Chapter II

REVIEW OF RELATED LITERATURE

The research scholar has made his sincere efforts to locate the literature related to this study from the libraries of Jiwaji University, Gwalior, Lakshmibai National Institute of Physical Education, Gwalior, Institute of Professional Studies, Gwalior and internet, and have found some of the important research studies pertaining to the study undertaken, and all of which have been cited in this chapter.

Olsson et.al.1 undertook the study on the group of active high jumpers who were trained in an internal imagery program for a total of 72 minutes. The second group also consisted of active high jumpers but instead of being trained in the mental imagery program, they simply maintained their normal workout schedule for the same six weeks. The two groups skill level was kept as even as possible by randomly assigning individuals to each group. There were four measured variables namely number of failed attempts, take-off angle, jumping height, and bar clearance. The results of the study revealed that there was noticeable improvement on bar clearance for the group which had under some imagery program and there was no change found in the control group. It was concluded that the use of imagery and imagery training can be used to improve the performance of a specific motor skill (Olsson, 2008). There is a chance of slight bias in the conclusion due to the fact that only the bar clearance measurements improved. However, because those improved by a significant amount, the conclusion that the mental imagery was the cause

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of it is most likely correct. In order to make this experiment more valid, the test could be done for multiple times.

Fontani and Migliorini\textsuperscript{2} undertook study on effect of mental imagery on the development of skilled motor actions. To test the effect of imagery in the training of skilled movements, an experiment was designed in which athletes learned a new motor action and trained themselves for a month either by overt action or by mental imagery of the action. The experiment was carried out with 30 male karate players (M age = 35 yr., SD = 8.7; M years of practice = 6, SD = 3) instructed to perform an action (Ura-Shuto-Uchi) that they had not previously learned. The athletes were divided into three groups: Untrained (10 subjects who did not perform any training), Action Trained (10 subjects who performed Ura-Shuto-Uchi training daily for 16 minutes), and Mental Imagery (10 subjects who performed mental imagery training of Ura-Shuto-Uchi daily for 16 minutes). The subjects were tested five times, once every 7 days. During each test, they performed a series of 60 motor action trials. In Tests 1, 3, and 5, they also performed a series of 60 mental imagery trials. During the trials, an electroencephalogram (EEG), electromyography (EMG), muscle strength and power, and other physiological parameters were recorded. The untrained subjects did not show significant effects. In the Action Trained group, training had an effect on reactivity and movement speed, with a reduction of EMG activation and reaction times. The muscle strength, power, and work increased significantly. The Mental Imagery group showed the same effects on muscle strength, power, and work, but changes in reactivity were not observed. In the Mental Imagery group, the study of movement related brain macro potentials indicated a progressive modification of the profile of the waves

from Test 1 to Test 5 during imagery, showing significant variations of the amplitude of the waves related to the pre motor and motor execution periods. The results showed that motor imagery can influence muscular abilities such as strength and power and can modify movement related brain macro potentials, the profile of which potentially could be used to verify the effectiveness of motor imagery training.

**Louis and Guillot** ³ investigated the effect of changing Motor Imagined speed on actual movement duration over a 3-week training period. The experiment 1 involved 2 series of body movements that is faster or slower than their actual execution speeds on 24 participants. The fast MI group's actual times decreased on subsequent performance. The participants in Experiment 2 were 21 skilled athletes who increased (decreased) their well-rehearsed actual movement times after MI training at a slow (fast) speed. The effect was task-related, however: MI affected only self-initiated movement. The effect of MI on actual speed execution supports the ideomotor theory because anticipation of sensory consequences of actions is mentally represented.

**Gentili et. al.**⁴ undertook study to compare the improvement and generalization of arm motor performance after physical or mental training in a motor task requiring a speed-accuracy tradeoff. During the pre- and post-training sessions, 40 subjects pointed with their right arm as accurately and as fast as possible toward targets placed in the frontal plane. The arm movements were performed in two different workspaces


called right and left paths. During the training sessions, which included only the right path, subjects were divided into four training groups (n = 10): (i) the physical group, subjects overtly performed the task; (ii) the mental group, subjects imagined themselves performing the task; (iii) the active control group, subjects performed eye movements through the targets, (iv) the passive control group, subjects did not receive any specific training. They recorded movement duration, peak acceleration and electromyographic signals from arm muscles. The findings showed that after both physical and mental training on the right path (training path), hand movement duration and peak acceleration respectively decreased and increased for this path. However, motor performance improvement was greater after physical compared with mental practice. Interestingly, we also observed a partial learning generalization, namely an enhancement of motor performance for the left path (non-training path). The amount of this generalization was roughly similar for the physical and mental groups. Furthermore, while arm muscle activity progressively increased during the training period for the physical group, the activity of the same muscles for the mental group was unchanged and comparable with that of the rest condition. Control groups did not exhibit any improvement. These findings put forward the idea that mental training facilitates motor learning and allows its partial transfer to nearby workspaces. They further suggest that motor prediction, a common process during both actual and imagined movements, is a fundamental operation for both sensorimotor control and learning.

