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Motor Skills and Mental Practice: A Tool for Physical Therapy

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MOTOR SKILLS AND MENTAL PRACTICE: A TOOL FOR PHYSICAL THERAPY

by

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This Independent Study, submitted by Kari L. Drevecky in partial fulfillment of the requirements for the Degree of Master of Physical Therapy from the University of North Dakota, has been read by the Faculty Preceptor, Advisor, and Chairperson of Physical Therapy under whom the work has been done and is hereby approved.

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This Independent Study is dedicated to the memory of Matt O'Hara.

Words cannot express my gratitude.

To my family; thank you for your patience and support. The past months would have been impossible without you.

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ABSTRACT

The purpose of this Independent Study is to review the literature concerning mental practice and its effects on motor skill performance and retention as important within the field of physical therapy. The study of mental practice as concerned with physical therapy is important as this modality is not often included in patient treatment programs, despite its potential applications. The content of this paper will consist of definitions, theoretical explanations, effectiveness of mental practice, and the effects of individual differences on mental practice. The primary research questions were: (1) What is mental practice? (2) How does mental practice work? (3) Does mental practice facilitate motor skill acquisition, performance and retention? (4) Do any differences between individuals affect the results achieved with mental practice? (5) Does mental practice have any application to physical therapy and what can be done to maximize its gains in a physical therapy setting?

CHAPTER 1

INTRODUCTION

Mental imagery has been a topic of scientific interest in the areas of psychology and physiology as early as 1910,[1] when Perky published "An Experimental Study of Imagination". In the years to follow, imagery has been commonly researched within the fields of psychology and physical education with pertinent literature included in the journals of those disciplines. Often, the research examined the effect of mental imagery on the performance of motor skills.

The performance and learning of motor skills are of particular interest to health care professionals, such as physical therapists,[2] concerned with the improvement of motor skills. This paper will review the literature concerning mental practice and motor skill learning and performance as factors important to physical therapy. Definitions will be included, as well as theoretical explanations of how mental practice functions to facilitate motor skill acquisition and retention. The concept of individual differences will be explored to determine which ones, if any, enhance or inhibit the effects of mental

practice. Finally, application to physical therapy will be discussed with specific suggestions for clinical use.

The specific research questions that served as the basis for the content of this review were: (1) What is mental practice? (2) How does mental practice work? (3) Does mental practice facilitate motor skill acquisition, performance and retention? (4) Do any differences between individuals affect the results achieved with the use of mental practice? (5) Does mental practice have any application to physical therapy and what can be done to maximize its gains in a physical therapy setting?

Before reviewing the body of literature regarding mental practice, an understanding of the terminology is essential. Richardson[3] defined mental practice as "the symbolic rehearsal of a physical activity in the absence of any gross muscular movements". Numerous other terms have been utilized instead of, or in the addition to, mental practice. Mental practice has also been referred to as symbolic rehearsal, mental rehearsal, imagery practice, implicit practice, conceptualizing practice and mental preparation.[4] In this paper, the author uses the terms mental practice and mental rehearsal interchangeably for purposes of clarity and to limit monotony.

An area of confusion is the meaning of imagery and its relationship to mental practice. According to Denis,[5] imagery has two components. The first component of the

definition states that imagery is a psychological activity that recalls the physical characteristics of an object or objects that are not in the current visual field. These objects may be moving, stationary or even undergoing a transformation. The second part of the definition goes beyond the imagination of past and present environment, and consists of imagining anticipated or theoretical objects or events.

Imagery refers to the visual realm. Mental imagery can be utilized to conjure up visual pictures of any object or conglomeration of objects. Mental practice may include a visual or imagery component (i.e. imagining seeing oneself shoot a free throw), but goes beyond visual images to include proprioceptive and kinesthetic sensations.[5] An example of this would be to imagine what the body feels like while shooting a free throw. Thus, visual imagery is one aspect of mental practice.

