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Physical Therapy and Music Therapy Collaboration for the Treatment of Chronic Stroke: A Case Study

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This Scholarly Project, submitted by Jamie Ronning and Kayla Smith in partial fulfillment of the requirements for the Degree of Doctor of Physical Therapy from the University of North Dakota, has been read by the Advisor and Chairperson of Physical Therapy under whom the work has been done and is hereby approved.

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PERMISSION

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Signature Jamie Rorning Signature Kayla Smith

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ABSTRACT

Background and purpose. Stroke is one of the leading causes of death and disability in the United States. Following a stroke, individuals may suffer from a number of severe and lasting adverse effects. Although there is current research to support the use of physical therapy (PT) and music therapy (MT) individually during stroke rehabilitation, few studies have examined collaboration of these two disciplines. The purpose of this case study was to evaluate the effectiveness of combined PT and MT interventions for strength, balance, gait, and functional activity in an adult with chronic stroke. **Case description.** The client is a 51-year-old Caucasian female with chronic functional impairments following a right cerebrovascular accident (CVA) secondary to a quadruple coronary artery bypass graft (CABG) occurring three years ago. **Intervention.** Therapy sessions combined PT and MT techniques provided by two PT students and two MT students. Assessments and interventions were completed in 13 sessions over a 13-week time period. Interventions included strengthening, balance training, pre-gait activities, gait training, and upper extremity (UE) interventions. All interventions were paired with music therapy techniques. **Outcomes.** The client had a clinically significant improvement on the Berg Balance Scale improving by 5 points (MCD = 5 points). **Discussion.** PT combined with MT led to improvements in balance, functional mobility, and a decreased risk of falls for this individual with chronic stroke. Further research is needed examining combined PT and MT interventions for chronic stroke.

CHAPTER I

BACKGROUND AND PURPOSE

Background. In the United States, strokes, or cerebrovascular accidents (CVA), are the fifth leading cause of death with approximately 140,000 deaths and nearly 800,000 occurrences annually.[1] A stroke occurs when an area of the brain becomes damaged due to an interruption of blood flow and oxygen to the brain.[1] There are two primary types of strokes, ischemic and hemorrhagic. Ischemic strokes are caused by a clot in a blood vessel that obstructs blood flow to the brain. Whereas, a hemorrhagic stroke is caused by the rupture of a blood vessel leading to excessive bleeding and swelling of the brain.[2] Some of the common risk factors associated with strokes include smoking, hypertension, cardiovascular disease, diabetes, obesity, physical inactivity, and poor diet.[1]

Strokes are also a major cause of serious disability in adults and lead to reduced mobility in more than half of stroke survivors age 65 and older.[1] Depending on the area of the brain where the stroke occurs, the effects can vary and result in several impairments that impact a person's life. Some of the areas that may be impacted include speech, memory, awareness, movement, and balance.[2] One of the most common complications of a stroke is hemiparesis, or weakness on one side of the body.[3] About 80% of individuals have reported experiencing some degree of muscle weakness on one side of their body following a stroke.[3]

Due to the high prevalence of strokes and the diverse effects that accompany them, adequate rehabilitation is crucial in helping individuals improve their functional abilities and quality of life following a stroke. Stroke rehabilitation is often a multidisciplinary process that will begin once an individual is medically stable and continues throughout his or her lifetime. It often consists of professionals from a variety of fields such as physical therapy (PT), occupational therapy (OT), speech language pathology, music therapy (MT), nursing, and medical doctors. The role of physical therapists is to help an individual restore as much function as possible and assist in adaptations needed for daily life by using various therapeutic interventions to address movement pattern difficulties, weakness in large muscle groups affecting daily activities, and abnormal gait patterns.

Music therapy is a well-established health profession that uses music in a therapeutic relationship to address physical, emotional, cognitive, and social needs of individuals.[4] Music therapists can utilize numerous different techniques such as Rhythmic Auditory Stimulation (RAS), Therapeutic Instrumental Musical Performance (TIMP), and Patterned Sensory Enhancement (PSE) to help coordinate and guide functional activities. One of the most common techniques used by music therapists is Rhythmic Auditory Stimulation (RAS), also referred to as rhythmic auditory cueing. In this case study, Rhythmic Auditory Stimulation will be used for consistency as the majority of literature uses this terminology. RAS is neurologic technique that is used to facilitate the rehabilitation of movements that are intrinsically biologically rhythmical such as gait.[5] The goal of this technique is to eliminate or reduce asymmetries in bilateral movements, which often occurs in patients with hemiparesis during gait or transfer activities such as

sit to stand. RAS uses an external rhythm that can serve as a timing reference for continuous and anticipatory movements.[6] For example, a metronome or chord progression may be used during gait to provide an auditory cue for an individual to take a step on each beat in order to have equal movements on each side.

Several research studies completed have established the positive effects of using RAS within stroke rehabilitation to improve gait parameters, balance, and sequencing of functional tasks. Specifically, research has reported RAS can have immediate effects on both gait velocity and cadence as well as improve symmetry in chronic stroke patients.[7] In general, RAS has been found to be successful in improving gait parameters and balance when performed more frequently. Research has demonstrated RAS performed for at least 30 minutes 3-5 times per week for 4-6 weeks is desirable in order to see significant differences in gait parameters such as velocity,[8,9] stride length,[9,10] cadence,[8,9] symmetry,[10] and knee flexion in swing phase,[6] along with improved overall stability[11] and Berg Balance scale scores.[9] A systematic review by Yoo et al[8] found gait velocity, stride length, and cadence were the most significantly improved gait parameters when using RAS in conjunction with gait training.

