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The Effect of Contingent Music with Physical Therapy in Children Who Toe-Walk

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IN CHILDREN WHO TOE-WALK

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TABLE OF CONTENTS

LIST OF TABLES .................................................................................................................. vi
LIST OF FIGURES ................................................................................................................ vii
ABSTRACT ............................................................................................................................ viii

REVIEW OF LITERATURE .................................................................................................. 1

Introduction .......................................................................................................................... 1
Brief Anatomy of Toe-walkers ............................................................................................ 1
Children With Toe-Walking Symptoms ............................................................................ 2
Etiology of Toe-walking ....................................................................................................... 6
Results of Long-term Toe-walking ...................................................................................... 8
Treatment Options .............................................................................................................. 9
Music Therapy and Special Needs Children ...................................................................... 13
Music Therapy and Gait Training ....................................................................................... 16

METHOD .............................................................................................................................. 21

Subjects .............................................................................................................................. 21
Materials ............................................................................................................................. 22
Procedure ............................................................................................................................ 22

CASE STUDIES .................................................................................................................. 23

Case Study A ....................................................................................................................... 27
Case Study B ....................................................................................................................... 31
Case Study C ....................................................................................................................... 35
Case Study D ....................................................................................................................... 39
Case Study E ....................................................................................................................... 43
LIST OF TABLES

Table 1.0  Subjects and their Diagnoses ................................................................. 21

Table 2.0  Summary of One-Way Analysis of Variance Test on Heel Scores ........ 52

Table 2.1  Mean of Heel Scores ........................................................................... 53

Table 2.2  Summary of Tukey HSD Test on Heel Score Data ............................. 53

Table 2.3  Summary of One-Way Analysis of Variance Test on Toe Scores ........ 53

Table 2.5  Summary of Tukey HSD Test on Toe Score Data ............................. 54

Table 2.6  Summary of One-Way Analysis of Variance Test on Non-Cooperation Scores ................................................................................................................... 54

Table 2.7  Summary of One-Way Analysis of Variance Test on Complaint Scores .... 55
LIST OF FIGURES

Figure 1.0 Brandon’s Heel and Toe Scores ................................................................. 25
Figure 1.1 Brandon’s Non-Cooperation and Complaint Scores .................................. 26
Figure 2.0 Cassie’s Heel and Toe Scores ................................................................. 30
Figure 2.1 Cassie’s Non-Cooperation and Complaint Scores .................................... 30
Figure 3.0 Diane’s Heel and Toe Scores ................................................................. 34
Figure 3.1 Diane’s Non-Cooperation and Complaint Scores .................................... 34
Figure 4.0 Edward’s Heel and Toe Scores Per Session .............................................. 38
Figure 4.1 Edward’s Non-Cooperation and Complaint Scores Per Session ............... 38
Figure 5.0 Francis’ Heel and Toe Scores ................................................................. 42
Figure 5.1 Francis’ Non-Cooperation and Complaint Scores ................................... 42
Figure 6.0 Gretchen’s Heel and Toe Scores ............................................................. 46
Figure 6.1 Gretchen’s Non-Cooperation and Complaint Scores ............................... 46
Figure 7.0 Harry’s Heel and Toe Scores ................................................................. 50
Figure 7.1 Harry’s Non-Cooperation and Complaint Scores ................................... 50
ABSTRACT

The purpose of this study was to determine if physical therapy may be more efficacious with the addition of music than without. Nine subjects who toe-walked and were between the ages of two-six years were selected and recommended for participation in this study by a physical therapist. Subjects participated four sessions, and served as their own control. Sessions were baseline, treatment, return to baseline, treatment. Sessions were videotaped and later analyzed by the music therapy researcher and an independent observer using a five second observe, five second record data collection process. A one-way analysis of variance (ANOVA) test showed a statistically significant difference in the number of heel and toe scores when music was added to the physical therapy sessions. Though not significantly different, the number of complaints and non-cooperation scores decreased as well. More extensive research is recommended to fully explore the most efficacious use of music in combination with children during physical therapy sessions.
REVIEW OF LITERATURE

Introduction

Talipes Equinus, more commonly called “toe walking,” is the condition in which the ball of the foot is the main or only portion of the foot to be placed on the ground. While the name implies the balance stays on the toes, balance is actually maintained on the balls of the feet.

Brief Anatomy of Toe-walkers

To understand the problems resulting from this gait, the reader must begin with an understanding of the anatomy involved. First, the largest muscle to be considered while discussing toe-walking is the gastrocnemius muscle, known in lay terms as the calf muscle. Directly deep to the gastrocnemius is the soleus. These two muscles grouped together are called the triceps surae. The gastrocnemius and the soleus are responsible for moving the foot down, called plantar flexion. The calcaneal tendon, in lay terms the Achilles tendon, begins at the base of the foot and eventually becomes the tendon of the gastrocnemius.
Dorsiflexion, or moving the foot up toward the head, is accomplished by the Tibialis anterior, the Fibularis terius, and the extensor hallucis muscles, all located on the front of the lower portion of the leg (Marieb, 2001).