Mental rehearsal can be divided into two categories based on varying perspectives: (a) "first-person" or internal mental rehearsal and (b) "third-person or external mental rehearsal. The "first-person" point of view includes the mechanisms other than visual imagery. When rehearsing mentally from the internal perspective, the subject would imagine what it would feel like being inside his/her body while performing a specific motor skill.[5]

The second type of mental practice is the "third-

person" or external point of view. This point of view is visual in nature and could be classified as imagery. The subject imagines seeing him/herself performing the skill as if he/she was an observer. This perspective is like watching the performance on video.[5]

With the pertinent terms defined, the foundation has been established upon which to describe the theoretical basis of the mechanism of mental practice. The following chapter will review the common theories offered to explain how mental practice effects motor performance.

CHAPTER 2

THEORY

The literature discusses several possible explanations as to how mental rehearsal facilitates motor learning, acquisition and retention. The two most accepted theories are the psychoneuromuscular theory and the cognitive processing or symbolic-perceptual theory. The text of this chapter will be devoted primarily to the above two theories. Other possible explanations are the mental preparation theory and the ideomotor theory. The older of the two most popular theories, the psychoneuromuscular explanation will be discussed first.

Psychoneuromuscular Theory

The psychoneuromuscular theory suggests that mental practice produces subthreshold muscle contractions in the musculature that resemble the larger contractions that would occur with performance of the actual activity. These subliminal contractions are thought to be strong enough to trigger kinesthetic feedback. This feedback would generate a kinesthetic picture closely resembling that of the actual movement.[5-7]

Subthreshold contractions can be monitored via electromyography (EMG).[8,9] Utilizing EMG, Jacobson[9] found that actual muscular activity did occur simultaneously with the mental performance of a motor skill. Thus, support for the psychoneuromuscular theory relies on the assumption that mental rehearsal causes an increase of neuromuscular electrical activity which, in turn, increases performance.[2]

In a study by Maring,[10] it was found that an experimental group using mental and physical practice demonstrated improvement in accuracy at a significantly faster rate on a ping pong toss than that of the control group. Twenty six subjects were divided randomly into two groups. The control group performed only physical practice of a ping pong toss while group two performed both physical and mental practice of the task. The long and lateral heads of the triceps and the biceps brachii were monitored with EMG to determine electrical changes during skill acquisition. The experimental group showed changes in the electrical timing rate that represented more effective movement (the peak of the agonist was significantly earlier and the agonist began firing later in the range of motion to slow the movement).[10] This study supports the psychoneuromuscular theory.

A review of the literature indicated that electrical activity is present in the muscles during imagery of movement or mental practice.[8,9] Some authors, however, do

not agree that the electrical activity in the muscles, as measured by EMG, provides support for the psychoneuromuscular theory. Kohl and Roenker[11] argued that even though the mental practice generates small neuromuscular patterns, these subthreshold contractions may not be able to trigger proprioceptive feedback that affects motor skill performance. They proposed that although muscular activity is present during mental rehearsal, it is coincidental and is not the mechanism for motor skill improvement. This leads to the other popular explanation, the cognitive processing theory.

Cognitive processing or Symbolic perceptual Theory

In this theory, mental practice serves as a tool to learn about the cognitive aspects of a skill. As such, mental practice is utilized as a vehicle for the individual to gain insight into "how to do" the activity. It provides the opportunity to solve potential problems before encountering them in actual performance of the skill. Therefore, the effects of mental rehearsal can be explained by the presence of cognitive processing.[5,12]

Strong support for the cognitive theory is found in studies on bilateral transfer of skill learning.[7,13] It has been found that transfer of learning occurs in the opposite limb when mental practice is performed by only one limb. The cognitive insight gained from practicing a skill

with one extremity had been applied by the subject when performing the same activity with the other extremity.

Ryan and Simons[12] noted more performance improvement on motor skills with high cognitive/ symbolic content than skills with low cognitive demands when mental practice was used. Wrisberg and Ragsdale[14] found that mental practice facilitated motor learning most effectively when the task was predominantly cognitive in nature.

Johnson[7] postulated that if movement had primarily a visual or cognitive basis, then a visual task performed during imagery should inhibit the image. If imagery was predominantly motor, then simultaneous performance of a motor task should inhibit the image. The results of the study showed that the visual task prohibited the imagery, thus supporting the cognitive/perceptual theory.