While RAS has been shown to be beneficial in improving gait and balance, it typically only addresses the lower extremity and does not take into consideration the affected upper extremity post-stroke. Currently, there seems to be limited research regarding the use of RAS for the upper extremity as a majority of the research focuses on the use of RAS during gait training. There is research indicating range of motion and strength may be improved in the affected upper extremity by performing functional pushing and pulling movements in a rowing motion with RAS.[12]

In addition to RAS, Therapeutic Instrumental Musical Performance (TIMP) and Patterned Sensory Enhancement (PSE) have also been documented for use in neurologic rehabilitation. PSE is broader in application than RAS, as it is applied to movements such as sit to stand transfers that are not inherently rhythmical in nature.[5] This technique uses musical patterns to integrate single, discrete motions into functional movement patterns.[5] Therapeutically, PSE is used to complement goals of improving physical strength, endurance, balance, and posture.[5] PSE in conjunction with sit to stand training has been shown to improve gross motor function, muscle power, and movement control in children.[13,14] During TIMP, musical instruments are placed in different locations to facilitate practice of desired functional movements and emphasize range of motion, strength, endurance, functional hand movements and limb coordination.[5] TIMP has been found to be improve functional movements during hemiparetic arm rehabilitation.[15] Research has shown this technique can lead to improvements in gross and fine motor skills, along with perceived benefits in performance of activities of daily living.[16]

Purpose. This case study outlines the 13-week combined physical therapy and music therapy intervention program for an adult with a chronic stroke. Compared to previous research, a lower frequency and longer duration of 1 hour per week for 13 weeks was used in this case study. This was due to time constraints in scheduling for both the students and the client. The client was treated by two student physical therapists and two student music therapists under the direct supervision of a licensed physical therapist and a licensed music therapist. While there is a large amount of research available regarding PT and MT for post-stroke treatments individually, there is currently limited research examining the effects of collaboration of these two disciplines in individuals

with chronic stroke. The purpose of this case study was to evaluate the effectiveness of combined physical therapy and music therapy interventions for strength, balance, gait, and functional activity in an adult with a chronic stroke.

CHAPTER II

CASE DESCRIPTION

Examination. The client signed a consent form prior to participation in the sessions. The client in this case study is a 51-year-old Caucasian female presenting to physical therapy with a past medical history of high blood pressure (BP), a quadruple coronary artery bypass graft (CABG), and a right cerebrovascular accident (CVA) with left sided hemiparesis and left visual deficit. The client reports the CVA occurred three years ago as a complication of the CABG. The client lives with her supportive husband in a single level home with three stairs to enter the home. A therapeutic pool and underwater walking treadmill are available to the client in her home. She has two adult children who have supported her throughout her rehabilitation.

The client currently uses a single point cane in the right hand and a knee ankle foot orthosis (KAFO) on the left lower extremity for most mobility. She occasionally uses a wheelchair for mobility in her home. Her activity participation includes utilizing a personal trainer two times per week for weight training and walking on her underwater treadmill at home. The client has a lift she uses to get in and out of the therapeutic pool. With the use of a railing, she is able to independently ascend and descend the stairs to get in and out of her home. The client is no longer able to drive, but her husband is readily available to drive her to and from appointments and activities as needed. The client reports previously having a single fall with no injuries.

Observation of the client's gait revealed: left lower extremity circumduction, left knee hyperextension, decreased stance time on left lower extremity, decreased step length with right lower extremity, and decreased dorsiflexion range of motion in the left ankle. The client's upper extremity function was assessed based on her ability to complete functional movements against gravity. Her left upper extremity demonstrated low muscular tone and decreased strength as she was unable to grasp objects or complete weight bearing through her left hand and shoulder. A systems review revealed high blood pressure, and blood pressure was monitored throughout sessions.

Functional assessments were used to measure the client's balance, functional strength, and gait speed. These included the Berg Balance Scale (BBS), five times sit to stand (FTSTS) test, timed up and go (TUG), and cognitive timed up and go (C-TUG). The BBS is a 14 item balance assessment used in PT practice with a maximum score of 56 and high intra-rater reliability.[17,18] Each item is scored on a 0 to 4 subscale with 4 indicating successful completion of the task.[17] A total score of 41 to 56 indicates a low fall risk, 21 to 40 a medium fall risk, and 0 to 20 a high fall risk.[19] In addition, a score of less than 36 indicates a fall risk close to 100 percent.[19] The client scored a 36 out of 56 indicating a medium fall risk at initial assessment. The FTSTS test is an assessment measuring lower extremity strength and fall risk by having the client complete 5 timed sit to stands as quickly as possible. The FTSTS test has an excellent intra-rater, inter-rater, and test-retest reliability and can be used as a functional muscle strength assessment in clients with chronic stroke but is unable to differentiate muscle weaknesses.[20] A score of 12 seconds or longer on this test indicates an increased risk of falls.[20] The client in this study completed the FTSTS test with her arms crossed on her chest and a chair at a height

of 18 inches. She demonstrated a right shift during both sit to stand and stand to sit transfers. The client completed the FTSTS test in 15.23 seconds. The TUG measures functional mobility and balance with a high intra-rater reliability in individuals with chronic stroke.[17,20] The TUG is completed by standing up, walking 3 meters, turning around, walking 3 meters back to the chair, and sitting back down in the chair.[17] A TUG time of greater than 13.5 seconds for older adults indicates a high chance of falling, while a time of less than 10 seconds indicates functional independence and more than 30 seconds indicates functional dependence.[17,20] The client completed the TUG in 25.74 seconds. The C-TUG combines counting backward in intervals from a specific number to measure if cognition has an effect on motor control.[21] Similar to the TUG, the C-TUG has shown a high intra-rater reliability.[21] The client in this case study counted backwards from 20 by ones during the C-TUG due to client request and compliance. She completed the C-TUG in 23.6 seconds. The client used a single point cane and KAFO during the BBS, TUG, and C-TUG. Table 1 shows the client's initial scores on these functional assessments.

Table 1.
Initial Functional Assessment Scores.

Functional Assessment	**Score of Assessment**	**Result of Score**
**Berg Balance Scale	36	21 to 40 indicates a medium fall risk
***Five Times Sit To Stand Test	*15.23 seconds	12 seconds or longer indicates increased risk of falls
**Timed Up And Go	*25.74 seconds	13.5 seconds or longer indicates increased risk of falls
**Cognitive Timed Up And Go	*23.6 seconds	

*Average of three trials
**Single point cane and KAFO used
***KAFO used

The client's gait parameters were measured using the GAITRite system.[22] Cadence, gait velocity, stance time, and step length were all measured using the GAITRite and subsequently evaluated. GAITRite has shown good test-retest reliability for people with chronic stroke participating in rehabilitation.[23] A study by Boudarham et al [24] studied gait parameters to determine if the gait of people with hemiplegia changes significantly over successive gait trials carried out during a gait analysis session; researchers found some variation among trials. The gait parameters found by Boudarham et al [24] for people with hemiplegia and for healthy subjects are given in Table 2. A study by Geiger et al [25] had similar conclusions for gait parameters in people with stroke. Gait trials were completed in this study at a normal pace and fast pace, and both speeds were completed with and without a musical beat. A metronome was used to provide the external musical beat. The client used a single point cane and KAFO in all trials. A summary of the client's gait parameters are shown in Table 3. See Appendix for further GAITRite information.

