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The effectiveness of mental practice as a complement to traditional therapy in rehabilitation outcomes of patients status-post total knee arthroplasty

Nancy T. Fell

To the Graduate Council:

I am submitting herewith a dissertation written by Nancy T. Fell entitled "The effectiveness of mental practice as a complement to traditional therapy in rehabilitation outcomes of patients status-post total knee arthroplasty." I have examined the final electronic copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Education.

Craig Wrisberg, Major Professor

We have read this dissertation and recommend its acceptance:

Accepted for the Council:

Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

To the Graduate Council:

I am submitting herewith a dissertation written by Nancy T. Fell entitled "The Effectiveness of Mental Practice as a Complement to Traditional Therapy in Rehabilitation Outcomes of Patients Status-Post Total Knee Arthroplasty." I have examined the final copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Education.

Craig A. Wrisberg

Craig Wrisberg, Ph.D.,
Major Professor

We have read this dissertation and recommend its acceptance:

Jeff P. DeSensi

Bill C. Wallace

Wendell Leeman

Accepted for the Council:

Interim Vice Provost and
Dean of The Graduate School

THE EFFECTIVENESS OF MENTAL PRACTICE AS A COMPLEMENT TO TRADITIONAL THERAPY IN REHABILITATION OUTCOMES OF PATIENTS STATUS-POST TOTAL KNEE ARTHROPLASTY

A Dissertation
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Over the past few months, while completing edits on my dissertation, I have reflected over the doctoral experience. It was not what I had anticipated. Coursework varied tremendously both in content and level of challenge. Because of work commitments, there was little opportunity for collaboration with other students or faculty outside of class. Without question, the dissertation research and writing process had the biggest educational impact on me. It challenged my endurance, commitment, and thinking. Overall, the doctoral process has positively impacted my ability to teach and participate in original research. It will also serve as a reminder of a goal that was set and then slowly, but surely met. This goal could not have been achieved without the love and support of many individuals.

I begin my thanks with my doctoral committee. The members were consistently prepared and supportive, yet always challenging. I have special appreciation and thanks for my committee chair, Dr. Craig Wrisberg. Dr. Wrisberg took the time necessary in class and through meetings to get to know me. He understood my background and strengths enough to challenge me to design and implement a clinical study. I now appreciate a new level of ability and understanding because of this unique challenge.

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Finally, I must thank my family. My mother, grandmother, father and mother-in-law, sisters, brother, brothers-in-law, nephews and niece all provided me with encouragement through loving conversations. Many hours of long-distance phone calls allowed me to release frustration and provided time away-from-it-all. It is my husband, Danny, who deserves my eternal love and tremendous gratitude for his support of me through this process. Danny married me in the midst of coursework and provided unwavering strength and support. He encouraged me when I was tired or lacked focus. Without him, the study would never have been completed. Throughout the five years of doctoral study, my family remained consistently positive and exceptionally caring, always managing to fill me with joy. Danny, Mom, Nannie, Bill, Gina, Christine, Craig, Sharon, Jim, John, Alex, Abby, David, Andy and Brent – Thank you!

ABSTRACT

Therapists are challenged daily with establishing care plans and structuring functional activities that will best assist their patients to decrease pain, recover motion and strength, and return to functional, high quality lifestyles. All of this must be accomplished in the most cost efficient manner. This research was designed to investigate the effects of mental practice (MP), when used in conjunction with traditional therapy for patients post-knee replacement surgery, on functional recovery and hospital length of stay.

Twenty-three individuals, post-total knee arthroplasty (TKA), meeting inclusion criteria while in a rehabilitation hospital participated in the study. Participants were randomly assigned, with gender matching, to motivational control and MP (experimental) groups. In addition to their regular therapy programs, members of the control group listened to an audio-tape with progressive relaxation while those of the experimental group participated in an audio-taped guided relaxation followed by MP. The participants' knee range of motion (ROM), knee strength, quality of gait via the Tinetti Gait Assessment, and functional ability via the Functional Independence Measure, were assessed pre- and post-intervention. Hospital length of stay was also measured through chart review.

Post-intervention results revealed significant differences between groups, with the experimental group demonstrating greater improvements than controls in ROM, knee flexion strength, gait quality, and functional ability in stair climbing ($p \leq 0.05$). Remarkably, the improvements made by the experimental group were made in a significantly shorter hospital length of stay than those of the controls ($p < 0.05$).

The main hypothesis of the study was supported: Patients with osteoarthritis, status-post TKA, who received a complement of MP with traditional therapy had enhanced rehabilitation outcomes as compared to a control group of patients who received traditional therapy alone. These results are consistent with those found for other non-therapeutic populations (e.g., Blair, Hall & Leyshon, 1993; Hall, Schmidt, Durand & Buckolz, 1994). Thus, it is recommended that, in this era of healthcare reform and cost containment, MP should be considered as a potential complement to conventional physical therapy.

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Chapter One

Introduction

Rehabilitation professionals, including occupational and physical therapists, commonly work with patients to facilitate the learning of motor activities, whether it be the fine-tuning of coordinated movements or the acquisition of new, compensatory strategies. Historically, the focus of physical rehabilitation has been on physical practice, with an emphasis on specificity of exercise in randomly structured practice sessions (Shumway-Cook & Woollacott, 2001; Carr & Shepherd, 2000; Ryerson & Levit, 1997; Umphred, 1995). In other domains (e.g., athletics, dance, music), performers often supplement physical training with mental practice (MP) in order to enhance their skill levels (Sheikh & Korn, 1994). A review of the literature supports the use of MP in a hierarchy of practice (see Figure 1) with optimal performance resulting from a combination of physical practice with MP (Corbin, 1972; Feltz & Landers, 1983; Richardson, 1967). Schmidt and Lee (1999) conclude that MP can produce large positive results and transfer improved skill to the performance of an actual physical task. For the most part, however, it appears that rehabilitation professionals have not considered the potential benefits of MP in lieu of or as a complement to physical practice.

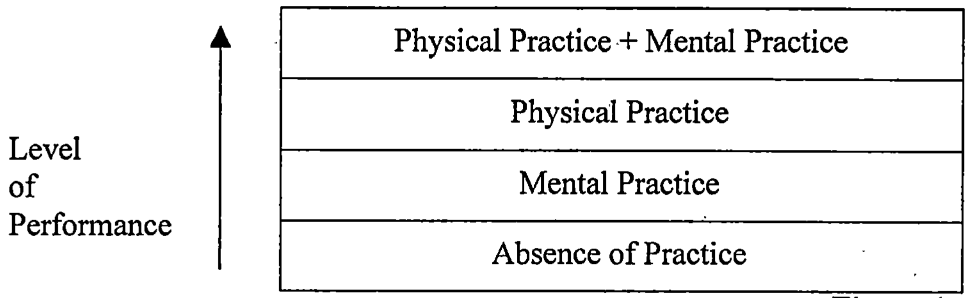

Figure 1
Hierarchy of Practice

Mental practice is referred to by many names in the scientific literature. Some of these include visualization, mental rehearsal, mental imagery, imaginary practice, conceptualizing, and covert rehearsal. While some authors attempt to distinguish the meanings of these terms (Schmidt & Wrisberg, 2000), more often the labels have been used interchangeably. For the purposes of this study, mental practice is defined as the mental or cognitive imagining of some aspect of the performance of a task or skill in the absence of any associated overt physical actions.

<u>Background to the Study</u>

The premise that MP is a potentially beneficial form of practice for improving physical performance is deeply embedded in the holistic notion of a mind-body connection. Unfortunately, the currently accepted medical model of scientific research seems to circumvent this connection (Chiaramonte, 1997). The traditional Western approach to medicine and the scientific method originated in the 17th century and was significantly influenced by the thinking of Rene Descartes, Isaac Newton, and John Dewey (Conant, 1964). Newtonian-Cartesian physics is based primarily on the mechanical laws of cause and effect and the search for that which is "real" by the proof or disproof of hypotheses. The scientific method has also been described as discovery through reductionism; that is, scientists attempt to reduce the influence of any interfering variables--including those of chance or luck to, as rigorously as possible, determine the effect of the treatment variable. It is clear that traditional Western medicine treats infectious disease, acute illness, and trauma more effectively than any other health care system in the world (Broderick, 2000; Chiaramonte, 1997; Davis, 1997). However, there are unexplained phenomena that exist which the current Western model largely ignores (Davis, 1997). Perhaps the best medical example of such a phenomenon is the placebo effect. Ironically, this effect may be the cornerstone of a new and improved understanding of the mind-body connection and physical healing (Rossi, 1986).

Traditional scientific methodology strives to separate the body from the mind and emphasizes only those phenomena that can be physically observed. Yet even C. Everett Koop, former United States Surgeon General, suggests that appropriate responses to crises in modern medicine lie in the development of alternative medicine (Koop, 1996). It is interesting to note that in 1990, one third of the population of the United States was estimated to have used some form of alternative therapy; and it is likely that today the percentage is far higher (Gordon, 1998). According to the World Health Organization, 80 percent of all people worldwide use these "alternatives" as their primary form of care (Gordon, 1998; Eisenberg, et al., 1993). The former Surgeon General's stance and the evolving curiosity of still other physicians practicing traditional Western medicine have been further impacted by discoveries emanating from psychoneuroimmunology.

In recent years, psychoneuroimmunology researchers have identified a continuous dialogue between the mind and nervous and immune systems which suggests that emotions can affect the immune system in both positive and negative ways (Kandel, et al., 2000). More specifically, two pathways of communication that have been identified are the autonomic nervous system (sympathetic and parasympathetic) and the immune system of neurotransmitters and neuropeptides (Felten, et al., 1985; Weber & Pert, 1984; Motulsky & Insel, 1982; Shapiro & Strom, 1980). Interactions between the mind and these two systems have been shown to exist in diseases such as human immunodeficiency virus (HIV) (e.g., Taylor, 1995; Theorell, et al., 1995), hypertension (e.g., Alexander, et al., 1996; Knox, et al., 1986; Patel, et al., 1985), cancer (e.g., Fawzy, et al., 1993; Spiegel, et al., 1989; Margolis, 1985; Simonton, et al., 1978), bronchitis and emphysema (e.g., Moody, Fraser & Yarandi, 1993), and arthritis (e.g., Broderick, 2000; Boisset, et al., 1994; Gorman & Kertzner, 1991). Such research makes it increasingly difficult to ignore the mind-body connection in the diagnosis and treatment of disorders.

Holistic medicine's theoretical base emphasizes the importance of the interaction of energy, people, and matter to the larger whole; which is always more than the sum of the parts (Davis, 1997). The biological reality of the human being is both the unseen mind and the material body, and all of the cells of the body are interconnected with the mind while the mind is very much interconnected with each cell in the body. The lay-terminology of "holistic, complementary, unconventional, and alternative" generally refers to forms of healing that emerged from traditional Eastern medicine and wellness notions that have been effectively utilized for thousands of years. Holistic medicine is, from a Western perspective, based on the theories of quantum physics as developed by Einstein, Bohm, and others (Davis, 1997; Bogdan & Taylor, 1975). This approach carries the assumption that all individuals are different and that the manifestations of disease depend on the unique characteristics of the individual patient. Alternative health care practitioners generally place greater emphasis on the validity of each individual therapeutic experience than on the statistically significant effectiveness of a medical procedure (Schmoll, 1993). Whatever the case may be, it appears that further research is needed, incorporating both qualitative and quantitative methodologies, to further substantiate the mind-body connection.