Bakker et al.\textsuperscript{5} undertook study on Motor imagery (MI) is widely used to study cognitive aspects of the neural control of action. Prior

studies were mostly centered on hand and arm movements. Recently a few studies have used imagery tasks to explore the neurophysiology of human gait, but it remains unclear how to ascertain whether subjects actually perform imagery of gait as requested. Here we describe a new experimental protocol to quantify imagery of gait, by behaviorally distinguishing it from visual imagery (VI) processes and by showing its temporal correspondence with actual gait. Fourteen young healthy subjects performed two imagery tasks and an actual walking (AW) task. During both imagery tasks subjects were sitting on a chair and faced a computer screen that presented photographs of walking trajectories. During one task (MI), subjects had to imagine walking along the walking trajectory. During the other task (VI), subjects had to imagine seeing a disc moving along the walking trajectory. During the AW task, subjects had to physically walk along the same walking trajectory as presented on the photographs during the imagery tasks. They manipulated movement distance by changing the length of the walking trajectory, and movement difficulty by changing the width of the walking trajectory. The subjects reported onset and offset of both actual and imagined movements with a button press. The time between the two button presses was taken as the imagined or actual movement time (MT). MT increased with increasing path length and decreasing path width in all three tasks. Crucially, the effect of path width on MT was significantly stronger during MI and AW than during VI. The results demonstrate a high temporal correspondence between imagined and AW, suggesting that MI taps into similar cerebral resources as those used during actual gait. These results open the possibility of using this protocol for exploring neurophysiological correlates of gait control in humans.
Saimpont and Lafleur\textsuperscript{6} undertook study on the effect of Motor Imagery training and Verbal Rehearsal on the learning and retention of a foot-sequence task. Thirty right-footed subjects, aged between 22 and 37 years old (mean: 27.4 ± 4.1 years) and randomly assigned to one of three groups, practiced a serial reaction time task involving a sequence of three dorsi flexions and three plantar flexions with the left foot. One group (n = 10) mentally practiced the sequence with MI for 5 weeks, another group (n = 10) mentally practiced the sequence with VR of the foot positions for the same duration, and a control group (n = 10) did not practice the sequence mentally. The time to perform the practiced sequence as well as an unpracticed sequence was recorded before training, immediately after training and 6 months after training (retention). The main results showed that the speed improvement after training was significantly greater in the MI group compared to the control group and tended to be greater in the VR group compared to the control group. The improvement in performance did not differ in the MI and VR groups. At retention, however, no difference in response times was found among the three groups, indicating that the effect of mental practice did not last over a long period without training. Interestingly, this pattern of results was similar for the practiced and non-practiced sequence. Overall, these results suggest that both MI training and VR help to improve motor performance and that mental practice may induce non-specific effects.

Chang et al\textsuperscript{7} compared the activation maps of elite archers and nonarchers during mental rehearsal of archery to test whether the neural


\textsuperscript{7} Chang Y., Lee J.J. and Seo J.H., “Neural Correlates of Motor Imagery for Elite Archers”, \textit{NMR Biomedicine}. 2011 May;24(4):pp.366-72
correlates of elite archers were more focused and efficiently organized than those of nonarchers. Brain activation was measured using functional MRI in 18 right-handed elite archers and 18 right-handed nonarchers. During the active functional MRI imagery task, the participants were instructed to mentally rehearse their archery shooting from a first-person perspective. The active imagery condition was tested against the nonmotor imagery task as a control condition. The results showed that the pre motor and supplementary motor areas, and the inferior frontal region, basal ganglia and cerebellum, were active in nonarchers, whereas elite archers showed activation primarily in the supplementary motor areas. The result of higher cerebellar activity in nonarchers indicated the increased participation of the cerebellum in nonarchers when learning an unfamiliar archery task. Therefore, the difference in cerebellar activation between archers and nonarchers provides evidence of the expertise effect in the mental rehearsal of archery. In conclusion, the relative economy in the cortical processes of elite archers could contribute to greater consistency in performing the specific challenge in which they are highly practiced.