Table 2.
Typical Gait Parameters.

	Cadence (steps/ minute)	**Velocity (meters/ second)**	**Step Length (meters)**
People with Hemiplegia[24]	91.0	0.78	0.50
Healthy Subjects[24]	114.8	1.26	0.65

Table 3.
Initial GAITRite Assessment.

	Cadence (steps/ minute)	**Velocity (meters/ second)**	**Stance Time (seconds)**	**Step Length (meters)**	**Step Length Differential (meters)**
Normal Pace Without Music	95.2	0.539	R= 1.039 L= 0.834	R= 0.21 L= 0.47	0.26
Fast Pace Without Music	95.8	0.548	R= 0.955 L= 0.81	R= 0.23 L= 0.47	0.24
***Normal Pace With Music**	93.8	0.53	R= 0.951 L= 0.817	R= 0.23 L= 0.46	0.23
****Fast Pace With Music**	93.8	0.578	R= 0.94 L= 0.809	R= 0.26 L= 0.47	0.21

R= Right
L= Left
All numbers are an average of 3 trials.
*Metronome 93 beats per minute
**Metronome 101 beats per minute

The client's chief complaints included left sided numbness, left sided weakness, and left sided nerve pain. She currently takes gabapentin and cannabidiol (CBD) gummies for nerve pain. Gabapentin reduces synaptic transmission in cells therefore decreasing pain.[26] It is commonly used for postherpetic neuralgia and peripheral diabetic neuropathy; there is limited evidence on gabapentin use for other nerve pain.[27] Side effects researchers were aware of included hypoventilation, dizziness, and visual field loss.[26] CBD comes from the cannabis sativa plant; CBD is the part of the plant that does not have any known psychoactive effect and may have properties of pain relief.[28] CBD is

currently on the List of Controlled Substances as a Schedule I drug, and more research is needed to conclude effects.[29]

The client has successfully worked with physical therapists and occupational therapists in the past and has further goals she would like to accomplish. The client's current goals include increasing strength, increasing gait speed and symmetry, and having the ability to line dance. There is a possibility of an electric ankle and foot orthoses device in the future for this client.

Evaluation and Diagnosis. Evaluation of this client was based off functional assessments and client history. Functional measures indicate the client is at risk for another fall and is a good candidate for PT. The client still reports difficulty walking in crowds and has decreased strength making it difficult for her to participate in dancing. Researchers hypothesize collaboration of PT and MT has the potential to increase strength, increase gait speed, improve gait symmetry, improve balance, and improve functional mobility for this client. Improving these deficits can improve BBS, FTSTS test, TUG, and C-TUG scores therefore decreasing risk of falls.

Prognosis and Plan of Care. Client prognosis is good due to her high motivation and enthusiasm about participating in this research. She had previous success with PT, and she is determined to reach the goals she set for herself. The plan of care for this client included 1 initial evaluation, 11 therapy sessions, and 1 final evaluation session. Each session was approximately 1 hour in length. Functional assessment measures were taken at the initial and final evaluation sessions. Vital signs including blood pressure, heart rate, and respiratory rate along with client subjective reporting were taken before and after every session. Physical therapy sessions included strengthening, balance training, pre-gait

activities, gait training, and upper extremity interventions. All interventions were paired with music therapy techniques provided by MT students. Researchers met throughout the 13 weeks to collaborate interventions. Short term goals included increased weight bearing on left lower extremity to improve gait symmetry and gait mechanics giving the client greater confidence walking at home and in crowds. Increasing weight bearing on left lower extremity would also improve sit to stand mechanics for everyday activities such as using the restroom or sitting in a chair to eat. Long term goals included muscular endurance and strengthening of bilateral lower extremities to further improve gait mechanics and symmetry to facilitate client's functional activities and dancing ability. These goals were important to the client, made her more functional in everyday life, and may decrease fall risk.

CHAPTER III

INTERVENTION

Interventions used in this study were based on the client's goals and improvement in functional mobility. Eleven one-hour intervention sessions were completed over an eleven-week time period. One to two sessions were completed per week. For the collaboration aspect of this research, all PT interventions were paired with MT techniques and were chosen by 2 PT students and 2 MT students. All sessions were supervised by 1 licensed physical therapist and 1 licensed music therapist. The client wore a gait belt through the entirety of every session and vitals were taken before and after every session for safety purposes.

Strength and Balance. Strength is essential for the completion of functional activities. To improve strength and functional symmetry, the client completed sit to stands throughout the sessions. Patterned sensory enhancement (PSE) is a technique used by music therapists to facilitate simple repetitive exercises and functional sequence patterns.[5] Often times, PSE is used in therapy to work towards goals such as increasing physical strength and endurance and improving balance and posture.[5] Static and dynamic postural balance in people with stroke can be improved by using asymmetric foot positions during sit to stand training.[30] Specifically using a step change with the non-paretic leg elevated has been shown to improve symmetry therefore improving balance in stroke patients with hemiplegia.[30,31] One study by Suchetha et al[32] found placing the

paretic foot posterior to the non-paretic foot improves symmetric weight bearing. In addition, mental practice combined with physical sit to stand practice has been found to improve balance and gait in post stroke patients.[32] Music therapy has been shown to improve motor function in people with chronic stroke through the connection between the auditory and motor regions in the brain.[33]

Sit to stand training with the client in this research applied many of the above concepts. The non-paretic leg was elevated using a 3 inch yoga block during most sessions. A combination of the left leg posterior to the right leg, the right leg posterior to the left leg, and both legs in equal positions was used during sit to stand training. The positioning used encourages weight bearing on the involved lower extremity leading to a more symmetrical movement pattern. Progressions were made by lowering the height of the chair surface from 24 inches to 20 inches. A standard chair of 18 inches was also used during sit to stand activities. Further progressions and variations were made by combining reaching activities with sit to stands. Two sets of 8 to 10 repetitions were completed during sessions. Music therapy during sit to stand interventions included a PSE technique playing ascending and descending notes on the guitar and autoharp. Ascending notes were played as the client stood up, and descending notes were played as the client sat down. The tempo was 70 to 90 beats per minute in 4/4 time. Mental practice was also used during sit to stand activities by having the client listen to the music and envision completing a sit to stand.

