The Effect of RAS on Individuals With Total Hip Replacement and Hip Revision Surgery

By

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Abstract

The purpose of this study was to investigate whether individuals receiving Rhythmic Auditory Stimulation (RAS) during gait training showed statistically significant differences in cadence, stride length and velocity compared to those who only received conventional gait training. Six eligible subjects from three facilities in the Midwest and Southwest agreed to participate, with three assigned to the experimental group that received RAS and three assigned to the control group that did not receive RAS. The experimental group did have higher means for cadence, stride length and velocity, but variability in the data made statistical analysis of the data undesirable. An outlier in the experimental group with extremely high cadence, stride length and velocity skewed the data considerably so no statistically significant differences were found between the experimental and control groups. The number of days subjects spent in rehabilitation appeared to be correlated very closely with their gait parameters. Subjects with more days of rehabilitation had higher cadence, stride length and velocity regardless of whether they were in the experimental or control groups. Implications for future research are discussed.

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Chapter 1

Introduction

Members of the post WWII generation, a large cohort, are entering older adulthood and facing the effects of aging, requiring increasing levels of medical care and intervention. As individuals age, they often experience a loss of muscle mass which can lead to frailty, and the incidence of arthritis increases. Frailty can lead to falls, causing hip fractures necessitating surgical repair. In addition, arthritis can lead to intractable pain in the hips that is significantly attenuated by surgery. The number of hip surgeries performed annually in the United States is rising and possible reasons include increased life expectancy and a tendency among Baby Boomers to get joint replacements to maintain active lifestyles (Shaw, 2007). This phenomenon is creating an opportunity to investigate and refine treatment methods to impact hip issues in the elderly. Finding innovative and cost effective methods to increase the efficacy of treatment and rehabilitation will benefit patients and reduce the resources needed to provide optimal outcomes. Traditionally, older adults who undergo hip surgery will participate in physical therapy to address gait rehabilitation. Pairing physical therapy with a sensory cue, such as rhythmic auditory stimulation, may enhance the characteristics of the gait rehabilitation.

Hip surgery statistics

Though 200,000-300,000 hip replacements are performed annually in the United States, one expert believes that number could surpass 600,000 in 2015 (Frey, 2011). An additional number of hip revision surgeries are done to correct problems following hip replacement surgery. These numbers are three to six times less than replacements with 32,000 revision surgeries performed in the United States in 2000 (Frey, 2011). The number of hip surgeries is projected to grow along with the increasing numbers of older adults.

Hip replacement and revision surgery

Hip replacement, or total hip arthroplasty (THA) is performed to improve joint function and range of motion. Common causes of joint deterioration include osteoarthritis, rheumatoid arthritis, avascular necrosis, and trauma. Often the cartilage between the acetabulum, or the hip socket, and the head of the femur breaks down, leaving bone rubbing against bone. This causes intense, debilitating pain and decreases range of motion (Frey, 2011).

During a hip replacement surgery, the surgeon removes the head of the femur and attaches a synthetic head in its place. The surgeon also shapes the acetabulum to receive the synthetic femur head. Most of the individuals who undergo this procedure are over fifty years old and have hip injuries for a number of reasons. These include arthritic pain and degenerative joint conditions that tend to worsen as individuals age. Surgeons recommend that patients wait as long as possible for surgical interventions to decrease the likelihood of a second hip surgery due to limited prosthetic life spans (Frey, 2011).

Hip revision surgery is the replacement of the prosthesis from a previous total hip replacement surgery. The prosthesis may have loosened, the patient may be experiencing pain, or x-rays may indicate that the joints are in danger of sustaining irreversible harm due to wear. The surgery may also be performed in cases of fracture, infection, or if the prosthesis has become dislocated (Frey, 2011).

Overall population aging

The increasing need for hip surgeries results from an ever-growing older population. Birth, fertility and death rates over the course of the 20th century have set the stage for this growth. A drop in the birth rate occurs as a nation becomes more industrialized and less agrarian

(Bongaarts, 2009), and this trend is clear in the history of the United States during the first four decades of the 20th century. From 1900 to 1936, birth rates decreased steadily as the United States became more urban and less rural. The birth rates then began to increase slightly until the last years of WWII when they once again began to decline. An exception to this trend of declining birth rates with expanding industrialization occurred from 1945-1960 in the years following the end of WWII, when the number of births skyrocketed (Guyer, Freedman, Strobino, & Sondik, 2000). This period has been called "The Baby Boom," and individuals who were born during this time are now aging into their fifties, sixties, and early seventies.

After 1960, birth rates fell again, perhaps due to oral contraceptives and legalized abortions. Birth rates have remained stable since 1961 although the number of births increased when female Baby Boomers reached childbearing age (Guyer, et al., 2000). Consequently, individuals born between 1945 and 1960 form an exceptionally large age cohort that is reaching a point when they will require hip surgeries to maintain life quality. Advances in medical science assure growing numbers of mature adults will achieve very old age and will have increasing potential for disabling joint wear (National Institute on Aging, 2011).

Future challenges in providing care to older adults

As the number of elderly individuals grows, it is essential that they remain as physically-functional as possible to remain independent and to preserve their life quality. Joint disease or injury can lead to dependence on younger, more able persons for care and support. This dependence is becoming a serious issue because the ratio of numbers of persons who require care are increasing while the numbers of persons who can provide the care are decreasing. The current nursing shortage has been precipitated by retirement and aging among nurses and the inability to train enough nurses to replace them. Nursing schools are unable to accept more students due to an inadequate number of faculty; in addition the average age of nursing instructors is currently 50 years old (Derksen & Whelan, 2009), thus adding to the shortage of faculty as current faculty move towards retirement. The number of primary care physicians has dropped as medical school graduates seek more lucrative work as specialists (Derksen & Whelan, 2009), and home health aides are leaving the profession due to low pay and meager benefits (Mosher, 2009). The number of elderly individuals who require medical care and intervention is increasing at a rapid rate and outstripping the number of healthcare workers who are entering the workforce. As Baby Boomers age they will require progressively more assistance from the public and private sectors and predictions indicate the 21st century will be marked by limited resources that exert pressures to decide between providing for children's care and paying the high health care costs for older adults (Guyer, et al., 2000). Such decisions will not be necessary if the majority of older adults are physically functional and independent. These independent older adults will have greater quality of life and lower health care expenditures than those who are less functional.

Providing health and rehabilitation services to older adults will become an issue of increasing concern as the population ages. By 2030, 14 million elderly Americans may be unable to complete their activities of daily living (Zedlewski, Barnes, Burt, McBride, & Meyer, 1990). Individuals who cannot walk may have difficulties with toileting, transferring, shopping, food preparation, and light housework, which may mean that they require help from others to survive. Needs for support services cost eight times more in elderly persons who are physically dependent than those who are physically independent. Furthermore, the shrinking workforce will make it increasingly more difficult for older adults to find those who can provide the support services they require (Plumer, 2013).

Costs of inactivity and disability

Inability to ambulate (walk) has physical, emotional, and financial consequences. Individuals who fail to ambulate following surgery and rehabilitation for hip fractures have higher rates of mortality than those who regain the ability to walk (Torpilliesi, et al., 2012). Furthermore, their muscles weaken and their bones become brittle and susceptible to fracture. The resulting physical inactivity is linked to digestive problems, frailty, pre-disability, reduced life expectancy and depression. Overall, well-being declines, as control over the environment is lost due to physical disability.