Ross et.al.\textsuperscript{8} undertook study on functional MR imaging during a control condition and during mental imagery of their golf swing. Two control conditions were evaluated--"rest" and "wall"--and were then subtracted from the experimental condition to give the functional activation map. These control conditions were then tested against the golf imagery; the participants were told to mentally rehearse their golf swings from a first person perspective. The percentages of activated pixels

in 137 defined regions of interest were calculated. The "rest-versus-golf" paradigm showed activation in motor cortex, parietal cortex, frontal lobe, cerebellum, vermis, and action planning areas (frontal and parietal cortices, supplementary motor area, cerebellum) and areas involved with error detection (cerebellum). Vermis, supplementary motor area, cerebellum, and motor regions generally showed the greatest activation. Little activation was seen in the cingulate gyrus, right temporal lobe, deep gray matter, and brain stem. A correlation existed between increased number of areas of activation and increased handicap. This study showed the feasibility of defining areas of brain activation during imagery of a complex, coordinated motor task. Decreased brain activation occurred with increased golf skill level for the supplementary motor area and cerebellum with little activation of basal ganglia.

Seif-Barghi et al.\textsuperscript{9}, undertook study on the effects of an imagery training on passing improvement in elite soccer players. Sixty nine soccer players taking part in the national championship leagues in four age categories including U16, U19, U21 and over 21 were randomly assigned to the imagery and control groups. Interventional group participants completed an 8 week video-aided, cognitive imagery program on how to make a perfect soccer pass. The performance analysis through close video analysis showed that successful pass rate increased significantly in the intervention group compared to control (OR = 1.19, P=0.002, (95%)CI = 1.06-1.33). Further analysis revealed that the results are statistically significant in U16 and U21 but not other categories. They concluded that successful soccer passing through real competitions as a

multidimensional and critical open skill could be enhanced by an ecologically sound method of mental imagery.

**Blair et. al.**\(^{10}\) undertook study on the effect of an imagery training programme on the performance of a soccer task by skilled and novice players. An initial assessment of performance on the soccer task was undertaken, and then 22 skilled and 22 novice players were equally and randomly assigned to either a control or an experimental group. The experimental group was given an imagery training programme consisting of both visual and kinesthetic imagery, and in which both internal and external imagery perspectives were included. The programme lasted 6 weeks, with the subjects attending bi-weekly sessions of approximately 15 min each. The control group developed a competitive strategy that was totally unrelated to the performance task. Similar to the experimental group, the controls did this over a 6-week period, attending bi-weekly sessions of 15 min duration. Two performance measures were recorded—response time (i.e. the time to complete the soccer task) and performance accuracy (i.e. errors in performing the soccer task recorded in the form of time penalties). Performance on the post-test as measured by response time revealed a significant improvement for both the skilled and novice players in the imagery group. The control group failed to show any such improvement. No effects were found for performance accuracy.

**Sarafrazi et. al.**\(^{11}\) investigated the effect of imagery on knee and hip flexion angle during jump landing in women. The landing motions were captured from 40 female physical education students (height: 166.05


± 7.52 cm; mass: 55.75 ± 9.23 kg; age: 20.45 ± 1.66 years) using a 3-dimensional technique at 60 Hz by 3 video cameras. There was a significant difference between no imagery (27.04 ± 2.40°) and imagery (22.98 ± 1.95°) on knee valgus angle, and also, there was a significant difference between no imagery (44.88 ± 13.46°) and imagery (62.35 ± 8.34°) on the knee flexion angle (p ≤ 0.001). There is, in addition, a significant difference between the effect of no imagery (28.60 ± 4.88°) and imagery (39.73 ± 7.29°) on hip flexion angle (p ≤ 0.001). It seems that imagery can be used to correct motions and movements. It was concluded that imagery, probably, can be used as a training strategy to change athletic motion; however, the authors suggest further investigation into the efficacy of imagery in the prevention of anterior cruciate ligament injury be investigated.