Side stepping, also known as lateral walking, was another intervention used to improve balance and weight bearing through the paretic limb. Side stepping challenges balance during weight shifting, and the ability to weight shift onto the paretic limb is

needed for increased step length in walking.[34] Balance and weight shifting through the use of lateral walking can decrease asymmetric gait patterns in stroke patients.[35] A study by Chang-Yong Kim et al[35] concluded gait velocity, stride length, and double limb support time improved more with lateral walking compared to backwards walking. The client in this study completed lateral walking during most sessions. The client used the turning of her head as a visual guide when side stepping towards the left due to left visual field deficit. Music therapy students used RAS during lateral walking by playing the guitar, tone drum, and tap shoes. The tempo varied throughout sessions from 68 to 94 beats per minute in 2/4 time.

Marching with stool taps was used as a lead up activity for stair training in order to improve hip and knee flexion. Stool taps were performed for two sets of 8 to 10 repetitions during sessions. The client began with a stool at a height of 4 inches and progressed to stool height of 8 inches prior to stair training. Stair training has been shown to improve lower extremity strength in people with stroke.[36] In addition stair training has shown to improve the functional mobility in people with stroke through improvement on the TUG test, step length, and the time in swing phase of the gait cycle.[36,37] Furthermore stair training improves balance in people with chronic stroke by increasing the limit of stability and improving weight bearing ability.[38] The client in this case study was initially nervous to complete facilitated step over step exercises. Anxiety in people with chronic stroke has been shown to reduce with the implementation of music therapy.[39] During stair training, music therapy students used their voice as an instrument to decrease the client's anxiety. Stair training included ascending the stairs forwards and descending backwards with the facilitation and support of physical therapy students.

Dance interventions included various line dances such as the Cupid Shuffle, Cha Cha Slide, and Fishin' in the Dark. Dances were modified to accommodate for the client's abilities and included side stepping, backward stepping, forward stepping, turns, and stomping. A study by Patterson et al [40] concluded people with chronic stroke who participated in dance had perceived walking and balance benefits. Supporting evidence is emerging for the use of dance as an intervention technique for adults with neurological conditions.[41] Dance was used as an intervention in this case study due to its importance to the client. Dance was important to the client because she was a dancer throughout her life, and she wanted to be able to dance at her daughter's wedding.

Upper Extremity. Seated proprioceptive neuromuscular facilitation (PNF) patterns were performed to work on improving coordination, range of motion, and strength in the client's affected left upper extremity. PNF intervention was paired with the therapeutic instrumental music performance (TIMP) technique to promote smooth movement. TIMP has been shown to improve gross and fine motor skills, along with skills in activities of daily living, in rehabilitation of hemiparetic upper extremity following a stroke.[15,16] The client used her right arm to assist her left upper extremity while performing both the lift and chop PNF patterns. A drum stick was held against her left upper extremity by her right hand with the goal of reaching to hit a tambourine placed at both the top and bottom of the motions. The tambourine was placed so emphasis was on big movements and reaching outside her base of support to initiate more weight shifting onto the left side. Other instruments used included a paddle drum, an electronic drum set, and small piano keyboard. In general, one set was performed until the client reported feeling fatigue. This activity worked on several aspects of motor control such as

perception of hitting the drum, weight shifting, and balance promoting trunk control. Progressions included moving the targets farther away and having the client sit on a balance disc. RAS in conjunction with functional pushing and pulling movements has been shown to improve range of motion and strength in individuals with chronic stroke.[12] Music therapists attempted to perform RAS to provide a steady beat for the client, however, she had difficulty maintaining a consistent beat likely due to fatigue.

Pre-gait activities. Pre-gait activities were used with this client based on GAITRite results and asymmetries observed. These activities were used to break gait down into smaller components to work on improving symmetry to allow the client to ambulate more efficiently in the community and for her daughter's upcoming wedding. These exercises included weight shifting forward and backward and crossover steps. The client stood behind a line taped on the floor then stepped forward using her right foot with the goal of reaching the yellow colored flooring. She then worked on crossing her right foot in front of her left foot to work on having a narrower base of support. She repeated both interventions with the other leg and a PT student provided stand-by assistance for safety. Music therapists provided RAS at 50 beats per minute in 4/4 time during initial session and progressed to 85 beats per minute in 4/4 time. Balance capacity has also been found to improve with therapy programs using weight-shifting and gait training.[42]

Walking forward over a series of three blocks was used to improve the client's hip and knee flexion in order to reduce the amount of circumduction of the client's left lower extremity. The client performed two sets of 8 repetitions for three sessions with a music therapy student playing a guitar at 70 beats per minute in 2/4 time. This intervention was

discontinued as the client was able to perform these same motions during stool taps and stair training. An article by Jaffe et al[43] found ambulation training involving stepping over objects and increased walking distance can improve gait velocity, stride length, endurance, and obstacle clearing capacity.

Gait training. Gait training was used during every session to accomplish the client's goal of increasing her gait speed and symmetry. The client performed weaving and turns around a series of 3 cones in order to work on improving step length on the right lower extremity. The client would weave in between the cones and alternate between right and left 360 degree turns around each cone for two sets of three repetitions each direction. Music therapy students provided RAS using both a guitar and electronic drum fill between 84 to 90 beats per minute in 4/4 time depending on client's energy level.