**Children With Toe-Walking Symptoms**

Toe-walking is often a temporary phase of walking which many children experience (Colbert & Koegler, 1958). However, when this phase becomes prolonged, the typically-developing child may be diagnosed with “idiopathic toe walking,” meaning there is no neurological or physical reason the child remains on their toes. Idiopathic toe-walkers may also be called “habitual toe-walkers.” Toe-walking occurs in only 7%-24% of the typically-developing childhood population. (Sobel, Caselli & Velez, 1997, p. 17) Toe-walkers are most often boys, and often a family history of the gait is documented (Stricker & Angulo, 1988, p. 291), with sometimes as much as a 50% positive incidence (Sobel, Caselli & Velez, 1997, p. 20).

Idiopathic toe-walkers are often referred to physical therapy simply because of the way toe-walking looks (Hobbs, Altman, & Halldin, 1980; Barrett & Linn, 1981; Selby 1988). Parents are often concerned their child’s walking pattern is socially maladaptive, and are usually unaware that toe-walking may also be detrimental to the physical growth and formation of the bones of the child (Selby, 1988, 1921). These delays and physical limitations all point directly to the need for evaluation and treatment of toe-walking, even assuming the idiopathic toe-walker has no other challenges.

In a 1997 study, however, Shulman, Salat, Chu, McCaul, & Sandler studied 13 children referred to physical therapy with the diagnosis of idiopathic toe-walking. The
children were assessed by neurologists, pediatricians, speech/language pathologists, and both physical and occupational therapists. None of the children had any neurological or physical diagnosis; this study revealed, however, that 75% of these toe-walkers examined had significant language delays, and “delays were also found in fine motor, visuomotor, and gross motor abilities, but to a lesser extent” (Shulman et al, 1997, p. 544). Furthermore, the authors suggest any child who toe-walks be referred for developmental assessment. A 1988 review of toe-walking treatments indicated that although all the subjects in its study were diagnosed as idiopathic toe-walkers, 28% had been previously assessed for developmental delay (Stricker & Angulo, 1988, p. 292).

Stricker & Angulo (1998) discovered some children have a shortened congenital contracture of the triceps, as well as congenital shortened heel-cords, accounting for some toe-walking (Stricker & Angulo, 1998, p. 292). These children stand on their toes even before they begin to walk (Furrer, 1982, p. 313).

In a study of 28 cases, Furrer found that, among a group of toe-walkers with minimal cerebral palsy, there was not a significant number of premature births or perinatal pathology reported. Additionally, these authors found in idiopathic toe-walkers, the condition was often “exacerbated by emotional stress” (Furrer, 1982, p. 309).

Toe-walking, however, is most commonly seen in populations who are developmentally delayed and/or physically challenged. Weber (1978, p. 73-74) found toe-walking to be most common in children with several conditions:

1. Spastic conditions, such as cerebral palsy. An example of this might be Little’s disease, a type of cerebral palsy in which the lower extremities in
particular suffer from bilateral spasticity. In cerebral palsy, it should be noted that the hypertonicity is present at all times, even at rest.

2. Progressive muscular dystrophy. Patients with muscular dystrophy experience disproportionate antagonistic balance and have a disturbance in fibrin, the clotting agent in the blood affecting the fibres in the muscles. Muscular dystrophy affects the myofibrils, present in voluntary muscle. The disturbance of these fibers in turn causes a disturbance in muscle contraction.

3. Autism, Oligophrenias (mentally handicapping conditions), and communication disorders. Weber (1978) notes that toe-walking has been cited many times in literature concerning autistic children. Accardo & Whitman (1989) report the presence of toe-walking in autism to be 62.9 %, and the combination of autism and communication disorders to be 47.6 % (p. 349). In this way, patients with autism are clearly the population with highest numbers of toe-walkers.

4. Schizophrenia. Colbert & Koegler (1958) noticed 19% of children with schizophrenic diagnoses consistently walked on the toes. However, the authors do note “all of the children tested…could be classified as autistic” (p. 220). The presence of schizophrenics in this toe-walking diagnosis is also discussed by Weber, who notes that at one time toe-walking was seen as a diagnostic differentiation between schizophrenia and autism, but has been removed from the criteria (p. 73). Ornitz & Ritvo, however, support the use of this term, as many children diagnosed as autistic eventually exhibit clinical sign of schizophrenia, and many adult schizophrenics were “typically autistic when
preschoolers” (1976m, p. 614). While this term is seldom used, one does encounter it in the literature.

A later study by Caselli, Rzonca & Lue (1988, p. 552-556) detailed additional examples of conditions in which toe-walking might appear. These authors report, however, premature and postmature infants are at risk for toe-walking in later life. In addition to those listed above, these authors include:

1. Dystonia muscularum deformans, a disease characterized by slow twisting and writhing movements. In this disease, persistent hypertonicity of the gastrocnemius results in plantar flexion, and thus, toe-walking.

2. Diastematomyelia, in which the spinal cord is bisected by tissue of the spinal canal;

3. Clumsy Child syndrome, in which the child experiences an inability to move the limbs in a coordinated manner;

4. Muscular Dystrophy, in which the antagonistic balances of the muscles groups are affected, and a pointed foot may appear at rest and during locomotion;

5. Peroneal Muscular Atrophy, in which the degeneration of muscles begins in the legs and feet. The authors note this disease is often familial, and the most often affected are male.