Schuster et al.12 The aim of this review was to identify the characteristics of a successful Motor Imagery Training Session (MITS) and compare these for different disciplines, Motor Imagery (MI) session types, task focus, age, gender and MI modification during intervention. An extended systematic literature search using 24 databases was performed for five disciplines: Education, Medicine, Music, Psychology and Sports. References that described an MI intervention that focused on motor skills, performance or strength improvement were included. Information describing 17 MITS elements was extracted based on the PETTLEP (physical, environment, timing, task, learning, emotion, perspective) approach. Seven elements describing the MITS temporal parameters were calculated: study duration, intervention duration, MITS duration, total MITS count, MITS per week, MI trials per MITS and total MI training time.

Both independent reviewers found 96% congruity, which was tested on a random sample of 20% of all references. After selection, 133 studies reporting 141 MI interventions were included. The locations of the MITS and position of the participants during MI were task-specific. Participants received acoustic detailed MI instructions, which were mostly standardized and live. During MI practice, participants kept their eyes closed. MI training was performed from an internal perspective with a kinesthetic mode. Changes in MI content, duration and dosage were reported in 31 MI interventions. Familiarization sessions before the start of the MI intervention were mentioned in 17 reports. MI interventions focused with decreasing relevance on motor-, cognitive- and strength-focused tasks. Average study intervention lasted 34 days, with participants practicing MI on average three times per week for 17 minutes, with 34 MI trials. Average total MI time was 178 minutes including 13 MITS. Reporting rate varied between 25.5% and 95.5%. MITS elements of successful interventions were individual, supervised and non-directed sessions, added after physical practice. Successful design characteristics were dominant in the Psychology literature, in interventions focusing on motor and strength-related tasks, in interventions with participants aged 20 to 29 years old, and in MI interventions including participants of both genders. Systematic searching of the MI literature was constrained by the lack of a defined MI term.

Warner and McNeill\textsuperscript{13} reviewed the mental imagery and the potential for physical therapy and to explore the feasibility of using them as adjunctive techniques in physical therapy. In the area of sports, evidence exists that mental practice can improve motor skills. Research that supports a mind-body relationship is cited, in addition to research

using mental imagery from the areas of medicine, biofeedback, psychoneuro immunology, and physical therapy. Variables that influence the outcome of mental practice such as vividness, kinesthetic imagery, and combining physical and mental practice are examined, and two major variables associated with ineffective results are identified. The advantages and disadvantages of using mental imagery for physical therapy patients are discussed with the conclusion that mental imagery has the potential to be a viable technique for physical therapists.

**Denis**\(^{14}\) reviewed mental imagery and its potential for physical therapy with special emphasis on works investigating the role of visual imagery in this type of learning technique. Relevant properties of images and conditions required for their effectiveness in mental practice of motor skills are analyzed in the light of empirical evidence. The paper examines the specific question of individual imagery differences in mental practice research. Finally, implications for future research are discussed as regards the impact of certain kinds of physical training on mental imagery.

**Ziv and Lidor**\(^{15}\) reviewed psychological preparation of competitive judokas was to review a series of studies (n = 18) on psychological preparation of competitive judokas. These studies were grouped according to the type of study performed - observational, experimental, and case studies. In addition, five psychological categories were identified: (a) imagery, (b) motivation, (c) stress, anxiety, and mood states, (d) eating attitudes and weight control, and (e) coach/athlete interactions. The main findings of this review are that (a) there is a lack of data regarding the use of imagery to improve judo performance; (b) goal involvement states of

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competitive judokas fluctuate and undergo abrupt changes during actual combat, according to the ecological constraints of the situation; (c) cortisol levels and somatic and cognitive anxiety tend to increase prior to and during a judo combat; (d) weight reduction programs that judokas undergo prior to a judo combat can lead to unpleasant moods, and cultural differences can lead to conflicting results; (e) psychological preparation plans should be tailored to each individual judoka, as there can be significant individual differences among the judokas. Based on the findings of our review, a number of research limitations and methodological concerns are discussed. Key Points This article reviews a series of studies (n = 18) examining psychological aspects of judokas who compete at the intermediate level, national team level, and international level, and who hold international titles. Weight reduction programs that judokas undergo prior to a judo combat can lead to unpleasant moods. Psychological preparation plans should be tailored to each individual judoka, as there can be significant individual differences among competitive judokas. An effort should be made to conduct experimental-designed studies in order to assess the effectiveness of psychological interventions in judo.