Hallway walking with RAS was used at the end of every therapy session. Physical therapy students walked alongside the client to provide verbal cueing for increased step length with the right lower extremity and stand-by assistance for safety. The distance varied based on client fatigue and tolerance. Music therapists provided a beat using variety of methods including chopped chords on guitar, an electronic metronome, and paddle drum. The tempo progressed from 81 to 86 beats per minute in 4/4 time throughout the sessions. The client demonstrated more consistency with tempo when RAS was performed by using chopped chords on guitar. RAS has been shown to lead to significant improvements in gait velocity, cadence, and stride length for individuals with chronic stroke.[8]

CHAPTER IV

OUTCOMES

By the final evaluation, the client reached her goals of performing a line dance and increasing her strength. She demonstrated improvement in strength and functional mobility. The client displayed improvement on the BBS, FTSTS test, TUG, and C-TUG. The most notable of these changes was on the BBS where the client improved by 5 points. The minimal detectable change of the BBS is 5 points making the change significant.[44] According to the BBS scoring guide, the client decreased her fall risk from medium risk to low risk.[19] This change is also significant to the client because of her history of a fall. The client improved her FTSTS test by 2.05 seconds. The minimal detectable change for this test is 2.5 seconds making the change clinically insignificant.[20] Additionally the changes in the TUG and C-TUG were clinically insignificant. The client would have needed a change of 8 seconds to have a minimal detectable change.[44] Table 4 show the functional assessment scores taken at the final evaluation session. Table 5 summarizes the changes seen between the initial and final evaluation sessions.

Table 4.
Final Functional Assessment Scores.

Functional Assessment	**Score of Assessment**	**Result of Score**
**Berg Balance Scale	41	41 to 56 indicates a low fall risk
***Five Times Sit To Stand Test	*13.18 seconds	12 seconds or longer indicates increased risk of falls
**Timed Up And Go	*22.24 seconds	13.5 seconds or longer indicates increased risk of falls
**Cognitive Timed Up And Go	*22.22 seconds	

*Average of three trials
**Single point cane and KAFO used
***KAFO used

Table 5.
Functional Assessment Score Changes.

Functional Assessment	**Initial Score of Assessment**	**Final Score of Assessment**	**Change**
**Berg Balance Scale	36	41	5
***Five Times Sit To Stand Test	*15.23 seconds	*13.18 seconds	2.05 seconds
**Timed Up And Go	*25.74 seconds	*22.24 seconds	3.5 seconds
**Cognitive Timed Up And Go	*23.6 seconds	*22.22 seconds	1.38 seconds

*Average of three trials
**Single point cane and KAFO used
***KAFO used

The final GAITRite assessment is shown in Table 6. Geiger et al [25] studied gait parameters using a three dimensional gait analysis in people with chronic stroke. The study concluded the minimal detectable change for parameters included a step length change of 0.0633 meters, cadence change of 8.58 steps/minute, and a velocity change of 0.1461 meters/second.[25] The GAITRite showed a decrease in cadence in the final assessment with a velocity that remained similar in the initial and final assessments. These changes were not clinically significant. In all four trials of the final GAITRite assessment step length on the right increased and step length on the left decreased or

stayed the same. The fast pace with a musical beat showed a clinically significant change of 0.07 meters on the left and normal pace without music showed a clinically significant change of 0.06 meters on the right. These changes demonstrate an increased weight bearing time on the left lower extremity during gait and a more symmetrical gait pattern. A change in stance time was seen in the initial assessment compared to the final assessment. These findings can be seen in Table 7. Reference Appendix for GAITRite statistics. In addition, the step differential decreased in the final GAITRite assessment compared to the initial as depicted in Figure 1. Refer to Table 2 for gait parameters found by Boudarham et al [24] for people with hemiplegia and for healthy subjects.

Table 6.
Final GAITRite Assessment.

	Cadence (steps/minute)	**Velocity (meters/ second)**	**Stance Time (seconds)**	**Step Length (meters)**	**Step Length Differential (meters)**
Normal Pace Without Music	82.1	0.512	R= 1.087 L= 0.925	R= 0.28 L= 0.47	0.18
Face Pace Without Music	91.9	0.53	R= 0.977 L= 0.826	R= 0.25 L= 0.46	0.21
***Normal Pace With Music**	87	0.496	R= 1.037 L= 0.872	R= 0.24 L= 0.45	0.21
****Fast Pace With Music**	88.6	0.519	R= 0.975 L= 0.905	R= 0.30 L= 0.40	0.10

R= Right
L= Left
All numbers are an average of 3 trials.
*Metronome 86 beats per minute
**Metronome 94 beats per minute

Table 7.
Initial GAITRite Assessment Compared to Final GAITRite Assessment.

	Cadence (steps/ minute)	**Velocity (meters/ second)**	**Stance Time (seconds)**	**Step Length (meters)**	**Step Length Differential (meters)**
Normal Pace Without Music	Initial: 95.2 Final: 82.1	Initial: 0.539 Final: 0.512	Initial: R= 1.039 L= 0.834 Final: R= 1.087 L= 0.925	Initial: R= 0.21 L= 0.47 Final: R= 0.28 L= 0.47	Initial: 0.26 Final: 0.18
Fast Pace Without Music	Initial: 95.8 Final: 91.9	Initial: 0.548 Final: 0.53	Initial: R= 0.955 L= 0.81 Final: R= 0.977 L= 0.826	Initial: R= 0.23 L= 0.47 Final: R= 0.25 L= 0.46	Initial: 0.24 Final: 0.21
Normal Pace With Music	Initial: 93.8 Final: 87	Initial: 0.53 Final: 0.496	Initial: R= 0.951 L= 0.817 Final: R= 1.037 L= 0.872	Initial: R= 0.23 L= 0.46 Final: R= 0.24 L= 0.45	Initial: 0.23 Final: 0.21
Fast Pace With Music	Initial: 93.8 Final: 88.6	Initial: 0.578 Final: 0.519	Initial: R= 0.94 L= 0.809 Final: R= 0.975 L= 0.905	Initial: R= 0.26 L= 0.47 Final: R= 0.30 L= 0.40	Initial: 0.21 Final: 0.10

R= Right
L= Left
All numbers are an average of 3 trials.