As of 2005, annual spending to support those who are frail or who have physical disabilities was nearly $54 billion (Spirduso, Francis, & MacRae, 2005). This included costs for residential long-term care for seven million elderly persons. The average cost of living per year in a residential care home facility varies depending on the location, with Shreveport, LA having an average of $39,000 per year and Arkansas having a statewide average of $205,000 per year (Mass Mutual Financial Group, 2006). Those older adults who are able to remain in their homes with health care workers to render assistance in completing activities of daily living pay high costs as well. Prudential (2010) reported an hourly wage between $12-$31 for home health aides (HHA'a) or certified nurse's assistants (CNA's) across the fifty states. Depending on the number of hours required, the costs could be prohibitive.

Reduced health care expenditures result when persons remain physically functional and independent. Therefore, those who treat the elderly must focus on maintaining functional abilities and reversing functional deficits when possible (Beck, 1990). One way to advance these goals is to identify effective interventions for the rehabilitation process of individuals who have undergone hip replacement and hip revision surgeries.

Effects of hip surgery on gait

Current physical therapy interventions for those who have had hip surgeries focus on building muscle strength and range of motion so individuals can walk progressively longer distances and complete activities of daily living (ADL's) safely with the minimum amount of assistance. Patients typically begin ambulating within a day or two after their surgeries, and the percentage of weight bearing depends on the type of surgery. Patients who have had total hip replacement begin bearing their full weight immediately, while those who have had hip revision surgery may only bear a small portion of their body weight on the affected limb when walking (Frey, 2011).

Due to subsequent pain, swelling, and unequal lengths between the limbs, hip replacement or hip revision surgery can decrease stride length, cadence, and velocity for a period of up to two years (Ajemian, 1997). Stride length is the distance covered in one step, cadence is the number of steps per minute, and velocity is the number of meters per minute. These parameters are significant because they exert considerable influence over fall risk and can be indicators of impending poor health outcomes (Guyer, et al., 2000). Ray and Wolf (2008) reported that older adults who fall tend to have shorter stride length and walk more slowly compared to those who do not fall. Blain et al. (2010) found that low gait speed and velocity are independent predictors of mortality for elderly individuals.

Potential benefits of RAS

Conventional physical therapy is effective in increasing cadence, stride length and velocity in individuals who have had hip surgery, but outcomes may be enhanced through rhythmic auditory stimulation (RAS). RAS is a music-based protocol in which a rhythmic stimulus (a metronome or music with strongly accented beats) is used during gait training to cue motor movements. The accented beats or pulses serve as cues for footfalls, and individuals often match their cadence to the pulse of the metronome or the music (Thaut, 2005). Studies have shown the efficacy of RAS for increasing cadence, stride length, and velocity with stroke, Parkinson's, traumatic brain injury, and the frail elderly (Thaut, 2005), but no published research concerning the effects of RAS on individuals who have had hip surgery. RAS may serve as a useful enhancement for conventional physical therapy and shorten the amount of time needed to regain normal gait functioning after hip surgery.

Therefore, the purpose of this study will be to answer the following research question. Will individuals receiving RAS during conventional gait training show statistically significant differences in cadence, stride length and velocity compared to those who only receive conventional gait training?

Chapter Two

Review of Literature

Numerous studies have shown the effectiveness of Rhythmic Auditory Stimulation (RAS) to improve cadence, velocity, and stride length among individuals with stroke, Parkinson's, traumatic brain injury, and the normal effects of aging. This chapter will review the literature concerning gait in older adults, changes in gait following hip surgery, and current rehabilitation practices for individuals who undergo hip surgery. The chapter will also address the perception of rhythm, the theoretical foundations of RAS, the use of RAS among various clinical populations and present a theoretical framework for the use of RAS following hip surgery.

Gait characteristics of older adults

Spirduso, Francis, and MacRae (2005) reported that as individuals age, gait velocity, or the number of meters a person can walk in one minute, appears to decrease naturally. Chui and Lusardi (2010) confirmed this finding, and a study by Blain et al. (2010) indicated that low velocity was an independent predictor of mortality for elderly individuals. Velocity, stride length, and gait variability correlate with fall risk. Guimaraes and Issacs (1980) reported that older adults who fell had low velocity, short stride length, and a great deal of variability in step length and velocity. Wolfson, Whipple, Amerman, and Tobin (1990) also found relationships among impaired velocity, decreased stride length and falls. Individuals who increased their velocity over a one-year period had a 58% reduction in fall risk and a 17.7% reduction in absolute risk of death for the subsequent eight years (Hardy, Perera, Roumani, Chandler, & Studenski, 2007). These benefits remained after adjusting for medical, functional and psychosocial factors.

Further, velocity is an effective predictor of mobility, independence, and survival in other patient populations including patients undergoing heart surgery
(Afilalo et al., 2010).

Gait variability can be defined as stride-to-stride fluctuations in walking and it has been associated with fall risk in numerous studies. Elements of gait variability include stride time, duration of a step cycle, stride length, and cadence, the number of steps per minute. Hausdorff, Rios, and Edelberg (2001) also found that stride time and stride length variability contributed to falls in a study that involved 52 subjects 70 years of age and older. Callisaya et al. (2011) found a significant linear relationship between stride length variability and increased risk of multiple fall incidents in a study that included 412 subjects between 60 and 86 years of age. Verghese, Holtzer, Lipton, and Wang (2009) also reported that gait speed, variability in stride length, and swing time were predictive of falls. These studies indicate fall risk reduction and functional gait facilitation are dependent on regulated stride length, which in turn, regulate the timing of the stride.

Changes in gait following hip surgery

Gait parameters change naturally with the process of aging, but individuals who undergo hip surgery face additional challenges. Sliwinski and Sisto (2006) found that walking velocity was significantly lower in hip replacement patients than in normal subjects. Other researchers found that patients experienced improvements in perceived and actual functional capacities (Vissers et al., 2011) and reduction in pain (Montin, Leino-Kilpi, Suominen, & Lepisto, 2008) following hip surgery; however, individuals may have also had some functional deficits after surgery.

Unlu, Eskioglu, Aydog, Aydoo, and Atay (2007) stated that individuals who undergo hip replacement may experience long term mild to moderate disability post-operatively, and that walking speed and cadence are important parameters in the rehabilitation process. Ajemian (1997) found that two years after surgery, hip patients' gait parameters of stride length, cadence, and velocity improved significantly but remained below the average values of control subjects who did not have hip surgery. Guedes, Dias, Borges, Lustosa, and Rosa (2011) reported that 2.6 years after hip surgery, individuals had an average velocity of 1.18 meters per second, while a velocity of 1.22 meters per second is the speed required to safely walk across a street. Members of the control group, who did not have total hip replacement, had an average velocity of 1.39 meters per second. It is clear that cadence and stride length play important roles in determining velocity.

It is clearly established that velocity is essential for functional ambulation, reduction of fall risk, and mortality in older adults. It is therefore necessary to improve velocity to the greatest extent possible through physical therapy gait training following hip surgery.

Gait training and physical therapy

Gait training is critical to ensure recovery of function following hip surgery for older adults. While the surgery greatly reduces or eliminates arthritic pain nearly immediately (Tankersley, Mont, & Hungerford, 1997), individuals still have surgical pain and may require a lengthy recovery period of one to two years to attain normal cadence, stride length and velocity (Ajemian, 1997).

Physical therapy for rehabilitation begins within the first day after surgery, with isometric and range of motion exercises. Ambulation with a physical therapist begins a day or two after surgery and is often implemented twice daily. Physical therapy goals include safe transfers, independent ambulation, independent dressing, strengthened hip and knee musculature, maintained integrity of the implant, and good health during bed-rest to avoid decubitus ulcer, pulmonary embolism, and pneumonia (Allen, Brander, & Stulberg, 1998). RAS may be used in conjunction with conventional physical therapy to facilitate independent ambulation.