Guillot et. al.\textsuperscript{16} conducted a study to investigate motor imagery contribution to enhance tennis serve performance. Twelve high-level young tennis players were included in a test-retest procedure. The effects of regular training were first evaluated. Then, players were subjected to a MI intervention during which they mentally focused on ball trajectory and specifically visualized the space above the net where the serve can be successfully hit. Serve performance was evaluated during both a validated serve test and a real match. The main results showed a significant increase

in accuracy and velocity during the ecological serve test after MI practice, as well as a significant improvement in successful first serves and won points during the match. Present data therefore confirmed the efficacy of MI in combination of physical practice to improve tennis serve performance, and further provided evidence that it is feasible to adopt external attentional focus during MI. The key Points of Motor imagery contributes to enhance tennis serve performance. The data provided evidence of the benefits of adopting an external focus of attention during imagery. The results showed significant improvement in successful first serves and won points during a real match.

Kizildag and Tiryaki 17 conducted a study to compare use of imagery in elite male and female athletes in open and closed and individual or team sports. A total of 151 elite Turkish athletes ages 15 to 29 years old (males' M age=20.7 yr., SD=3.3; females' M age=20.0 yr., SD=3.5) from open-team sports (n=66), open-individual sports (n=26), and closed-individual sports (n=59) completed the sport imagery questionnaire. A significant multivariate effect of sport type was found. Univariate analyses indicated that male and female athletes in team open-skill sports and individual closed-skill sports used more motivational general-mastery imagery than did athletes in individual open-skill sports.

Roberts et.al.18 examined two studies on the interactive effects of different visual imagery perspectives and narcissism on motor performance. In both studies participants completed the Narcissistic Personality Inventory (NPI-40: Raskin & Hall, 1979) and were assigned to

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either an internal visual imagery or external visual imagery group. Participants then performed a motor task (dart throwing in Study 1 and golf putting in Study 2) under conditions of practice, low self-enhancement, and high self-enhancement. Following completion of the respective tasks, participants were categorized into high and low narcissistic groups based on their NPI-40 scores. In both studies, high narcissists using external visual imagery significantly improved performance from the low to the high self-enhancement condition, whereas high narcissists using internal visual imagery did not. Low narcissists remained relatively constant in performance across self-enhancement conditions, regardless of perspective. The results highlighted the importance of considering personality characteristics when examining the effects of visual imagery perspectives on performance.

**Toussaint and Blandin** 19 examined specifically how the sensory conditions available during physical practice of a task might influence the subsequent use of motor imagery. First, as a pre-test, participants had to physically reproduce knee joint positions with or without vision. Second, they practiced motor imagery (15 and 150 trials) with visual, kinesthetic or visuo-kinesthetic imagery. A control group with no imagery was included. Post-tests were then performed 10 min and 24 h after each imagery session in a sensory condition similar to that used in the pre-test. The results showed that efficient motor imagery instructions have to take account of the sensory information available during physical experience of the task: kinesthetic or visuo-kinesthetic imagery in a no-vision condition, and visual imagery or, to a lesser extent, visuo-kinesthetic imagery in a vision condition.

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Olsson and Nyberg investigated that since long, motor imagery has been recognized as a method for studying motor representations. In the last few years, important advances regarding the use of motor imagery have been made. In particular, issues concerning the functional equivalence between imagery and action have been addressed, and how equivalence affects the use of imagery to study motor representations. In this paper, we review recent findings in order to highlight the current state of knowledge about motor imagery and its relation to motor action. Three topics are discussed: (i) the imagery perspective, (ii) task complexity, and (iii) the importance of physical experience. It is shown how these factors are closely related and how previous studies may have underestimated to what extent these factors affect the interpretation of results. Practical implications for imagery interventions are considered. It is concluded that if you cannot perform an action physically, you cannot imagine it in a way that is necessary for a high degree of functional equivalence.

Wei and Luo conducted study on kinesthetic imagery task to induce the mental representation of sport expert’s extraordinary performance in view of the shared substrates of executing movement and motor imagery. For the first time, we compared, through functional magnetic resonance imaging (fMRI), the pattern of cerebral activations in 12 professional divers and 12 normal people without extensive training, during imagery of professional skills and imagery of simple motor skills. The sport experts showed significant activation in the parahippocampus during imagery of professional skills relative to the novices, which might


reflect the representation adapted to experience-related motor tasks. No significant difference was found between experts and novices when they imagined simple motor skills. These results indicated the experts might utilize their kinesthetic imagery more efficiently than novices, but only for the activity in which they had expertise. The sport experts also demonstrated more focused activation patterns in prefrontal areas in both of imagery tasks, which may be relevant to higher order of motor control during motor imagery. Moreover, this study suggested that the brains of sport experts could be regarded as the ideal subjects to explore the relationship between cerebral plasticity and learning of complex motor skills.