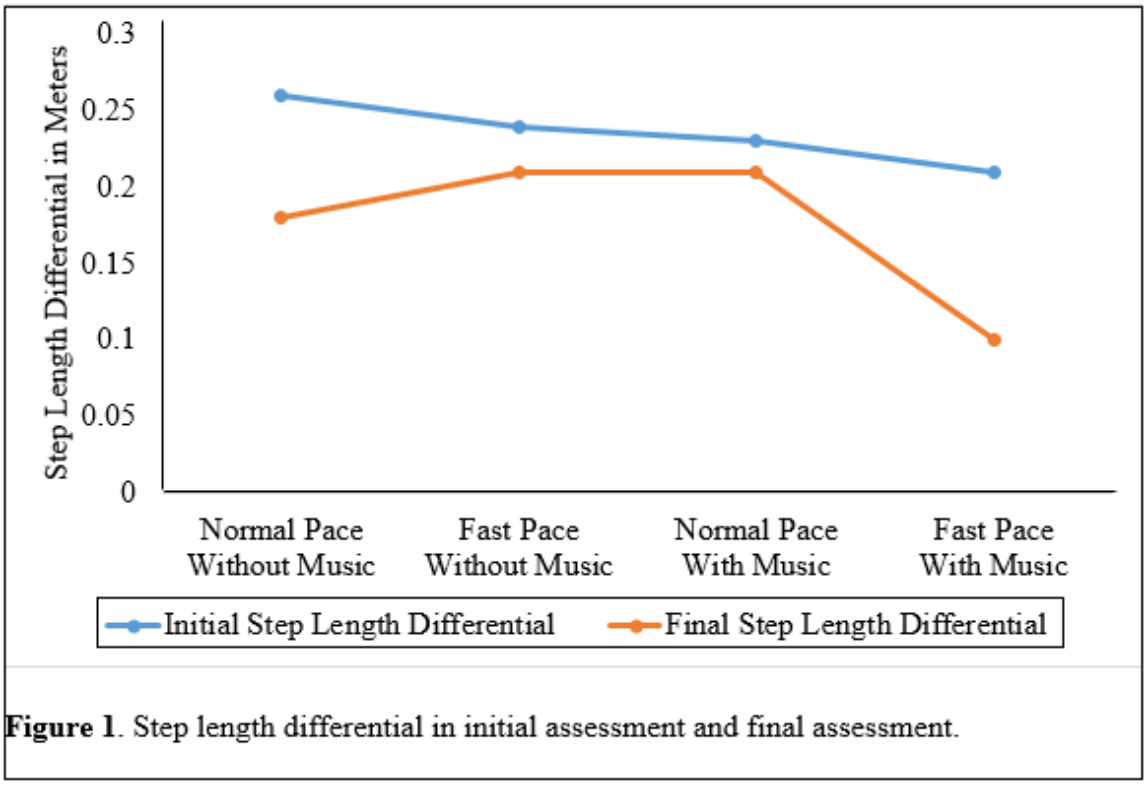

Figure 1. Step length differential in initial assessment and final assessment.

CHAPTER V

DISCUSSION

Strokes and their long-term effects have been heavily researched throughout the world. In the United States, strokes are a leading cause of long-term disability with almost half of people experiencing moderate to severe disability following a stroke.[45] Rehabilitation after stroke commonly involves the use of physical therapy. However, there is limited research on physical therapy combined with music therapy for the rehabilitation of stroke. The purpose of this study was to determine the effectiveness of combined physical therapy and music therapy treatment techniques for the rehabilitation of an individual with chronic stroke.

This case study demonstrates the thirteen-week collaboration between physical therapy and music therapy for the treatment of chronic stroke in a 51-year-old female. Throughout the treatment sessions the client tolerated therapy interventions well and enjoyed the addition of music therapy. She reported her friends and family noticed a change in her mobility throughout the sessions. The client herself also reported a notable change, especially sidestepping through narrow aisles at church and in a plane. After the completion of the study, the client was able to demonstrate a clinically significant change on the BBS, clinically significant change in gait parameters, and reached her personal goals including improving gait symmetry and having the ability to line dance.

The findings of this study were consistent with research regarding the use of RAS in addition to gait training. Articles by Yoo et al[8] and Cha et al,[9] found RAS in

conjunction with gait training can lead to significant improvements in gait parameters including velocity, stride length, and cadence, along with improved Berg Balance scale scores. While most research studies have found beneficial effects for the use of PSE during sit to stand transfers, these studies have all been performed in children with cerebral palsy.

There were limitations present in this study. Time was limited to one hour per week due to researchers' and client schedules. The client missed two weeks of interventions for a vacation. The extra sessions were made up by completing two sessions per week instead of one during some weeks. This may have affected client outcomes due to fatigue in weeks with multiple intervention days and no interventions in the two weeks she was absent. Client attention was also a limitation of this study as she demonstrated a tendency to become distracted and lose focus on the external beat provided by music therapy students. Further limitations include the small sample size and the inability to generalize across the population.

Researchers suggest future studies with the collaboration of physical therapy and music therapy due to clinically significant outcomes as well as client attitude towards combined physical therapy and music therapy. Future studies should include more specific intervention lengths and treatments. Future studies may also focus on a specific functional assessment or gait analysis measures such as step length or gait speed.

APPENDIX

Tested on: 1/16/2019 4:48:19 PM

niversity of North Dakota

Tel#

Age	Gender	Left LEG	Right	Height	Weight
51	F	0	0	167.64	0

Parameters

Distance (cm)	1087.2
Ambulation Time (sec)	20.16
Velocity (cm/sec)	53.9
Mean Normalized Velocity	.00

Cadence (Steps/Min)	95.2
Step Time Differential (sec)	.55
Step Length Differential (cm)	25.79
Cycle Time Differential (sec)	.04

Walk # / Footfall #	L/R	Mean(%CV)	Sample Normal Values
Step Time (sec)	L	.921(32.4)	0.53 0.59
	R	.372(68.5)	
Cycle Time (sec)	L	1.300(2.0)	1.06 1.18
	R	1.259(13.7)	
Swing Time (sec)	L	.466(6.7) /35.8	36 44
/ %GC	R	.221(73.3) /17.6	
Stance (sec)	L	.834(3.0) /64.2	56 64
/ %GC	R	1.039(19.7) /82.5	
Single Support (sec)	L	.221(73.3) /17.0	38 42
/ %GC	R	.466(6.7) /37.0	
Double Support (sec)	L	.661(32.8) /50.8	16 24
/ %GC	R	.658(33.3) /52.3	
Step Length (cm)	L	46.867(6.1)	58 85
	R	21.082(23.9)	
Stride Length (cm)	L	68.194(11.3)	116 170
	R	68.057(11.3)	
Base of Support (cm)	L	18.60(9.2)	
	R	18.53(13.0)	
Toe In / Out (deg)	L	18(.0)	
	R	8(.0)	

