THE EFFECTS OF MOTOR IMAGERY ON FUNCTIONAL

POSTURAL BALANCE

by

Katherine Delude B.S., ATC, LAT, CES

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Committee Members:

Jack Ransone, Chair

Darcy Downey

John Walker

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CHAPTER I

INTRODUCTION

In the sports medicine field, researchers try to find different methods to enhance athletic performance. Motor imagery has been used to enhance injury prevention, athletic skill, movement efficacy, and therapeutic rehabilitation. Imagery has been shown reduce injuries and increase confidence when implemented as an injury prevention or rehabilitation program[1]. This investigation focuses on the application of visual motor imagery, kinesthetic motor imagery and combined visuo-kinesthetic motor imagery on dynamic balance compared to a control group through baseline and post intervention tests.

This investigation examined if motor imagery impacts functional balance performance. Balance is a primary focus within sports for injury prevention and rehabilitation[2]. The application of mental imagery in these areas is a consideration for clinicians to implement.

Balance is a combined effort of visual, vestibular, and somatosensory systems to maintain postural stability.[3] In order for coordinated and synchronized movements to occur throughout daily life, balance must be established. One's center of gravity changes during movement and the three balance components work together with the neuromuscular system to perform tasks without falling down. Functional balance is maintaining postural stability during motor movements[4] such as walking, running, jumping, athletics, or physical movement in movements associated with daily living.

The goal of motor imagery is to train the nervous system to elicit a similar neurological response without the physical motor outcome.[5-7] Practicing the motor pattern with motor imagery will help the anticipation response of the nervous system,[6] and can be practiced in the first or third person point of view. By using motor imagery questionnaires such as the Vividness of Movement Imagery Questionnaire-2, the investigator can establish the best way for an individual to practice.[5]

The first person perspective is performed with visual imagery. This is when participant mentally views him or herself perform a specific task. The third person perspective of visual imagery is when the participant mentally views someone else perform a specific task. The other method of motor imagery is kinesthetic motor imagery. This is when an individual imagines their body performing the task, what it feels like, without the physical movement.[8,9] Visual and kinesthetic imagery are effective at improving assigned tasks if used properly.

There is evidence that motor imagery will help improve upon the neurological system[5], proprioception[3], and balance.[3] It has been used to improve athletic skills and as part of rehabilitation[1]. Motor imagery is a safe way to practice desired motor patterns that may be lacking or want to be enhanced.[10]

Purpose

The purpose of this study was to compare the effects of motor imagery through visual motor imagery, kinesthetic motor imagery, and a combination of visuo-kinesthetic motor imagery on functional postural balance.

Operational Definitions

1. Kinesthetic Imagery: In this study it is a form of motor imagery where the subject perceives the specifically described physical movement taking place within their body. They feel themselves performing the motion without actual movement.[9,11]

2. Mental Imagery: A technique stimulated with only the brain with the goal of focusing on a task.[12]
3. Motor Imagery: A specific task or skill mentally stimulated without any physical movement.[13-15]
4. Neuromuscular Control: The efferent response to afferent information.[8]
5. Static Balance: The ability to maintain center of gravity on a base support known as the center of pressure[8]. In this study the intervention was visual imagery for static balance.
6. Visual Imagery: The subject will see the physical task or skill in the first or third person perspective without any physical movement.[9,11,15] For this study visual imagery was guided through a third person video performance.

<u>Hypotheses</u>

1. Visual motor imagery significantly improved functional positional balance in a healthy population.
2. Kinesthetic motor imagery significantly improved functional positional balance in a healthy population.

Visuo-kinesthetic motor imagery significantly improved functional postural balance in a healthy population.

<u>Delimitations of the Study</u>

While designing this investigation, certain delimitations were accepted, which possibly could compromise the outcome. These delimitations were set to determine the effects of motor imagery on a healthy population. This healthy population is defined by the delimitations.

1. Subjects must have been between the ages of 18-40 because it is that targeted population with optimal health due to availability of subjects to investigate.
2. Subjects must have been healthy: no concussion within past 12 months and must have been symptom free, no history of lower extremity surgery, and no lower extremity injury within past 6 months. Any injury to the muscular or neurological system would not have provided the optimal potential for performance and concentration.
3. Balance is made up of three types of feedback: visual, vestibulocochlear, and somatic. Subjects therefore must have had at least 20/50 vision for the purpose of reading the computer monitor. No medical history of balance problems due to hearing limitations for safety reasons were allowed in this study.

Limitations of the Study

The limitations of this investigation reflected the effects of the delimitations on the collection and interpretation of data and on the ability to expand the scope of inference beyond the sample population. Generalizations made from the results could have been compromised by the following limitations:

1. Subject population does not allow inference of geriatric or pediatric populations. This study was not inferred to an unhealthy population.

Assumptions of the Study

The basic assumptions for this investigation include:

1. It was assumed that all participants were honest with their medical history.
2. It was assumed that all participants in the intervention group were focusing as instructed on the video of tandem walking and step quick turn.

3. It was assumed that all participants in the intervention group were correctly performing the kinesthetic motor imagery as instructed.
4. All group assignments were completely random.
5. The examiner had zero bias.
6. The control group did not practice the tandem walk or step quick turn physically or mentally as instructed at the initial meeting.

Significance of the Study

Motor imagery has been applied to athletics specifically in injury prevention and therapeutic rehabilitation. This investigation helped provide a representation of the importance of preparing the neuromuscular system to perform a physical task. Motor imagery can prevent injuries through the use of proper biomechanics. Mental practice can bring awareness of proper motor skills in physical practice[15].

Rehabilitators can use motor imagery in injury prevention and rehabilitation to improve confidence levels and ideally improve task ability. Some gaps in the research are proving that mental imagery can be applied to athletic performance because there may be limitations to measuring applicable athletic performance. However, if motor imagery can improve, balance has the potential to prevent future injuries due to instability. This study provided quantitative information on the effectiveness of motor imagery in training the body to perform specific tasks through three methods of motor imagery.

CHAPTER II

REVIEW OF LITERATURE

In the sports medicine field researchers try to find different methods to enhance athletic performance. Mental imagery has been used in injury prevention, athletic performance, efficacy, and rehabilitation. Imagery can reduce injuries and increase confidence when implemented as an injury prevention or rehabilitation program.[1] The review focuses on the application of motor imagery on functional balance as it relates to injury prevention and rehabilitation.

The application technique that was questioned was, does motor imagery impact functional balance? Balance is a component of sport that plays a role in injury prevention and rehabilitation. The application of motor imagery in this area is a consideration for clinicians to implement.

Types of Imagery

Motor imagery is when a specific motor skill is mentally simulated without any physical movement.[13,16] Motor imagery can be performed by kinesthetic and/or visual imagery. Kinesthetic imagery is when the individual perceives the task taking place within the body, they feel themselves performing the task without actual movement. Visual imagery is when the individual sees the image taking place in the first or third person perspective.[9] Visual imagery is broken down into internal and external imagery. With internal imagery the participant is imagining themselves performing the task. External imagery is when the patient imagines someone else performing the task.[9,11]

A study differentiating kinesthetic and visual imagery had participants standing barefoot on a balance platform to assess postural displacement. While on the platform the participant is asked to imagine themselves executing bilateral plantar flexion. They are asked to feel themselves perform the movement. This assessed kinesthetic motor imagery. To test visual imagery the participants were asked to imagine someone else perform the same movement.[3] In a study performed by Callow and Hardy,[9] participants stated kinesthetic imagery was preferred over visual imagery.

Many different studies have been performed to determine the benefits of mental imagery in an athletic population, specifically in the sports medicine field. Some studies measured skill performance,[11,17] efficacy,[18] balance,[3,8,10,19] and strength.[20,21] The variety of focus points with imagery reflects the versatility of the skill.