Adegbesan 22 examined Five types of imagery used by 188 Nigerian athletes in track and field, soccer, and table tennis were examined using the Sport Imagery Questionnaire [ age for men 24.7 yr. (SD=3.6) and for women 23.3 yr. (SD=3.4)] to assess whether these participants differed in their use of imagery. Significant differences were noted for the three sports on subscales of Cognitive General, Motivational Specific, Motivation General-Mastery, and Motivation General-Arousal, while moderate to strong positive correlations were identified among scores on imagery subscales, especially Motivation General-Mastery and Motivation General-Arousal. Cronbach alpha for the questionnaire was suitable for all subscales but one.

Hall et.al. 23 investigated 345 athletes’ (male = 152, female = 193) use of observational learning and imagery for practice and at competition

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and how this related to sport confidence. The Functions of Observational Learning Questionnaire (Cumming et al., 2005), the Sport Imagery Questionnaire (Hall et al., 1998), and the Trait Sport Confidence Inventory (Vealey, 1986) were contextualized by asking participants to rate each item twice, once for practice and once for competition. The athletes reported using each of the different functions of observational learning and imagery in these situations, but the pattern of use differed. Whereas nearly all of the imagery functions were more frequently used at competition, the majority of observational learning functions were used more for practice. Cognitive specific and motivational general-mastery imagery were significant predictors of sport confidence in practice and competition, whereas the skill function of observational learning significantly predicted practice confidence only.

**Shoenfelt and Griffith**\(^{24}\) undertook study on the preseason mental skills program for serving was implemented for the 11 members of an intercollegiate volleyball team (M age = 20.0 yr.; SD = 1.1; years of intercollegiate volleyball experience M = 2.6; SD = 0.9). The key mental skills taught were relaxation, imagery, attentional focus, goal setting, behavioral modeling, and performance routine. A videotaped behavioral model articulated and demonstrated technical performance keys to effective serving. Players utilized a three-phase service routine to increase automaticity of performance and to incorporate key mental skills. End-of-season reported use of imagery was significantly correlated with Good Serve Percentage, as was reported use of a service routine. The mean Good Serve Percentage for the season was 49% (SD=7); the team goal was 50%. Serve-specific self-efficacy significantly increased from the pre training program to the end of the season. The results indicated that implementing

the mental skills training program was associated with enhanced service performance

**Munroe-Chandler et. al.**\(^{25}\) examined the relationship between imagery use and confidence in soccer (football) players. The participants included 122 male and female soccer athletes ages 11-14 years participating in both house/recreation (n = 72) and travel/competitive (n = 50) levels. Athletes completed three questionnaires; one measuring the frequency of imagery use, one assessing generalized self-confidence, and one assessing self-efficacy in soccer. A series of regression analyses found that Motivational General-Mastery (MG-M) imagery was a significant predictor of self-confidence and self-efficacy in both recreational and competitive youth soccer players. More specifically, MG-M imagery accounted for between 40 and 57% of the variance for both self-confidence and self-efficacy with two other functions (MG-A and MS) contributing marginally in the self-confidence regression for recreational athletes. These findings suggest that if a youth athlete, regardless of competitive level, wants to increase his/her self-confidence or self-efficacy through the use of imagery, the MG-M function should be emphasized.

**Fourkas**\(^{26}\) examined specific physical or mental practice may induce short- and long-term neuroplastic changes in the motor system and cause tools to become part of one’s own body representation. Athletes who use tools as part of their practice may be an excellent model for assessing the neural correlates of possible bodily representation changes that are

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\(^{26}\) Fourkas, "Kinesthetic Imagery and Tool-Specific Modulation of Corticospinal Representations in Expert Tennis Players,* Cerebral Cortex*, 2008 Oct;18(10):2382-90
specific to extensive practice. We used single-pulse transcranial magnetic stimulation to measure corticospinal excitability in forearm and hand muscles of expert tennis players and novices while they mentally practiced a tennis forehand, table tennis forehand, and a golf drive. The muscles of expert tennis players showed increased corticospinal facilitation during motor imagery of tennis but not golf or table tennis. Novices, although athletes, were not modulated across sports. Subjective reports indicated that only in the tennis imagery condition did experts differ from novices in the ability to form proprioceptive images and to consider the tool as an extension of the hand. Neurophysiological and subjective data converge to suggest a key role of long-term experience in modulating sensorimotor body representations during mental simulation of sports.