Normal Pace
Without Music

Tested on: 1/16/2019 4:51:43 PM

University of North Dakota

Tel#

Age	Gender	Left LEG	Right	Height	Weight
51	F	0	0	167.64	0

Parameters

Distance (cm)	1099.7
Ambulation Time (sec)	20.05
Velocity (cm/sec)	54.8
Mean Normalized Velocity	.00

Cadence (Steps/Min)	95.8
Step Time Differential (sec)	.23
Step Length Differential (cm)	23.65
Cycle Time Differential (sec)	.00

Walk # / Footfall #	L/R	Mean(%CV)	1/ 1	1/ 2	1/ 3	1/ 4	1/ 5	1/ 6	1/ 7	1/ 8	1/ 9	1/ 10	1/ 11	2/ 1	2/ 2
Step Time (sec)	L	.750(13.2)			.758		.758		.800		.816		.759		
	R	.518(15.1)		.567		.534		.592		.600		.575			.508
Cycle Time (sec)	L	1.266(6.0)			1.325		1.292		1.392		1.416		1.334		
	R	1.265(11.1)				1.292		1.350		1.400		1.391			
Swing Time (sec)	L	.455(5.1) /35.9				.466		.458		.483		.491		.483		
/ %GC	R	.310(27.7) /24.5					.350		.400		.400		.333			
Stance (sec)	L	.810(7.4) /64.0	.859		.834		.909		.925		.851			.759	
/ %GC	R	.955(11.5) /75.5		.942		.950		1.000		1.058					.901
Single Support (sec)	L	.310(27.7) /24.5			.350		.400		.400		.333				
/ %GC	R	.455(5.1) /36.0		.466		.458		.483		.491		.483			.458
Double Support (sec)	L	.504(18.8) /39.8			.484		.509		.525		.518				
/ %GC	R	.500(19.8) /39.5		.476		.492		.517		.567		.476			.443
Step Length (cm)	L	46.930(4.4)			46.859		49.606		48.600		48.776		49.306		
	R	23.280(13.5)		26.386		25.150		31.642		25.576		27.779			20.700
Stride Length (cm)	L	70.312(6.7)			73.249		74.762		80.279		74.449		77.091		
	R	70.244(6.7)				72.040		81.248		74.176		76.607			
Base of Support (cm)	L	17.99(5.8)			17.327		19.286		16.694		19.014				
	R	17.92(5.1)		16.657		18.878		17.983		18.520		17.133			18.037
Toe In / Out (deg)	L	17(.0)			14		12		12		14				
	R	11(.0)		12		12		12		15		12			11

Fast Pace
Without Music

Tested on: 1/16/2019 4:56:33 PM

University of North Dakota

Tel#

Age	Gender	Left LEG	Right	Height	Weight
51	F	0	0	167.64	0

Parameters

Distance (cm)	1119.8
Ambulation Time (sec)	21.12
Velocity (cm/sec)	53.0
Mean Normalized Velocity	.00

Cadence (Steps/Min)	93.8
Step Time Differential (sec)	.19
Step Length Differential (cm)	22.96
Cycle Time Differential (sec)	.00

Walk # / Footfall #	L/R	Mean(%CV)	Sample Normal Values
Step Time (sec)	L	.740(3.9)	0.53 0.59
	R	.546(3.7)	
Cycle Time (sec)	L	1.283(3.0)	1.06 1.18
	R	1.287(2.3)	
Swing Time (sec)	L	.466(6.4) /36.3	36 44
/ %GC	R	.336(4.2) /26.1	
Stance (sec)	L	.817(3.3) /63.7	56 64
/ %GC	R	.951(3.4) /73.9	
Single Support (sec)	L	.336(4.2) /26.2	38 42
/ %GC	R	.466(6.4) /36.2	
Double Support (sec)	L	.489(5.7) /38.1	16 24
/ %GC	R	.488(6.1) /37.9	
Step Length (cm)	L	45.762(6.4)	58 85
	R	22.802(22.3)	
Stride Length (cm)	L	67.970(10.6)	116 170
	R	68.800(10.9)	
Base of Support (cm)	L	17.43(9.8)	
	R	17.39(11.7)	
Toe In / Out (deg)	L	18(.0)	
	R	11(.0)	

Normal Pace
With Music

Tested on: 1/16/2019 4:59:54 PM

University of North Dakota

Tel#

Age	Gender	Left LEG	Right	Height	Weight
51	F	0	0	167.64	0

Parameters

Distance (cm)	1146.4
Ambulation Time (sec)	19.82
Velocity (cm/sec)	57.8
Mean Normalized Velocity	.00

Cadence (Steps/Min)	93.8
Step Time Differential (sec)	.20
Step Length Differential (cm)	21.41
Cycle Time Differential (sec)	.00

Walk # / Footfall #	L/R	Mean(%CV)	Sample Normal Values
Step Time (sec)	L	.737(4.5)	0.53 – 0.59
	R	.535(3.6)	
Cycle Time (sec)	L	1.270(3.4)	1.06 – 1.18
	R	1.266(3.8)	
Swing Time (sec) / %GC	L	.462(4.3) /36.4	36 – 44
	R	.326(2.8) /25.8	
Stance (sec) / %GC	L	.809(4.4) /63.7	56 – 64
	R	.940(5.1) /74.2	
Single Support (sec) / %GC	L	.326(2.8) /25.7	38 – 42
	R	.462(4.3) /36.5	
Double Support (sec) / %GC	L	.481(8.3) /37.9	16 – 24
	R	.478(7.5) /37.8	
Step Length (cm)	L	47.341(4.8)	58 – 85
	R	25.927(12.8)	
Stride Length (cm)	L	73.389(7.0)	116 – 170
	R	73.242(7.0)	
Base of Support (cm)	L	16.88(6.0)	
	R	16.73(8.6)	
Toe In / Out (deg)	L	17(.0)	
	R	12(.0)	

Fast Pace
With Music

Tested on: **4/24/2019 4:15:54 PM**

University of North Dakota

Tel#

Age	Gender	Left LEG	Right	Height	Weight
-68	F	0	0	167.64	0

Parameters

Distance (cm)	972.5
Ambulation Time (sec)	19.00
Velocity (cm/sec)	51.2
Mean Normalized Velocity	.00