Other Theories

In the ideomotor theory, mental images of movement may substitute for actual motion in the production of motor programs. The mental preparation theory suggests that mental rehearsal functions to block out disrupting thoughts, and increases concentration and arousal.[5,6,15]

CHAPTER 3

MENTAL PRACTICE: EFFECT ON MOTOR SKILLS

When reviewing the effects of mental practice on motor skills, two areas of question emerge. The first is whether or not mental practice enhances the acquisition of a motor skill measured by change in performance. The second pertains to mental rehearsal's effect on retention of a skill.

Acquisition and Performance

Most studies concerned with acquisition and performance are comprised of a no-practice control group, a physical practice group, and a mental practice group. Often a experimental group is included, comprised of both physical and mental practice. Performance of the activity is scored prior to and after the treatment for comparison.

The effect of mental rehearsal on isometric strengthening of the quadriceps was studied by Cornwall, Bruscato and Barry.[16] They found the mental rehearsal group to have significantly improved isometric quadricep strength over the no practice group after four, 30 minute mental practice sessions over four days. An actual practice group was not included. However, Feltz and Landers[6] found no

significant difference between mental practice and no-practice groups on grip strength. A combination group was not included. The apparently contradictory findings of the above two studies could suggest the effectiveness of mental rehearsal in increasing muscular strength depends upon the specific motor skill.

Vandell, Davis and Clugston[17] found mental practice to be as effective as physical practice in increasing performance on shooting free throws and throwing darts. Unfortunately, no statistical tests were performed to determine significance. Clark[18] found that mental practice was almost as effective as physical practice in improving a one hand foul shot for experienced basketball players. Mental practice was not as effective as physical practice, in this study, for novice groups. The author concluded that a certain amount of motor experience was necessary to obtain the best results from mental rehearsal. The advantage of physical practice seemed to decrease with an increase in task familiarity. Both mental practice and physical practice groups performed better than a no-practice group in Twinning's[19] study on learning a ring-tossing task.

Mental practice was found to be associated with a significant improvement of a motor skill in a study performed by Smith and Harrison.[20] In another study, physical practice paired with mental practice facilitated a significant increase in accuracy of the forearm ping-pong

toss when compared to physical practice alone.[10] Mental practice combined with physical practice appeared to be effective in acquisition of motor skills in an open and closed environment.[21]

In dart throwing, Mendoza[22] found physical practice to be more effective than mental practice combined with physical practice or mental practice alone. However, Maring[10] found that the group that underwent both physical and mental practice performed better on a ping pong toss than the group consisting of physical practice alone. Both mental practice and physical practice were found to facilitate gains in rotary pursuit skills.[11]

In summary, physical practice appeared to increase performance the most.[19,21,22] Combined physical and mental practice demonstrated the next best treatment, although, some studies found the combination of mental and actual practice or mental practice alone improved performance as much as physical practice.[10,13,17,18,23] Mental practice was significantly more effective than no practice.[11,22] The literature was divided on the effect of mental practice on strength.[6,16]

A few studies failed to find significant improvement in motor performance in regards to mental practice alone, or in combination with physical practice.[24,25] In at least one study, the lack of significant findings could be due to massed mental practice which may produce more interference

for acquisition than massed physical practice would produce.[24,3]

Retention

Sackett[26] found no significant difference between the retention of the mental practice group and the physical practice group in a maze drawing activity. However, in a study by Housner and Hoffman,[27] visual imagery was found to be a significant factor in retaining location information. The type of activity could dictate the effect of mental rehearsal on retention of learning.

A study conducted by McBride and Rothstein[21] produced data that indicated both physical and mental rehearsal to be effective in increasing the retention of an skill in open and closed environments. Mental practice could therefore be useful in a closed environment such as the clinic and an open environment such as a city street or a shopping mall.

In researching the most advantageous combination of mental and physical rehearsal for optimal retention, Rubin-Rabson[28] reported the highest level of retention of a piano skill after one week by a group completing a program of physical practice, 4 minutes mental practice, followed again by physical practice. The group demonstrating the second best retention had a program that consisted of physical practice, followed by 4 minutes of mental practice. The least successful group underwent two sessions of physical

practice. The results of this study supported the use of combined, alternating sessions of physical and mental practice.