Experimental Support for Mental Practice

There is a significant body of motor behavior and sport research that supports the benefits of MP for physical performance. However, it is important to consider the many nuances involved in the designs used in different studies. One conclusion that appears warranted is that physical practice has a greater effect on motor performance than does MP, which in turn is better than no practice at all (Feltz & Landers, 1983; Corbin, 1972; Richardson, 1967). This conclusion is based on the results of studies that have primarily examined three types of practice conditions: physical practice, MP, and no practice (control). In one of the earliest studies, Sackett (1934) found that physical practice was superior to MP, but that MP was more effective in improving performance than no practice. Vandell, Davis, and Clugston (1943) investigated the effects of physical and mental practice on dart throwing and basketball free throw shooting with junior and senior high school and college students. They found that MP improved performance almost as much as physical practice.

Early reviews of the MP literature suggest that a combination of MP and physical practice is superior to either MP or physical practice alone (Weinberg, 1982; Richardson, 1967). More recent reviews (e.g., Feltz, et al., 1988) suggest that if the total number of practice trials (mental and/or physical) is equated, a combination of MP and physical practice (involving relatively fewer physical trials) is not more effective than physical practice alone.

Surburg (1976) randomly assigned 140 participants representing two elder age groups (65-79 and 80-100) to one of four practice conditions: physical practice, one-half physical practice, physical-mental practice, or a control group with no practice. Individuals were initially tested on a pursuit rotor task, then practiced the task (according to their respective conditions of group assignment), and then were retested immediately and again eight weeks later. The results revealed that, for both age groups, the combination of physical and mental practice was as effective as either of the other two types of physical practice alone.

More recently, Hall, et al., (1994) found that the use of MP as a supplement to physical practice, rather than as a replacement for a portion of physical practice, resulted in improved performance (as compared to physical practice alone). In this study, an MP program was incorporated into athletes' overall training program without reducing the total amount of physical practice time (Hall, et al., 1994). Using a similar approach, Blair, Hall, and Leyshon (1993) compared the performance of soccer players who were assigned to a physical practice group and to that of players assigned to a physical practice plus MP group. The results revealed that the combined practice group improved significantly more than the group engaging in physical practice alone. Therefore, the authors suggested that MP be used as an adjunct to physical practice in order to facilitate performance.

Other considerations in the sport literature on MP include the skill level of the participant and the type of skill being performed or learned. Feltz and Landers (1983) conducted a meta-analysis of 60 MP studies and found that, regardless of the skill level of participants, MP was more effective for tasks that contained a greater number of cognitive-symbolic components than for tasks that were more motoric in nature. There is also considerable evidence that, for less experienced individuals, alternating mental practice with physical practice is an effective strategy for improving motor performance and learning (Etnier & Landers, 1996; Gabriele, et al., 1989; McBride & Rothstein, 1979).

Theoretical Basis for the Study

While outcome measures seem to support the notion that MP is an effective tool for improving physical performance, less is known about the mechanisms producing these effects. How can MP enhance physical performance in the absence of movement? How can motor learning occur as the result of a type of rehearsal in which there is neither movement nor movement-produced feedback?

Some theories suggest that MP exerts an influence on several areas of the neuromuscular system. Washburn (1916) proposed one of the first hypotheses to explain the mechanisms underlying the MP effect. She contended that slight muscle movements were made when a person-imagined himself/herself engaged in physical activity. These "movements" were presumed to be identical to the movements of the actual activity, except of much smaller magnitudes. Later, Jacobson (1932) produced support for this hypothesis by using electromyography (EMG) and observing that minute muscle contractions during MP occurred only in the muscles that were involved in the imagined activity. Shaw (1938) corroborated these findings by having subjects imagine typing the alphabet while upper extremity musculature EMG was monitored. As a result, Jacobson proposed the psychoneuromuscular theory for MP. This theory holds that during the imaging of an activity, the brain sends out low levels of impulses that travel along the nerves to the muscles producing the imagined movement. These impulses are presumed to be similar to those that would be emitted during actual physical performance of the activity, but are so slight as to be only detectable with EMG (Janssen & Sheikh, 1994).

While some researchers (Decety & Ingvar, 1990; Shimizu & Inoue, 1986; Bird, 1984; Suinn, 1972; Shaw, 1938; Freeman, 1933) have provided experimental and clinical support for Jacobson's theory, others have been unable to replicate similar EMG patterns for imagined and real movements, suggesting that muscle activation may not be exactly the same for both mental and physical practice. Feltz and Landers (1983) and Hecker and Kaczor (1988) have pointed out that some of the early research lacked appropriate methodological precision and, in several cases (e.g., Shaw, 1938), researchers reported that MP produced increased muscle action potentials that occurred throughout a broader section of the body rather than in task-specific muscle groups. More recently, Hall (1980) found that action potentials did not mirror the action of the agonists' and antagonists' muscles used in a biceps curl. He reasoned that it was more likely that the minute innervations associated with MP were more general throughout the whole body or a whole limb.

Suinn (1983) suggested inconsistency in research reports to be related to the type of MP performed. Thinking about performing the skill does not typically generate EMG activity and may be compared to external imagery in which individuals "see" themselves performing as if watching a movie of themselves. Conversely, EMG activity may more consistently be demonstrated when subjects participate in kinesthetic (internal) imagery in which they mentally practice the skill as though participating in an actual game or situation (Suinn, 1983).

Another early theory that was advanced to explain the beneficial effects of MP was the symbolic learning theory of Sackett (1934). According to Sackett, MP facilitated learning of a motor skill by the symbolic coding of movement patterns in the central nervous system (CNS). It was therefore predicted that tasks possessing a greater number of cognitive elements benefited relatively more from MP than tasks that were primarily motoric. As a result of their meta-analysis, Feltz and Landers (1983) proposed that MP effects are primarily associated with cognitive-symbolic rather than motor elements of tasks. Magill (1998) and Sage (1984) further supported the symbolic learning theory by suggesting that MP is beneficial in assisting the learner to consolidate cognitive strategies as well as to correct symbolic errors.

Sackett also contended that symbolic learning was important only during the very early stages of motor learning (i.e. cognitive stage) when individuals were trying to grasp a general idea of the desired movement pattern. However, more recent scholars have discovered that MP can be important at all stages of practice depending upon the nature of the task (Magill, 1998; Feltz & Landers, 1983). For example, MP might assist performers at all skill levels in sports like gymnastics and golf in focusing their attention on task-relevant cues that are necessary for subsequent physical performance (Schmidt & Wrisberg, 2000; Wrisberg & Ragsdale, 1979).

Other investigators (Ryan & Simons, 1981; Richardson, 1967; Morrisett, 1956) have questioned the efficacy of MP in tasks that are predominantly motoric or strength related and that have little symbolic control. Results from Feltz and Landers' meta-analysis (1983) suggest support for their notion that cognitive tasks, such as the peg board test, dial-a-maze and card sorting, had much larger effect sizes than tasks that were essentially motoric or involved strength.

In more recent years, a third theory has been proposed that contends that MP becomes more important after an individual has participated in sufficient physical practice to create an internal image of the movement (Lang, 1977). Lang's bio-informational theory holds that, during MP, the internal image is activated, rehearsed and reinforced, leading to improved performance once physical activity is resumed. MacKay (1981) further suggested that muscle units are "primed" for action during MP, and that the extent to which this priming benefits subsequent physical performance depends on the previous amount of physical practice or experience the person has with the task. Such a view supports the notion that high-performance athletes benefit considerably more from mental imagery than do novice performers (Vealey & Greenleaf, 1998).

The bioinformational theory has neuroanatomical support as well. A close functional equivalence between motor imagery and motor preparation for physical performance is suggested by the positive effects of imagining motor activity, the similarity between the neural structures involved, and the similar physiological correlates observed in both imaging and preparing (Jeannerod, 1994). Electrical activity mapping (Breitling, 1986) and positron emission tomography (Roland, et al., 1986) have been used to provide evidence that MP mimics actual performance to a greater degree than had been previously thought. More recently, neuroimaging advances such as functional magnetic resonance have identified the following brain areas to be active during MP: occipital lobe (including visual motor cortex), parietal lobe (including primary motor cortex and supplementary motor area), temporal lobe, and an emphasis on activity in the left hemisphere (Schnitzler, et al., 1997; D'esposito, et al., 1997; Decety, 1996; Porro, et al., 1996).

Based on the premise that MP improves motor performance and is accompanied by heightened CNS activity in healthy individuals, Weiss and colleagues (1994) studied brain activation during MP in patients post-stroke. Using electroencephalography (EEG), these researchers observed significant decreases of theta, alpha and beta-1 brain waves during MP in comparison to a control period of rest only. Such changes were similar to those obtained for healthy individuals. Decreases in theta and alpha waves during MP may indicate an activation of the sensorimotor cortex which, in accordance with the hypothesis of internal feedback mechanisms, is a necessary prerequisite for motor learning.

Statement of the Problem

The overwhelming evidence from a number of different performance domains reveals that physical practice is superior to MP in facilitating the learning of motor skills. However, it has also been shown that MP is superior to no practice in many situations (Feltz & Landers, 1983). This evidence suggests that MP is a potentially effective technique for patients whose physical activity is restricted or whose physical practice is limited or prohibited (Warner & McNeill, 1988). In the rehabilitation professions there are numerous instances in which physical practice is contraindicated or must be provided only with extreme caution. For many patients, a safe environment, necessary equipment, or the presence of a person to assist in physical exercise may not always be available. There are also times when patients' physical practice must be limited because of cardiac or pulmonary complications. For the deconditioned person, fatigue may extremely inhibit the rehabilitative process following injury or surgery. In such instances, use of MP as a complement to physical practice would seem logical. Moreover, MP might be beneficial in minimizing functional losses associated with bed-rest and in facilitating the rehabilitation process.

Recently, managed care and prospective payment health systems have decreased the available number and length of therapy visits for many patients. Cost containment within all practice settings is a high priority. Often, patients are spending less and less time engaging in the physical practice of functional tasks under the supervision of a therapist. Thus, it would appear that, more than ever, MP should be considered as a potential complement to conventional therapy.

Purpose of the Study

The purpose of this study was to investigate the effectiveness of MP as a complement to physical practice in the rehabilitation of patients status-post total knee arthroplasty (prosthetic knee replacement surgery).

Hypothesis:

Patients with osteoarthritis, status-post total knee arthroplasty, who receive a complement of mental practice with traditional therapy will have enhanced rehabilitation outcomes as compared to a control group of patients who receive traditional therapy alone.

Operational Definitions

For the purpose of this study the following operational definitions were employed:

- Osteoarthritis (OA) – Also known as degenerative joint disease, osteoarthritis is a slow, progressive degeneration of joint structures. This many times leads to loss of mobility, chronic pain, deformity, and loss of function. The most commonly involved joints associated with OA are the hip, knee, and the lumbar and cervical spine (Boissonnault, 1998).

- Total Knee Arthroplasty (TKA) - Total knee arthroplasty, also known as total knee replacement, is a surgical procedure involving the removal or resurfacing of distal aspects of the femur, proximal tibia and/or patella, and placement of a prosthesis made of metal alloy and high-density plastic. The procedure, lasting approximately two hours, is performed under spinal or general anesthesia by an orthopedic surgeon (Mayo Clinic, 2001).
- Traditional Physical Therapy - Most physical therapy following TKA appears to be based upon local custom. Consistent with Moncur (1996), the therapists at the study's rehabilitation hospital utilized a generalized protocol of activities and exercise (Table 1). All patients in the study received two hours of physical therapy and one hour of occupational therapy on weekdays and two hours of combined therapy on Saturdays and Sundays (excluding continuous passive motion machine use).

Table 1 Physical Therapy TKA Protocol
• reinforcement of postoperative precautions (weight-bearing as tolerated and no pivoting/twisting of the involved knee); • continuous passive motion (CPM) machine 2 hours, twice daily; • gentle passive mobility of the patella; • general active range of motion exercise in both lower extremities to encourage circulation and pain-free motion; • education in and practice of bed mobility, transfers, gait and stair climbing skills; • passive, active assisted and active range of motion exercises; • gentle isometric and isotonic strengthening exercises; • education in and practice of activities of daily living; • education in and practice of a home exercise program; and • ice pack to knee for 15 minutes following therapy.