It is clear that whether or not the child who toe-walks may have other concomitant issues to be addressed. Every toe-walker, idiopathic or otherwise, should be evaluated by a team of developmental professionals.
Etiology of Toe-walking

Children for whom the etiology of toe-walking is physical are obviously unable to produce the movements required of the muscles to produce a heel-toe gait. Children with or other spastic conditions are unable to control the muscle contraction. Indeed, Tardieu, Lespargot, Tabary & Bret (1989) examined a group of toe-walking children with CP to determine if all toe-walking in this population is caused by excessive contraction of the triceps surae. The authors measured the amounts of both active and passive, and internal and external movement during toe-walking. Results indicated while contraction of the triceps surae may be the cause of toe-walking in some cases for this population, knowledge of how and for what length of time this muscle is contracted leads to the best course of treatment. It is the role of the physical therapist and/or occupational therapist to assist the child with passive and/or active stretches and orthotics, if needed, to aid in muscle development, flexion, and other physical therapy goals.

The etiology of other toe-walking is unclear. Doudlah (1973) suggested toe-walkers use this gait in a defensive response to sensory input. In this example, a person hypersensitive to sound may walk only on the toes to avoid the sound of the heel striking the floor (p. 121-143). Furrer asserts that toe-walking is “a minor motor manifestation (often neglected and not carefully examined) of a central organic disorder” (Furrer, 1982, p. 313). As children with autism are often hypersensitive to sensory stimuli and children who toe-walk are often autistic, this explanation rings true.

Ayres’ explanation for toe-walking (as cited in Montgomery & Gauger, 1978) also involves sensory input. Sensory input involves two receptive systems: the spinothalamic system and the lemniscal system. The spinothalamic system is activated by
threatening stimuli, and is not able to differentiate between real and potential threat. That is, this system is stimulated both by a painful prick on the skin, and hairs simply being moved. The lemniscal system, however, is able to discriminate between immediate and potential threat. Ayres suggests persons who toe-walk have a disproportionate amount of lemniscal input. The joints are not able to stimulate the spinothalamic system (threatening), but neurons in the ventrobasal thalamic complex respond to such motion (Poggio & Mountcastle, 1960, p. 367-369). Montgomery & Gauger suggest “continual activation of the joint surfaces in the forefoot may provide constant input into the lemniscal system”, and that by toe-walking, a balance between the two systems is achieved (1978, p. 1196).

Montgomery & Gauger reviewed vestibular input as an alternate explanation for toe-walking in their 1978 study. A child’s supporting response is elicited by providing support vertically, then allowing the feet to touch a flat plane. An infant’s tone or amount of tension of the muscles will automatically increase in this position, and in the older child, it is difficult to distinguish between supporting tone and tone found in standing. Due to missing input from the vestibular input, toe-walking children may be creating a positive tone to “increase tactile and proprioceptive input to facilitate support tone in the lower extremities” (Ayres, 1975, as cited in Montgomery & Gauger, 1978, 1196). Ornitz & Ritvo agree with this conclusion, saying many behaviors of people with autism suggest “they are actively inducing vestibular and provocative stimulation” (p. 610).

Montgomery & Gauger explain “the major direct pathway to extensor musculature is the lateral vestibulospinal tract, which transmits information from the lateral vestibular nucleus (Dieter’s) to motoneurons throughout the length of the spinal
cord. The extensor tone produced by way of this mechanism is essential for the maintenance of posture and for subsequent movement” (1978, p. 1196). The authors’ 1978 study worked with 17 mentally handicapped children, and provided them with vestibular stimulation by bouncing the subjects on a trampoline and spinning them in a hammock. Directly after this stimulation, 13 of the 17 subjects walked with a heel-toe gait, although for a short time. Additionally, ten of the 17 children appeared more alert directly following this stimulation. Montgomery & Gauger suggest that children who toe-walk may have “inadequate integration of vestibular input” (p. 1197) and may be compensating by increasing somatosensory input “via peripheral pathways to the central vestibular mechanism (Dieter’s nucleus). Stimulation of Deiter’s nucleus results in an increased flow of impulses to the lateral vestibulospinal tract for increased extensor tone during gait” (p. 1203). A 1981 dance therapy study by Couper supports this theory. Couper was able to produce better results in motor performance when combining vestibular stimulation movement with music and rhythm than the control group, who performed the same movements without this stimulus (p. 26).

Results of Long-term Toe-walking

“Walking is…the pattern which allows human beings to drive their intentional behavior through the environment” (Mauerberg & Adrian, 1995, p. 851). With this in mind, when walking is distorted, the subject loses the ability to maneuver through his/her environment effectively, and a host of other problems appear.

When toe-walking persists, several conditions may result. Among these is hypertonicity, or rigidity and/or contracture of the muscles. The triceps surae muscle
may become permanently contracted. Additionally, the child’s Range of Motion (ROM) in the ankle is limited, the trunk rotation may be impeded (Barrett & Linn, 1981, p. 13), and the child may have resulting delayed gross motor movement. Also, as “muscle length and bone formation are affected by the functional demands placed on them,” the physical formation of bone and muscle has now been delayed (Selby, 1988, p. 1921). Additionally, these children may have general trouble manipulating their environments. In fact, children who toe-walk are often referred to physical therapy due to clumsiness (p. 1921).

Regardless of etiology of this abnormal gait, whether it be neurological or idiopathic, it is obvious that toe-walking must be addressed in some fashion. Determining the most efficacious treatment is the next boundary.

