, 107(1), 47–63. <https://psycnet.apa.org/doi/10.1037/a0037142>
- Liu, K.P.Y., Lai, M., Fong, S. S. M., & Bisset, M. (2019). Imagery ability and imagery perspective preference: a study of their relationship and age and gender-related changes. *Behavioural Neurology*, 1-8. <https://doi.org/10.1155/2019/7536957>
- Mann, T. Y., Williams, A. M., Ward, P., & Janelle, C. (2007). Perceptual-cognitive expertise in sport: A meta-analysis. *Journal of Sport & Exercise Psychology*, pp. 29, 457–478. <https://doi.org/10.1123/jsep.29.4.457>
- Miyake, A., & Friedman, N. P. (2012). The nature and organization of individual differences in executive functions. *Four General Conclusions*, 21(1), 8–14. <https://doi.org/10.1177/0963721411429458>
- Moen, F., Hrozanova, M., & Stiles, T. (2018). The effects of perceptual-cognitive training with Neurotracker on executive brain functions among elite athletes. *Cogent Psychology*, 5(1), 1–13. <https://doi.org/10.1080/23311908.2018.1544105>
- Morris, T., Spittle, M., & Watt, A. P. (2005). *Imagery in Sport: Human Kinetics*.
- Pearson, J., Naselaris, T., Holmes, E. A., & Kosslyn, S. M. (2015). Mental imagery: Functional mechanisms and clinical applications. *Trends in Cognitive Sciences*, 19(10), 590–602. <https://doi.org/10.1016/j.tics.2015.08.003>
- Pylyshyn, Z. (1994). Some primitive mechanisms of spatial attention. *Cognition*, 50(1-3), pp. 363–384. [https://doi.org/10.1016/0010-0277\(94\)90036-1](https://doi.org/10.1016/0010-0277(94)90036-1)
- Rees, T., Hardy, L., Gu'lich, A., Abernethy, B., Co' te', J., Woodman, T., ... Warr, C. (2016). The Great British Medalists Project: A review of current knowledge on the development of the world's best sporting talent. *Sports Medicine*, 46, 1041–1058. <https://doi.org/10.1007/s40279-016-0476-2>
- Romeas, T., Guldner, A., & Faubert, J. (2016). 3D-Multiple Object Tracking training task improves passing decision-making accuracy in soccer players. *Psychology of Sport and Exercise*, 22, 1–9. <https://doi.org/10.1016/j.psychsport.2015.06.002>
- Romeas, T., Guldner, A., & Faubert, J. (2016). 3D-Multiple object tracking training task improves passing decision-making accuracy in soccer players. *Psychology of Sport and Exercise*, 22, 1–9. <https://doi.org/10.1016/j.psychsport.2015.06.002>
- Sari, I. (2015). An investigation of imagery, intrinsic motivation, self-efficacy and performance in athletes. *Anthropologist*. 20. 675–688. <https://doi.org/10.1080/09720073.2015.11891773>
- Simonsmeier, Bianca & Andronie, Melina & Buecker, Susanne & Frank, Cornelia. (2020). The effects of imagery interventions in sports: A meta-analysis. *International review of sport and exercise psychology*, 1-22. <https://doi.org/10.1080/1750984X.2020.1780627>