Neurologic music therapy

During the 1990's researchers conducted numerous studies concerning the biomedical effects of music and its effectiveness in addressing various medical and neurological problems including Parkinson's disease, traumatic brain injury, and stroke. In the late 1990's, music therapists and neuroscientists sought to codify therapeutic techniques that used music to reach non-musical outcomes. These techniques form the Neurologic Music Therapy (NMT) approach to rehabilitation in which interventions are designed to facilitate sensory, motor, and cognitive outcomes (Thaut, 2005).

NMT and the *rational scientific mediating model*

NMT is based on a model articulated by Thaut (2005) as the Rational Scientific Mediating Model (R-SMM). The model represents a theoretical framework for determining music therapy interventions. Thaut presented the R-SMM in four parts:

1. Musical response models where musical behavior is based on neurological, physiological, and psychological foundations.
2. Non-musical parallel models where non-musical brain and behavior functions are processed.
3. Mediating models that describe the influence of music on non-musical brain and behavior functioning.
4. Clinical research models that describe the therapeutic effects of music

In consideration of musical response models, a therapist or researcher studies musical responses, investigates the physical and psychological components of perceiving and performing music (Thaut, 2005). For non-musical parallel models the therapist studies non-musical models of perception and behavior to determine if there is any common ground between musical performance/perception and non-musical behavior (Thaut, 2005). With regard for mediating models, the researcher considers how to use music interventions to influence non-musical behaviors without an emphasis on determining long-term effects (Thaut, 2005). Finally in clinical research models the researcher is concerned with using musical interventions to facilitate lasting change in non-musical behaviors and with creating experiments that can effectively gauge the effectiveness of the music interventions (Thaut, 2005).

Rhythmic auditory stimulation

Rhythmic Auditory Stimulation (RAS) is an NMT technique, which utilizes the physiological effects of rhythm on the motor system to enhance control of movement in therapy and rehabilitation (Thaut, 2005). RAS consists of providing a metronome pulse or music with heavily accented beats while individuals walk. Each beat, or pulse, is a cue for a footfall. The beats are in a 4/4 or a 2/4 meter that cues gait parameters of cadence, stride length, velocity, and stride duration (Thaut, 2005). RAS is effective in modulating these gait parameters because of rhythmic auditory entrainment, a phenomenon in which motor movements synchronize with an external timekeeper without cognitive processing or training. Synchronization of motor movements with the pulse may occur after only one or two repetitions of the rhythmic stimulus (Thaut, 2005). Research has also indicated that the effects of RAS on gait parameters carry over after the removal of the rhythmic stimulus (Hausdorff et al., 2007).

Research indicates that RAS is most effective in gait rehabilitation, and is well suited to the task because walking is innately rhythmic (Thaut, 2005). The consistency of the rhythm provides temporal cues for the frequency of movement and provides the brain with a means of planning and anticipating motor movement (Thaut, 2005). An investigation of how the brain perceives rhythm is helpful in understanding rhythmic auditory entrainment and the beneficial effects of RAS.

Rhythm and perception

Randel (1999) defines rhythm as "the aspect of music concerned with the organization of time (p. 559)," and the musical element that creates durations of sounds and silences. A regularly occurring pulse or beat provides periodicity in music. It divides music into equal temporal units, creating structures and patterns that help humans derive meaning from musical stimuli (Thaut, 2005). The perception of rhythm is complex and multifaceted. The sensitivity of the human ear to changes in sound intensity helps individuals detect accent patterns (Thaut, 2005), and the brain's ability to compute intervals of time between events assists in the processes of discerning and internalizing a pulse (Thaut, 2005). Research indicates that the brain can detect variations of a few milliseconds when listening to a pulse (Grahn, 2009). Therefore, rhythmic pulses can influence entrainment of motor movements. Two factors that facilitate auditory motor entrainment are integer ratios between beat events and a predictable pattern of accents (Grahn & Brett, 2007).

One plausible theory for entrainment states that the brain anticipates the pulse and sends signals to motor areas in advance so that movements are synchronized with the beat, rather than sending those signals in the instant that the beat occurs (Thaut, 2005). This has relevance to the current experiment in that individuals may match their cadence to the rhythmic stimulus nearly instantaneously (Thaut, 2005). Synchronization of motor movements with a rhythmic stimulus may be due to the brain's ability to predict when the next rhythmic pulse will occur. Numerous connections exist within the central nervous system between auditory processing and motor responses to make this possible.

Auditory stimuli excite neurons in the spinal cord to prepare muscles for movement, demonstrating the strong connection between auditory perception and motor movement (Miller, et. al. 1996). Brain imaging has revealed that one of the neural networks involved in entrainment includes areas in both hemispheres of the brain, the cerebellum, and the basal ganglia (Thaut, 2005). The motor system entrains and synchronizes with the stimuli from the auditory system, and the periodicity of the rhythm gives the brain an exact sense of how much time it has to complete the movement (Thaut, 2013). Entrainment includes areas in both hemispheres of the brain, the cerebellum, and the basal ganglia (Thaut, 2005). This network is activated when listening to rhythm as well as during motor movement. The basal ganglia and supplemental motor areas appear to be involved in perception and the motor response to rhythm (Grahn & Brett, 2007). These parts of the brain are involved in temporal sequencing and steady, internally generated movements. Rhythmic stimuli provide cues through the whole course of a movement, and not only at the start and endpoints. This leads to greater stability and efficiency in the movement and optimization of the movement's trajectory (Thaut, 2005).

Employing RAS in the clinical setting

RAS is used in physical rehabilitation to enhance gait characteristics of cadence, velocity, and stride length (Thaut, 2005). When RAS is used to enhance gait in an individual one must assess his or her natural movement frequencies to determine whether he or she is functional.

Individuals may need to alter these parameters, depending on their condition to obtain the best outcomes. For instance, clinicians may use RAS to increase the cadence and stride length of individuals with Parkinson's disease, while individuals with nearly normal gait may need to reduce their cadence to increase stride length to enhance the safety and efficiency of ambulation (Thaut, 2005). RAS provides external cuing to facilitate the best possible gait pattern. One approach to enhance velocity rehabilitation is the application of RAS. It may be possible that RAS can enhance traditional physical therapy gait rehabilitation outcomes following hip surgery.

RAS has been used in gait training for individuals with traumatic brain injury, Parkinson's disease, stroke, frailty and the natural decline of aging. Numerous studies have shown that it has been effective in improving cadence, stride length and velocity among those populations, and a review of these studies can be helpful in building a rationale for the use of RAS with individuals who have had hip surgery. RAS can be used as an immediate stimulus or as a longer-term training tool. As an immediate stimulus, music is heard while persons walk. The music is continued throughout training but it is discontinued as the individual transfers the skills developed during RAS to daily functioning without musical cuing (Thaut, 2005).

RAS with traumatic brain injury

Hurt, Rice, McIntosh and Thaut (1998) found that individuals with traumatic brain injury immediately increased their stride length, cadence, velocity, and stride symmetry when RAS was used to cue normal and fast walking, but the immediate effects were not statistically significant. After five weeks a training effect was evident, however, through statistically significant increases in cadence, stride length, velocity and stride symmetry.

Other research by Goldshtrom, Knorr, and Goldshtrom (2010) indicated that a series of exercises performed with a metronome significantly improved the cadence of a woman who had an acquired traumatic brain injury. She had difficulties with movement due to spasticity in her hip, was unable to walk backward, and usually did not walk without a cane. At the end of a year of treatment, which consisted of performing a set of exercises 4-5 days a week for 20-30 minutes with a metronome, her cadence improved significantly. She could also walk backward, and was able to ambulate without a cane.