CHAPTER 4

INDIVIDUAL DIFFERENCES AFFECTING MENTAL PRACTICE

Before mental rehearsal can be effectively utilized as a tool in physical therapy, the known effects of individual differences on mental practice should be understood. Individual difference refers to the variance in strengths and capabilities found in people due to the uniqueness of the individual. The following sections will review the literature concerned with these differences.

Intelligence

The variable of intelligence has been the subject of studies conducted by Perry,[29] Clark,[18] Whiteley,[30] and Start.[31,32] Except for Perry, these authors found an insignificant correlation between intelligence and improvement in motor skill performance after mental rehearsal. Perry found a positive correlation between intelligence, as measured by the Kuhlman-Anderson test, and the performance on a mirror drawing task after mental practice.[29]

A study looking at the use of imagery to improve reaction and movement time in adolescents with mild mental retardation was conducted by Surburg.[33] The results

demonstrated significant changes in reaction time, and in some instances, movement time. This study suggested that imagery has the potential of facilitating motor skill improvement in individuals with below average intelligence.

Abstract Reasoning and Spatial Relationships

An insignificant correlation was obtained between improvement on a tennis forehand and backhand drive after mental practice in respect to both abstract reasoning and spatial relationships.[34] Abstract reasoning and spatial relationships were represented by scores on the corresponding sections of the Differential Aptitude Test (D.A.T.) battery. This article was the only one found concerning abstract reasoning and spatial relationship skills.

Mechanical reasoning

The effect of mechanical reasoning skills on improvement of a ball throwing skill with mental rehearsal was another variable included in Wilson's[34] study. An insignificant correlation was obtained between tennis drive improvement and D.A.T. scores on mechanical reasoning.

Age

Rapp and Schroder[35] found that children as young as five and six years of age can use mental rehearsal to

improve rope-skipping. On the other end of the spectrum, Fansler, Poff and Shepard[36] found a significant increase in one-leg balance times in volunteers with a mean age of 80 years. Mental practice appeared to be effective for a wide variety of age groups.

Games ability

Those individuals who were rated high in games ability made significant improvement on a basketball task practiced mentally for 5 minutes a day for 7 days when compared to subjects with low ratings of games ability.[37] However, when interpreting the results from research on games ability, the involvement of two confounding variables must be considered.

Those individuals who have been identified by their peers as having high games ability may have been more motivated by the ego to perform new activities well. In addition, subjects high in games ability may have capitalized more on the initial physical trials. The performance gains noted in individuals with high games ability may not be due to mental practice. These confounding variables must also be considered when looking at mental practice and motor ability.[3]

Motor Ability

The research is divided in regards to the effect of motor ability on the effectiveness of mental rehearsal.

Start[38] found an insignificant correlation between Iowa-Brace test scores and gains on a gymnastic skill. In contrast, Whiteley[30] reported a significant correlation between scores on the above mentioned test and a ball throwing task.

Locus of Control

Locus of control refers to an individual's perception of control over events. An individual with an internal locus of control believes that events are due to consequences of their actions. In contrast, a person with an external locus of control attributes events to the environment. According to Wichman and Lizotte,[39] after 4 days of mental practice, participants with an internal locus of control improved their accuracy in dart throwing significantly over the control no-practice group as well as those subjects possessing an external locus of control.

Ethanol consumption

Mental rehearsal of a task after consuming ethanol limited the behavioral effects of the drug when compared to mental practice before drinking.[40] In other words, individuals who consumed the drug and then mentally rehearsed a task performed better than subjects who performed mental practice first. Clinically, this research has implications when utilizing mental rehearsal with

patients under the influence of alcohol. Mental practice performed before the patient consumes alcohol will not facilitate motor performance improvement if the patient drinks later. Mental practice would not be appropriate for this population.

Selective Attention

A significant correlation was obtained by Start[38] between gymnastic skill gains after mental rehearsal and Form B of the Gottschaldt Figures Test. This finding supports the assumption that an individual must possess adequate selective attention to utilize the technique of mental rehearsal. Attention to mental rehearsal may only be possible for a short period of time. According to Twining,[19] adequate mental concentration was not present after mental rehearsal lasting more than five minutes.