Laguna27 studied one hundred right handed participants who were randomly assigned to one of four model demonstration / physical practice treatment groups or a no "model demonstration control group to examine the observation to physical practice ratio for optional facilitation during acquisition and performance of a complex motor task. Each group was exposed to total of sixteen-model demonstration and / or physical practice combination with no KR or KP. Cognitive representation was assessed using a recognition test, a pictorial arrangement test and a temporal timing test. The cognitive representation assessment was given five times over the course of acquisition and performance. Performance accuracy was assessed using special and temporal accuracy. - Results indicated that the groups exposed to model demonstrating were superior in both cognitive representation scores (Special and temporal) than the control group. More specifically, the temporal cognitive representation

assessment scores were highest than physical practice, while the special
cognitive representation assessment scores were highest in groups with
equal or more physical practice than model demonstration observations
and facilitate both spatial and temporal components of motor skills, the
model demonstrating appear to have a greater influence on the timing
aspects while physical practice has a greater influence on the spatial aspects.

**Hordy and Collen**\(^{28}\) examined the relative efficacy of different
imagery perspective on the performance of tasks. In experiment, 25
experienced Karateists learned a new kata using either external or internal
visual imagery or stretching. Results indicated that external visual
imagery was significantly more effective than stretching. In experiment two,
40 sport science students learned a simple gymnastics floor routine under
one of four conditions, external or internal visual imagery with or without
kinesthetic imagery. Results revealed a significant main effect for visual
imagery perspective (external visual imagery was best) but no effect
for kinesthetic imagery. Experiment-3 employed the same paradigm as
experiment-2 but with high ability rock climbers performing difficult
boulder problems results showed significant main effects for both visual
imagery perspective (external imagery was best) and kinesthetic imagery.

**Bohen, Pharmer and Stokes**\(^{29}\) studied, at what point in the learning
process does imagery have the greatest effect on motor performance? This
question was addressed in an experiment that controlled for both the
amount of imagery practice and the amount of physical practice on a

\(^{28}\) Lew Hordy and Nichola Callon, "Efficacy of External and Internal Visual Imagery
Perspective for The Enhancement of Performance on Tasks in Which Form is

\(^{29}\) Bohan, Pharmer and Stokes., "When does Imagery Practice Enhance Performance a
Motor Task? Perceptual and Motor Skill", *Journal of Sport and Exercise Psychology*,
novel motor task. Participants (N=30) completed one of three levels of physical practice on a manual aiming task: none (early learning condition) 20 trials intermediate learning condition), or 40 trials (late learning condition). After the physical practice, task performance was measured in a 10 trial pretest, all participants then performed 20 trials of imagery practice before completing 10 trials post test analysis indicated that only the early learning and intermediate learning conditions had significant performance improvement after imagery rehearsal. The early learning group made the greatest improvements. It is interesting that although the early learning group performed worse than the other groups did on the pretest, they performed just, as well as on the posttest. Apparently 20 trials of imagery practice made up for the absence of physical practice. These results suggest that imagery is most beneficial during the early stages of learning and that under certain conditions (novel tasks with well rehearsed and easily transferred underlying motor skill components), imagery rehearsal might be sufficient to enhance motor performance with little or no additional physical practice. The authors caution, however that those results might not generalize to more complex motor tasks.

Burke studied to identify which types of performance enhancement strategies were employed most frequently by 115 professional tennis players who completed in the 1992 Lipton Tennis Tournament. A 13 — item questionnaire revealed that the most common strategies used by the tennis players were (imagery / visualization, using a consistent pre—service or pre service return preparatory routine (i.e., mental preparation), relaxation, goal setting and self talk the players felt that their motivations to complete, maintain concentration throughout a match, and self confidence affected their performance considerably

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self confidence and for behavior effected the performance of female
tennis players more than male tennis players. Higher ranked
professionals attributed significantly more of their performance to
psychological variables then lower ranked players. The professional
athletes suggested that either a coach or sport psychologist should
teach and be responsible for educating athletes to use performance
enhancement strategies.