RAS with stroke patients

In addition to effectively modifying the gait of individuals with traumatic brain injury, RAS has also improved various gait parameters in individuals who have had a stroke. A study by Thaut, McIntosh, and Rice (1997) demonstrated that stroke patients who received RAS along with conventional gait training significantly increased their stride length and velocity in comparison to a control group that received only conventional gait training after participating in a six-week program. In the study, the experimental and control groups participated in two 30 minute walking sessions a day, with one in the morning and the other in the afternoon. The experimental group received RAS while walking to music or a metronome. In the second and third quarter of each session, the patient's walking speed was increased by 5-10% depending on the patient's ability, and in the last quarter the music or metronome was faded out to measure any possible carryover effect from the RAS. Individuals in the control group walked without RAS but were also instructed to increase their walking speed during the second and third quarter of the session.

The RAS group made statistically significant gains in stride length and velocity in comparison to the control group. The RAS group's velocity increased by 164% while the non RAS group's velocity increased by 107%, and the RAS group's stride length increased by 88% while the control group's stride length increased by 34%.

These findings are important because they demonstrate that RAS can modulate the gait parameters of velocity and stride length in persons who have had a stroke and may have implications for persons who have had hip surgery (Thaut, McIntosh & Rice, 1997).

In other research examining the effects of RAS on individuals with stroke, Thaut et al. (2007) reported that a group of 43 individuals receiving RAS made significantly greater progress in cadence, stride length, velocity, and stride symmetry than a group of 35 individuals who received Neurodevelopmental Therapy/Bobath method gait training. The training period was three weeks with five 30-minute sessions per week, and individuals entered the study as soon as they could complete five stride cycles. For most patients in both groups this was a period of 21 or 22 days post stroke. The RAS group walked 13.1 meters per minute more than the control group, gained .18 meters more in stride length, gained 19 steps per minute more in cadence, and .10(swing ratio) in gait symmetry. The effects in this study were smaller than a previous study that had a training period of six weeks, which may indicate that the effects of RAS grow with more training.

RAS and individuals with Parkinson's disease

Research has indicated that individuals with Parkinson's disease also respond favorably to RAS. Hausdorff et al. (2007) found that for individuals with Parkinson's disease, RAS increased velocity, swing time, and stride length immediately during a 100 meter walk at 100% of the subject's normal walking speed. When walking speed was 110%, stride variability decreased when RAS was introduced. In addition, all of these effects appeared to carry over after the RAS was removed.

In this study, there were 29 subjects with Parkinson's disease, and 26 healthy controls.

The researchers assessed gait under six conditions, which included: (a) walking at a comfortable pace without RAS (baseline), (b) walking at a comfortable pace with RAS, (c) walking at a comfortable pace without RAS to examine any possible carryover effects, (d) walking with RAS at 110% of baseline step rate (e) walking without RAS to examine any immediate carryover effect (f) walking without RAS after a 15 minute break to evaluate any delayed carryover effect. Individuals in the experimental group with Parkinson's disease walked at an average velocity of one meter per second without RAS. With RAS at 100% of their baseline step rate, the experimental group's average velocity was 1.04 meters per second and with RAS at 110% of baseline step rate, velocity increased to 1.09 meters per second. Without RAS, stride length was 1.06 meters, but with RAS at 100% and 110% of the subjects' baseline step rate, stride length increased to 1.10 meters. This study demonstrates that individuals with Parkinson’s disease have immediate, significant response to RAS in their stride length and velocity. It may be possible that RAS will influence stride length and velocity in patients who have had hip surgery (Hausdorff et al., 2007).

Another study was designed to investigate the effects of RAS on individuals with Parkinson's. Thaut, McIntosh, Rice, Rathbun and Brault (1996) demonstrated that a walking program with RAS can be more effective than one without it. In the study, all the subjects had a diagnosis of Parkinson's disease. One experimental group (*n*=15) received RAS through metronome clicks embedded in music with heavy rhythmic accents while walking. In addition, there were two control groups that did not receive RAS. One control group (*n*=11) did participate in any gait training while the other group (*n*=11) participated in a self-paced ambulation program.

The results were that individuals with Parkinson's disease who walked with RAS increased their cadence by 25%, stride length by 12% and velocity by 10% more than the group that walked without music. The group that did no training decreased their cadence, stride length, and velocity to levels below baseline.

McIntosh, Brown, Rice and Thaut (1997) reported that elderly individuals with Parkinson's disease increased their stride length, cadence and velocity when they walked with RAS. The 41 subjects included 31 individuals with Parkinson's and 10 healthy elderly individuals. Of those with Parkinson's, 21 were on dopaminergic medication and 10 were not. The study also demonstrated that individuals not taking dopaminergic medications and thus experiencing more Parkinsonian symptoms entrained to the rhythm and improved their velocity. Subjects walked under four conditions: (a) without RAS at their own speed, (b) with RAS that was provided through a metronome click embedded in music at the subjects' baseline cadence, (c) with RAS at a tempo 10% greater than the subjects' baseline cadence, (d) without RAS to measure any carryover effects.

All groups saw statistically significant increases in cadence, velocity, and stride length. Also, the step frequency and the rhythm were very close to one another in all of the groups as well, indicating that the individuals with Parkinson's were entraining to the RAS and matching their steps to the rhythm. This study demonstrated that even individuals with damage to the basal ganglia can effectively entrain their movements with a rhythmic stimulus.

Arias and Cudeiro (2010) found that individuals with Parkinson's in the experimental group who received RAS had decreased incidences of freezing of gait, a potentially dangerous phenomenon of unknown origin in which an individual is unable to start or continue walking. When subjects walked with RAS in the study they showed increased cadence and velocity.

Subjects included 10 individuals with Parkinson's and freezing of gait, nine individuals with Parkinson's and no freezing of gait, and ten healthy control subjects. All of the subjects completed six walks. Two walks without RAS established baseline gait parameters, then subjects did two walks without RAS and two walks with RAS. This study demonstrated once again that RAS is effective for adaptive modification of gait parameters for individuals with Parkinson's disease.

RAS and the frail elderly

RAS is effective among those with neurological impairments like stroke, Parkinson's disease, and traumatic brain injury, but can also produce positive outcomes for individuals experiencing frailty and the normal effects of aging. Ogata (2006) conducted a study with 30 frail elderly individuals divided into an experimental group and a control group. Over the course of 12 gait-training sessions, the experimental group received RAS via live acoustic guitar music while walking and the control group did not receive RAS. Both groups walked a 12-meter course, turning around at each end and continuing walking until they were fatigued. The first two meters of the walk were a warm-up, and then the researcher recorded data for cadence, stride length and velocity for ten meters. The researcher also recorded the total distance walked by each subject. Over the course of the study walking distance in the RAS group increased by 29.5% while walking distance in the control group decreased by 10.65%. The RAS group increased velocity by 8.7% while the control group decreased velocity by 3.7%. The RAS group increased stride length by .85% while the control group decreased stride length by .48%. Cadence did not increase in the RAS group, but increased velocity indicated that group members were walking further in shorter periods of time, meaning that their ambulation became more efficient.