**Treatment Options**

Several treatment options exist for remediation of toe-walking. The treatment chosen depends mostly upon the mental and physical challenges the child faces in addition to this abnormal gait. For example, if the child has concomitant physical conditions limiting mobility, physical therapy specifically for toe-walking must wait until the child is able to stand. Additionally, if the child is moderately to severely/profoundly mentally handicapped, auditory feedback may not be a viable option, as this requires instruction and patient comprehension and cooperation. Assessment by many disciplines will assist the parent or guardian in choosing the most efficacious treatment available.

The first treatment option may be physical therapy. The goal of physical therapy may be either solving the problem causing the toe-walking, such as hypertonicity in cases
of spasticity, or remediation of toe-walking as an impairment of functionality. Physical therapy may also allow for assessment of the body’s evolution, and determine the best time for surgical lengthening of the calcaneal tendon, if this is the etiology of the toe-walking. Physical therapy can provide both active and passive stretches in children with cerebral palsy in order to allow facilitation of the muscles used in a heel-toe gait. Physical therapists may also fit the child for orthotic devices to correct toe-walking, although toe-walking usually occurs more frequently and is more pronounced when the child is barefoot. (Stricker & Angulo, 1998, p. 291).

A study by Selby (1988) reviews treatment of toe-walking with neutral-position, serial-inhibitory casts. These casts were serial because they could be gradually altered to systematically lengthen the patient’s gastrocnemius-soleus tendon, and neutral because of the position in which the casts were placed. The patient in this study wore these casts five hours per day for an eight-month period. Orthoses were made after eight months of treatment, when the child was walking with a heel-toe gait approximately 70% of the time. The child continued to wear the orthoses five hours per day, and his parents created opportunities for gross motor movement. Results of this treatment were positive; one year after treatment began, the child was walking with a heel-toe gait at 70% with normal shoes, and 100% with orthoses. However, heel-toe gait dropped to 50% when the child was barefoot. In addition, the child’s hypertonicity was reduced and passive ROM increased (p. 1923).

Physical therapy has also been applied in conjunction with the behavioral technique of positive practice over correction. Barrett & Linn (1981) were first in using the combination of these techniques in the treatment of toe-walking. While the physical
therapist in this study implemented a program to meet traditional physical therapy objectives: equilibrium, body rotation, decrease rigidity while increasing flexion, overcorrection was used in conjunction. The overcorrection in this case paired a mildly aversive stimulus with each incidence of toe-walking, preceded by a verbal warning. Here the subject had to engage in a repetitive gross motor routine he disliked each time he was unable to correct his toe-walking. The subject in this study showed a reduction in toe-walking by 80% (p. 18). Additionally, the subject was observed toe-walking less than 50% of the time following the treatment (p. 20).

Toe-walking has also been successfully remediated using positive reinforcement. That is, the subject is rewarded for the target behavior versus punishment for unwanted behavior. In a 1980 study by Hobbs, Altman & Halldin, the subject is assumed to be an idiopathic toe-walker, as no mention is made of any mental or neurological impairments. In this case, the child was asked to wear commercially available heavy boots based on the author’s assertion that the weight would weigh down the child’s heel. The subject wore these boots virtually all the time, the exception being a structured play interval designed by the researcher for data-collection purposes. The positive reinforcement in this case was differential reinforcement. That is, the child was given positive reinforcement in the form of food, for all behavior other than toe-walking. The treatment consisted of data collection during sessions while the subjects wore the boots, sessions with reinforcement only, and sessions with boots and reinforcement combined eventually were added. Results indicated the greatest difference during the combination sessions, with a 40% reduction of toe-walking behavior, with a decline to levels below 50% with these conditions after a return to baseline (p. 228).
Using physical therapy in conjunction with other types of feedback has also been documented. In a 1980 study by Conrad & Bleck, auditory feedback was combined with physical therapy. The authors state, “Muscle response is established by feedback in the auditory modalities so that it can be transferred to proprioceptive control” (p. 716); thus greater control could be attained with auditory input. Eight idiopathic and toe-walkers with CP had shoes fitted with a device that made a buzzing sound each time the heel was depressed. These subjects were able to practice with this system at home and were instructed to do so one hour per day for four months. Results indicated that each child showed increased heel contact following treatment, but stress it is only of use in children without contracture of the gastrocnemius soleus muscle. The authors suggest a longer study period with this technique.

The last and most dramatic option is surgical correction of tendons. In children who have toe-walked for some time, surgery seems to be the last remaining option. In one study, children who showed no improvement in the contractures of the triceps surae muscles underwent surgical lengthening of the Achilles tendon, or heel-cord lengthening surgery. After three years, a follow-up revealed all children walked with a heel-toe gait, and only the older children in this group occasionally walked on their toes (Hall, Salter, & Bhjalla, as cited in Stricker & Angulo, 1998, p. 292).

In a review of treatment options for toe-walking, Stricker & Angulo compared children treated with surgery (either Achilles lengthening or gastrocnemius recession), heel-cord stretching exercises supervised by a physical therapist, and treatment with casts or orthoses. Of the children treated with physical therapy or casts/orthoses, only one-fourth of parents were satisfied with the outcome of the treatments, whereas children who
underwent surgery had parental satisfaction of 66%. While surgery may be the last option for many toe-walkers, results indicate this option maintains the highest satisfaction rate among families (p. 290).