Neurological Benefits

There is evidence that motor imagery shares the same neurological networks as physical performance. This is known as functional equivalence, meaning although the neurological pathways between motor imagery and physical movement may have subtle differences they overlap and are trainable.[22-24] The trainability depends on the subject's imagery ability. An individual's motor imagery ability can be measured prior to testing.[5] Williams, Pearce, Loporto, Morris, and Holmes report that using the Vividness of Movement Imagery Questionnaire-2 (VMIQ-2) the clinician can determine the ability of the subjects motor imagery to have patients with the most optimal results.[5] The VMIQ-2 measure kinesthetic and visual motor imagery ability.[5] After being measured by the questionnaire the motor evoked potential (MEP) of the corticospinal tract is measured with a transcranial magnetic stimulations (TMS). After the neurological testing the results are compared to the VMIQ-2 scores. These results show that a higher VMIQ-2 score results in higher TMS results, therefore better motor imaging.[5]

A well produced motor imagery program will stimulate a similar neural pattern as the physical act. The functional equivalence should parallel the corticomotor pattern.[25] The corticospinal tract is an efferent neural pathway in which skeletal muscle movement patterns run. Areas of highest neural activation include primary motor cortex,[26] premotor cortex,[26,27] posterior parietal,[7] supplementary motor cotex.[7,26] These have been measured is studies using measurement tools such as H-reflex,[28] functional magnetic resonance imaging (fMRI)[15,25] and transcranial magnetic stimulation (TMS).[5,27,29] These brain centers are the association areas for skeletal muscle activation.

In a study by Fourkas, Avenanti, Urgesi, and Aglioti, corticospinal facilitation was measured using a transcranial magnetic stimulation (TMS).[27] This measured index finger abduction and adduction movements. The study used a mirror method third person visual imagery perspective and imagined their dominant hand performing the task for first person visual imagery. The study concluded that a combination of first and third person perspective elicits the highest TMS reading compared to only one mental imagery technique. This training was successful in proving increased excitability during motor imagery on index finger abduction and adduction. [27]

These neural patterns that are measured throughout many studies have proved to excite similar brain and spinal tract areas for motor movement.[5,25-27,29] Imagery ability may be a limiting factor in motor imagery ability but it activates the same neural network as good imagers, the patterns however are not as strong due to activation of other brain areas.[25]

Proprioception

The goal of implementing imagery is to aid in neuromuscular control and assess and increase body awareness.[3] Having efficient body awareness allows for proper balance. Balance can be measured quantitatively by the Balance Error Scoring System (BESS) or more accurately though a computerized force plate. This system measures balance ability with a standardized scoring system. The basics of neuromuscular training can help in injury prevention and rehabilitation. It assists in the fundamentals of sports. The proper training can improve biomechanics and performing specific tasks.[14]

Strength was not a common measurement with mental imagery programs. One study measured bench press and leg press at a one repetition max. The motor imagery group performed the exercises and practiced kinesthetic imagery over 12 sessions. The control group only performed the physical task for 12 sessions. A one repetition max was measured and then measured again three days later. There was no significant difference between the mental and physical group however both groups improved. It is suggested that motor imagery can modify efferent (motor) activity of the brain through prepositional content. The muscle is prepared for the movement.[30] A future question may be to see if there is a connection in strength gains with improved proprioception for stabilizers.

The use of imagery and neuromuscular control can be seen in measuring center of pressure and displacement when balancing. Rodrigues et al, Lemos, Gouvea, Volchan, Imbiriba, and Vargas explained the center of pressure refers to how steady the individual is while balancing.[3] The task of postural stability is a strong indicator of proprioception. This study used a different technique of measuring imagery by using a balance platform.

When measuring the center of pressure displacement or postural sway the goal was to determine if visual or kinesthetic imagery was more effective, however the results were insignificant. The visual group and kinesthetic group showed similar statistical improvements. A suggestion to improve the study would be to teach imagery techniques before testing. An informational session would teach correct visual and kinesthetic imagery methods.

Motor Imagery Training

A difference seen in imagery studies is training the participants in proper techniques prior to participating in the study. Myer, Ford, McLean, and Hewett instructed participants to perform motor imagery in aroused and relaxed conditions.[16] This teaching method allowed participants to adapt to surroundings and use motor imagery in different situations. There was no significant difference between the groups, however it showed to be a training tool for motor imagery.[16]

An imagery study, performed by Guillot and Collet that examined muscular responses used a questionnaire to determine the participant's mental imagery ability, but did not educate the participants on how to correctly implement imagery.[31] The study measured physical strength with an EMG and mental imagery through response from the autonomic nervous system.[31] A different imagery study performed by Callow and Hardy[9] required participants to attend a three hour imagery training workshop. The purpose of the study was to compare kinesthetic imagery and different visual imagery perspectives. However there was no experiment performed with this study. A questionnaire was used to measure which type of visual imagery or kinesthetic imagery was used or preferred.

As discussed earlier, a study comparing kinesthetic imagery and body sway used participants with no imagery knowledge. Participants were given a questionnaire to evaluate their imagery abilities, but were not instructed on how to use or perform it. The test measured balance when executing bilateral plantar flexion on a force platform. They were given a kinesthetic imagery technique, a visual technique, and a control where the participants sang a song. The test consisted of a physical practice, two imagery techniques, and a control technique. An EMG of the right lateral gastrocnemius was also measured to provide a more detailed look into the postural sway.[3] This study provides an example of implementing proper imagery training. With proper imagery training for task performance there may be a greater quantitative significance in the data.

<u>Injury Prevention and Rehabilitation</u>

Efficacy is confidence in performing a task.[18] Efficacy can play an important role in injury prevention and rehabilitation. Higher confidence from imagery techniques can lead to greater self-confidence resulting in an injury preventative technique.[1] The more confident a patient is the greater the results should be. A study on softball athletes showed through a survey method an increase in confidence levels through practicing motor imagery.[32]

Injury prevention comes from proper training techniques and mechanics. A positive of practicing motor imagery is the ability to practice the task with zero risk of injury.[10] Proprioception skills allow for a greater variance of movement skill. When building an imagery protocol the script should focus on simple tasks and as the participant improves the imagery becomes more complex. The neurological response time correlates with the motor imagery response time indicating that motor imagery practice can be effective in motor skill training.[3] By practicing the neurological response the body will adapt and expect what is to come, even without physically performing the task. By mentally training strength ability, the body will know how to adapt to different stimuli during athletics.[21]

A study focusing on anterior cruciate ligament rehabilitation proved that there is a significant increase in muscle activation post-surgery when using motor imagery. This was compared to a control group that had zero motor imagery or physical intervention. This early intervention is key in post-surgical cases after being immobilized.[20]

A participant's confidence in the ability to perform a task can increase the measured outcome. Implementing a steady rehabilitation protocol with progressive mental imagery has shown improvements in task completion and confidence. Important points to remember when using imagery are imagery ability, steady progression, and positive encouragement. Rehabilitation is a step by step process and the imagery protocol should mirror the physical protocol with goals in mind. As the athlete progresses the imagery protocols should be similar to sports specific tasks and sensations. This may include the noise of the crowd or a nervous feeling prior to the start of a race. When working with injured athletes imagery should follow the progression of the short term and long term goals.[33] Motor imagery combines sensory and motor experience when dealing with the athlete's perception. This will increase confidence and decrease anxiety.[20]

<u>NeuroCom Balance Master</u>

Tandem walk and Step Quick Turn are a good predictor of balance. Functional measures equate better to activities of daily living than static postural measurements.[34]

The reliability of test retest for intrarater and interrater reliability was excellent for Step Quick Turn-turn time. The step quick turn showed good reliability for the turn sway for intrarater reliability and interrater reliability.[35]

Summary and Conclusions

Different studies utilize various training techniques. What is interesting about each study is that very little statistical significance is reported. This may be because it is difficult to give a quantitative value to a mental technique. The variations in testing protocols and statistics leave many questions and research for imagery use. There were limited tests that tested reproducibility of previous tests. The broad variety of context in imagery leaves many gaps within the research. A goal of sports medicine professionals should be to determine significance in imagery and its effects efficacy, injury prevention, and rehabilitation.