- Mental Practice (MP) – Mental practice consists of the mental or cognitive imagining of some aspect of the performance of a task or skill in the absence of any associated overt physical actions. For this study, MP involved five minutes of relaxation followed by ten minutes of facilitated MP via audiocassette tape. The experimental MP protocol was incorporated into patients' therapy programs five days per week.

Chapter Two

Review of the Literature

Introduction

The following literature review progresses through the medical and imagery related issues that had potential impact on the study. The chapter begins with an overview of the knee and of knee replacement surgery. Total knee arthroplasty is defined followed by descriptions of the normal anatomy and kinesiology of the knee, the TKA surgical procedure, and traditional post-operative therapy. Since insurance companies and hospital administrators pay significant attention to the cost efficiency of medical treatment, a review of hospital-based joint replacement cost containment research is presented. The review of research related to the use of MP in rehabilitation progresses through the applied areas of strength, endurance, and functional applications. The chapter concludes with an overview of MP variables that may influence the effectiveness of MP in this study. These variables include imagery ability, positive versus negative imagery, the use of relaxation in combination with MP, the type of skill practiced, and effect of participant age on imagery effectiveness.

Total Knee Arthroplasty

Definition

Before the 1970's, painful arthritic knees caused permanent disability for many of the elderly. That is not true for many persons today. Total knee arthroplasty now helps more than 137,000 Americans get back on their feet each year (Mayo Clinic, 2001). Most individuals who undergo knee replacement are age 60 or older (Mayo Clinic, 2001). Arthroplasty, literally meaning "surgical shaping," is used to treat osteoarthritis, severe rheumatoid arthritis, and post-traumatic arthritis. The most common reason for TKA is osteoarthritis, which causes a gradual deterioration of the cartilage between the femur and tibia. Without the cartilage, the bones rub together during movement and weight bearing activities and cause pain (Boissonnault, 1998). Total knee arthroplasty has become a reliable surgical procedure with excellent long-term results and low failure rates (Martin, et al., 1998; Hosick, et al., 1994; Wasielewski, et al., 1994). Within three months post surgery, pain relief and functional improvement are generally excellent and allow return to an active lifestyle. Remarkably, after 15 years, more than 93 percent of original knee replacements are still intact (Mayo Clinic, 2001).

Normal Knee Anatomy

The knee is an amazing joint that is more than a simple hinge, it has one of the widest ranges of motion of any joint in the body. It not only bends, but slides, glides and swivels. In addition, it has the capacity to absorb force of up to seven times a person's body weight (Mayo Clinic, 2001). The knee is comprised of the distal portion of the femur articulating with the proximal tibia. When the knee is bent, the ends of these two bones move against each other, much like a hinge. In between the femur and tibia is a cushion of cartilage. Ligaments connect the femur and tibia, while muscles and tendons stabilize the joint and enable it to move. The patella helps protect the joint and anchors the quadriceps muscle group (Pick & Howden, 1974).

Surgical Procedure

The TKA involves the removal or resurfacing of parts of the femur, tibia and/or patella, and placement of a prosthesis made of metal alloy and high-density plastic. Much of the surgery focuses on preparation of the joint. After making an incision, the orthopedic surgeon moves aside the muscles, patella and connective tissues. Before the area is ready for the prosthesis, diseased bone is removed. The prosthesis usually consists of several parts not directly connected to one another. One metal alloy piece is applied to the distal femur while another, resembling a tray on a pedestal, is anchored into the shaft of the proximal tibia. The platform of the tibial component has a surface of high-density plastic. It provides support, serving the function of cartilage in the normal knee, for articulation with the femur. Once the prosthesis is in place, the existing connective tissues are realigned and continue to work to hold the joint together. Leg alignment is carefully checked and, if necessary, realigned (Mayo Clinic, 2001; Walker & Helewa, 1996).

Traditional Post-Operative Therapy

Although many surgeons and physical therapists consider rehabilitation to be imperative following a total joint replacement, there are few published studies that describe the ideal therapy program. As noted previously, it is customary for rehabilitation to stress range of motion and strengthening exercises, education in joint protection, and functional activities. Figgie (1994) suggests that a patient should be able to bend the knee to 90 degrees and be able to climb up and down stairs prior to leaving the hospital. Kampa (1993) and others (e.g., Knortz, 1993; Nelson & Rasmussen, 1985) have suggested guidelines for postoperative rehabilitation that are important to consider. These include continuous passive motion, deep breathing and coughing exercises, exercises for circulation and range of motion, gentle mobility of the patella, iliotibial band stretches, education in joint protection and a home exercise program, and functional activities such as bed mobility, transfers, gait, and stair climbing.

Cost Containment Research

Clinical pathways and other hospital protocols have been designed to decrease length of stay and, thus, cost of services after joint replacements. Forrest, Roque, and Dawodu (1999) investigated the effect of protocols on the efficiency and discharge disposition of patients at a university hospital. Their first observation was that while the protocol was in use, older patients who lived alone were more likely to require significant follow-up services. While discharge from the acute care hospital did indeed significantly decrease length of stay and result in a cost containment for the facility, the percentage of patients admitted to rehabilitation units increased from 18 percent in 1995 to 33 percent in 1997. Cost was effectively shifted to post-acute service providers. This should be a cause for concern as a second admission to a different inpatient hospital is potentially much more expensive than allowing patients to stay a few days longer in acute care.

Therapy intensity is another consideration. The provision of physical therapy service on weekends remains a debated topic among hospital administrators. Little research, however, is available to support the efficacy of such a schedule. Lang (1998) studied the length of stay and discharge status of patients post hip or knee replacement surgery. Comparisons were made between an 80-person control group that received therapy six days per week and 60 persons receiving daily physical therapy services. No significant differences were found in postoperative length of stay, discharge destination, nor discharge disposition.

Mental Practice in Rehabilitation

Mental Practice for Strength and Endurance

There have been a number of studies looking at the effect of MP on strength and endurance. More specifically, isometric muscular strength and endurance have been shown to improve when physical practice is coupled with MP (e.g., Cornwall, Buscato & Barry, 1991; Yue & Cole, 1992; Kelsey, 1961). As early as 1961, researchers were investigating the effects of MP on muscle strength and endurance. Kelsey (1961) reported statistically significant increases in endurance for an MP group performing sit-ups, although physical practice groups demonstrated greater increases. In their meta-analyses, Feltz and Landers (1983) and Feltz, et al. (1988) also reported positive, but small, effect sizes for MP studies investigating muscle strength gains.

Yue and Cole (1992) compared force outcomes of two training programs: maximal isometric exercise and MP. Thirty young adults trained their non-dominant hypothenar muscles five sessions per week for four weeks. The isometric exercise group produced repeated maximal isometric contractions of the abductor muscles of the fifth digits'metacarpophalangeal joint. The MP group imagined producing these same, effortful isometric contractions. A control group did not train their fifth digit. Maximal abduction force, flexion/extension force and electrically evoked twitch abduction force of the fifth digit were measured along with maximal integrated EMG of the hypothenar muscles of both hands before and after training. Increases in average abduction force were 22, 30 and 3.7 percent for the MP, isometric exercise, and control groups respectively. Maximal abduction force of the contralateral, untrained fifth digit also increased significantly in both exercise groups, but not the control group. The authors concluded that strength changes could be achieved without repeated muscle activation. Due to the carryover effect to the contralateral, untrained side, the force gains appeared to result from practice effects on central motor programming (Yue & Cole, 1992).

Cornwall, Buscato, and Barry (1991) randomly assigned 24 female subjects to either a control or MP group. The MP group participated in four, 30-minute practice sessions. During these sessions, subjects were instructed to cognitively practice isometric contractions of their right quadriceps muscle. Surface EMG was monitored during each practice session to ensure that subjects were not physically contracting their muscles. The MP group significantly ($p<.05$) increased their quadriceps muscle strength compared to the control group. The authors concluded that MP had the potential to greatly influence strength.

Maring (1990) investigated the effect of MP on rate and outcome of skill acquisition on a novel ball-throwing task. Electromyography was used to provide evidence of the changes that occur in muscle activity during to motor learning. Twenty subjects were randomly assigned to control (physical practice) and experimental (physical practice plus MP) groups. Following physical practice trials, the experimental group participated in two minutes of MP while the control group participated in a task that demanded their mental attention (two minutes of poem memorization). The control group participated in a total of 50 practice throws. The experimental group participated in 50 physical practice throws plus two minutes of MP (total number of MP throws were not counted). Maring found that the subjects who used MP in conjunction with physical practice increased their accuracy for the task at a significantly faster rate than the subjects who used physical practice alone. In addition, EMG results for the experimental group demonstrated decreased time from onset of muscle activity to peak activity and increased time elapsed from the onset of agonist contraction to the onset of antagonist contraction: both suggestive of more efficient muscle unit recruitment and movement as compared to the control group.

Functional Applications of Mental Practice

While the vast majority of research examining the effects of MP has involved laboratory models using discrete motor or sports-related tasks, a few studies have addressed the use of MP with more functionally applied tasks. Ulich (1967) studied typewriting speed and accuracy, peg hole test manual dexterity and speed, and riveting speed and sequencing. The results of this study support the use of MP to facilitate performance improvements. Interestingly, the nursing profession has applied MP during the learning of psychomotor tasks required in their entry-level curriculum. Bucher (1993) and Dohney (1993) found that MP combined with physical practice enhanced nursing students' capability of donning and doffing sterile gloves and giving an intramuscular injection. Additionally, researchers have demonstrated that musical performance has been enhanced through the combination of MP and physical practice (e.g., Coffman, 1990; Theiler & Lippman, 1995).

Incorporating Mental Practice into Rehabilitation

Fansler, Poff, and Shepard (1985) were the first therapists to apply the concepts of MP to clinical research in the physical therapy profession. In their study, 12 female elders utilized ideokinetic facilitation, a type of MP, in an effort to enhance physical performance of balance tasks. Following training, an experimental group, that participated in a combination of mental and physical practice, demonstrated significant improvements in performance. However, these improvements were not significantly greater than those of control groups participating in physical practice and relaxation or in physical practice and listening to nonsense tapes. While the results of this study were inconclusive, the authors suggested that, "Mental practice of a physical task can improve performance and may be of use to the physical therapy clinician (p. 1332)." Warner and McNeill (1988) further addressed the issue of MP with an article published in *Physical Therapy* presenting a review of the pertinent literature and suggesting the feasibility of MP as an adjunct technique for rehabilitation. They concluded that physical therapists have not adequately considered the potential benefits of MP in physical rehabilitation.

Still other rehabilitation studies incorporating MP into the therapy fields include those of Linden, et al. (1989) and Fairweather and Sidaway (1993). Walking balance and foot placement measures, important components for equilibrium, improved for elderly women as a result of a therapy program combining physical practice with MP (Linden, et al., 1989). Fairweather and Sidaway (1993) found that a three-week MP training program combined with physical practice improved postural form, reduced back pain, and improved spinal angles among individuals with increased lordosis and/or kyphosis who regularly experienced low back pain.

Most recently, in a pilot study, Page (2000) investigated the clinical application of MP with sixteen sub-acute patients with stroke and right upper extremity hemiparesis. Patients were randomly assigned to one of two groups that received either four weeks of traditional occupational therapy or four weeks of traditional occupational therapy plus MP. Those patients with MP incorporated into their therapy achieved significantly greater function in their upper extremities (as measured by the Fugl-Meyer Scale) than did the traditional therapy patients. Page concluded that, while more research is warranted, MP certainly should be considered as a potential inexpensive, noninvasive complement to occupational therapy.