Regardless of which treatment the family chooses, the most important variable in toe-walking treatment seems to be early intervention. According to Burnett & Johnson (1981), children initially make contact with a plane with a flat foot, and the normal heel strike consistently develops as the knee mechanisms of movement mature. In this analysis of gait, heel strike appeared at an average of 22 weeks after independent locomotion was attempted, and in most cases was apparent within 40 weeks (Burnett & Johnson, 1971, p. 214). Sutherland asserts a heel strike should be present at 18 months, (as cited in Sobel, Caselli & Velez, 1997, p. 17) while Statham asserts a normal heel-toe gait pattern should be established and consistent by age two (as cited in Stricker & Angulo, 1998, p. 289) In fact, the subject of study in Barrett & Linn’s research was scheduled for surgery if his toe-walking was not solved by age 12 (p. 14). In addition to the lack of necessary bone formation and muscle length suffering due to toe-walking, Selby reminds his audience “the central nervous system learns what it practices” (Selby, 1988, p. 1921), indicating the great need for early intervention in the remediation of toe-walking.

Music Therapy and Special Needs Children

Music Therapy is often used to assist children with special needs such as autism, Mentally Handicapping Conditions, Specific Learning Disabilities, etc. In Ornitz &
Ritvo’s 1976 study, the authors outline several clinical and behavioral characteristics of autism. The behavioral symptoms of autism can be grouped into five categories:

1. Disturbances of perception, in which the child may lack reaction to sound or visual stimuli, or may be hypersensitive to either;

2. developmental rate, such as a delay in the progression of learning to walk;

3. relating, such as aversion to physical contact or manipulation of objects to create sameness of environment;

4. speech and language, such as echolalia;

5. and motility, as in the case of toe-walking.

Of additional interest to this study is the prevalence of concomitant physical conditions in children with autism including clumsiness, poor muscle tone, hypotonia, and ankle clonus in as many as 40-75% of patients (Goldfarb, Hinton, as cited in Ornitz & Ritvo, 1976, p. 616). All of these physical conditions are often present in children who toe-walk, and as they are also present in children with autism, indicate the need for close observation of gait.

Music therapy has been useful in behavior modification with impaired children. Gunter, Fox McEvoy, Shores & Kenton (1993) applied music to the case of a teenaged boy with autism who often engaged in repetitive, disruptive vocalizations and physical maladaptive behaviors in the classroom and vocational training setting. These researchers used both contingent and non-contingent recorded music for this study. While the non-contingent music reduced unwanted behavior, the number of vocalizations and physical disruptions decreased approximately three times as much when the music
was played contingent upon desired behavior (Gunter, Fox McEvoy, Shores & Kenton, 1993, p. 193).

Contingent music assisted patients with CP in the acquisition of proper head posturing (Wolfe, 1980) and aided in improving the motor skills of severely mentally handicapped children through listening and instrument playing. (Holloway, 1980). Music also assisted in the improved dorsiflexion of the ankle, a spastic gastrocnemius and quadriceps muscle and facilitated monitoring of other muscles as well (Basmajian, 1979).

Ferrari & Harris (1981) compared the reinforcing properties of verbal praise, food, tactile vibration via music, and a strobe-light for children with autism. This study showed some of these children had a significant preference for music, and would perform the required task more often and for longer periods of time for the music reward than other forms of reinforcement (Ferrari & Harris, 1981). Additionally, Kinnealey (1973) found some mentally handicapped children who also met the criteria for autism, many of whom were toe-walkers, were especially sensitive to sensory stimulation. This study was able to elicit significant responses with the sensory stimulation toward which the child was inclined. If children with autism are often toe-walkers and sensory stimulation is speculated to be one of the causes of toe-walking, music may easily be used to modify the behavior when the child prefers it to other forms of reward.

A 1987 study by Thaut compared visual and auditory stimuli in children with autism. Thaut allowed both autistic and typically-developing children to manually choose between music and colored slides of animals by pressing buttons as they wished. Results indicated autistic children have a strong preference for musical stimuli over
visual; the autistic children stayed longer in the music than the visual settings, and they listened to the music significantly longer than did the typically-developing children. The power of music to assist with behavior modification in children is an exciting phenomenon, and can be applied to many different rehabilitation settings.

**Music Therapy and Gait Training**

Locomotion is undoubtedly a rhythmic action, and several authors have studied the effect of rhythmic stimulation on motor movements. Turvey, Schmidt & Rosenblum (1989) examined absolute coordination, or the oscillation of two or more limbs at the same speed. This coordination is essential for many activities, including walking and running. In this study, subjects were asked to swing pendulums from their wrists either together or in an oscillatory fashion. Results indicate subjects experienced variance only when their natural tempo was disturbed, and when the “wrist-pendulum departure from characteristic frequency” occurred, the right and left sides were correlated (p. 8). This indicates that absolute coordination is directed by a synchronized internal clock but can be altered externally.

These data are further supported by a 1982 study by Safranek, Koshland & Raymond which examined the effect of auditory rhythm on muscle activity. This study measured the activity of the biceps muscles when subjects performed a task first in silence, then with an external auditory rhythm being played simultaneously. Results indicated the subjects all found a preferred rate of 2.08 strikes per second both with and without rhythmic intervention. However, in the group exposed to rhythm during the task, biceps activity began before the strike was made. In addition, the muscles co-contracted
with increased duration of muscle activity. The authors theorize that in the second session of this task (the same task but now with added rhythm), the subjects were engaged in learning a new task (p. 165-166). Clinically, this study is applicable in several ways. In designing music therapy activities to assist in a physical therapy session, an added rhythm could produce longer engagement of muscle and decrease variation of muscle activity. Manipulation of the beat could produce muscle activation sooner than the task at the patient’s personal tempo. In this way, addition of rhythm could greatly add to the efficacy of physical therapy.