There are many different aspects of imagery that can be measured and studied. Within each aspect the procedures to evaluate it can be greatly varied. In the sports medicine profession proving imagery and its positive impacts on injury prevention and rehabilitation could alter many standardized protocols. Efficacy is a large predictor of injury and rehabilitation.[18] If the athlete's self-efficacy is higher after imagery and rehabilitation it may be able to enhance their athletic abilities.

Using imagery to prevent injuries through the use of proper biomechanics would be a significant breakthrough. Balance and proprioception is a standard rehabilitation technique in lower extremity injuries. Decreased proprioception can lead to chronic instability in the joint.[36] If imagery can improve balance it will aid in preventing future injuries due to instability. The use of imagery and correct techniques can also aid in constructing injury prevention and rehabilitation programs with higher confidence levels and ideally better task abilities. Although testing protocol needs to be standardized each athlete is different. A specific imagery program should be designed for the athlete. This is important when dealing with injuries. Each athlete will be in a different mental state, have different mental images, be in different stages of healing, and different severities. Like all rehabilitation programs imagery may be best implemented when designed for the athlete. A combined program of motor imagery and physical performance has the potential to improve desired outcomes.[12,36]

CHAPTER III

METHODS

The purpose of this study was to determine the effects of motor imagery on functional postural balance in tandem walking and step quick turn. The subjects performed a pre and post-test protocol measuring the effectiveness of the visual motor imagery only, kinesthetic imagery only, and visuo-kinesthetic motor imagery techniques on tandem walking and step quick turn. The visual intervention group took part in performing motor imagery as they watched a video of each task (tandem walk and step quick turn) performance. The participants in the kinesthetic imagery group listened to an audio recording describing in detail what the participant felt during each task. The visuo-kinesthetic methods group performed both visual and kinesthetic interventions. The performance of the treatment group was then compared to that of a control group.

Subjects

To participate in the research study all subjects were required to read and sign an informed consent form (Appendix A) and complete a medical history questionnaire (Appendix B). Forty males and females between the ages of 18 and 40 years old were recruited to participate in this investigation. Participants could not have suffered a concussion within the past 12 months and could not have any symptoms from past concussions. The subjects could not have any lower extremity surgeries or have had suffered a lower extremity injury within the past 6 months. Participants could not have any history of brain or spinal injury. All participants were cleared with a medical history clear of hearing or balance problems and must have had at least 20/50 vision.

Instruments

A medical history questionnaire was distributed to assess the subject's ability to participate in the study. This form was adapted from the Texas State Athletic Training pre-participation screening.[37] The medical history questionnaire included the following questions: Have you had a concussion within the past 12 months? If you received a concussion longer than 12 months ago do you still have symptoms? Have you suffered from a lower extremity injury in the past 6 months? If you had a lower extremity injury beyond 6 months ago do still have symptoms? Do you have a medical history of hearing or balance problems? Institutional Review Board approval was achieved prior to all subject contact and testing procedures.

Each subject performed an eye examination to assess visual acuity. The subjects were asked to read a Snellen Eye Chart. The subject stood 20 feet away and read the chart with both eyes open. Subjects were allowed to have corrective lenses on, however they must have used their corrective lenses while performing the tests as well. Subjects must have had a minimum of 20/50 vision to participate in the investigation. This was documented in the Appendix B medical history questionnaire.[37]

All participants performed the same pre-test and a post-test, which was measured by the NeuroCom Balance Master (Clackamas, OR). The participants performed a tandem walk and step quick turn test. These tests were chosen due to their ability to assess balance during functional movements rather than injury assessment.[38] When the participant performed the tandem walk they started with their feet together and their center of gravity behind the line on the computer monitor. The monitor instructed the participant to start. The participant took three to four steps and then held their end position in the tandem stance. This was repeated three times.[39] The dependent variables being measured were: 1) step width, 2) step speed, and 3) end sway. The average score of the three trials was be used for each dependent variable. Step width was how far each step is displaced from the center line. Step speed was the rate at which the tandem walking is performed. The end sway was the static control once the individual stops walking. The step quick turn started with feet together and the participants center of gravity behind the line displayed on the computer monitor. When instructed to do so on the monitor the participant started with his/her left foot forward, then step with his/her right foot. Once the right foot was planted the participant turned left and then stepped forward with his/her right foot. This procedure is repeated three times and the average score was used as a final measurement. The same process is performed when stepping with the right foot, however the participant turned to his/her right and then stepped forward with the left foot.[40] The dependent variables measured were: 1) turn time and 2) turn sway. Turn time was the amount of time it takes for the individual to turn 180 degrees on the force plate. The turn sway was how displaced is the center of gravity while turning 180 degrees on the force plate.

<u>Procedures</u>

The participants first signed the informed consent form (Appendix A). The participant then completed the medical history questionnaire (Appendix B). Upon the approval that all criteria were met the subject was randomly assigned into a control group or an intervention group. The randomization was performed by marking four pennies with permanent marker. One was labelled as “C” for control group, the second was labelled as “VI” for visual intervention group, the third penny was labelled “KI” for kinesthetic imagery group, and the last penny was labeled “B” for the combined visuo-kinesthetic imagery group. The penny was drawn by the participant without any visibility of the pennies by him/her or by the evaluator performing the testing. Once the penny was drawn it was shown to the investigator and the subject. The penny remained in removed the bag until its associated group was full. This method eliminates bias in group assignment.

Each participant in the control and intervention groups then performed the pre-test procedures of tandem walking and left and right step quick turn on the NeuroCom Balance Master. The data was recorded and the next meeting date was established depending on the group assignment.

The intervention group had four motor imagery sessions within the seven days following the pre-test. The post-testing was performed the day following the third imagery session. The fourth imagery session took place directly before performing the post-testing protocol. The first intervention session included an educational session. It described the goal of the investigation and how to interpret the mental imagery provided. The investigator explained the visual imagery through the video clip and the importance of focusing on how the subject moves to adjust to the stimulus. The kinesthetic education focused on feeling what the audio described within them as they performed the tests but without physical movement.

Each imagery session for all three intervention groups started with a short session describing the motor imagery techniques while the subjects sat alone in quiet room with minimal distractions. For the visual imagery group each person was seated a comfortable distance away from the monitor, sitting upright with their hands placed on their lap.

While watching the video there was zero movement visible in the surrounding environment and a minimal noise level will be maintained. While performing visual motor imagery the participant was in the same position but with their eyes closed. The kinesthetic imagery group was seated the same as the visual group while listening to the audio the subjects had headphones on and eyes closed. The audio described the detailed feeling of movement when performing a tandem walk and step quick turn. The visuo-kinesthetic motor imagery group performed both requirements visual and kinesthetic motor imagery requirements. The visuo-kinesthetic group first completed the visual motor imagery section then immediately following, performed the kinesthetic motor imagery requirements.

Visual Intervention

The visual intervention used visual motor imagery with video assistance. The patient was seated with both feet on the floor a comfortable distance away from the monitor. Each individual was placed in front of a screen displaying a video of an individual performing the tandem walking and step quick turn NeuroCom testing. The visual imagery session was approximately the same length as the testing sequence. The video was shown ten times from the lateral view for tandem walking. Next the participant closed their eyes and imagined the tandem walking video. They were asked to imagine the tandem walking ten times. The participant marked a tally on a post-it note for each imagery practice to ensure the time and frequency of each tandem walking visual image. The participant was then shown left step quick turn ten times from the lateral view. The participant was then be asked to close their eyes and imagine the left step quick turn video five times. Just as done in the tandem walking the participant marked a tally on a post-it note to mark each imagery practice. The same process was repeated for right step quick turn. The group was asked to not physically practice tandem walking and step quick turn.