Cadence (Steps/Min)	82.1
Step Time Differential (sec)	.24
Step Length Differential (cm)	18.28
Cycle Time Differential (sec)	.01

Walk # / Footfall #	L/R	Mean(%CV)	Sample Normal Values
Step Time (sec)	L	.849(7.1)	0.53 0.59
	R	.612(4.7)	
Cycle Time (sec)	L	1.461(5.5)	1.06 1.18
	R	1.466(6.1)	
Swing Time (sec)	L	.537(5.2) /36.8	36 44
/ %GC	R	.379(8.2) /25.9	
Stance (sec)	L	.925(7.2) /63.3	56 64
/ %GC	R	1.087(6.1) /74.1	
Single Support (sec)	L	.379(8.2) /25.9	38 42
/ %GC	R	.537(5.2) /36.6	
Double Support (sec)	L	.554(8.5) /37.9	16 24
/ %GC	R	.553(9.4) /37.7	
Step Length (cm)	L	46.542(6.5)	58 85
	R	28.266(11.3)	
Stride Length (cm)	L	74.930(5.2)	116 170
	R	74.355(5.7)	
Base of Support (cm)	L	15.27(38.1)	
	R	15.28(42.2)	
Toe In / Out (deg)	L	16(.0)	
	R	12(.0)	

Normal Pace
Without Music

Tested on: 4/24/2019 4:18:59 PM

University of North Dakota

Tel#

Age	Gender	Left LEG	Right	Height	Weight
51	F	0	0	167.64	0

Parameters

Distance (cm)	900.1
Ambulation Time (sec)	16.98
Velocity (cm/sec)	53.0
Mean Normalized Velocity	.00

Cadence (Steps/Min)	91.9
Step Time Differential (sec)	.19
Step Length Differential (cm)	21.29
Cycle Time Differential (sec)	.00

Walk # / Footfall #	L/R	Mean(%CV)	Sample Normal Values
Step Time (sec)	L	.756(3.8)	0.53 0.59
	R	.565(3.7)	
Cycle Time (sec)	L	1.322(3.5)	1.06 1.18
	R	1.322(3.1)	
Swing Time (sec)	L	.496(5.6) /37.5	36 44
/ %GC	R	.345(3.8) /26.1	
Stance (sec)	L	.826(4.4) /62.5	56 64
/ %GC	R	.977(3.9) /73.9	
Single Support (sec)	L	.345(3.8) /26.1	38 42
/ %GC	R	.496(5.6) /37.5	
Double Support (sec)	L	.485(6.2) /36.7	16 24
/ %GC	R	.486(5.8) /36.8	
Step Length (cm)	L	46.083(2.9)	58 85
	R	24.790(9.2)	
Stride Length (cm)	L	70.939(4.5)	116 170
	R	70.702(4.3)	
Base of Support (cm)	L	17.34(7.2)	
	R	17.17(6.2)	
Toe In / Out (deg)	L	19(.0)	
	R	7(.0)	

Fast Pace
Without Music

Tested on: 4/24/2019 4:21:47 PM

University of North Dakota

Tel#

Age	Gender	Left LEG	Right	Height	Weight
51	F	0	0	167.64	0

Parameters

Distance (cm)	1128.7
Ambulation Time (sec)	22.77
Velocity (cm/sec)	49.6
Mean Normalized Velocity	.00

Cadence (Steps/Min)	87.0
Step Time Differential (sec)	.23
Step Length Differential (cm)	21.33
Cycle Time Differential (sec)	.01

Walk # / Footfall #	L/R	Mean(%CV)	Sample Normal Values
Step Time (sec)	L	.806(3.8)	0.53 – 0.59
	R	.581(4.8)	
Cycle Time (sec)	L	1.385(4.0)	1.06 – 1.18
	R	1.392(4.0)	
Swing Time (sec)	L	.513(5.8) /37.0	36 – 44
/ %GC	R	.356(3.9) /25.6	
Stance (sec)	L	.872(4.4) /63.0	56 – 64
/ %GC	R	1.037(4.7) /74.5	
Single Support (sec)	L	.356(3.9) /25.7	38 – 42
/ %GC	R	.513(5.8) /36.9	
Double Support (sec)	L	.526(6.8) /38.0	16 – 24
/ %GC	R	.525(5.5) /37.7	
Step Length (cm)	L	45.191(8.3)	58 – 85
	R	23.863(16.4)	
Stride Length (cm)	L	69.335(10.4)	116 – 170
	R	68.545(11.0)	
Base of Support (cm)	L	16.80(7.4)	
	R	16.75(6.8)	
Toe In / Out (deg)	L	16(.0)	
	R	10(.0)	

Normal Pace
With Music

Tested on: 4/24/2019 4:23:56 PM

University of North Dakota

Tel#

Age	Gender	Left LEG	Right	Height	Weight
51	F	0	0	167.64	0

Parameters

Distance (cm)	913.4
Ambulation Time (sec)	17.61
Velocity (cm/sec)	51.9
Mean Normalized Velocity	.00

Cadence (Steps/Min)	88.6
Step Time Differential (sec)	.09
Step Length Differential (cm)	9.50
Cycle Time Differential (sec)	.00

Walk # / Footfall #	L/R	Mean(%CV)	Sample Normal Values
Step Time (sec)	L	.722(16.3)	0.53 0.59
	R	.633(12.3)	
Cycle Time (sec)	L	1.372(4.3)	1.06 1.18
	R	1.371(3.9)	
Swing Time (sec)	L	.466(16.7) /34.0	36 44
/ %GC	R	.396(16.9) /28.9	
Stance (sec)	L	.905(5.5) /66.0	56 64
/ %GC	R	.975(10.4) /71.1	
Single Support (sec)	L	.396(16.9) /28.9	38 42
/ %GC	R	.466(16.7) /34.0	
Double Support (sec)	L	.513(7.0) /37.4	16 24
/ %GC	R	.515(5.2) /37.6	
Step Length (cm)	L	39.882(25.6)	58 85
	R	30.380(29.3)	
Stride Length (cm)	L	71.796(2.7)	116 170
	R	72.031(1.7)	
Base of Support (cm)	L	15.59(21.8)	
	R	15.96(29.5)	
Toe In / Out (deg)	L	9(.0)	
	R	7(.0)	

Fast Pace
With Music

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