- Tobin, D., Munroe-Chandler, K. J., Hall, C. R., Guerrero, M. D., Shirazipour, C. H., & Cooke, L. M. (2017). Examining the relationship between children's active play imagery and basic psychological needs. *International Journal of Sport and Exercise Psychology*, pp. 15, 92–102. <https://doi.org/10.1080/1612197X.2015.1069875>
- Trick, L.M., Perl, T., & Sethi, N. (2005). Age-related differences in multiple-object tracking. *Journal of Gerontology Series B: Psychological Sciences*, 60(2), 102–105. <https://doi.org/10.1093/geronb/60.2.P102>
- Vaeyens, R., Lenoir, M., Williams, A.M., Mazyn, L., & Philippaerts, R.M. (2007). The effects of task constraints on visual search behavior and decision-making skill in youth soccer players. *Journal of Sport & Exercise Psychology*, 29(2), 147–169. <https://doi.org/10.1123/jsep.29.2.147>
- Vater, C., Williams, A. M., & Hossner, E.-J. (2020). What do we see out of the corner of our eye? The role of visual pivots and gaze anchors in sport. *International Review of Sport and Exercise Psychology*, 13(1), 81–103. <https://doi.org/10.1080/1750984X.2019.1582082>
- Vecchi, T. (2019). Imagery and imagination in psychological science. *Imagery Journal*, 1(1), 312–317. <https://doi.org/10.6092/issn.2724-2463/11078>
- White, A.R. (1990). The Language of Imagination, *ch.12*, Blackwell, pp.88–92.
- Williams, A. M., Davids, K., & Williams, J. G. (1999). *Visual perception and action in sport*. New York: Routledge.
- Williams, M.A. (2000). Perceptual skill in soccer: Implications for talent identification and development. *Journal of Sports Sciences*, 18(9), 737–750. <https://doi.org/10.1080/02640410050120113>
- Williams, M.A., & Davids, K. (1995). Declarative knowledge in sport: A by-product of experience or a characteristic of expertise? *Journal of Sport & Exercise Psychology*, 17(3), 259–275. doi: <https://doi.org/10.1123/jsep.17.3.259>
- Williams, M.A., Hodges, N.J., North, J.S., & Barton, G. (2006). Perceiving patterns of play in dynamic sports tasks: Investigating the essential information underlying skilled performance. *Perception*, 35(3), 317–332. <https://doi.org/10.1068/p5310>
- Williams, S. E. & Cumming, J. (2011). Measuring athlete imagery ability: The Sport Imagery Ability Questionnaire. *Journal of Sport & Exercise Psychology*, 33, 416–440. <https://doi.org/10.1123/jsep.33.3.416>
- Williams, S. E., Cooley, S. J., & Cumming, J. (2013). Layered stimulus response training improves motor imagery ability and movement execution. *Journal of Sport & Exercise Psychology*, 35(1), 60–71. <https://doi.org/10.1123/jsep.35.1.60>

Appendix A

Sport Imagery Ability Questionnaire

Instructions and Scoring

Instructions

Athletes are asked to image each item and then rate how easy they are able to image each scenario in relation to their sport.

Ratings are made on a 7-point Likert type scale ranging from 1 (very hard to image), to 7 (very easy to image). When validating the SIAQ we demonstrated that this rating is a combination of how well the athlete can see the image and how well the athlete can feel the image.

Scoring Information

We have validated the SIAQ to be scored in two different ways:

1. Separate subscales of imagery ability

Items are averaged to form five separate subscales as follows:

Skill imagery ability = Item 3 + Item 8 + Item 12 /3

Strategy imagery ability = Item 1 + Item 6 + Item 13 /3

Goal imagery ability = Item 5 + Item 9 + Item 14 /3

Affect imagery ability = Item 4 + Item 7 + Item 11 /3

Mastery Imagery Ability = Item 2 + Item 10 + Item 15 /3

2. Global measure of sport imagery ability

All 15 items are averaged to produce one score reflective of sport imagery ability as follows:

Global sport imagery ability = Item 1 + Item 2 + Item 3 + Item 4 + Item 5 + Item 6 + Item 7 + Item 8 + Item 9 + Item 10 + Item 11 + Item 12 + Item 13 + Item 14 + Item 15 / 15

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 B

Quickboard



Appendix C

Training Interface of Neurotracker

MOT is a task where spectators are approached to keep up with the attentional spotlight on a limited number of preselected subgroups of components in a unique scene where all components cooperate either by bouncing off one another or occluding each other.