Kinesthetic Intervention

The kinesthetic imagery group listened to a detailed audio clip describing the subject's specific feelings, muscle, and body movements during NeuroCom Balance Master tandem walk and step quick turn testing. The detailed audio clip described the kinesthetic movements of the individual shown in the video displayed to the visual imagery group. The participants first listened to the tandem walking audio clip for ten repetitions. They then listened to the step quick turn left for five repetitions followed by step quick turn right for five repetitions. The individual marked a tally on a post it note for each repetition. The group was asked to not physically practice tandem walking and step quick turn. The kinesthetic audio clip that was played for each participant was as follows:

Tandem Walking: "Feel yourself standing on your left foot. Feel your right leg swing through and plant on the line in front of your left toes. Acknowledge your hips as you maintain your center of gravity. Feel your left foot transfer weight to the ball of your foot and come forward in from of your right foot. Feel your hips contract to maintain a steady walking balance. Feel your core contract to stay centered. Feel the ground beneath your feet. Feel the muscles in your ankles contracting to stay steady as you continue to walk with one foot in front of the other in line. Feel this process during a controlled and consistent speed".

Step Quick Turn Left Foot Start: “Feel the force plate underneath your bare feet. You are standing on the back edge of the board. You step forward with your left leg. Your center of gravity stays steady and centered over the split in the force plate. Your right foot toes off while walking. Your right foot steadily plants on the force plate at a constant and controlled speed and pressure. On your right foot you shift your center of gravity. Feel your core, hips, knee, ankle, and foot support your body. Feel the ball of your left foot planted on the force plate as you initiate your turn. Feel your right foot push down and pivot left as your body turns to the left. Feel your body turn left as your center of gravity stays steady. Once you’ve turned 180 degrees feel your center of gravity shift forward to your left foot. Feel your right foot toe off and your right hip flexors drive forward. Feel your right leg step down on the force plate”.

Step Quick Turn Right Foot Start: “Feel the force plate underneath your bare feet. You are standing on the back edge of the board. You step forward with your right leg. Your center of gravity stays steady and centered over the split in the force plate. Your left foot toes off while walking. Your left foot steadily plants on the force plate at a constant and controlled speed and pressure. On your left foot you shift your center of gravity. Feel your core, hips, knee, ankle, and foot support your body. Feel the ball of your right foot planted on the force plate as you initiate your turn. Feel your left foot push down and pivot right as your body turns to the right. Feel your body turn right as your center of gravity stays steady. Once you’ve turned 180 degrees feel your center of gravity shift forward to your right foot. Feel your left foot toe off and your left hip flexors drive forward. Feel your left leg step down on the force plate”.

Visuo-Kinesthetic Imagery Group

The visuo-kinesthetic group performed the visual intervention procedures followed by the kinesthetic imagery group procedures. The group was asked to not physically practice tandem walking and step quick turn.

Control Group

The control group was asked to return for post testing on the assigned testing date that will occurred eight days after the initial testing date. They were asked to not practice these specific balancing skills mentally or physically.

After the required three imagery sessions with the intervention groups over the six days following the pre-test, the post testing was performed. Post testing was performed seven days after the initial testing. It took a total of eight days to complete the study.

Data Analysis

The independent variables were: 1) group (intervention or control) and 2) time (pre-testing and post testing). The dependent variables for tandem walking were 1) step width, 2) step speed, and 3) end sway. The dependent variables for step quick turn were turn time and turn sway. Two separate mixed factor ANOVAs with repeated measures were performed for each dependent variable.

CHAPTER IV

MANUSCRIPT

Context: Motor imagery is the mental rehearsal of a task without physical movement. It is a common method throughout athletics. However, little research has been performed to evaluate the effects on functional postural balance.

Objective: To examine the effects of motor imagery on functional postural balance through the use of visual motor imagery, kinesthetic motor imagery, and visuo-kinesthetic motor imagery.

Design: Controlled laboratory study

Setting: Motion research laboratory

Patients or Participants: A total of forty participants (27 female, 13 male) volunteered between the ages of 18-40 (23.45± 5.0). These individuals were cleared of any lower extremity injury or surgery in the past 6 month and were cleared of any concussion within the past 12 months.

Intervention(s): Participants pre-tested tandem walking and left and right step quick turn on the NeuroCom Balance Master. Intervention groups performed 4 sessions of assigned motor imagery over 7 days followed by post testing of tandem walking and left and right step quick turn.

Main Outcome Measure(s): Tandem walking measured: step width (cm), speed cm/sec), and end sway (deg/cm). Left and Right Step Quick Turn measured: turn speed (sec) and turn sway (deg).

Results: It was observed that step quick turn left-turn time improved from the pretest score of 0.581±0.271 to 0.445±0.229 seconds on the post test score (p=0.001). Tandem walking-speed also improved from 27.02±9.73 on the pre-test to 30.30±9.30 cm/sec on the post test score (p=0.003), which are statistically significant.

Conclusions: There was improvements in all groups especially pre and post-tests of tandem walking speed and step quick turn left-turn time. Others groups had small effects but still showed evidence of improvement. Motor imagery can improve functional balance, and it is still recommended as a use for functional movements.

Key Words: motor imagery, visual imagery, kinesthetic imagery, visuo-kinesthetic imagery, functional balance

In the sports medicine field, researchers try to find different methods to enhance athletic performance. Motor imagery has been used to enhance injury prevention, athletic skill, movement efficacy, and therapeutic rehabilitation. Imagery has been shown to reduce injuries and increase confidence when implemented as an injury prevention or rehabilitation program.[1] This investigation focuses on the application of visual motor imagery, kinesthetic motor imagery and combined visuo-kinesthetic motor imagery on dynamic balance compared to a control group through baseline and post intervention testing.

This purpose of this investigation was to examine if motor imagery positively impacted functional balance performance through the use of visual motor imagery, kinesthetic motor imagery, and visuo-kinesthetic motor imagery. Balance is a primary focus within sports for injury prevention and rehabilitation.[2] The application of mental imagery in these areas is a consideration for clinicians to implement.

Balance is a combined effort of visual, vestibular, and somatosensory systems to maintain postural stability.[3] In order for coordinated and synchronized movements to occur throughout daily life, balance must be established. One's center of gravity changes during movement and the three balance components work together with the neuromuscular system to perform tasks without falling down. Functional balance is maintaining postural stability during motor movements such as walking, running, jumping, athletics, or physical movement in movements associated with daily living.[4]

The goal of motor imagery is to train the nervous system to elicit a similar neurological response without the physical motor outcome.[5-7] The practice of motor pattern with motor imagery helps the anticipation response of the nervous system, and can be practiced in the first or third person point of view.[6] By using motor imagery questionnaires such as the Vividness of Movement Imagery Questionnaire-2, the investigator establish the best way for an individual to practice.[5] The Questionnaire-2 asks a series of questions to establish how well an individual can perform motor imagery and what the best method is for that individual.[5]

The first person perspective is performed with visual imagery. This is when a participant mentally views him or herself performing a specific task. The third person perspective of visual imagery is when the participant mentally views someone else performing a specific task. The other method of motor imagery is kinesthetic motor imagery. This is when an individual imagines how their body performed the task, what it felt like, without the physical movement.[8,9] Visuo-kinesthetic imagery is effective to improve assigned tasks if used properly.