Mental Practice Variables for Consideration

Murphy (1994) suggested that certain factors mediate MP effectiveness. Specifically, he identified four areas for consideration: participant imagery ability, participant imagery perspective, imagery outcome, and the combination of imagery with relaxation (Murphy, 1994). Hall (1985) suggested that researchers consider three variables when studying the effects of MP on motor performance and learning: the imagery ability of the participant, the nature of the task being performed, and the imagery instructions given to participants. Smith (1987) has also suggested that researchers and practitioners consider the preferred imagery perspective of participants. Some individuals prefer an internal perspective (e.g., seeing and feeling the task exactly the way they would if they were physically performing it). Other people prefer an external imagery perspective (e.g., seeing themselves performing the task as if they were a spectator). In addition, several researchers have reported that prior motor experience may be necessary for effective use of MP (Schimdt, 1991; Carpinter & Cratty, 1983).

Imagery ability may be one of the most important factors that mediate MP effects (Marks & Isaac, 1995; Fishburne & Hall, 1988; Goss, et al., 1986; Ryan & Simons, 1982; Epstein, 1980). Good imagery has been defined by the characteristics of vividness and controllability (Murphy, 1994). Vividness relates to the person's self-report of clarity and reality of the image. Controllability is the individual's ability to influence the content of the image. A number of studies have revealed that the effects of imagery on performance are more profound for participants with higher levels of imagery ability than for those with lower levels (Goss, et al., 1986; Housner, 1984; Ryan & Simons, 1981; Start & Richardson, 1964). Thus, it would seem imperative for any MP research conducted to consider individual differences in imagery ability.

Most MP programs instruct participants to image the performance of the skill exactly the way they wish to perform it. One of the first researchers to investigate the impact of negative imagery was Powell (1973). His study compared imagery of perfect dart throwing outcomes with imagery of missing the target. The author concluded that negative MP resulted in degraded performance as compared to positive MP (Powell, 1973). Woolfolk, et al. (1985) extended the Powell protocol to include a control group. The motor task (putting a golf ball) was mentally practiced (positively, negatively, and not at all) and then performed. They found that the negative image group performed significantly worse (21.2 percent decline) than both the positive MP (30.4 percent improvement) and control (9.9 percent improvement) groups. However, Hall, et al. (1994) suggest that negative MP may be less of a concern if the participant is able to manipulate the image and turn it into a positive outcome. Murphy (1994) suggested that negative MP either interferes with the participant's motor program, causing a decline in performance, or negatively affects performance through its impact on confidence, concentration, or motivation. Given the evidence, it seems sensible to, when facilitating MP, focus on positive performance outcomes.

Many researchers suggest prefacing MP with a short period of relaxation (e.g., Vealey, 1986; Suinn, 1985). Murphy (1994) suggested that evidence of the mediating effect of relaxation on MP effectiveness is lacking and Hall, et al. (1994) failed to list relaxation as a critical consideration in MP. These conclusions follow a number of studies that combined MP with relaxation and found no significant effects (e.g., Weinberg, et al., 1987; Gray, et al., 1984; Weinberg, et al., 1981; Hamberger & Lohr, 1980). Other studies have demonstrated strong MP effects without the use of relaxation (e.g., Woolfolk, et al., 1985; Corbin, 1967; Clark, 1960). While relaxation may influence the MP experience for some individuals, it does not seem to be a necessary component of a

MP program for significant outcomes. However, there is no evidence that relaxation impairs the imagery and thus it is not surprising that many imagery protocols begin with a brief period of relaxation (Vealey, 1986).

Hall, et al., (1994) agreed with Feltz and Landers' (1983) meta-analysis conclusion that MP facilitates the performance of cognitive tasks more than those that are motoric in nature or based on strength and endurance. Paivio (1985) reinforced this concept and suggested that task analysis should be a part of any MP research. Researchers continue to investigate the effect of MP on a variety of tasks and in various phases of motor learning (e.g., cognitive, associative, and autonomous). When interpreting the outcomes of any particular study, consideration should be given to the type of task(s) being performed.

Effect of Age on Mental Practice

One might also assume that age would be of prime importance when considering prior experience with motor skills and the ability to visualize or imagine. However, little research has investigated the effect of age on MP outcomes. Jarus and Ratzon (2000) reported that MP affected three age-defined groups differently (children, adults, and older adults). Mental practice in the acquisition phase of a bimanual coordination task was found to be beneficial for children and older adults only. In the retention phase, this benefit was confined to older adults. Adults in the MP and physical practice groups did not differ in performance of the acquired task. These findings indicate that in childhood and old age greater potential benefit from MP exists, at least for the learning of a novel task. The authors further noted that MP was especially beneficial for older adults in facilitating task retention.

When considering the application of MP to the elderly population, thought must be given to normal age-related changes in the musculoskeletal and neurological systems. For example, Briggs, Raz, and Marks (1999) investigated the age-related slowing of information processing in mental imagery tasks and found that age was associated with a prolongation of response time. Moreover, older individuals benefited relatively less from MP as the information to be processed increased in complexity. These researchers concluded that the slowing of information processing and reduction in accuracy of older individuals was mediated by declines in working memory rather than by decreases in sensorimotor speed. However, Dror and Kosslyn (1994) compared the performance of young and elderly adults on four visual mental imagery tasks (rotation, activation, composition, and scanning) and found that, while there was a slowing with age, individual imaging processes appeared to be selectively affected by aging.

In an applied study, Surburg (1976) randomly assigned 140 participants representing two elder age groups (65-79 and 80-100) to one of four practice conditions: physical practice, one-half physical practice, physical-mental practice, or a control group with no practice. Individuals were initially tested on a pursuit rotor task, then practiced the task (according to their respective conditions of group assignment), then were retested, and then were re-tested again eight weeks later. The results revealed that, for both age groups, the combination of physical and mental practice was as effective as either of the other two types of physical practice alone.

Summary

For many individuals with osteoarthritis, a TKA is a reliable and successful treatment option that alleviates pain and allows for significant functional improvement. While there is no universal standard for therapy following TKA surgery, surgeons and therapists agree on rehabilitative guidelines that include continuous passive motion, deep breathing and coughing exercises, exercises for circulation and range of motion, gentle mobility of the patella, iliotibial band stretches, education in joint protection and a home exercise program, and functional activities such as bed mobility, transfers, gait, and stair climbing. A few studies have investigated the effects of clinical pathways and various intensities of therapy on hospital cost containment and patient outcomes. Continued research is needed to adequately assess the effects of rapidly changing health care policies and procedures.

The use of MP in rehabilitation remains somewhat equivocal and controversial. If MP is to be useful in the current health care environment, it must be cost efficient and effective. The effectiveness of MP in conjunction with traditional therapy has not been adequately studied. Review of the literature suggests that any study of MP should evaluate the participants' imagery ability, provide positive rather than negative MP in skill performance, and consider the type of skill being practiced. Relaxation, while not critical for successful MP, may be used without detriment to outcome. One could suggest that a relaxation procedure should be incorporated within a MP protocol when participants are novices, fatigued, and/or experiencing pain. Additionally, while one might assume older age to be a significant factor in the usefulness of MP, research suggests that elders are able to successfully use MP to enhance physical performance.

Chapter Three

Methodology

Introduction

This study investigated the effectiveness of MP used in conjunction with traditional therapy post-TKA in patient rehabilitation. This chapter includes a description of the following components of the research process: participant recruitment and inclusion criteria, data collection instrumentation and procedures, study procedures and design, and data analysis procedures.

Participants

Participants were recruited from the in-patient population at a local rehabilitation hospital. Over the study's six-month duration, 87 patients were admitted to the hospital status-post TKA. Fifty-two patients volunteered to participate. To be included in the study, participants had to meet the criteria shown in Table 2 and provide informed consent (Appendix A) in compliance with the University of Tennessee at Knoxville's Institutional Review Board and the hospital's human subjects review board. Of the 52 volunteers, 21 failed to meet inclusion criteria.

Table 2 **Inclusion Criteria**
• Medical diagnosis of osteoarthritis; • Surgical diagnosis of status-post TKA; • Medically stable to participate in physical therapy twice daily; • May not be on medical bedrest; • May not have a history of a prior knee replacement on either lower extremity; • May not have a history of a prior hip replacement on either lower extremity; • Prior to surgery: must have been independent with ambulation within their home with or without an assistive device; • Bilateral lower extremity weight-bearing status of at least weight-bearing as tolerated; and • Adequate cognition and hearing to independently utilize audiocassette recorders, earphones, and audiotapes.

Once inclusion criteria were met, participants were randomly assigned to one of two groups: Group A (motivational control) or Group B (MP). While patients were not included in or excluded from the study based upon gender, research group assignments were gender matched. All participants were from the same geographic area. The final sample was comprised of 25 females (15 white/of non-Hispanic origin and 10 African American) and 6 males (4 white/of non-Hispanic origin and 2 African American).

Instrumentation

In an effort to remain clinically relevant, this study utilized standard physical therapy evaluative tools to gather pre-intervention and post-intervention data: goniometry (Norkin & White, 1995), manual muscle tests (MMT) (Hislop & Montgomery, 1995), the Tinetti Gait Assessment (Tinetti, 1986), and the transfer, gait, and stair climbing components of the Functional Independence Measure (FIM) (Linacre, et al., 1994). (See Appendix B for data collection protocols and forms.

Reliability of knee goniometric measures has been established in a number of clinical and laboratory studies. Rothstein, Miller, and Roettger (1983) found elbow and knee measures obtained by clinicians following a simple protocol to be highly reliable (intratester $r = 0.91$ to 0.99 and intertester $r = 0.70$ to 0.97). Watkins and colleagues (1991) studied the clinical reliability of goniometric measurements and visual estimates of knee ROM. Intraclass correlation coefficients (ICCs) for intratester reliability were 0.99 and 0.98 for goniometric measures of knee flexion and extension, respectively. Intertester reliability was also high with 0.90 for flexion and 0.86 for extension. Other authors (e.g., Gajdosik & Bohannon, 1987; Watkins, et al., 1991) have suggested that, when applied with care, goniometry can be quite reliable.

Physical therapists often require an accurate, reliable method for measuring muscle strength. Although not the most reliable of tools available, manual muscle tests (MMT) remain the most common clinically applied strength assessment tool. Many authors conclude that, if proper protocol is followed, clinicians can be reasonably reliable with manual muscle testing (Wadsworth, et al., 1987). Hislop and Montgomery (1995) suggest that optimal reliability is dependent upon patient positioning and the strict adherence of therapists to operational definitions.

The Tinetti Gait Assessment is a simple, easily administered clinical tool that measures quality of walking a functional distance with or without an assistive device at a usual and then rapid but safe pace. High interrater and intrarater reliability has been reported in previous studies (e.g., Capriany-Dacko, et al., 1997; Ruben & Sui, 1990; Tinetti, 1986). Validity has also been established. For example, the Tinetti Gait Assessment has been used as a clinical model in a prospective study of posturography in normal older adults (Baloh, et al., 1998) and has been validated by simultaneous comparisons with The Physical Performance Test (Reuben & Sui, 1990).

Many studies have demonstrated high intrarater and interrater reliability of the FIM (e.g., Ottenbacher, et al., 1996; Pollack, et al., 1996; Kidd, et al, 1995; Hamilton, et al., 1994). Interrater ICC scores range from 0.95 to 0.96 and intrarater ICC scores range from 0.90 to 1.00 (Ottenbacher, et al., 1996; Pollack, et al., 1996; Hamilton, et al., 1994). Pollack, Rheault, and Stoecker (1996) demonstrated high test-retest reliability and construct validity of the FIM for older adults (i.e., persons over 80 years old). Additionally, Kidd and colleagues (1995) compared the FIM to the Barthel Index, a standardized tool for measuring independence in activities of daily living, and found that the FIM was reliable and easy to use in the rehabilitation setting. The FIM was found to be more valid than the Barthel Index, and equally reliable in the assessment of disability.