RAS and late stage dementia

Clair and O'Konski (2006) investigated the effects of RAS on 28 individuals (4 males, 24 females) between the ages of 70 and 92 with late-stage dementia who demonstrated significant fall risk. Subjects needed one or two people to assist them when walking 50 meters due to their scores on standardized Functional Independence Measure (FIM) which measures locomotion status. The researchers wanted to determine whether RAS would have a significant impact on the cadence, stride length, and velocity of the subjects and in turn reduce fall risk. The researchers noted that falls precede many of the most serious health problems faced by older adults and more adaptive gait parameters can prevent a negative chain of outcomes where an individual falls, deteriorates physically, and dies. Subjects walked three times in each of the three conditions: (a) a metronome pulse embedded in music, (b) a metronome pulse by itself, and (b) without any auditory stimulus for a total of 9 sessions. The parameters of cadence, stride length and velocity were analyzed for significant differences among the conditions, but none were found. The aides who walked with the subjects did report that those walking with auditory cues required less physical support and that the care burden was reduced. The protocol and procedure were adapted for use in the current investigation of the effects of RAS on individuals who have had hip surgery.

In summary, music therapy interventions that include Rhythmic Auditory Stimulation (RAS) are effective in increasing stride length, cadence, and velocity with elderly individuals with stroke or Parkinson's disease in addition to individuals with traumatic brain injury and frailty. It is possible that RAS can also enhance the gait characteristics in persons who are in rehabilitation following hip surgery.

The Rational Scientific Mediating Model provides a framework for inquiry concerning the effectiveness of music therapy interventions in facilitating non-musical outcomes. This study pertains to the third step of the model (mediating models that describe the influence of music on non-musical brain and behavior functioning) as it investigates the immediate effects of musical rhythm on the non-musical behavior of ambulation in individuals who have had hip surgery without testing for long-term effects (Thaut, 2005).

The purpose of this study was to test the feasibility of adding RAS to traditional physical therapy with older adults who have undergone hip revision surgery or hip replacement surgery. Introducing RAS into traditional physical therapy may increase cadence, stride length and velocity of surgery patients. The research question is as follows. Will individuals receiving RAS during gait training show statistically significant differences in cadence, stride length and velocity compared to those who only receive conventional gait training?

Chapter 3

Method

This study was a two-sample experimental design to test the limited efficacy of adding RAS (Rhythmic Auditory Stimulation) to traditional physical therapy treatment for older adults who have undergone hip revision or hip replacement surgery. It is hypothesized that the addition of RAS during independent ambulation, a component of physical therapy rehabilitation for hip surgeries, will increase cadence, stride length and velocity of surgery patients. The null hypothesis is that there will be no change in cadence, stride length and velocity of surgery patients. Therefore, the research question is as follows: Will individuals receiving RAS during gait training show statistically significant differences in cadence, stride length and velocity compared to those who only receive conventional gait training?

Recruitment

Upon approval of this study by the human subjects committee of a major Midwestern university, subjects were recruited from a convenience sample of individuals participating in rehabilitation for gait training following hip replacement or hip reconstruction surgery. The researcher presented the study to physical therapists, orthopedic surgeons, and administrators at three rehabilitation hospitals, four long term care facilities, five physical therapy clinics, and two orthopedic surgery clinics located in major metropolitan cities in the Midwest and Southwest. Five facilities and one orthopedic surgeon agreed to assist in the recruitment of volunteer subjects.

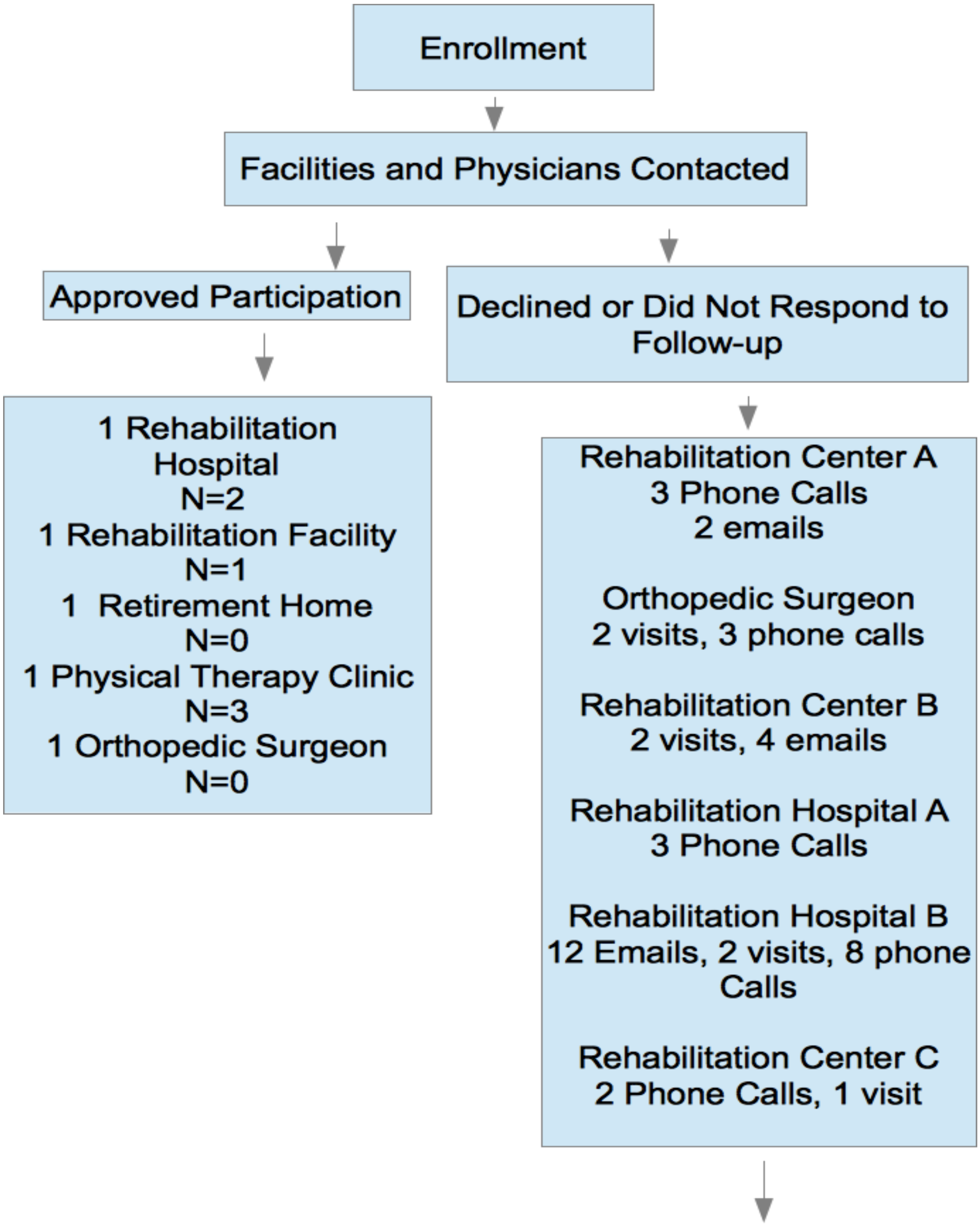
A designated representative from each facility signed the consent forms to affirm he or she had authorized the recruitment of subjects for this study.