There is evidence that motor imagery will help improve upon the neurological system,[5] proprioception,[3] and balance.[3] It has been used to improve athletic skills and as part of rehabilitation.[1] Motor imagery is a safe way to practice desired motor patterns that may be lacking or want to be enhanced.[10]

Methods

Participants

Forty participants completed the study (27 female, 13 male) between the ages of 18-40 with an average of 23.45± 5.0 years. There were four groups, each group contained ten participants. The control group (4 females, 6 males) held an average age of 23.3± 3.9 years. The visual motor imagery group (9 females, 1 male) contained an average age of 21.6±2.7 years. The kinesthetic motor imagery group (8 females, 2 males) contained an average age of 25.7± 8.3 years. The visuo-kinesthetic motor imagery group (6 females, 4 males) contained an average age of 22.9± 2.6 years. Participants were recruited through university professors offering extra credit opportunities in labs and word of mouth to students, graduate assistants, faculty and staff at the university, and local residents. Forty-one participants were recruited however, one dropped out of the study. All participants had no history of lower extremity injury or surgery within the last six months and no history of concussion in the past 12 months. This demographic represents a healthy population. Each participant had a blind draw to declare their group assignment. Each participant completed a consent form and medical history questionnaire. The study was approved by the university Institutional Review Board.

Protocol

The quantitative study looked at the improvement among participants after completing a motor imagery intervention compared to a control group. There were three intervention types: visual motor imagery, kinesthetic motor imagery, and a combined visuo-kinesthetic motor imagery group. The pre-test procedures included three trials per test of: Tandem Walking, Step Quick Turn Left, and Step Quick Turn Right on the NeuroCom Balance Master. Tandem walking and step quick turn are good predictors of balance. The NeuroCom Balance Master reliability of test retest for intrarater and interrater reliability was excellent for step quick turn-turn time. The step quick turn showed good reliability for the turn sway for intrarater reliability and interrater reliability.[35]

The data was compiled of an average of the three trials per skill tested. The data measured during Tandem Walking included: Tandem Walking Step Width, Tandem Walking Speed, and Tandem Walking End Sway. The data measured during Step Quick Turn included: Step Quick Turn Left Turn Time, Step Quick Turn Left Sway, Step Quick Turn Right Turn Time, and Step Quick Turn Right Sway.

The motor imagery interventions were performed three times (once per assigned day) in the following six days. On the eighth day of the study the participants completed a forth motor imagery session immediately followed by post-testing on the NeuroCom Balance Master. The post-testing procedures were the same as the pre-testing procedures.

For pre and post testing participants were instructed to stand at the assigned end of the NeuroCom Balance Master force plate barefoot. The primary investigator read the prompt on the monitor for instructions on how to perform the test. Participants were instructed to keep their hands on their hips for all testing procedures and to keep their eyes on the monitor in front of them at all times during testing. The participant would follow the directions on the monitor during the testing procedures which instructed him/her to start and stop. The order of tests was tandem walking, step quick turn-left, followed by step quick turn- right.

Visual Intervention

The visual motor imagery group watched a video of tandem walking for ten repetitions followed by closing their eyes and imagining the video they had just watched for ten repetitions of imagery. Once the tandem walking imagery was completed the participant then watched the step quick turn left video demonstration for five repetitions. Once the five repetitions were completed the participant closed his/her eyes and imagined the video he/she had just watched for five repetitions. The last visual imagery performed was for step quick turn right. The participant watched the step quick turn right video demonstration for five repetitions followed by closing their eyes and imagining the video for five repetitions. This intervention was performed as a whole a total of four times within the eight day testing period and no more than once per day. Each participant was instructed by the primary investigator on proper visual motor imagery techniques before starting the intervention. Each participant was instructed to not perform mental imagery outside of the assigned times and to not practice these tasks physically.

Kinesthetic Intervention

For the kinesthetic motor imagery group each individual was instructed on proper kinesthetic imagery techniques before starting the intervention. The participants were instructed to listen to three audio recordings focusing on the sensory output experienced utilizing neural motor pathways. Each individual was instructed to listen to the tandem walking audio for ten repetitions. They then listened to the audio of step quick turn left for five repetitions, followed by listening to step quick turn right for five repetitions. This intervention was performed four times within the eight days of the study and no more than once per day. Each participant was instructed to not perform mental imagery outside of the assigned times and to not practice these tasks physically.

Visuo-Kinesthetic Intervention

The visuo-kinesthetic intervention group consisted of the use of visual and kinesthetic motor imagery techniques. Each participant in this group started with the visual motor imagery protocol. The participant watched the tandem walking video ten times followed by closing their eyes and performing visual motor imagery of what he/she just watched for ten repetitions. They then watched step quick turn left for five repetitions followed by visual motor imagery of that video for five repetitions. Step quick turn right was the last visual imagery. The video was watched for five repetitions and then the participant performed the visual imagery of it for five repetitions. The individual then performed the kinesthetic imagery. The participant listened to the tandem walking audio for ten repetitions, then step quick turn left for five repetitions, followed by step quick turn right for five repetitions. This intervention was performed four times within the eight days of the study and no more than once per day. Each participant was instructed to not perform mental imagery outside of the assigned times and not to practice these tasks physically.

Control

The control group was instructed to return on their assigned date eight days after pre-testing to perform post testing on the NeuroCom Balance Master. They were instructed to not practice these tasks physically or mentally.

Design and Analysis

A three-way 2x2x2 repeated measures ANOVA was used to determine the improvement among the two types of motor imagery (visual and kinesthetic) as well as pre- and post-test differences between trials for each dependent variable. A MANOVA was used to establish any significance among pre-test differences between the four intervention combinations. The dependent variables were: 1) tandem walking step width (cm), 2) tandem walking speed (cm/sec), 3) tandem walking end sway (degrees/sec), 4) left step quick turn time (sec), 5) left step quick end sway (degrees), 6) right step quick turn time (sec), and 7) right step quick end sway (degrees).

The three independent variables were: 1) the visual motor imagery (control versus intervention), 2) the kinesthetic motor imagery (control versus intervention), and 3) trials (pre- versus post-tests). The four intervention combinations were control (neither intervention), visual motor imagery (visual only), kinesthetic motor imagery (kinesthetic only), and visuo-kinesthetic (both visual and kinesthetic). Both visual and kinesthetic the motor imagery are between-subjects variables, while the type of trial is a within-subjects (repeated) variable. Since all tests between interventions and trial combinations are between two sample means (one degree of freedom), no post-hoc tests and no adjustment of probability for any variation in sphericity among the trials were needed. Partial eta^2 was used to determine effect size for each statistical test. Overall statistical significance was defined as $p < .05$.

<u>Results</u>

Table 1 reports the descriptive values across interventions, for both pre- and post-test measures. MANOVA indicated no significant pre-test differences among the four intervention combinations, Wilks' Lambda = 0.688, $F(14,23) = 0.75$, $p = .710$, indicating that the random assignment of subjects to intervention groups effectively prevented any performance bias.

For tandem walking step width, repeated measures ANOVA indicated no significant overall difference between trials (pre-test versus post-test), F(1, 36) = 0.03, p = .860, partial eta^2 = .001, a very small effect. There was also no significant difference in improvement between the visual and non-visual interventions, F(1,36) = 0.01, p = .915, partial eta^2 = .0003, another very small effect. There is no significant difference in improvement between the kinesthetic and non-kinesthetic interventions, F(1,36) = 0.05, p = .823, partial eta^2 = .001, another very small effect. There was also no interaction in improvement for the visuo-kinesthetic interventions, F(1, 36) = 1.44, p = .238, partial eta^2 = .038, a moderately small effect.