Imagery ability

Imagery ability is often cited as an extremely important aspect of mental rehearsal.[5,17,18,25] Kinesthetic and visual imagery have been found to facilitate effective mental rehearsal[41] and were effective in movement memory.[27] Internal rehearsal appears to be more effective than external.[42] Other studies failed to find imagery ability significant, possibly due to lack of control of interindividual variables and validity of imagery questionnaires.[5,12]

Gender

Perry[29] failed to find a correlation between sex and gains on five tasks that involved mental practice. This study found no difference between males and females in motor skill improvement due to mental practice.

In summary, the individual differences that appeared to exert influence upon skills learned with mental rehearsal were imagery ability, motor ability, games ability, and locus of control. Those differences that have not been found to significantly effect the outcome of mental practice were abstract reasoning, mechanical reasoning, gender, intelligence, age, and spatial relationships.

CHAPTER 5

APPLICATION TO PHYSICAL THERAPY

Mental practice has been proven to aid acquisition, performance, and retention of motor skills. It has commonly been used to improve sporting performance, and has recently been utilized in the rehabilitation of athletes.[43] The author proposes that this technique could also be effectively applied to the individuals who seek the services of a physical therapist, such as the "industrial athlete", the neurologically impaired individual, or the orthopedic patient. The following sections will discuss the most effective use of mental rehearsal, as well as offer suggestions for potential application in the area of physical therapy.

According to the literature, mental practice is most effective when alternated with physical practice.[17,18,23] Attention is limited to short periods of time; five minutes or less.[19] Sessions should take place over a period of time instead of massed over several days.[15] Therefore, it would be beneficial to alternate short sessions of mental rehearsal with actual practice for a period of weeks.

On the basis of this literature review, the author suggests the following when utilizing mental rehearsal.

Because concentration will be required to practice mentally, a quiet place free of distractions is ideal. Closed eyes and/or a darkened room block visual interference.

Initially, guide the patient's images to obtain mental practice as close to "perfect form" as possible. Imperfect practice should be discouraged as it reinforces imperfect performance. Verbal descriptions and demonstration are useful.[5]

For example, tell the patient "Bend your good elbow slowly. Concentrate on what the movement feels like. What are the muscles doing? Notice how your arm looks as it bends. Now, close your eyes and imagine you are bending your other arm at the elbow. Imagine what it looks like (external imagery). Imagine how the motion feels, and the feel of the skin and muscles (internal imagery) as your elbow bends."

As soon as possible, relinquish control of the rehearsal to the patient. Encourage patients to change the scenario to serve their particular needs. The speed of mental practice can be modified. Slow images allow for perfection of the imagined skill and performing the mental activity at actual speed most closely mimics the functional aspect of the skill.

The example of bending an elbow is a simple motor skill when compared to the activities of ambulating with a walker or lifting a crate from the floor with good body mechanics,

but the basic concepts of mental practice can be applied and modified to best simulate each unique skill.

Several authors have suggested specific instances in which mental practice would be beneficial. After reviewing the literature, Weinburg[15] recommended that mental practice could be utilized in activities that are fatiguing or impractical. Fatigue could be a significant factor in conditions such as multiple sclerosis and Guillain-Barre syndrome. The use of special equipment may make home exercise impractical. One advantage of mental practice, however, is that no special equipment or facility is required. Patients can practice at any time, in any environment, including their home.[2]

In addition, Weinburg suggested that mental practice can decrease recovery time.[15] This is attractive from an economic standpoint in two ways: 1) hospital stays can be shortened due to an accelerated functional return, and 2) therapists can be performing other jobs while the patient is practicing mentally in the clinic, at home or when the patient has been discharged.[36]

Immobilization, pain, or swelling, secondary to injury or surgery, can cause a loss of voluntary control of musculature. Mental rehearsal increases the probability of maintenance of functional neuroanatomical circuits.[2] If these circuits are maintained, return of voluntary muscle function will theoretically be facilitated.

Mental practice is a modality that patients perform on themselves. This technique encourages patients to take responsibility for their own rehabilitation[36] and develop a sense of ownership of their abilities, disabilities, and recovery.