<u>Procedures and Design</u>

Participants in Group A received an orientation interview. Group B participants received an orientation interview followed by an evaluation of imagery ability using a modified version of the Sport Imagery Questionnaire (Vealey & Greenleaf, 1998). The primary investigator then collected baseline performance data, consisting of knee range of motion (ROM) in flexion and extension, knee strength in flexion and extension, and gait assessment. Flexion and extension ROM measures were combined to indicate the participant's knee arc of motion or Available ROM.

All participants received a portable audiocassette recorder with earphones and batteries. Audiocassette tapes and written handouts, including a compliance log, were also provided. Group A listened to a tape with five minutes of facilitated progressive relaxation followed by ten minutes of relaxing music (see Appendix C for narrative). Group B's intervention tape consisted of five minutes of progressive relaxation followed by ten minutes of guided MP in lower extremity exercises and functional activities (see Appendix D for narrative). Participants in both groups listened to their respective audiocassettes five times per week during weekday afternoon or evening hours. The primary investigator was available to participants in both groups at least three days per week to answer questions and to facilitate compliance. Participation in the study ceased on the day of discharge from the hospital.

Staff physical therapists and physical therapist assistants collected post-intervention data. Group membership was blind to participating therapists; the evaluating therapist did not know the group to which each participant belonged. Physical therapists and assistants participating in data collection were instructed in study procedures and were provided with detailed supplementary handouts that defined the measurement tools and provided guidance in the data collection process. During post-intervention testing, participants' flexion and extension ROM measures were again combined to reflect Available ROM.

Upon discharge from the hospital, all participants were referred to either home health or outpatient physical therapy for continued progression in range of motion (ROM), strengthening, and functional activity. Additional data regarding participants' demographics, orthopedic surgeon, hospital length-of-stay (LOS), and functional ability upon admission and discharge, via the FIM, were collected from the hospital chart.

Data Analysis

Important considerations must be made when utilizing statistics to interpret data. While widely accepted as more powerful, parametric statistics are based on some important assumptions, not the least of which is an adequate total sample size, a certain level of measurement, and a normal distribution of the dependent variable. In this study, the data violated a number of these assumptions and so, more conservative non-parametric statistical analyses were utilized in an effort to minimize Type I error. Type I error occurs when, based on the sample evidence, the null hypothesis is rejected when, in fact, if evidence had been gathered from the entire population, the null hypothesis should have been accepted as true. This type of error becomes more problematic in studies of small sample size. Power refers to the ability of a statistical test to correctly reject the null hypothesis. Monte Carlo simulations have indicated that nonparametric tests tend to be more powerful than parametric tests when the distribution of the data being considered is unimodal but nonnormal in shape (Harwell, 1991). In this study, every effort was made to meet test assumptions and utilize analyses that would minimize Type I error.

The study utilized the SPSS statistical package for Windows (Norusis, 1995). An alpha of 0.05 was chosen as the indicator for significance because of its traditional usage for most health care research (Pett, 1997). Frequencies in categories of vividness ratings were determined to examine the results of Group B's Sport Imagery Questionnaire responses. Age and gender differences were assessed with the Mann-Whitney U test. The pre-intervention data were assessed for normalcy and homogeneity of groups with the Pearson Skewness Coefficient (Sk_p), Kolmogorov-Smirnov (K-S), Shapiro-Wilk (S-W), and Kolmogorov-Smirnov 2-Sample (Z) tests. Post-intervention data were examined for significant differences between groups using the Mann-Whitney U test.

Chapter Four

Results

Introduction

The purpose of this study was to investigate the effectiveness of MP as a complement to physical practice in the rehabilitation of patients status-post total knee arthroplasty (prosthetic knee replacement surgery). The main hypothesis stated that patients with osteoarthritis, status-post total knee arthroplasty, who received a complement of mental practice with traditional therapy would demonstrate enhanced rehabilitation outcomes as compared to a control group of patients who received traditional therapy alone. Results of the study are provided in this chapter. These include descriptions of participant characteristics, pre-intervention data characteristics, homogeneity of groups pre-intervention, data characteristics post-intervention, and differences between groups post-intervention.

Description of Participants

Of the 31 participants initially enrolled, three developed medical complications while five demonstrated inadequate compliance (< 80 percent) in either their traditional therapy or the experimental protocol. Thus, these individuals were eliminated from the study.

Twenty-three participants, between the ages of 42 and 88 (Mean = 68.43; SD = 11.66) successfully completed the requirements of the study. Nineteen female and four male participants were randomly assigned, with gender matching, to Group A (motivational control) or Group B (MP). Group A consisted of ten females and two males with a mean age of 68.67 ± 3.98 years. Group B was comprised of nine females and two males, mean age of 68.18 ± 2.86 years. The Mann-Whitney U was employed to investigate age and gender differences between groups. Since there were no significant differences between Groups A and B with regard to age (Mann Whitney U = 59.00; p = 0.70) or gender (Mann Whitney U = 65.00; p = 0.99), it was concluded that these demographic variables did not have significant impact on pre- and post-intervention performance results.

Group B's results from the Sport Imagery Questionnaire are presented in Table 3. All participants had had no prior experience with MP. Ratings were based on two imagery scenarios with which the participants were very familiar (e.g., making coffee, brushing teeth, backing the car out of the driveway). The second of the two scenarios was consistently scored higher for all participants. Thus, it was assumed that

Table 3 Results of Sport Imagery Questionnaire – Group B Frequencies					
	1	2	3	4	5
A. How vividly the image was visualized		1	7	3	
B. How clearly sounds were heard	3	7	1		
C. How vividly body movements were felt		6	5		
D. How clearly emotions were felt		5	6		
E. How clearly the image was seen internally	3	2	5	1	
F. How clearly the image was seen externally				9	2
G. How well the image could be controlled		2	8	1	

KEY:
N = 11
1 = No image present / No control at all of image
2 = Recognizable image but unclear; not vivid / Image very hard to control
3 = Moderately clear and vivid image / Moderate control of image
4 = Clear and vivid image / Good control of image
5 = Extremely clear and vivid image/Complete control of image

participants were becoming accustomed to imagery in the first scenario and the second scenario was a more accurate reflection of their imagery ability. Generally speaking, participants were able to more vividly image the activities using an external perspective (F) than using an internal perspective (E). Imagery of sounds (B) and kinesthesis (C) appeared to be the most difficult for the majority of participants. The majority of participants reported at least moderate vividness for all other imagery areas.

Pre-Intervention Data Characteristics

Pre-intervention data were first analyzed for normality for both the total sample and for the two subgroups. Lehman (1991) has suggested that values of Pearson skewness coefficients (Sk_p) with a range between –0.5 and +0.5 indicate acceptable levels of skewness. The results revealed that less than 50 percent of the data categories possessed acceptable skewness levels (Table 4). These results, combined with the study's sample of convenience and small number of subjects, suggested the use of nonparametric statistical tests for further evaluation of the data.

Subgroups (A and B) were compared for normality of distribution with the Kolmogorov-Smirnov (K-S) and Shapiro-Wilk (S-W) tests. The objectives of these nonparametric goodness-of-fit tests are to compare the obtained distributions with a theoretically normal distribution and to

Table 4
Pre-Intervention Frequencies and Distributions

	Mean	Median	s	Sk_p
Extension ROM	-9.13	-9.00	4.58	*0.03
Flexion ROM	56.91	57.00	12.99	*-0.01
Available ROM	47.78	49.00	13.39	-9.09
Extension MMT	1.52	2.00	0.51	-0.94
Flexion MMT	1.52	2.00	0.51	-0.94
Tinetti Gait	2.52	2.00	1.34	*0.39
FIM Transfers	4.04	4.00	0.64	-0.69
FIM Gait	2.22	2.00	1.20	*0.18
FIM Stairs	1.04	1.00	0.21	1.53

*Acceptable skew for normal distributions; N=23 determine whether the deviations from normality are sufficiently large to conclude that the distributions under investigation are not normal (Pett, 1997). The null hypotheses, that the data are normally distributed, for K-S and S-W tests are rejected if levels of significance (p) are less than alpha ($\alpha = 0.05$). Table 5 contains the results of these analyses. Almost 80 percent of the K-S and S-W statistics were significant, suggesting that the majority of these data categories were not normally distributed.

Table 5
Kolmogorov-Smirnov and Shapiro-Wilk Tests of Normality by Group

	Group	df	K-S	p	S-W	p
Extension ROM	A	12	0.30	*0.00	0.80	*0.01
	B	11	0.23	0.12	0.84	*0.04
Flexion ROM	A	12	0.13	0.20	0.94	0.44
	B	11	0.21	0.20	0.89	0.18
Available ROM	A	12	0.15	0.20	0.92	0.33
	B	11	0.18	0.20	0.92	0.39
Extension MMT	A	12	0.37	*0.00	0.61	*0.01
	B	11	0.35	*0.00	0.63	*0.01
Flexion MMT	A	12	0.42	*0.00	0.65	*0.01
	B	11	0.40	*0.00	0.66	*0.01
Tinetti Gait	A	12	0.26	*0.02	0.89	0.12
	B	11	0.40	*0.00	0.63	*0.01
FIM Transfers	A	12	0.33	*0.00	0.77	*0.01
	B	11	0.28	*0.02	0.82	*0.03
FIM Gait	A	12	0.28	*0.01	0.83	*0.02
	B	11	0.33	*0.00	0.83	*0.03
FIM Stairs	A	12	0.53	*0.00	0.32	*0.01
	B	11	0.53	*0.00	0.32	*0.01

*Significant $p < 0.05$

Homogeneity of Groups Pre-Intervention

The Kolmogorov-Smirnov 2-Sample Test (Z) compares the homogeneity of distributions of two populations. Some authors have argued that the advantages of this test over Mann-Whitney U and t tests include a more complete examination of the similarity of cumulative distributions, not merely the measures of central tendency (Pett, 1997; Campbell, et al., 1993; Thornbury, 1992). With this analysis, if the p value is smaller than alpha ($\alpha = 0.05$), the null hypothesis that the control and experimental groups are similar is rejected. In all nine categories of measurement, Z was found to be not significant with $p > 0.05$ (Table 6), thus the two groups' distributions, while individually skewed from a normal distribution, were considered significantly similar to one another.

Table 6
Kolmogorov-Smirnov 2-Sample Test

	Z	p
Extension ROM	1.14	0.15
Flexion ROM	0.91	0.38
Available ROM	0.73	0.67
Extension MMT	0.73	0.67
Flexion MMT	0.31	1.00
Tinetti Gait	0.60	0.87
FIM Transfers	0.25	1.00
FIM Gait	0.25	1.00
FIM Stairs	0.20	1.00

Post-Intervention Measures

Post-intervention measures demonstrated similar problems to those of pre-intervention scores with respect to normality of distributions. The only two categories of measurement that were not significantly skewed were Available ROM and Tinetti Gait. Thus, the Mann-Whitney U test was used to compare differences between post-intervention data for the two groups. An additional category of data was also compared: hospital length of stay (Table 7). Five categories of measurement differed significantly ($p \leq 0.05$) between Groups A and B: Flexion ROM, Available ROM, Flexion MMT, Tinetti Gait, FIM Stairs, and Length of Stay. The seven sub-component parts of Tinetti Gait were also assessed for differences between Groups A and B in pre-intervention and post-intervention data. However, these analyses revealed no significant differences.