During which part of the walking phase to impose the external rhythm has also been explored. In a 1995 study, Mauerberg & Adrian imposed an external auditory rhythm during the heel-strike, mid-swing, and toe-off conditions of the walking cycle. Results indicated the natural coupling of the external auditory beat occurred most frequently at the heel-strike phase. Furthermore, their subjects, who were typically-developing university students, were generally unsuccessful in coupling during mid-swing and toe-off portions of the walking cycle. The authors conclude “the success of coupling an external auditory constraint to different parts of a walking cycle depends upon the natural phase coupling. This natural phase is near the heel-strike.” Furthermore, “the sound of the landing may provide another sensory input” (p. 860). If lack of sensory input is suspected, addition of an external auditory rhythm may be of assistance in maintaining a heel-toe gait.

Many studies have been done to examine the effect of auditory stimulation on the brain and its regulation of movement and motor responses. In a 1997 study by Thaut, Rathbun, & Miller, 24 subjects were asked to tap to a rhythm. The subjects were divided
into two groups separated by age. The subjects were asked to tap to a beat first of a metronome, then to a beat embedded in music. The stimulus was presented in different frequencies. Results indicate subjects are able to tap closest to the beat impetus at frequencies at four, two, and one Hz, with accuracy higher at either ends of the spectrum as well. The authors suggest “at medium range frequencies, the musical texture may have provided additional timing information that facilitated tracking, anticipation, and movement synchronization to the beat” (p. 10). However, the authors continue, metronome settings at very fast and very slow frequencies allow for music which may overload the listener, and “reduction of musical texture to enhance the perception of rhythmic structure may lead to better results” (p. 11). As children with autism may experience sensory overload or deprivation, careful manipulation of musical texture when used in physical therapy may aid in efficacy of treatment.

Thaut also published a 1988 paper discussing rhythmic intervention techniques in patients with gross motor dysfunctions. Results show tasks can become automatic when conscious control is decreased if the task is expected via serial ordering. Music provided a predictable, reliable stimulus that could aid in motor responses becoming more like reflexes. As “rhythmic movement involves the synchronous sequencing of any act in a coordinated manner” (p. 127) and rhythm is “recurrence of events in time that constitute the organization of temporal relationships,” (p. 128) music is assistive in translating the auditory into voluntary muscle control, which may then lead to automatized movement.

Thaut goes on to say “auditory presentation mode produces consistently faster reaction times and better response qualities than the visual, tactile, or combined auditory/visual presentations” (p. 129). This is supported by Marteniuk (1976), who
reported unpleasant physical stimuli is perceived *less* than the simultaneous perception of pleasant auditory stimulation. Anshel & Marisi (1978) added that movement synchronized to music lasted even longer than un-synchronized movement to music or in silence. In this way, music assists during the process of unpleasant physical activity by reducing perception of physical fatigue, and can easily be applied during physical therapy sessions during remediation of toe-walking.

Another technique using music therapy to premeditate gait involves the combination of music containing a strong rhythmic sense with gait. In a 1983 study, Staum was able to increase proprioceptive control of walking in hemiparetic patients, as well as patients with spastic, arthritic, and scoliotic conditions. McIntosh, Brown, Rice & Thaut explored this further in a 1997 study with Parkinsonian patients. These authors were able to increase velocity, cadence, and stride length by first measuring the gait of the patients and translating it to a musical tempo, then gradually increasing this tempo by 10% (p. 24).

One must conclude that combining music with physical therapy will aid in efficacy of the physical therapy. Beisman (1967) found combining rhythmic accompaniment allowed faster acquisition of motor skill, as did Couper (1981), who facilitated gains for learning-disabled children in hopping, walking, and jumping by adding music. Music therapy in the physical therapy session would allow for tempo adjustments according to the needs of the patient, and can allow the CNS to practice what it has learned by making audio recordings for practice at home. Additionally, Staum (1983) reminds the reader that children, especially young children, will have limited
tolerance for repeated practice, and may respond only when the practice is made enjoyable.

Music has consistently been shown to assist in the engagement of muscles for longer periods of time, reduce perception of discomfort, and facilitate desired behaviors. Research has proven where the musical impetus should be placed, at what frequency the music is most efficacious, and how thick the musical texture should be. Combining these indications in a physical therapy session in treatment of a child who walks on his/her toes could produce the desired behavior faster and make the activity more enjoyable.

The purpose of this study is to determine the efficacy of contingent music when added to a pre-determined physical therapy session in the treatment of children who toe-walk.
METHOD

Subjects

Subjects in this study were seven children two to six years of age. The children may have been idiopathic toe-walkers or diagnosed with any neurological disorder. All were required to be receiving physical therapy for toe-walking at the time of the study.