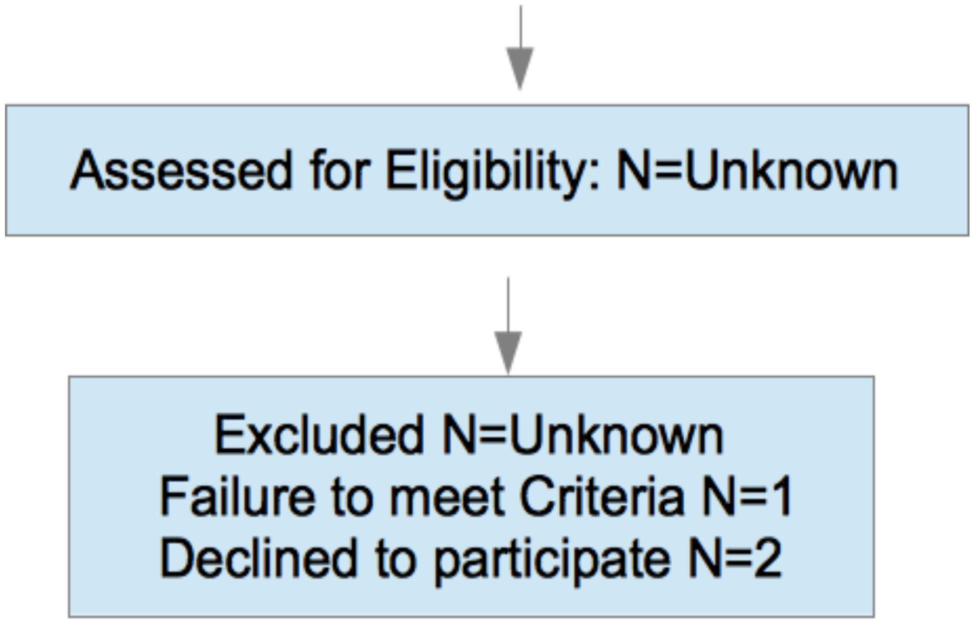
Physical therapists at the facilities presented the study to patients who met the following criteria: (a) had undergone a hip repair or replacement procedure within five days prior to the experiment, (b) were age 55 or over, (c) had no evidence of rheumatoid arthritis or other degenerative bone conditions, (d) had no history of stroke, (e) had no neurological conditions which would impair gait, and (f) had received at least one day of inpatient acute post surgical rehabilitation for gait training.

If an individual agreed to participate, the physical therapist contacted the researcher and the researcher then came to the facility when the subject had a gait training appointment. The researcher spoke with subjects about the study at that time to obtain their informed written consent and the study was conducted with the subjects immediately after consent forms were signed. The researcher recorded subjects' age, gender, date when they began rehabilitation, and type of hip surgery (total hip replacement or resurfacing). Subjects were given a unique identifier.

Subjects were alternately assigned to the RAS experimental group and the control group as they enrolled in the study. The experimental group received RAS during one occurrence of walking in conventional physical therapy gait training. The control group completed the same task as the RAS group, but without the addition of RAS within their conventional physical therapy gait training. Figure 1 displays the flow of subjects throughout the recruitment process.

Figure 1. Recruitment and enrollment of subjects throughout the study.




Assessed for Eligibility: N=Unknown
Excluded N=Unknown
Failure to meet Criteria N=1
Declined to participate N=2

Procedure

Cadence is the number of steps taken within one minute. The formula to calculate cadence is:

60 sec/______time(sec) x ______ steps. Velocity is the numbers of meters walked within one minute. The formula to calculate velocity is: 60 sec/______ time(sec) x _______ distance (10 meters). Stride length is the average number of meters per step. It is calculated by dividing velocity by cadence and multiplying by two, i.e. velocity ____(meters/min)/Cadence____(steps/min) x 2. Cadence, velocity and stride length are important parameters in determining whether an individual is walking safely. Low cadence, stride length or velocity can indicate elevated fall risk, so measures that increase these parameters may reduce fall risk and contribute to walking safety.

The independent variable is Rhythmic Auditory Stimulation (RAS). The RAS gait training protocol for this study was developed from the RAS research clinical protocols designed by Clair and O'Konski (2006) and Ogata (2006). For the current study, subjects walked in the physical therapy gym or other straight, level and hard surface at the facility in which they were receiving rehabilitation services. The walking path was marked with colored tape or chalk placed on the surface at the starting point, the two-meter line, and the 12-meter line to guide the subjects' walk and indicate points of measurement for the researcher. RAS was added for the experimental group by the researcher's provision of guitar strums on the downbeat in 4/4 time synchronized to the individual subject's heel strikes. The strumming started after the researcher observed a few of the subject's steps and continued until the subject crossed the 12-meter line or indicated the need to stop walking. For the control group the researcher walked with the subject, but did not provide RAS.

Subjects in both groups were asked to walk the 12-meter path and to stop at the end of it. The researcher walked beside the subjects as the walk was executed to keep conditions as similar as possible between the two groups and to the researcher. The researcher planned to operate the stopwatch and count the steps taken by the subjects. To ensure safety, a physical therapist or assistant accompanied each subject throughout the duration of the walk. Physical therapists provided gait belts for subjects who needed them. Subjects were free to use an assistive device, such as a walker, during the 12-meter walk if necessary. The physical therapists and assistants were asked to make no verbal comments once the walk began. The researcher did not engage in conversation with the subjects during their walks. The outline of the procedure for both conditions was as follows:

1. Transport or arrival of patients: subjects were transported to the physical therapy gym or clinic in a wheelchair or they walked into the facility
2. Greeting: simple greeting such as “Hello! How are you?”
3. The researcher explained the protocol to the subject along with the subject's right to refuse to participate at any point. The researcher read over the consent form with the subject and answered any questions that arose. The subject then signed the consent form. Subjects who walked in on their own sat in chairs in the lobby of the facility while written consent was obtained. Subjects who arrived in wheelchairs sat in them during this step.
4. The researcher gathered information from the subject including age, date of surgery, date rehabilitation began, gender and type of surgery. The information was then written down by the researcher or entered into a spreadsheet.

5. Sitting in the wheelchair: The subject's wheelchair was positioned at the start line. While the subject sat for one minute the researcher chatted casually with him or her.
6. Reaching the starting line: The subject's wheelchair was positioned at the start line, or the subject stood at the start line, with or without an assistive device.
7. Instructions: the researcher then verbally cued the subject, “It's time to walk now.” For subjects in wheelchairs, the wheelchair brakes were engaged, a gait belt was secured around the subject's waist if necessary, and foot rests were raised or removed from the wheelchair. The researcher then gave the following verbal cues: a) put your feet on the floor, b) place your hands on the chair arms, c) on the count of three, stand up, d) position your hands on your cane or walker, e) walk when you are ready, and you may stop walking at any time if you become tired.
8. a) Walking Control Group: After giving the instructions to the subject, the physical therapist or assistant positioned himself or herself to walk beside the subject to ensure safety. The researcher walked on the opposite side of the subject and carried the guitar to provide consistency between conditions. When the subject reached the two-meter line, the physical therapist or an assistant started the New Balance Professional stopwatch and counted the number of steps as the subject walked. When the subject reached the 12-meter line, the physical therapist or assistant stopped the stopwatch and ceased counting steps. Upon completing the walking task, the researcher offered to sing and play a requested song while the subjects stood or sat in the wheelchair. This functioned as a courtesy to the subject. If the subject declined the song the researcher thanked the subject for participating and the subject transitioned to the next phase of physical therapy treatment for the day.

At this point, the researcher recorded the subject's data (duration of walk and number of steps).

b) Walking Experimental Group: After giving the instructions to the subject, the physical therapist or assistant positioned himself or herself to walk beside the subject to ensure safety. The researcher walked on the opposite side of the subject and provided RAS as a supplement to the walking experience. RAS involved downstroke strums on downbeats provided by the researcher on an acoustic guitar matched to the heel strikes of the subject. The researcher observed the subject's cadence during the warm-up walk and began providing RAS to match the subject's heel strikes. When the subject reached the two-meter line, the physical therapist or an assistant started the stopwatch, counted the number of steps and recorded the number of seconds needed to walk 10 meters. When the subject reached the 12-meter line, the researcher or assistant stopped the stopwatch and ceased counting steps. The researcher thanked the subject for participating and the subject transitioned to the next phase of physical therapy treatment for the day. At this point, the researcher recorded the subject's data (duration of walk and number of steps). If the subject became fatigued and asked to discontinue the walk, the data for the session were not used.