Palmer and Shawna\textsuperscript{31} investigated the influence of two distinct
mental practice techniques on figure skating performance. Twelve pre
novice and novice level competitive figure skaters each performed two
figures, which were assessed as a pre treatment measure. In phase I the
subjects were assigned to one of three groups. Martin self talk
technique, paper patch technique, or a no treatment control group.
Following a 4 — week period of using the assigned technique a second
performance assessment revealed no significant differences between the
reaction group and the control group, while the paper patch group
showed significant improvements over both. In phase 2 a multiple
comparison across subjects design was used. A third assessment was
competed after an additional 4—week period, which demonstrated that a
significantly greater number of skaters using the paper patch technique
improved in performance. This study reveals the importance of
investigation the efficacies of different type of mental practice when
applied to specific sporting or performance activities.

\textsuperscript{31} Palmer Scater Shawna L, A Comparison of Mental Practice Techniques as Applied to the
Developing Competitive Figure Sketar, \textit{The Sport Psychologist}, June 1992, vol.6, no.2, pp.148-155.
Steven\textsuperscript{32} conducted the study to investigate the effects of goal setting, imagery, and a combined goal setting and imagery training programme on the free throw performance among female collegiate basketball players over the course of an entire season. A multiple baseline, single subject design was employed in which participants were randomly assigned to one of three interventions: (1) goal setting (n = 4) (2) imagery (n = 4); 3) goal setting & imagery (n=4). Free throw data was collected during practice sessions and games. Data were examined by way of changes in mean, level, trend, latency and variability between baseline and intervention, and then between intervention and a second baseline phase. Results revealed that three participants in the goal setting program, and one participant in the goal setting and imagery program increased their mean free — throw performance during practice from baseline to intervention. However, three participants in the imagery proposed decreased their mean free — throw performance during practice from baseline to intervention. Game competition data were found to be un-interpretable due to confounding variables, satisfaction and goal discrepancy scores were also investigated positive correlations were found between participants free — throw performance and performance satisfaction, and between free — throw performance and personal goals.

Michael\textsuperscript{33} examined the effectiveness of two methods of teaching three electric arts kicks to 60 female subjects with no prior experience in the martial arts. These were selected from students who had registered to take beginning self-defense at middle Tennessee


State University. The subject's age ranged from 18 to 24. The 60 female subjects were randomly assigned to one of two groups: one group (n=30) designated the experimental group, received the traditional method of instruction immediate videotape visual feedback. The other group (n=30) designated the control group, received the traditional method of instruction with no videotape visual feedback. Both groups met twice a week for five weeks practicing various aspects of self-After five weeks, each subject received a pretest score on the front kick, the use kick and the lunging sidekick. Three black belts experienced in judging techniques of the martial arts served the judges. They used a 1-5 scale commonly used in Karate Tournaments to administer a score to each subject in both groups on each of the three kicks.

After the pretest, each subject in the experimental group was videotaped performing the three kicks. Immediately following the taping session, the subjects watched the tape with the comments from the instructor. The subjects in the control group performed the same number of kicks with no visual feedback. The subjects in the experimental group were videotaped are class session per week. Both groups practiced the same techniques on non-taping days. This procedure lasted for three weeks. After the three-week period, each subject received a posttest score on the three kicks by the same three judges. An analysis of variance between groups was used to treat the pre and post data. The results indicated that both groups significantly improved at the 0.05 level for all three kicks. The experimental group improved significantly at 0.05 level as compared to the control group on the lunging sidekick.
Cremadas and Berto\textsuperscript{34} studied to investigate difference in alpha activity during imagery emphasizing stimulus proposition (SP) and imagery emphasizing response propositions (RP) as related to the skill level of the subjects. It was hypothesized that individuals in the expert group would produce greater alpha power increase in the right parietal region and lower alpha power increase in the left posterior region during imagery emphasizing response proposition as opposed to individuals in the above group. Twenty-two right-handed male subjects were assigned to either an expert (n = 11) or novice (n = 11) group depending on post experience on a golf-putting task. These findings advocate that novice subjects needed to process more information based on their attenuation of alpha power in comparison to the expert individuals. Thus, the attenuation of alpha power may be an indicator of the back of familiarity with the task at hand. This suggests that novice individuals should physically learn the task prior to imagery performance. Further, results revealed that individuals in the expert group produced greater lower alpha power. These differences in the lower alpha band suggest that greater arousal, attention and effort was needed in the novice subjects in both imagery perspective as opposed to expert subjects.

\textsuperscript{34} Cremadas and Juan Gual Berto, "The Effects of Imagery Perspective as a Function of Skill Level on Alpha Activity", \textit{Dissertation Abstracts International}, Vol. 60, No.4 October, 1999.