Table 1.0 Subjects and their Diagnoses

<table>
<thead>
<tr>
<th>Subject</th>
<th>Age</th>
<th>Gender</th>
<th>Diagnosis</th>
<th>Race</th>
<th>Other Therapies</th>
<th>Days per week in PT</th>
<th>Length of PT Session</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>4</td>
<td>M</td>
<td>Hemiparetic CP</td>
<td>C</td>
<td>Speech, Occupational</td>
<td>2</td>
<td>60 minutes</td>
</tr>
<tr>
<td>B</td>
<td>4</td>
<td>F</td>
<td>Autism</td>
<td>C</td>
<td>Speech, Occupational, Music Therapy</td>
<td>1</td>
<td>30 minutes</td>
</tr>
<tr>
<td>C</td>
<td>3</td>
<td>F</td>
<td>Developmental Delay</td>
<td>AA</td>
<td>Speech</td>
<td>1</td>
<td>30 minutes</td>
</tr>
<tr>
<td>D</td>
<td>4</td>
<td>M</td>
<td>Ataxic CP</td>
<td>C</td>
<td>Speech, Occupational</td>
<td>2</td>
<td>60 minutes</td>
</tr>
<tr>
<td>E</td>
<td>4</td>
<td>M</td>
<td>Angelman’s Syndrome</td>
<td>C</td>
<td>Speech, Occupational, Hippo</td>
<td>2</td>
<td>60 minutes</td>
</tr>
<tr>
<td>F</td>
<td>4</td>
<td>F</td>
<td>Diplegic CP</td>
<td>C</td>
<td>Occupational</td>
<td>2</td>
<td>60 minutes</td>
</tr>
<tr>
<td>G</td>
<td>6</td>
<td>M</td>
<td>Diplegic/Quadriplegic CP</td>
<td>AA</td>
<td>Occupational</td>
<td>2</td>
<td>60 minutes</td>
</tr>
</tbody>
</table>
Materials

Materials included a guitar, rhythm and pitched instruments, original music, and pre-composed children’s music (See Appendix E). No recorded music was used during any of the sessions.

Procedure

This study utilized an ABA_B_ format, and all subjects were their own control. During the A_and B_ sessions, music was contingent upon subject cooperation and non-complaint. Five subjects were seen at private physical therapy clinics, and three were seen at pre-schools with physical therapists on staff. Subjects were videotaped and the tapes later viewed by the researcher; an independent party also reviewed the tapes for reliability purposes.

Data were collected via a form designed by the researcher, and utilized a five second observe/five second record procedure (See Appendix E). During the observation period, the observers noted any heel or toe gait, as well as any exercises facilitating these movements such as stretching. That is, when the child with contracted hamstrings allowed his/her hamstrings to be stretched, the observer recorded this as a heel score. If the child resisted any exercises the physical therapist attempted, a toe gait was recorded. Complaints were also recorded, as was non-cooperation of the child. Periods of time during which no physical therapy was attempted were not recorded. Percentage of each score was attained by dividing the number of each type of score by the number of observation periods.

Each subject’s diagnosis, PT objectives and music treatment process are described individually.
CASE STUDIES

Case Study A

Brandon had just turned four years old at the beginning of the study and had been receiving physical therapy for approximately five months at this particular facility. Brandon had been previously fitted with orthotics to correct his toe-walking, but these orthotics did not fit properly and he was waiting for new ones to be completed. The physical therapist focused on stretching exercises to promote and maintain flexibility as these orthotics were finished. Brandon has hemiparetic cerebral palsy (CP). That is, only the left side of his body is affected by the CP, producing toe-walking in the left foot. Brandon has a pronounced speech impediment, and received physical, occupational, and speech therapy at this clinic.

Brandon’s heel scores included stretching, maintaining balance while kicking the ball, and walking with toes pointing up. Toe scores were recorded if Brandon lost his balance during kicking, refused to stretch or be stretched, or walked on his toes.

Baseline sessions one and two

Each of the sessions consisted of:

1. Passive stretching of the hamstrings, during which Brandon laid on a physical therapy padded table
2. Kicking a soccer ball
3. Active stretching of the gastrocnemius, accomplished by placing Brandon’s affected leg on the floor, with the other leg resting on a stool.

4. Walking with the toes pointed up, also actively stretching the calf muscles.

Brandon complained once during the stretching portion of the first baseline session but was generally cooperative at all times. Much time was wasted during transition, and Brandon often became bored. Also, the physical therapist generally placed toys on the physical therapy mat during the active stretching of the gastrocnemius, and had trouble focusing Brandon’s attention on the toys while simultaneously manipulating the legs for maximum therapeutic benefit. The physical therapist allowed two breaks during the sessions, during which Brandon engaged in free-play. After the sessions, Brandon was tired though not exhausted.

**Music Session One**

In this session, all previous activity was repeated, but with the contingent music condition. During the stretching portion of the session, whether on the mat or standing, Brandon sang along with the music therapy researcher and played instruments, all contingent upon his cooperation. During the portion of the session in which Brandon walked with his toes pointing up, the researcher played guitar and sang a marching song, matching the rhythmic impetus to the child’s heel-strike. This was facilitated by the physical therapist, who guided Brandon from behind and moved to the downbeat of the music. Music was played at all times the child was cooperative, whether engaged in an activity or in transition between activities.
Music Session Two

Brandon was much easier to engage during this session, and was eager to play the instruments provided. During the passive gastrocnemius stretching exercise, the music therapy researcher encouraged Brandon to play a drum with the affected hand, producing multi-limb involvement. The physical therapist did not assist Brandon during the toe-up walking portion of this session; live music was played with the rhythm matching the energy and movements of the child., and the impetus again matched the heel-strike.