For tandem walking speed, repeated measures ANOVA indicated a significant overall difference between trials (pre-test versus post-test), F(1, 36) = 9.92, p = .003, partial eta^2 = .216, a very large effect. For all groups combined, the sample mean tandem walking speed improved from 27.02± 9.73 cm/sec for the pre-test to 30.39±9.30 cm/sec for the post-test. This effect is demonstrated in Figure 1. There was no significant difference in improvement between the visual and non-visual interventions, F(1,36) = 0.01, p = .919, partial eta^2 = .0003, a very small effect., and no significant difference in improvement between the kinesthetic and non-kinesthetic interventions, F(1,36) = 0.40, p = .529, partial eta^2 = .011, a small effect. There was also no interaction in improvement for the visuo-kinesthetic interventions, F(1, 36) = 0.17, p = .686, partial eta^2 = .005, a very small ef

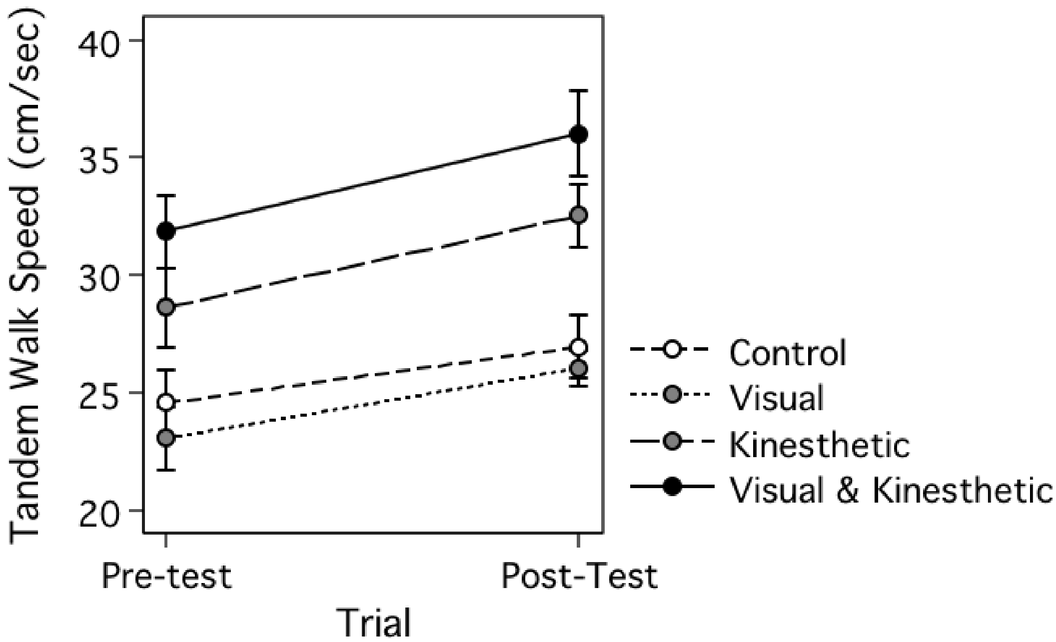

Figure 1: Tandem Walking Speed

For tandem walking end sway, repeated measures ANOVA indicated no significant overall difference between trials (pre-test versus post-test), $F(1, 36) = 0.44$, $p = .514$, partial $eta^2 = .012$, a small effect. There was also no significant difference in improvement between the visual and non-visual interventions, $F(1,36) = 0.97$, $p = .332$, partial $eta^2 = .026$, a moderately small effect., and no significant difference in improvement between the kinesthetic and non-kinesthetic interventions, $F(1,36) = 0.54$, $p = .467$, partial $eta^2 = .015$, another small effect. There was also no interaction in improvement for the visuo-kinesthetic interventions, $F(1, 36) = 0.62$, $p = .438$, partial $eta^2 = .017$, another small effect.

For left step quick turn time, repeated measures ANOVA indicated a significant overall difference between trials (pre-test versus post-test), $F(1, 36) = 12.13$, $p = .001$, partial $eta^2 = .252$, a very large effect. For all groups combined, the left step quick turn time improved from 0.581± 0.271 seconds for the pre-test to 0.445±0.229 seconds for the post-test. This effect is demonstrated in Figure 2. There was no significant difference in improvement between the visual and non-visual interventions, $F(1,36) = 0.04$, $p = .834$, partial eta^2 = .001, a very small effect., and no significant difference in improvement between the kinesthetic and non-kinesthetic interventions, $F(1,36) = 0.12$, $p = .726$, partial eta^2 = .003, another very small effect. There was also no interaction in improvement for the visuo-kinesthetic interventions, $F(1, 36) = 0.05$, $p = .824$, partial eta^2 = .001, another very small effect.

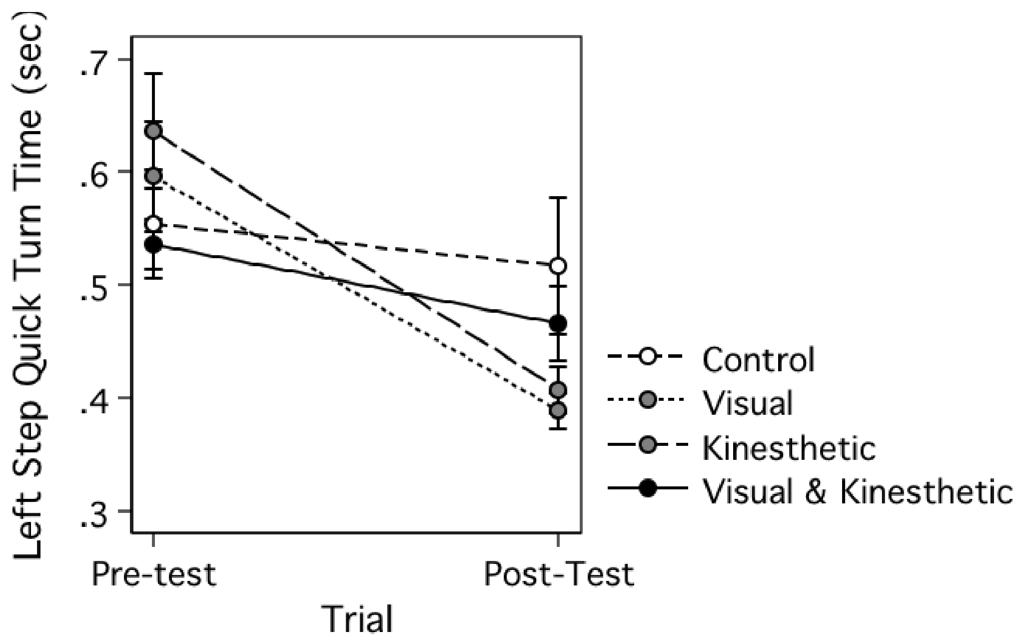

Figure 2: Left Step Quick Turn Time

For left step quick turn sway, repeated measures ANOVA indicated no significant overall difference between trials (pre-test versus post-test), $F(1, 36) = 2.14$, $p = .152$, partial eta^2 = .056, a moderate effect. There was also no significant difference in improvement between the visual and non-visual interventions, $F(1,36) = 1.09$, $p = .304$, partial eta^2 = .029, a moderately small effect., and no significant difference in improvement between the kinesthetic and non-kinesthetic interventions, $F(1,36) = 0.14$, $p = .707$, partial eta^2 = .004, a very small effect. There was also no interaction in improvement for the visuo-kinesthetic interventions, $F(1, 36) = 0.13$, $p = .723$, partial eta^2 = .004, another very small effect.

For right step quick turn time, repeated measures ANOVA indicated no significant overall difference between trials (pre-test versus post-test), $F(1, 36) = 2.21$, $p = .146$, partial eta^2 = .058, a moderate effect. There was also no significant difference in improvement between the visual and non-visual interventions, $F(1,36) = 0.68$, $p = .415$, partial eta^2 = .019, a small effect., and no significant difference in improvement between the kinesthetic and non-kinesthetic interventions, $F(1,36) = 0.25$, $p = .621$, partial eta^2 = .007, a very small effect. There was also no interaction in improvement for the visuo-kinesthetic interventions, $F(1, 36) = 1.82$, $p = .186$, partial eta^2 = .048, a moderate effect.