Table 7
Post-Intervention Comparison of Groups

	Group	Mean	Standard Deviation	Mann-Whitney U	p
Extension ROM	A	4.92	4.23	65.50	0.98
	B	4.81	2.68		
Flexion ROM	A	79.91	14.13	32.00	*0.04
	B	91.09	11.50		
Available ROM	A	75.00	16.30	33.50	*0.04
	B	86.27	11.85		
Extension MMT	A	3.08	0.90	43.50	0.17
	B	3.64	0.50		
Flexion MMT	A	2.33	0.65	26.00	*0.01
	B	3.27	0.79		
Tinetti Gait	A	7.33	1.72	34.50	*0.05
	B	8.73	1.19		
FIM Transfers	A	6.00	0.85	65.50	0.98
	B	6.09	0.30		
FIM Gait	A	5.50	1.24	55.00	0.53
	B	6.00	0.00		
FIM Stairs	A	4.58	1.88	33.00	*0.04
	B	6.00	0.00		
Length of Stay	A	15.42	5.09	27.50	*0.02
	B	10.27	3.77		

*significant differences ($p \leq 0.05$)

Chapter Five

Discussion and Conclusions

Introduction

In this study the effects of MP in conjunction with traditional therapy on the recovery of patients status-post TKA was examined. Participants were selected from a sample of convenience. The control group of patients (Group A) participated in traditional therapy while the experimental group (Group B) participated in traditional therapy and MP. Data were collected using a variety of standard physical therapy evaluative tools: goniometry, MMT, the Tinetti Gait Assessment, and the transfer, gait, and stair climbing components of the FIM. While pre-intervention baseline data suggested that many measurement categories deviated from a normal distribution, random group assignment produced homogeneity between sample groups. Post-intervention data analysis revealed significant differences between groups, with Group B demonstrating significantly greater ROM (knee flexion and Available ROM), knee flexion strength, gait quality, and functional ability in stair climbing than Group A (Table 7). Remarkably, the improvements made by Group B were made in a significantly shorter hospital length of stay ($p < 0.05$). Thus, the main hypothesis was generally supported: Patients with osteoarthritis, status-post TKA, who received a complement of MP with traditional therapy had enhanced rehabilitation outcomes as compared to a control group of patients who received traditional therapy alone. In the remainder of this chapter the present study's results are discussed and related to relevant theoretical and applied literature. In addition, conclusions and recommendations for future research are offered.

Discussion

Previous investigators have generated a variety of explanations to account for the success of MP in improving performance. The motivation hypothesis postulates that MP increases the performer's motivation to improve (Wichman & Lizotte, 1983). Richardson (1967) originally suggested that motivation might be at least partly responsible for the effectiveness of MP. Specifically, MP groups may be more "ego involved" when asked to mentally rehearse a task (Feltz & Landers, 1983). To control for this motivational explanation, the present study included a non-MP group (i.e., placebo group) that had the same number of scheduled experimental sessions as the MP group.

The psychoneuromuscular theory of Washburn (1916) and Jacobson (1932) cannot be confirmed nor refuted by the current results because EMG data were not collected and analyzed. Sackett's (1934) symbolic learning theory is also frequently hypothesized to explain the effects of MP. As mentioned previously, the most clear support for symbolic learning comes from MP effects in cognitive tasks more so than in motoric or strength and endurance tasks. Knee ROM, hamstring strength, and gait could hardly be considered highly cognitive tasks. It may be that when rehabilitation involves the teaching of new motor skills in a compensatory approach, such as wheelchair locomotion or prosthetic gait, patients who utilize MP in the cognitive and associative phases of motor learning will experience even greater improvements than those gains experienced in the present study.

Some researchers have suggested that the greater the number of mental rehearsals, the greater the effect on performance (Hall, et al., 1994; Smyth, 1975; Sackett, 1934), whereas others have suggested that there may be an optimal number of practice sessions and length of practice period for which MP is most effective for skill learning (Corbin, 1972; Twining, 1949). Feltz and Landers found that the length of practice sessions under one minute or between 15 or 25 minutes produced the largest MP effects. In their meta-analyses, studies that employed either less than six trials, or between 36 and 46 trials per practice session, demonstrated the largest effect sizes (Feltz, et al., 1988; Feltz & Landers, 1983). Feltz and Landers' meta-analysis indicated that studies employing cognitive tasks had larger average effects size than motor or strength tasks. The improvements for cognitive tasks were most often achieved in a relatively short practice session (M = 3.17 minutes) and with only a few trials (M = 4.17) compared to motor (M = 7.3 minutes and 17.97 trials) and strength (M = 7.5 minutes and 10.0 trials) tasks (Feltz & Landers, 1983). In the present study MP session times of ten minutes were employed and each session included three to five trials of MP per task.

The bioinformational theory appears to receive some support from the results of the current study. As MacKay (1981) suggested, MP may prime muscle units for action during MP sessions. Internal images, already present from the physical practice experiences in daily therapy sessions were potentially activated, rehearsed, and reinforced, leading to improved performance. Richardson (1967) and others (Clark 1960; Corbin 1972) concluded that the degree of familiarity a subject has with the physical performance of a task, the more efficacious the effects of MP. All of the skills involved in this study were ones that participants had significant previous experience with (knee motion, strength, transfers, gait, and stair climbing).

In the present study, MP could also have functioned as a supplement to inadequate internal feedback. The importance of feedback for motor learning and even muscle strengthening is commonly accepted by therapists (Shumway-Cook & Woollacott, 2001). The rehabilitation of a person following stroke who demonstrates motor and sensory deficit(s) is just one example. Initially, much of the therapist's focus in exercise and reestablishment of functional independence is on the provision of external feedback, manual guidance of normal movement, and the facilitation of compensatory mechanisms by spared sensory systems. External feedback is then quickly faded to allow the patient to rely on his or her own sensory capacity and problem solving ability.

The present results suggest that the rehabilitation of patient's with arthritis and/or post-TKA may also benefit from the incorporation of complementary mental rehearsal. In a comparison of proprioception in arthritic and age-matched normal knees, Koralewicz and Engh (2000) found that middle-aged and elderly persons with advanced knee arthritis were significantly less able to detect passive motion of the knee than were middle-aged and elderly persons without knee arthritis. They also demonstrated that persons who had arthritis in only one knee had a reduced ability to detect passive motion of both knees. Fuchs and colleagues (1999) investigated the differences in proprioception following TKA (64 months post-surgery). They found that patients with TKA did not have significant differences in proprioceptive sensation between the operated knee and the contralateral knee. These patients did, however, have significantly less proprioception compared to a group of age-matched healthy subjects. These findings were replicated in a more recent study by Pap and colleagues (2000). If MP in the present study provided a vivid representation of proprioception between therapy sessions, MP participants should have demonstrated improved performance as compared to controls.

It should be noted that follow-up data were not obtained in this study and therefore the effects of MP on retention of performance remain to be determined. This should be a priority of future research as it has been suggested that external feedback, when not appropriately faded, produces patient dependence on the therapist rather than patient independence and thus, decreased ability to generalize tasks practiced in therapy to everyday life (Shumway-Cook & Woollacott, 2001).

Research that has concerned itself with gender differences and the impact of gender in MP is scarce. Feltz and Landers (1983) found no significant differences between males and females in the limited sources available for their meta-analysis. In the present study there were only four men, two in each group. Therefore, it was not possible to adequately evaluate gender difference among groups.

With much more available data to draw from, Feltz and Landers (1983) also looked at age related differences but found no differences.

Jones and colleagues (2001) studied the impact that older age has on the success rates post-TKA. Differences in TKA outcome were not significantly altered by age. They concluded that with increasing life expectancy and elective surgery improving people's quality of life, age alone should not be a limiting factor when considering who should receive TKA surgery (Jones, et al., 2001). The results of the present study suggest that older adults may also benefit from a MP complement to conventional TKA therapy.

Study Limitations

Limitations in study design may have impacted the present results. As previously mentioned, subjects volunteered from a limited sample of convenience. There were many more women than men who volunteered for and then successfully completed participation in the experimental protocol. A larger numbers of participants are needed to increase the probability of achieving normality. Thus, the present results, while very interesting, cannot be generalized to larger populations. The study was strengthened by the blinded post-intervention data collection but this task was performed by multiple staff therapists, which could, regardless of care in data collection methods, previously established tool reliability, and reliability checks, have impacted the accuracy of measures obtained.

The intent of this study was to clinically test the effectiveness of MP in conjunction with therapy post-TKA. Therapy is traditionally individualized per patient needs and may vary between therapists. There were no controls for therapy outside of a generally accepted protocol. While attendance and participation in therapy were monitored, there were possible differences in care plans between participants that could not be controlled for in the hospital setting. Additionally, MP was implemented in a very clinical fashion without individualization. This was done in order to implement a MP protocol for increased control within the study and to function within the productivity and reimbursement restrictions in which therapists work. In order for MP to be a viable therapeutic tool in today's healthcare environment, MP must be shown to be an effective technique characterized by ease of implementation and cost minimization (e.g., facilitated use via audiocassette versus direct therapist to patient personal MP facilitation).

Recommendations for Future Research

Based on the results of this study, the following recommendations are suggested for future research in the use of MP as a complement to traditional occupational and/or physical therapy.

- Researchers should consider the use of MP as a treatment modality in practical and cost effective terms: MP use should be guided through means that do not demand significant time away from the therapist's more traditional role;
- Studies should minimally include a motivational control group;
- To support generalization, research needs to incorporate groups with large numbers of participants from a truly random, and not convenient, sample;
- Studies should recruit comparable numbers of male and female participants to better investigate possible gender differences;
- The potential benefit of MP should be investigated across age groups through studies that categorize participants by both age and diagnostic groups.
- Special populations within rehabilitation need to be identified so that the effectiveness of MP may be tested across cultural and diagnostic categories; and

- When possible, specific traditional therapy protocol controls should be incorporated into research designs to better test the effectiveness of MP.

Summary and Conclusions

Therapists are challenged daily with establishing care plans and structuring functional activities that will best assist their patients to decrease pain, recover motion and strength, and return to functional, high quality lifestyles. All of these goals must be accomplished in the most cost efficient manner. Mental practice has been traditionally employed to enhance the performance and retention of skills in non-therapeutic settings. This study provides support for the use of MP in a rehabilitation environment. The efficacy of MP, a practice procedure where the learner imagines the practicing of skill without overt physical activity, has not previously been adequately tested or applied in rehabilitation. At the same time, evidence from various motor behavior and sport experiments convincingly demonstrate its benefits for motor learning (Murphy, 1994; Hall, Buckolz & Fishburne, 1992; Zervas, 1986). Mental practice is also a potentially effective technique for patients whose physical activity is restricted or whose physical practice is limited or prohibited (Warner & McNeill, 1988). In such instances, use of MP as a complement to physical practice would seem logical. Moreover, MP might be beneficial in minimizing functional losses associated with bed-rest.

This study focused on the clinical application and efficacy of MP used in conjunction with traditional therapy in an inpatient rehabilitation setting. Results indicate that the addition of MP to conventional therapy enhanced patient outcomes post-TKA. Perhaps most importantly, patients who used MP in conjunction with their therapy left the hospital significantly earlier than the control group. In this era of healthcare reform and cost containment, economics may be the most important reason to seriously consider the results of this study. A decreased length of patient hospital stay by four days could save as much as three thousand dollars per patient. It would appear that, more than ever, MP should be considered as a potential complement to conventional physical therapy.

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Appendices

Appendix A

Informed Consent Forms

Control Group Informed Consent Form

Title of Project:
The Effectiveness of Mental Practice as a Complement to Traditional Physical Therapy in Rehabilitation Outcomes of Patients Status-Post Total Knee Arthroplasty

Principal Investigator:	Nancy T. Fell, PT, NCS Doctoral Student
Faculty Advisor:	Craig Wrisberg, PhD Professor, University of Tennessee Educational Administration & Cultural Studies

Date: June 30, 2000

General Information
I have been asked to participate in the above-titled clinical research study conducted at ____________ Rehabilitation Hospital. I understand that I have the option not to participate in this study.

Purpose and Duration of the Study
I understand that the objective of this research is to determine whether mental practice combined with traditional physical therapy decreases the total number of hospital rehabilitation days required to achieve independence.