Music Selection

For the experimental group the researcher provided Rhythmic Auditory Stimulation (RAS) with a Simon Patrick 6 Spruce acoustic guitar with steel strings to supply a strong rhythmic beat that matched the heel strikes of each subject while he or she walked. The chord progression sequences included ii V I I, I vi ii V, and I IV V V in the key of E or C.

The researcher used a simple downstroke strumming pattern on the downbeats in 4/4 time to match the heel strike of the subjects. The downstroke strum pattern acted as a cue for the subject's gait pattern. The researcher did not sing during RAS, as a previous study showed that subjects sang along with familiar songs, causing the subjects to walk and breathe irregularly (Ogata, 2006). In addition, it has been suggested that vocal music distracted subjects from exercising and decreased the number of repetitions per exercise (Johnson, Otto, & Clair, 2001).

Subjects in the control group were given the opportunity to have a song played for them by the researcher after they completed their walking task. The researcher asked subjects for their stylistic preferences and if they had requests. All of the control subjects told the researcher to play whatever he wanted, so the researcher selected songs based on the expressed stylistic preferences of the subjects. Songs played for subjects included *Has Anybody Seen My Gal* (Henderson, Lewis, & Young, 1925), *Sitting on the Dock of the Bay* (Redding & Cropper, 1968), and *Ring of Fire* (Cash, 1963).

Interventionist

The researcher has a Bachelor of Arts degree in Music, Graduate Equivalency in Music Therapy and became a board certified music therapist in 2010. The researcher had 1.5 years of practice prior to the start of the study and continued to practice as a clinician throughout the duration of this study. Professional experience has included adults with dementia, adult inpatient psychiatric, children with severe and profound disabilities, and early intervention.

Data Collection

Demographic information was collected by the researcher and recorded in a spreadsheet coded with the subject's unique identifier. The researcher recorded subjects' age, gender, the date their rehabilitation began, type of hip surgery, and number of steps and duration of their individual timed walk of 10 meters.

From the time and number of steps, the researcher computed the independent measures, the subjects' cadence, stride length and velocity.

Chapter 4

Results

This study was a two sample experimental design to test the limited efficacy of adding Rhythmic Auditory Stimulation (RAS) to traditional physical therapy treatment for older adults who have undergone hip revision or hip replacement surgery. It was hypothesized that the addition of RAS during independent ambulation, a component of physical therapy rehabilitation for hip surgeries, would increase cadence, stride length and velocity of hip surgery patients. The null hypothesis stated there would be no change in cadence, stride length and velocity of surgery patients. Therefore, the research question was: Will individuals receiving RAS during gait training show statistically significant differences in cadence, stride length and velocity compared to those who only receive conventional gait training?

Subject Demographics

Subjects were recruited from six facilities in Kansas and New Mexico who had approved subject recruitment. The researcher contacted another six sites, but these facilities either declined or did not respond to the request for subject recruitment. A total of 9 subjects were recruited for participation; two declined to participate and one failed to meet the inclusion criteria, thus six subjects participated in the RAS protocol. Figure 1 diagrams the facility and subject flow chart and Table 1 displays the demographic information of the participants. All subjects had total hip replacements and were between the ages of 59 and 85, with an average age of 72. There were five females and one male who participated.

Table 1. *Demographic information of subjects and data*

	Age	Sex	Days in Rehab	Cadence	Stride Length	Velocity
			Experimental			
Subject 1	85	Male	7	63.85	0.69	22.03
Subject 2	81	Female	6	56.76	0.71	20.28
Subject 3	59	Male	139	100.42	1.37	62.89
Group Means	75		50.67	73.68	0.92	35.07
			Control			
Subject 1	69	Female	8	53.77	0.74	19.92
Subject 2	73	Female	46	68.31	0.8	27.32
Subject 3	67	Female	28	71.75	0.95	34.13
Group Means	69.67	Female	27.33	64.61	0.83	27.12

Two subjects came from a mid-western rehabilitation hospital. This 106,000 square foot facility had 98 beds, providing inpatient and outpatient rehabilitation for orthopedics, stroke, cardiac, and pulmonary conditions, as well as brain injury, spinal cord injury, amputation, and neurological conditions. One subject came from a southwestern short-term rehabilitation center. As part of a nationwide chain, this facility specializes in short-term rehabilitation between a hospital stay and return to home; outpatient rehabilitation is also available. Skilled nursing can be provided along with occupational, physical, and speech therapy. Three subjects were recruited from a southwestern private physical therapy clinic. It is also part of a national chain. This organization focuses on providing physical therapy and athletic training services.

Intervention reporting

Sessions took place inside the physical therapy gym at the Midwestern rehabilitation hospital in May 2012, and at the Southwestern short-term rehabilitation center in February 2013. Sessions at the private physical therapy clinic took place in April 2014. There was inadequate space inside the facility to conduct RAS so the researcher marked out a 12-meter course on the sidewalk outside of the clinic using chalk. The sessions at this facility took place on April 10 and 11, 2014.

Fidelity

Recruitment of subjects started in April 2012 and ran through September 2014. Recruitment of subjects was particularly challenging due to several factors. Doctors tend to perform more hip replacements during the winter, meaning that more subjects were available at that time, but the researcher did not receive approval to conduct the study until the spring of 2012. Therefore, recruitment proved challenging at the start of the study period. In addition, the researcher moved from the Midwestern United States to the Southwest during the summer of 2012. Some facilities in the Midwest and Southwest did not return repeated phone calls or emails from the researcher despite managers' expressed interest in participating. Even when consent was provided, challenges remained. The researcher obtained approval to conduct the study at a Southwestern short-term rehabilitation center and recruited one subject, but then the facility began sending their hip replacement patients to a hospital for rehabilitation. A physical therapist at a Southwestern private physical therapy clinic initially gave consent, but then later reported that he would be unable to assist the researcher because he was under pressure from management to increase his caseload and he could not spare any staff to assist with the walks during data collection.

At other facilities privacy officers were hesitant to give their consent due to concerns about violating the Health Insurance Portability and Accountability Acts in spite of the researcher's assurances that he would not use identifiable personal health information in the study. Workers in the health care industry also told the researcher that individuals were waiting to have surgical procedures after the passage of the Affordable Care Act because they were uncertain about what would be covered by their insurance and how much they would have to pay out of pocket.

Therefore, modifications to recruitment strategies were made. Patients who had hip repair surgery were minimal, so the researcher only requested recruitment for subjects who had total hip replacement due to promising leads at rehabilitation hospitals in both the Midwest and Southwest. The researcher initially sought subjects who had experienced five days of rehabilitation, but reduced it to one day in an attempt to increase the number of potential subjects. The age of subjects was lowered from 65 to 55 for the same reason. Subjects from the rehabilitation hospital (n=2) were in the acute phase of recovery from surgery, so they were brought to the physical therapy gym in a wheelchair. At short-term rehabilitation center, the researcher did not record whether the subject (n = 1) came in a wheelchair and was unable to recall this information. At the private physical therapy clinic, subjects (n = 3) walked in without a wheelchair because they were one to four months post surgery, whereas the first three subjects were seven to eight days post surgery.

The protocol required a one-minute period of sitting before walking. During the implementation of the study, it was determined that this period of sitting naturally occurred when the researcher presented the protocol to subjects and obtained their written consent after they indicated their interest in participating to their physical therapists. Therefore, it was not incorporated as a distinct step in the protocol.

Gait belts were not used for any of the subjects, and the researcher did not record which subjects used walkers or wheelchairs. Documentation of mobility assistance devices was not planned due to the acute nature of the hip replacement patients that the researcher initially planned to see and the assumption that they would all use wheelchairs and walkers. Later in the recruitment process, the researcher accepted subjects who were no longer using these devices due to the difficulty of finding patients who met the study criteria.