Lastly, for right step quick turn sway, repeated measures ANOVA indicated no significant overall difference between trials (pre-test versus post-test), $F(1, 36) = 0.19$, $p = .669$, partial eta^2 = .005, a very small effect. There was also no significant difference in improvement between the visual and non-visual interventions, $F(1,36) = 1.96$, $p = .170$, partial eta^2 = .052, a moderate effect., and no significant difference in improvement between the kinesthetic and non-kinesthetic interventions, $F(1,36) = 0.09$, $p = .766$, partial eta^2 = .002, a very small effect. There was also no interaction in improvement for the visuo-kinesthetic interventions, $F(1, 36) = 2.09$, $p = .157$, partial eta^2 = .055, another moderate effect.

Discussion

The purpose of this study was to compare the effects of motor imagery through visual imagery, kinesthetic imagery, and visuo-kinesthetic imagery on functional postural balance. The present study chose the postural functional balance tasks of tandem walking and step quick turn for the for the purpose of relating to activities of daily living. There were no significant differences between the control group, visual imagery group, kinesthetic group, and visuo-kinesthetic group. The results showed there is a moderate effect in right step quick turn-turn time and turn sway in pre and post-testing between all four groups, and visuo-kinesthetic versus non visuo-kinesthetic groups. It also showed a moderate effect in right step quick turn-turn sway for visual versus non visual groups and visuo-kinesthetic versus non visuo-kinesthetic groups. A very large statistical effect was seen in pre and post testing in all groups of tandem walking speed and left step quick turn-turn time. The results showed some improvement with imagery groups as well as the control group. One outlier of the data came in the control group, the individual greatly improved during post testing. This dramatic improvement may have altered the control group.

Some studies have showed greater statistical results with the use of motor imagery when measured in different ways.[3,10,15] One discrepancy in motor imagery research is a lack of consistency with imagery time and measurement. There are various motor imagery intervention time periods and techniques. Rodrigues et al. focused on a one day intervention with three bouts of four tasks.[3] The four tasks were control, physical performance, kinesthetic imagery, visual imagery of plantar flexion and center of gravity displacement. There were two minutes between each bout. The study was measured through EMG recordings. Similarly Lorey et al. performed 60 trials of motor imagery, lasting 40 minutes, over one day.[15] This is another short motor imagery intervention. The results showed there is a higher first person kinesthetic imagery in left hemisphere activation compared to third person motor imagery. In contrast to short term motor imagery intervention performed 30 minutes of training, five days a week, for three weeks.[10] The motor imagery group improved significantly compared to the control group when performing postural balance tasks. These three examples show the versatility of motor imagery training. It is unclear how long an intervention should last or how many motor imagery sessions should be administered for optimal results.

Different methods of measurement are used throughout motor imagery research. This study is best measured with the use of the NeuroCom Balance Master to measure functional balance after motor imagery practice. Some different measurements that have been used include: electromyography (EMG),[3] functional magnetic resonance imaging (fMRI),[15] Transcranial Magnetic Stimulation (TMS),[27] and the Good Balance System.[10] Although each of these measurement devices measure different areas each has a common goal of establishing the effectiveness of motor imagery.

The present investigation showed statistical significance in tandem talking speed and step quick turn left turn time in all pre and post groups. The other dependent variables showed improvements although not statistically significant. This study is another tool to establishing the effectiveness and best use for to optimize motor imagery uses. Functional balance had not been examined until this point. As functional balance is related to daily movement, with the proper training athletic training professionals can use motor imagery methods to improve functional activities.

Conclusions

Upon review of the data some improvement is evident with each motor imagery technique, especially among tandem walking speed and left step quick turn-turn time. The motor imagery effects may be small, however they are a step in the right direction. Motor imagery is suggested to improve physical outcomes.[1,3,10,12,15] The present study is a start to researching the effectiveness of motor imagery on functional postural balance.

Key Words

Motor imagery, visual imagery, kinesthetic imagery, visuo-kinesthetic imagery, and functional balance.

CHAPTER V

CONCLUSIONS

It can be concluded from the evidence that a very large statistical significance was found in tandem walking speed and left step quick turn-turn time from pre-testing to post-testing. Similarly a moderate effect was seen in pre and post left step quick turn-turn sway, pre and post right step quick turn- turn time, visual versus non visual groups and visuo-kinesthetic versus non visuo-kinesthetic groups for right step quick turn-turn sway. There was no significant difference between the four groups. This data states that there the study had potential for clinical significance.

When analyzing Table 1 the mean pre-testing versus post testing data can show improvements in most of the variables. Visual motor imagery demonstrated improvements in all of the mean testing variables. The highest improvement was from tandem walking speed with an average speed improvement of 2.41 cm/sec. Upon examination of the kinesthetic pre and post testing mean variables showed improvement in tandem walking step width, tandem walking speed, step quick turn left turn time and speed, as well as step quick turn right turn time. The visuo-kinesthetic pre and post testing means showed numeric improvements in tandem walking step width, tandem walking speed, and step quick turn left turn time. These means simply show the average improvement per variable in each group. However, this evidence is helpful to perform future research on motor imagery and functional postural balance.

According to the data analysis there is some improvement with each motor imagery technique especially among tandem walking speed and left step quick turn-turn time. The motor imagery effects may be small, however they are a step in the right direction. Motor imagery is suggested to improve physical outcomes.[1,3,10,12,15] The present study is a start to researching effectiveness of motor imagery on functional postural balance.

Limitations

There are three major limitations that must be addressed. Firstly, the capabilities of this study did not allow the investigator to determine if the participants were focusing on the assigned tasks as directed. Participants were directed and educated on proper motor imagery technique however for the purpose of the study it is assumed the participants are correctly applying the techniques. The second limitation was outlying trials that affected the average of the three. Occasionally a participant would perform one trial exceptionally poorly. This negatively skewed the average despite the other two trials. The last limitation is time, this study may be more appropriate with more intervention periods. With one principle investigator, scheduling more motor imagery sessions was not possible.

Suggestions for Future Research

Although this study did not reach statistical significance it is a useful agent for future research. It is a start into research for whole body motor neural activation with the use of motor imagery. Research should investigate the time needed to achieve cortical plasticity, which is desired for long term effects of motor imagery.[15] Future research should examine the length of time needed and the frequency needed of motor imagery practice for optimal physical benefits. More research should investigate functional balance. Functional balance measures equate better to activities of daily living than static postural measurements.[34] Therefore, it could provide a more clinical use.

Table 1. Descriptive Values Across Interventions

Overall	Variable	PreTestMean	PreTestStdDev	PostTestMean	PostTestStd Dev
	TWSW	6.39	1.21	6.35	1.08
	TWS	27.02	9.72	30.38	9.29
	TWES	3.37	1.15	3.24	1.12
	SQTLTT	0.58	0.27	0.44	0.22
	SQTLS	20.50	8.54	18.78	5.14
	SQTRTT	0.55	0.38	0.46	0.28
	SQTRS	20.10	9.87	20.94	15.04

Control	Variable	PreTestMean	PreTestStdDev	PostTestMean	PostTestStd Dev
	TWSW	6.07	1.19	6.41	1.10
	TWS	24.54	9.03	26.95	8.46
	TWES	3.02	1.19	2.61	1.00
	SQTLTT	0.55	0.30	0.51	0.38
	SQTLS	18.82	5.01	19.00	6.31
	SQTRTT	0.71	0.67	0.58	0.47
	SQTRS	25.30	16.38	26.75	27.54