Individuals afflicted with chronic or slowly improving conditions can see performance improvement and experience success via mental images. They can practice perfect performance in potentially real-life situations without moving a muscle.[2] Patients with spinal cord injuries can practice a successful movement long before actually performing it. Clients who have experienced a stroke can imagine moving from sit to stand before they are physically able to execute the skill.

Concentration and focusing abilities can also be promoted when using mental rehearsal.[5] Practicing mentally requires concentration on the task at hand. The imagery commonly used before athletic competitions serves this purpose.

Although studies specific to physical therapy are few, the findings of some articles could be applicable. The Cornwall, Bruscato and Barry[16] study, which demonstrated significant isometric quadriceps strengthening with mental practice, could be considered pertinent to physical therapy. Patients recovering from painful knee reconstructions and arthroscopies, and those who suffer from chronic conditions

such as patellar-femoral syndrome and osteoarthritis could limit the pain and edema sometimes caused by active exercise by interspersing actual practice with mental practice, while improving isometric strength.

Another study, conducted by Fansler and Poff,[36] examined the usefulness of mental practice in improving balance in elderly women.[36] This study examined ideokinetic facilitation (IF) as a means by which one-legged balance times could be improved. IF consisted of perfect mental performance of the motor skill combined with relaxation. Thirty six elderly women from two senior-citizen residence centers were randomly assigned to three groups: a) Group A (recorded non-sense + physical practice, b) Group B (recorded, guided relaxation + physical practice), and c) Group C (recorded, guided IF + physical practice). The subjects participated in their assigned group activities over a three day period.

A review of the results indicated that all groups showed improved one-legged balance times. Group C, however, improved the most, at 91%. The findings of this study showed that IF + physical practice improved balance more than physical practice with relaxation or physical practice alone. Because balance is a crucial component of movement and function, this article supports the clinical usefulness of IF in physical therapy.[36]

CHAPTER 6

CONCLUSIONS

Mental practice is a technique rarely utilized in the physical therapy clinic. Given its apparent effect on the performance and retention of motor skills, however, consideration of this treatment technique as a treatment method is due. Significant performance gains and increased retention have been documented in skills such as shooting free throws,[17,18] throwing darts,[17,22] and tossing rings.[19] Although these skills may not apply directly to physical therapy, the majority of research in this area leads to the assumption that mental rehearsal does improve motor performance and retention of motor skills.

Because each individual is unique, mental practice will affect skill acquisition and performance differently for each person. Differences that were found to encourage skill improvement with mental practice were an internal locus of control,[39] ability for selective attention,[38] and imagery ability.[5,17,18,25] Intelligence and gender were not found to have a significant effect. Mental practice appears effective in most age groups.

The literature contains suggestions for maximizing the effects of mental practice. These suggestions are

summarized as follows. Use mental rehearsal in combination with physical practice, alternating actual and mental sessions. Mental practice sessions should be short and frequent as opposed to "massed" practice. Practice should take place over a period of time instead of within a day or two. Internal imagery is more effective than external imagery. Maximum effectiveness depends on numerous factors, some of which are beyond the control of the individual. In addition to utilizing the above techniques, further research specific to physical therapy is essential to ensure the most effective use of mental rehearsal in the future.

Fansler and Poff[36] demonstrated that mental practice improved a skill fundamental to physical therapy; balance. Other specific motor skills common to physical therapy should be researched, among them ambulation with or without an assistive device, range of motion, negotiating stairs, bed mobility, and learning to lift with proper body mechanics. Because these areas are unlikely to be addressed by professionals other than physical and occupational therapists, it is left to them to research the effects mental practice has on therapy specific motor skills.

This paper has attempted to show that mental practice is applicable to physical therapy. The technique is flexible. It can be modified to closely approximate any motor skill. It is not meant to take the place of actual practice, but to be used as an adjunct. Although gains

achieved with mental practice are not as dramatic as actual practice, mental rehearsal is superior to no-practice at all. Mental practice is the ideal technique if physical trials cannot be performed due to such circumstances as pain, immobilization, or fatigue. Thus, mental practice is not a magical means of dramatically improving motor performance, but is one more technique to be added to the arsenal of treatment tools used, when appropriate, to aid individuals in achieving maximal physical function.

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