For the first three subjects the researcher operated the stopwatch and the physical therapist counted steps, but on the last three an assistant to the researcher operated the stopwatch and counted steps. This reduced the likelihood of error on the part of the researcher by eliminating the need to multi-task. The researcher pressed a button on the stopwatch twice while timing the first subject, causing the stopwatch to stop prematurely, so the researcher had the subject repeat the walk to obtain an accurate measure of the time needed for the 10-meter walk. The researcher's assistant forgot the number of steps for the last subject before the researcher could enter the data into the spreadsheet, so the last subject also repeated the walk. The researcher had planned to discard the data if more subjects were found, but this was not the case, so the researcher retained the data of those two subjects in spite of the errors in data collection. The researcher discarded the data of the second subject because upon review of the demographic information it was noted this subject was 51 years old and therefore did not meet the minimum age parameter 55 years of age.

Data Analysis

Will individuals receiving RAS during gait training show statistically significant differences in cadence, stride length and velocity compared to those who only receive conventional gait training?

Due to the limitations in subject recruitment, the small number of subjects enrolled in this study, and the variability in individual subject scores for cadence, stride length and velocity, statistical analysis is unwarranted. Therefore, data cannot indicate statistical significance between those receiving RAS and the control group. The raw data for each subject, as well as the means of the experimental and control groups for cadence, stride length, and velocity are listed in Table 1. Descriptive statistics were calculated for the mean of the subjects' age, number of days in rehabilitation, cadence, stride length and velocity. These averages offer an opportunity to describe possible trends in the data.

Some apparent differences between the experimental and control groups may have been due to the varying time period individual subjects had spent in rehabilitation. The first two of the experimental group subjects were in the acute stage of recovery with 7 and 6 days of rehabilitation respectively, but the third member of the experimental group was an outlier with 139 days of rehabilitation. This outlier in the experimental group may have skewed the data considerably on all of the dependent variables. The first control group member had experienced 8 days of rehabilitation and was still in the acute phase of recovery, while the other two control group members had 46 and 28 days of rehabilitation respectively.

The mean of the experimental group's cadences was 73.68 while the mean of the control group was 64.61, with a difference of 12.31%. This figure may have been affected by the third member in the experimental group who had cadence of 100.42. The first two experimental group members had cadences of 63.85 and 56.76, while the three control subjects had cadences of 53.77, 68.31, and 71.75. The person with a cadence of 100.42 was clearly an outlier who had 139 days in rehabilitation while the other subjects ranged from 6 to 46 days of rehabilitation.

When comparing the first two experimental subjects and the first control subject, all of whom were in the acute stage of recovery with 6-8 days of rehabilitation, it is evident that the control subject had a higher cadence than the two experimental subjects. This appears to indicate that RAS did not increase cadence in this instance. Cadence is an important parameter in gait because it indirectly affects velocity, but it must be optimized. Individuals with a low cadence may be walking too slowly or they may have a long stride length and be walking more efficiently. Higher cadence may lead to higher velocity, which is directly correlated with decreasing fall risk and reducing premature mortality.

The stride length figures were also affected by the outlier in the experimental group. The mean stride length for the experimental group was 0.92 while the mean stride length for the control group was 0.83, showing a difference of 9.78%. When the outlier was removed and the rest of the data were viewed individually the remaining members of the experimental group had lower stride lengths than those in the control group. The one control group member who was in the acute phase of recovery had a stride length of 0.74 while the two experimental group members in the acute phase of recovery had stride lengths of 0.69 and 0.71. Again, in this instance RAS did not increase stride length. Short stride length has been correlated with fall risk in older adults, so increasing it could be instrumental in preventing falls in older adults who undergo hip replacement.

The experimental group had a mean velocity of 35.07 and the control group had a mean velocity of 27.12, with a difference of 22.67%. Again, the outlier in the experimental group and the varying number of days in rehabilitation were the drivers of this apparent difference. The outlier in the experimental group had a velocity of 62.89 and 139 days of rehabilitation while the other two group members had velocities of 22.03 and 20.28 with 7 and 6 days of rehabilitation respectively. Within the control group, velocities also appeared to vary on the basis of the amount of time spent in rehabilitation. The first control subject had 8 days of rehabilitation and a velocity of 19.92, but the second control subject had 46 days of rehab and a velocity of 27.32. The final control subject had 28 days of rehabilitation and a velocity of 34.13.

While the experimental group had higher means for cadence, stride, length, and velocity, upon closer investigation the differences between the groups were largely created by the outlier in the experimental group and the most significant factor in determining cadence, stride length, and velocity appeared to be the amount time spent in rehabilitation rather than whether or not one received RAS in this instance.

Chapter 5

Discussion

This study was conducted to determine the effect of Rhythmic Auditory Stimulation (RAS) on the gait parameters of cadence, stride length, and velocity in older adults who had hip surgery. RAS has been shown to affect these parameters in a significant way among individuals with stroke, Parkinson's, traumatic brain injury, and the frail elderly, but there was no literature concerning the effects of RAS on individuals who had hip surgery.

Results of cadence, stride length and velocity:

The mean cadence of the RAS experimental group was 12.31% higher than that of the control group, but due to the small sample size and variability of the data, the significance of this difference could not be determined and statistical analysis was not employed. In both groups, individuals with more days in rehabilitation had higher cadences. The mean stride length of the RAS experimental group was 9.78% higher than that of the control group, but as with cadence the variability of the data and the small sample size made statistical analysis undesirable so the significance of the difference could not be ascertained. In both groups, individuals with more days in rehabilitation had higher stride lengths. The mean stride velocity of the RAS experimental group was 22.67% higher than that of the control group, but as with the other two dependent variables, the significance of the difference could not be judged due to the small sample size and variability of the data. In both groups, individuals with more days in rehabilitation had higher velocities.

Due to the variability in days in rehabilitation, it may be noteworthy to examine those subjects who had less than ten days of rehabilitation. The two experimental subjects, ages 85 and 81 years, who had seven and six days of rehabilitation respectively, had higher cadence and velocity scores than the single younger control subject (69 years) who had 8 days of rehabilitation. RAS appeared to produce higher cadence and velocity even though the patients were older and had less time in rehabilitation. This may indicate that RAS has the potential to counter the anticipated deficits in the rehabilitation process. Future research should examine the effectiveness of RAS on hip replacement rehabilitation process for people who are older and have had less time in rehabilitation.

Limitations and future recommendations

The sample size was small due to the complexities of recruiting subjects; findings of studies with small sample sizes often cannot be generalized. The failure to obtain ten subjects made calculating statistics impractical and the failure to specify an upper boundary on the number of days in rehabilitation introduced outliers and excessive variability into the study. Also, the researcher did not record whether subjects were using assistive mobility equipment because it was assumed at the outset that all subjects would be in the acute stage of rehabilitation and using such devices. Assistive equipment could have affected outcomes but the researcher did not foresee this possibility. The researcher had the first and last subjects repeat the walk due to errors by the researcher and the assistant rather than discarding them, but the researcher retained the data of these subjects due to recruitment difficulties.

In addition, the use of RAS with individuals who have had hip surgery merits more inquiry since this study was inconclusive. Researchers should plan to collect data in the winter to maximize the number of potential subjects and to do so at rehabilitation hospitals where patients are still in the acute stage of recovery. Specifying minimum and maximum numbers for days of rehabilitation and limiting the age range of subjects would assist a researcher in determining whether RAS is producing differences in cadence, stride length, and velocity by limiting potentially confounding variables.

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