The duration of my participation will be during my hospitalization at

__________.

Description of the Study
The research will consist of the following procedure:

An initial evaluation will be performed by Mrs. Fell for knee range-of-motion, knee strength, and a walking assessment.

I will then participate in my regularly prescribed physical therapy program at the hospital. Five days/week, on weekdays, I will also listen to a 15-minute audiocassette tape consisting of relaxation.

I will also be required to complete a daily diary recording my participation.

I will receive, on loan, a portable audiocassette recorder with earphones and batteries. Tapes and written handouts, including a compliance log, will be provided. Mrs. Fell will follow-up with me three times/week to answer questions.

I understand that Mrs. Fell will be using data from my medical record regarding my medical stability, therapy attendance, functional ability, cost of rehab, and length of stay.

On the day of discharge from the hospital, my _________ physical therapist will take additional measurements of my knee range-of-motion, knee strength, and a walking assessment.

The goal is to continue with the study until discharged from ___________ Rehabilitation Hospital. However, I may withdraw from the study at any time.

Risks of the Research Study

By participating in this research study, I understand that I will not be exposing myself to risks or side effects outside of those normally associated with physical therapy treatment.

There are no foreseen risks associated with the mental practice/audiotape portion of this research project.

Benefits of the Research Study

I understand that the potential benefit of my participation in this study is in the improvement of physical therapy in knee rehabilitation. The benefit of the study to society may be the use of the information gained on the effectiveness of mental practice combined with physical therapy for patients in the future.

Confidentiality

I understand that the information gained in this research study will be reviewed by a number of individuals and institutions, but that my identity will not be revealed. I understand that the records compiled in this study may be inspected and audited by The University of Tennessee's IRB Committee. However, I also understand that all hospital medical records precautions will be taken to otherwise maintain the privacy and confidentiality of my records.

Procedure for Termination of Participation
I understand that if I at some point during this research study decide to withdraw, I must notify Mrs. Fell or my _________ physical therapist as soon as possible.

Patient Consent

I understand that my participation in the study will be for the time that I am a patient at __________, but I have the option to refuse to participate or to withdraw from the study at any time without incurring any penalty or loss of benefits otherwise available to me, including medical care at this institution.

I understand that if I have questions about the research being performed in this study or regarding my rights as a subject to this research, I should contact: Nancy Fell, PT, NCS - 785-2240.

While there are not costs associated with participating in the study, I understand that the cost of my medical care remains my responsibility and not that of my physician, the principal investigator, ___________ Rehabilitation Hospital or The University of Tennessee.

In the event of some medical problem or complication, I have been given the telephone number of ___________'s medical director: Dr. Sai Oh - 698-0221

_____________________________ Date: __________

Patient Signature

I was present, heard and observed the reading of this document and the explanation presented to the patient. In my opinion, I believe that the patient understood the explanation presented and volunteers to participate without coercion.

_____________________________ Date: __________

Witness Signature

I was present, heard and observed the reading of this document and the explanation presented to the patient. In my opinion, I believe that the patient understood the explanation presented and volunteers to participate without coercion.

_____________________________ Date: __________

Witness Signature

Experimental Group Informed Consent Form

Title of Project:
The Effectiveness of Mental Practice as a Complement to Traditional Physical Therapy in Rehabilitation Outcomes of Patients Status-Post Total Knee Arthroplasty

Principal Investigator:	Nancy T. Fell, PT, NCS Doctoral Student
Faculty Advisor:	Craig Wrisberg, PhD Professor, University of Tennessee Educational Administration & Cultural Studies

Date: June 30, 2000

General Information
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The duration of my participation will be during my hospitalization at

___________.

Description of the Study
The research will consist of the following procedure:

An initial evaluation will be performed by Mrs. Fell for knee range-of-motion, knee strength, and a walking assessment.

I will then participate in my regularly prescribed physical therapy program at the hospital. Five days/week, on weekdays, I will also listen to a 15-minute audiocassette tape consisting of relaxation and mental practice in leg exercises and functional activities (such as standing up, walking and climbing stairs).

I will also be required to complete a daily diary recording my participation.

I will receive, on loan, a portable audiocassette recorder with earphones and batteries. Tapes and written handouts, including a compliance log, will be provided. Mrs. Fell will follow-up with me three times/week to answer questions.

I understand that Mrs. Fell will be using data from my medical record regarding my medical stability, therapy attendance, functional ability, cost of rehab, and length of stay.

On the day of discharge from the hospital, my _________ physical therapist will take additional measurements of my knee range-of-motion, knee strength, and a walking assessment.

Additionally, I agree to participate in a 15-20 minute discharge interview led by Mrs. Fell.

The goal is to continue with the study until discharged from ___________ Rehabilitation Hospital. However, I may withdraw from the study at any time.

Risks of the Research Study
By participating in this research study, I understand that I will not be exposing myself to risks or side effects outside of those normally associated with physical therapy treatment.

There are no foreseen risks associated with the mental practice/audiotape portion of this research project.

Benefits of the Research Study
I understand that the potential benefit of my participation in this study is in the improvement of physical therapy in knee rehabilitation. The benefit of the study to society may be the use of the information gained on the effectiveness of mental practice combined with physical therapy for patients in the future.

Confidentiality
I understand that the information gained in this research study will be reviewed by a number of individuals and institutions, but that my identity will not be revealed. I understand that the records compiled in this study may be inspected and audited by The University of Tennessee's IRB Committee. However, I also understand that all hospital medical records precautions will be taken to otherwise maintain the privacy and confidentiality of my records.

Procedure for Termination of Participation
I understand that if I at some point during this research study decide to withdraw, I must notify Mrs. Fell or my __________ physical therapist as soon as possible.

Patient Consent
I understand that my participation in the study will be for the time that I am a patient at __________, but I have the option to refuse to participate or to withdraw from the study at any time without incurring any penalty or loss of benefits otherwise available to me, including medical care at this institution.

I understand that if I have questions about the research being performed in this study or regarding my rights as a subject to this research, I should contact: Nancy Fell, PT, NCS - 785-2240.

While there are not costs associated with participating in the study, I understand that the cost of my medical care remains my responsibility and not that of my physician, the principal investigator, ___________ Rehabilitation Hospital or The University of Tennessee.

In the event of some medical problem or complication, I have been given the telephone number of ___________'s medical director: Dr. Sai Oh - 698-0221

_____________________________ Date: __________
Patient Signature

I was present, heard and observed the reading of this document and the explanation presented to the patient. In my opinion, I believe that the patient understood the explanation presented and volunteers to participate without coercion.

_____________________________ Date: __________
Witness Signature

I was present, heard and observed the reading of this document and the explanation presented to the patient. In my opinion, I believe that the patient understood the explanation presented and volunteers to participate without coercion.

_____________________________ Date: __________
Witness Signature

Appendix B

Facilitated Progressive Relaxation Script

Appendix B
Facilitated Progressive Relaxation Script
(Motivational Control Group Intervention)

Soft acoustic guitar music begins and continues playing in the background of the tape. A female voice provides the direction for relaxation. The following script reflects the exact language used. The script was designed by Nancy T. Fell and should not be used without her express permission.

Okay, its time for you to do this exercise program. I think you'll enjoy it. What you need to do is to get yourself positioned in a very comfortable posture...probably the best position to be in would be lying in bed with your arms and legs supported....where you can just relax back and close your eyes.

Once you're in this position, we're going to go through a series of simple relaxation exercises. And we're going to follow it with just some time where you can focus on some deep breathing and let all of the stress of the past day out of your system. So, what I'd like you to do, I'd like you to go ahead and take a deep breathe in...and slowly let it out. Again, breathe in...and out. Breathe in...and out. Now, as you continue with some deep breathing, we're going to switch over to some tightening up and relaxing muscles throughout your body. So with that, what I'd like you to do is to tighten up your face muscles...really tight...scrunch them up...and hold it there...and relax. Again, scrunch up those face muscles really tight...and relax. One more time, face muscles tighten up...and relax.

Okay, we're going to move to your shoulders. I want you to pull your shoulders up to your ears...tighten up those muscles...and let them drop...relax. Tighten up those shoulders...pull them up toward your ears...hold...and relax. One more time. Shoulders up...hold...and relax. Okay, we're to move to your arms now. I want you to make a fist in each hand, push those arms down into the bed...push hard...squeeze...squeeze...and relax. Again. Tighten up those hands, make a fist in both hands, push those arms down into the bed and hold it there...push hard...and relax. This is the last time for the arms. Tighten up the hands, push the arms into the bed...push...and relax. Take some nice deep breaths in...and out. In...and out. Again, breathe in...and out.

Okay, we're going to move to your back now. I want you to tighten up all the muscles in your back: your shoulders and hips and legs. Tighten up and push into the bed...really tight...and relax. Again, shoulders, back, and hips push back into the bed...tighten up as many muscles as you can find...and relax. Again tighten up...relax.

Okay and we're moving down to the legs. Let's go ahead and push those legs down into the bed. Tighten up those leg muscles...relax. Again, tighten those leg muscles, push hard into the bed...relax. One more time. Push down into the bed...push hard...tighten up those hip muscles, those leg muscles...and relax. Take a deep breathe in...and out. Breathe in...and out. Again, breathe in...and out. Good. The final relaxation exercise is to tighten up your whole body. Tighten up your hands, your shoulders, your face, your neck, your back, your legs...and relax. Tighten up...tighten up...and relax. One final time. Tighten up all those muscles again...relax. Good.

At this point we're going to focus on deep breathing. Just keeping your eyes closed and relaxing, listening to the music and letting all the distractions of the day leave you.

Music continues.

Breathe in...and out. Breathe in...and out. Again, breathe in...and out. Very good.

Music continues.

Congratulations. You've finished your exercise relaxation program for the day. I thank you for completing it and we'll do it again tomorrow.

Music continues.

Appendix C

Guided MP Script

Appendix C

Guided MP Script

(Experimental Group Intervention)

Soft acoustic guitar music begins and continues playing in the background of the tape. A female voice provides the direction for relaxation. The following script reflects the exact language used. The script was designed by Nancy T. Fell and should not be used without her express permission.

Okay, its time for you to do this exercise program. I think you'll enjoy it. What you need to do is to get yourself positioned in a very comfortable posture...probably the best position to be in would be lying in bed with your arms and legs supported....where you can just relax back and close your eyes.

Once you're in this position, we're going to go through a series of simple relaxation exercises and then your mental exercises. So, what I'd like you to do, I'd like you to go ahead and take a deep breathe in...and slowly let it out. Again, breathe in...and out. Breathe in...and out. Now, as you continue with some deep breathing, we're going to switch over to some tightening up and relaxing muscles throughout your body. So with that, what I'd like you to do is to tighten up your face muscles...really tight…scrunch them up…and hold it there…and relax. Again, scrunch up those face muscles really tight…and relax. One more time, face muscles tighten up…and relax.

Okay, we're going to move to your shoulders. I want you to pull your shoulders up to your ears…tighten up those muscles…and let them drop…relax. Tighten up those shoulders…pull them up toward your ears…hold…and relax. One more time. Shoulders up…hold…and relax. Okay, we're to move to your arms now. I want you to make a fist in each hand, push those arms down into the bed…push hard…squeeze…squeeze…and relax. Again. Tighten up those hands, make a fist in both hands, push those arms down into the bed and hold it there…push hard…and relax. This is the last time for the arms. Tighten up the hands, push the arms into the bed…push…and relax. Take some nice deep breaths in…and out. In…and out. Again, breathe in…and out.

Okay, we're going to move to your back now. I want you to tighten up all the muscles in your back: your shoulders and hips and legs. Tighten up and push into the bed…really tight…and relax. Again, shoulders, back, and hips push back into the bed…tighten up as many muscles as you can find…and relax. Again tighten up…relax.

Okay and we're moving down to the legs. Let's go ahead and push those legs down into the bed. Tighten up those leg muscles…relax.