Visual	Variable	PreTestMean	PreTestStdDev	PostTestMean	PostTestStd Dev
	TWSW	6.15	0.96	5.83	0.72
	TWS	23.06	8.27	26.05	4.77
	TWES	3.09	1.01	2.94	0.86
	SQTLTT	0.59	0.31	0.38	0.10
	SQTLS	21.01	9.15	18.28	3.35
	SQTRTT	0.47	0.16	0.37	0.06
	SQTRS	19.17	3.98	18.23	3.32

Kinesthetic	Variable	PreTestMean	PreTestStdDev	PostTestMean	PostTestStd Dev
	TWSW	6.69	1.67	6.42	1.09
	TWS	28.62	10.65	32.53	8.47
	TWES	3.37	1.02	3.39	1.14
	SQTLTT	0.63	0.32	0.40	0.13
	SQTLS	21.67	9.93	17.81	5.70
	SQTRTT	0.53	0.28	0.44	0.26
	SQTRS	18.44	7.63	19.78	12.00

Visuo-Kinesthetic	Variable	PreTestMean	PreTestStdDev	PostTestMean	PostTestStd Dev
	TWSW	6.66	0.94	6.76	1.29
	TWS	31.84	9.69	36.02	11.57
	TWES	4.02	1.24	4.03	1.08
	SQTLTT	0.53	0.13	0.46	0.21
	SQTLS	20.5	10.20	20.03	5.30
	SQTRTT	0.48	0.15	0.46	0.16
	SQTRS	17.50	6.22	19.00	3.96

1.TWSW=Tandem Walk Step Width 2. TWS=Tandem Walk Speed 3. TWES= Tandem Walk End Sway 4. SQTLTT=Step Quick Turn Left Turn Time 5. SQTLS=Step Quick Turn Left Speed 6. SQTRTT=Step Quick Turn Right Turn Time 7. SQTRS=Step Quick Turn Right Speed

APPENDIX SECTION

APPENDIX A

Consent Form

Texas State University Consent Form – IRB # 2014X4012

Title of Project: The effects of motor imagery on functional balance

Principal Investigator:
Katherine Delude ATC, LAT, CES
Department of HHP
1850 Aquarena Springs Dr. Apt. 1512
San Marcos TX, 78666
kad119@txstate.edu
(413)658-7330

Academic Advisor:
Jack Ransone PhD, ATC, LAT
Department of HHP
A112 Jowers Building
San Marcos, TX 78666
Ransone@txstate.edu
(210)-798-8584

Purpose of the Study:
The purpose of this study is to determine the effects of motor imagery visual motor imagery, kinesthetic motor imagery, and visuo-kinesthetic motor imagery on functional postural balance.

This research study will attempt to establish a benefit of motor imagery after using motor imagery techniques. You are eligible to participate in this study because you are meet the criteria for the study.

Procedures to be Followed:
Upon agreement to participate in the study you complete a medical history questionnaire and an eye exam to assess your vision using a Snellen Eye Chart conducted by the investigator. You will then perform a pre-test baseline evaluation of tandem walking and step quick turn on the NeuroCom Balance Master force plate. If you are in the control group you will schedule a date to return in eight days to repeat the test. If you are in the intervention group you will meet with the principal investigator to practice motor imagery. The visual intervention will include watching a video of the tandem walking and step quick turn followed by using motor imagery to mentally perform the tasks that were just on the video. The kinesthetic group is listening to an audio of how you will feel physically when performing the tandem walk and step quick turn. The visuo-kinesthetic group will complete the requirements of the visual and kinesthetic group. There is no physical practice during the intervention. You will meet three times within six days following the pretest. You will complete your fourth imagery session directly before post testing which will be one day after the third session. Once you have completed the post-test you have completed the study.

Duration/Time:
The control group will take approximately 10-15 minutes per testing session. There are two sessions to complete. The intervention groups will take 10-15 minutes for the two testing

sessions. The motor imagery practice sessions will take approximately 10-20 minutes each session for three sessions.

Discomforts and Risks:
There are few minor risks or possible discomforts associated with this study. The testing during this exam using functional balancing skills and should not make you cause any physical discomfort or cause you to feel mentally or emotionally uncomfortable. The intervention of motor imagery has minor risk and should not make you feel uncomfortable. The questions on the forms ask for your general feelings about your mood, fear, and health and should not make you feel uncomfortable.

Benefits:
By participating in this study you will help athletic trainers understand how to make sure athletes are psychologically ready to return to sports after an athletic injury.

Statement of Confidentiality:
Your participation in this study will remain confidential. Only one person may have access to your files, myself and a designated athletic trainer at Hays High school; however, all files will be locked and stored in the biomechanics laboratory at Texas State University to help make sure no other individuals will have access to it. Once you have completed your testing your name will be removed and a number will be assigned to help make sure information cannot be associated to you. If the research is published, personal identifying information will be withheld. At the end of the project all of the files will be kept in the Athletic Training Research Lab for a 5 year period. All records will be destroyed after that period of time.

Right to Ask Questions:
You may ask any questions about the research procedures and questions at any time. Your questions will be answered and can be directed to Katherine Delude at kad119@txstate.edu or (413)-658-7330 (cell) or Jack Ransone at ransone@txstate.edu or (210)-798-8584.

Voluntary Participation:
Participation within this study is completely voluntary. You may withdraw from the study at any time for any reason. If you decide to withdraw from the study please notify Katherine Delude of your intent to withdraw. Withdrawing from this study will not affect decisions made by the athletic trainers and it will not negatively affect you.

Request for Further Information:
You should feel comfortable participating in this study. If you have any concerns or questions regarding the study you may contact the investigator at any time. You may also contact the Texas State University of San Marcos Institutional Review Board Chairperson, Dr. John Lasser, at (512-245-3413 – lasser@txstate.edu), or Ms. Becky Northcut, Compliance Specialist (512-245-2102).

Disclosure and Funding:
The researcher has no financial or other potential conflict of interest in performing this project. Summary findings will be provided to the participants upon request.

Approval:
This study has been approved by the Texas State University's Human Subject Institutional Review Board #2014X4012

You have been given an opportunity to ask any questions that you may have and all questions have been answered to your satisfaction.

You will be given a copy of this consent form to keep for your records.

____
Participant Name (please print in all caps)

_______________________________________ _____________________
Participant Signature Date

I, the undersigned, verify that the above informed consent procedure has been followed.

_______________________________________ _____________________
Investigator Signature Date

APPENDIX B

Medical History Questionnaire

Medical History Questionnaire
(Adapted from Texas State Athletics Preparticipation Physical Evaluation- Medical History)

Name:	Sex: M / F	Age:
Height:	Weight:	Date of Birth:
Vision: Bilateral 20/	Vision Corrected: Yes / No	Pupils: Equal / Unequal

Yes No

1. Have you been hospitalized overnight in the past year?
2. Have you had any surgeries in the past year?
3. Have you ever been dizzy during exercise?
4. Have you had a severe viral infection in the past month? (ex: myocarditis or mono)
5. Have you had a head injury or concussion? If so, when was the most recent?
6. Have you ever been knocked out, unconscious or lost your memory? If yes, when was the last occurrence?_______________.
7. How severe was each one? Explain below.
8. Do you have frequent headaches?
9. Have you ever had a seizure?
10. Have you ever had significant numbness or tingling in your hands, arms, legs, or feet?
11. Have you ever had any problems with your eyes or vision?
12. Have you ever had a sprain, strain, or swelling after an injury? If yes, when was the most recent?____________.
Has your injury since healed completely?
13. Have you broken bone, fractured a bone, or dislocated a joint? If yes, what/when?
14. Have you had any problems with pain or swelling in muscles, tendons, bones, or joints within the past six months? If yes explain below.
15. Have you ever been diagnosed with any vestibulocochlear impairments?
16. Have you ever been diagnosed with any spinal injuries or impairments?

If you answered yes to question (7) and (14) please explain here:

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