Again, tighten those leg muscles, push hard into the bed…relax. One more time. Push down into the bed…push hard…tighten up those hip muscles, those leg muscles…and relax. Take a deep breathe in…and out. Breathe in…and out. Again, breathe in…and out. Good. The final relaxation exercise is to tighten up your whole body. Tighten up your hands, your shoulders, your face, your neck, your back, your legs…and relax. Tighten up…tighten up…and relax. One final time. Tighten up all those muscles again…relax. Good.

Take a deep breathe in…and out. In…and out. In…hold…and relax. Take a few more deep breaths as you prepare to do some leg exercises. Okay we're going to be doing some leg exercises, some very similar to what you have been doing in therapy with your physical therapy program. As we are doing them, I want you to image yourself actually doing the exercises without physically moving. So use your active imagination and think about what the exercises look like, what they sound like in the therapy area, what they feel like and how your knee might feel and as we get into moving around, transferring and walking, I want you to think about being independent in these activities.

So the first thing we're going to do, is we're going to think about bringing that knee up, sliding your heel up along the bed with your knee approaching your chest. Hold it up there with you knee bent. Your knee feels good…it's moving smoothly. And then relax it on out straight. Again, bend up…slide that knee up…and down. This is number three. Slide up…bend that knee, bring it toward your chest…and slide it out straight. Number four and up…bend and stretch…and straighten that leg out. Let's do number five…up…and straighten it out. Your knee is doing just fine. Bend up and stretch …this is all great exercise for that knee that you had surgery on…and straighten it out. Imagine doing this perfectly in your mind. Bend up…and down. Bend that knee up toward your chest, and down. Three more. Lift up…stretch…relax on out straight. Again, up…stretch…relax on out straight. This is the last one. Lift up…stretch…and relax on out straight. Good job.

Now, I want you to imagine yourself rolling on over to your stomach. Again, just imagine doing this. You're lying on your stomach with your face turned to the side with your legs straight out behind you. We're going to work on bending that knee that you had surgery on. So your going to bend your foot up so that it is pointing toward the ceiling. And your foot comes up toward your buttocks. Let's try that. Bend up…and down. Again, up…and down. Good job. Number three, up…and down. Bend up…and down. Up…and down. Five more times for me, bend the knee up…down. Up…down. Up…down. Up…down.

Last one, bend up…down. Good. You've been getting some great motion out of your knee.

Now I want you to imagine yourself sitting up on the edge of your bed. Let's work on straightening out you knee. Kick that foot up and straighten your knee…hold it there…and slowly lower your foot to the floor. Same thing again, lift your foot up…hold…and lower. Good. Straighten out your knee…hold it tight…straighten it out…and down. Repeat this exercise six more times. Up and down with your leg so that you are practicing straightening the knee out. Continue with the exercise….. Okay, let's do one last one together. Straighten out your knee…hold it tight…and lower your foot to the floor. Good job.

We're going to finish up this session with some functional activities. I want you to imagine yourself sitting on the edge of the bed. We're going to place your leg that has had the surgery slightly behind the other leg and we're going to get ready to stand up. You can feel free to imagine your weight on that knee…it's good, solid and strong…there's no pain and you're going to push up and stand. Good. Now slowly sit down. Control it very carefully and don't flop down. Sit softly. Again, and get your feet in position, push with your arms, lean forward, and stand up. Good. Good equal weight on both legs and slowly sit. Great. Again, sit softly, don't flop down. One last time. Feet in position, push with the arms, lean forward and stand. Good weight on each foot. Great. Once you are standing nice and tall, slowly lean forward and control yourself as you sit down. That's great.

Now we're going to do a little bit of walking. Go ahead and imagine standing up. You will use your wheeled walker. Hang onto it with both hands once you stand up and we're going to being walking with your involved leg. Allow yourself to put weight through that leg…it feels good and solid…the weight on it is helping to stimulate bone growth so that your new knee will be strong. You're going to work on getting your heel down first, and then step forward with the next foot. Okay, we've got the surgical knee coming forward again with heel hitting the floor first, foot flat, and push off as you bend your knee to lift the leg and swing it forward. Let's do it again. Really, just think about how you are walking, that it is slow and real precise with one foot in front of the other…real smoothly and you're not having any trouble at all. You can shift weight to that leg…that leg is not going to buckle. It's going to accept the weight and there's not going to be pain. You want your steps to be equal and even. And you want to stand nice and tall. Very good.

Now, we're coming up to a set of stairs similar to those in the therapy gym. Go ahead and push your walker to the side and grab onto the railings. You're going to start by climbing the stairs, there are three of them. You're going to lead with the leg that did not have surgery – the good leg. So, go ahead and step up and bring that other leg up behind it so that both feet are on that first step. Step up again with the good leg. And follow with the other leg. One more time. And step up. Great. And we're going to turn slowly around, take your time. Don't pivot on that surgical leg. Pick it up and step with little steps. Now you've got both handrails again and we're going to step down with the leg that had surgery first. Slowly down with the surgical leg, then the good leg. Again…surgical leg…good leg. Good. Slowly take your weight on that surgical leg. One more time. . Down with your surgical leg, your good leg, and you're there! Go ahead and grab onto your walker and walk on over to a chair. Just imagine a chair in front of you, turn slowly and sit. Now I want you to take a few deep breaths again. Breathe in…and out. Again, breathe in…and out. Very nice. We're done with this therapy session and we'll do it again tomorrow.

Appendix D

Data Collection Instruments

Appendix D

Data Collection Instruments

I. **Goniometry (ROM):**

Measurement following traditional rules of goniometric measure. Patient should be supine for both measures.

Fulcrum:	Over the lateral epicondyle of the femur.
Proximal Arm:	Lateral midline of the femur, using the greater trochanter for reference.
Distal Arm:	Lateral midline of the fibula, using the lateral malleolus for reference.

Knee flexion: Bring femur to approximate 90 degrees of hip flexion. Allow the knee to passively drop into flexion. Measure. (R)_____(L)_____

Knee extension: Allow the leg to move into full extension. Instruct the patient to perform a quad set to achieve full available extension. Have the patient relax and measure. (R)_____(L)_____

II. **Manual Muscle Tests (MMT)**:

Following Kendall's protocol, measure knee flexors and extensors.
Knee flexors: 1) Position: The patient should be positioned prone unless contraindicated. A small pillow may be used under the abdomen for comfort. If the prone position is not possible, the patient should be tested in sitting. For a grade of 2 or less, the patient should be positioned sidelying.
2) Fixation: Examiner should hold the thigh firmly on the table. The patient is instructed to bend the knee from a straightened position up toward his/her buttock. If able to achieve the motion against gravity, the leg is placed in 50-70 degrees of flexion. Pressure is against the lower leg, proximal to the ankle without a rotational component. (R)_____ (L)_____
Knee extensors: 1) Position: The patient should be tested in a sitting position on a surface that fully supports the femur. For a grade of 2 or less, the patient should be positioned sidelying.
2) Fixation: The examiner places his/her hand under the distal aspect of the thigh to cushion against the table pressure. The patient is instructed to straighten the knee within their available ROM. Apply resistance at best extension range or 10 degrees of flexion. Do not measure between 10 degrees of flexion and full extension. (R)_____ (L)_____

MMT Rating Scale:

5 = normal (able to hold the test position against strong pressure)

4 = good (able to hold the test position against moderate pressure)

3 = fair (able to achieve and hold the test position against the resistance of gravity, but cannot hold even the slightest pressure)

2 = poor (able to complete the ROM in gravity eliminated plane)

1 = trace (palpable muscle contraction can be felt; unable to achieve poor)

0 = zero (no palpable muscle contraction)

III. **Tinetti Gait Analysis**:

Have the patient stand with the examiner. Have the patient ambulate 100' on an even surface, at their "usual" pace. Have them turn and return to the examiner at a "rapid, but safe" pace. They may use assistive devices as necessary. Make note of any assistive devices or orthotics used. Complete the form below.

1) Initiation of gait (immediately after told to "go")
   - Any hesitancy or multiple attempts to start = 0
   - No hesitancy = 1 ______/1

2) Step length and height
   - a) Right swing foot
     - Does not pass left stance foot with step = 0
     - Passes left stance foot = 1
     - Right foot does not clear floor completely with step = 0
     - Right foot completely clears floor = 1
   - b) Left swing foot
     - Does not pass right stance foot with step = 0
     - Passes right stance foot = 1
     - Left foot does not clear floor completely with step = 0
     - Left foot completely clears floor = 1 ______/4

3) Step Symmetry
   - Right and left step length not equal = 0
   - Right and left step length appear equal = 1 ______/1

4) Step continuity
   - Stopping or discontinuity between steps = 0
   - Steps appear continuous = 1 ______/1

5) Path (estimated in relation to floor tiles, 12-inch diameter; observe excursion of 1 foot over about 10 ft. of the course)
   - Marked deviation = 0
   - Mild/moderate deviation or uses walking aid = 1
   - Straight without walking aid = 2 ______/2

6) Trunk
   - Marked sway or uses walking aid = 0
   - No sway but flexion of knees or back or spreads arms out while walking = 1
   - No sway, no flexion, no use of arms, and no use of walking aid = 2 ______/2

7) Walking stance
   - Heels apart with feet abducted = 0
   - Heels almost touching when walking = 1 ______/1

Total Gait Score: ______/12

IV. Sport Imagery Questionnaire:

Two scenarios are chosen based upon the participant's experience and are facilitated by the primary investigator. The participant is asked to rate their imagery ability by answering the following questions. Average time for implementation and rating of each scenario should be approximately five minutes.

1) How vividly did you see or visualize the image?
    A. No image present
    B. Not clear or vivid, but a recognizable image
    C. Moderately clear and vivid image
    D. Clear and vivid image
    E. Extremely clear and vivid image

2) How clearly did you hear sounds?
    A. No image present
    B. Not clear or vivid, but a recognizable image
    C. Moderately clear and vivid image
    D. Clear and vivid image
    E. Extremely clear and vivid image

3) How vividly did you feel your body movements during the activity?
    A. No image present
    B. Not clear or vivid, but a recognizable image
    C. Moderately clear and vivid image
    D. Clear and vivid image
    E. Extremely clear and vivid image

4) How clearly were you aware of your mood or feel your emotions in the situation?
    A. No image present
    B. Not clear or vivid, but a recognizable image
    C. Moderately clear and vivid image
    D. Clear and vivid image
    E. Extremely clear and vivid image

5) How well did you see the image from inside your body?
    A. No image present
    B. Not clear or vivid, but a recognizable image
    C. Moderately clear and vivid image
    D. Clear and vivid image
    E. Extremely clear and vivid image

6) How well could you control the image?
    A. No control at all of the image
    B. Very hard to control
    C. Moderate control of the image
    D. Good control of the image
    E. Complete control of the image

VITA

Nancy T. Fell holds the Doctor of Philosophy degree in Education from the University of Tennessee, Knoxville with a concentration in Motor Behavior and a minor in Gerontology. She was awarded the Bachelor of Science in Physical Therapy from St. Louis University in St. Louis, Missouri, and the Masters of Health Science from Washington University in St. Louis. She holds the designation of Neurologic Clincal Specialist as awarded by the American Board of Physical Therapy Specialties.

Dr. Fell has worked in diverse practice settings as an adult physical therapist for 14 years and has 8 years of experience working in adult neurorehabilitation. She is currently an assistant professor in the Physical Therapy Program in the School of Rehabilitation Sciences at the University of Tennessee at Chattanooga. In addition to teaching all courses of the program's adult neurorehabilitation, Dr. Fell teaches human growth and development from adulthood through death, and the evaluation and treatment of patients with cancer, immune disorders, and pelvic floor dysfunction. Her research interests include motor learning in special populations and the use of mental practice as an adjunct modality in physical therapy.