Results

![Brandon’s Heel and Toe Scores](image)

Figure 1.0 Brandon’s Heel and Toe Scores
Discussion

Brandon responded well to music as the above graph shows. Toe scores consistently declined while heel scores increased. Complaints were reduced to zero, and non-cooperation scores minimized.

Music proved to be an effective distraction and motivation during these sessions. Brandon voiced no complaints during the music sessions and remained engaged at all times. Brandon cooperated completely during all portions of the music sessions, and his energy level remained high. During the on-table portions of the sessions, the music therapy researcher was able to provide motivation for cooperation for the child via the contingent music while simultaneously allowing the physical therapist to focus on physical manipulation of the legs and musculature. In this way, this shift in focus allowed maximum benefits for both child and physical therapist. Additionally, the two breaks were not needed, as Brandon remained mentally and physically eager. Music allowed more on-task, cooperative behavior during the physical sessions with this child.
Brandon’s high energy level indicates music provided the necessary distraction to endure physical manipulation. Brandon also smiled and laughed much more during the music sessions; it is assumed a more positive view of future physical therapy sessions will make life much easier for parent, child and physical therapist.

**Case Study B**

Cassie was four years old at the time of this study and diagnosed with autism. Cassie received speech therapy, occupational therapy, music therapy for sensory integration, and physical therapy. Conversation with Cassie’s regular music therapist revealed this child would originally only communicate via animal sounds such as barking or meowing, and had a strong passion for animal songs. At the time Cassie’s music therapy treatment began, she displayed antisocial behavior and would only respond to “Twinkle, Twinkle Little Star,” when played repetitively on the glockenspiel. Cassie had both good and bad days. On good days she was very communicative and would even appear as typically-developing; her speech was clear and sentences well-formed, with no tactile defensiveness displayed. On bad days she would revert to animal sounds, allow no one but her mother near her, shake her head repetitively, and cry violently. Cassie wore Ankle Foot Orthoses (AFO) to stabilize her ankles, but these did not correct her toe-walking. Cassie was able to climb stairs, but ascending, would place both feet on each new stair before moving on. Descending, Cassie was able to place one foot per step.

Cassie’s received a heel score if she climbed stairs while maintaining balance and a heel-toe gait, and if she actively stretched or allowed her hamstrings to be stretched
passively. Toe scores were received if she toe-walked, refused to be stretched, or lost her balance while manipulating the stairs.

**Baseline sessions one and two**

Each of Cassie’s baseline sessions consisted of:

1. Climbing stairs, both ascending and descending. Colored stars were placed on the left and right side of these stairs, and the child climbed them according to the color as directed by the PT. This took place at the beginning and end of each session

2. Passive and active stretching of the gastrocnemius and hamstring muscles

3. Active stretching of the hamstrings.

As Cassie is a child with autism, transition often took time. That is, when the music therapy researcher engaged Cassie in an activity to distract her during which the PT stretched her, time had to be taken to wrap up the activity before moving on to a different portion of the session. Cassie was also intent on creating sameness in her environment, and displayed this tendency by grouping toys by color, one color at a time. While Cassie was very cooperative during the baseline session, she did complain that the PT was hurting her leg during the stretching portion. Additionally, Cassie was hesitant to climb the stairs, and the PT reminded her on which star to place her foot with every step.

Cassie’s PT documented her ankle would only go to the neutral position; that is, the muscles surrounding her ankle were so tight the foot could not move up more than 90 degrees.
Music Session One

Cassie was very excited to see the researcher’s guitar and engaged immediately in the greeting song. Cassie participated fully in all activities, and was able to tolerate the multi-sensory stimulation of simultaneous music and physical therapy. The first portion of the session consisted of the stair exercise. While Cassie agreed to participate, she was uncomfortable and held the hand of the physical therapist; Cassie did not engage in this exercise for very long. During the hamstring stretching, instruments were placed in front of Cassie, and she was instructed via music to reach for specific ones. She did so willingly, and reached forward quite far, engaging the hamstrings in a deep stretch. Cassie remained on-task and very communicative throughout this session. The most notably different part of this session occurred during the second stair-stepping exercise. During this time, the music therapy researcher played a stepping song and included Cassie’s name in the action. Cassie did not need foot placement directions at all, and engaged in this activity much longer than without music. In fact, the researcher observed Cassie smiling when her name was mentioned. The PT commented after this session that she was able to flex Cassie’s ankle in a way she would usually not tolerate, and that Cassie engaged in stair-stepping for a much longer time than without music.

Music Session Two

Cassie was removed from her mainstream classroom for physical therapy. When Cassie was approached for PT time, she was sitting in circle time with her best friend. Cassie wanted her friend to come along, but her friend remained in the classroom. Unfortunately, this led to a difficult session for Cassie in which she participated reluctantly and minimally. Cassie was difficult to engage, but did not complain during
any of the procedures. Additionally, due to room setup, Cassie was positioned directly in front of a mirror, and she could not be repositioned. This contributed to distraction and an unwillingness to participate with the music therapy researcher. As with the first music session, Cassie was able to climb and descend stairs without foot placement prompt from the physical therapist due to music contingency.

Results

![Cassie's Heel and Toe Scores](image1)

**Figure 2.0 Cassie’s Heel and Toe Scores**

![Cassie’s Non-Cooperation and Complaint Scores](image2)

**Figure 2.1 Cassie’s Non-Cooperation and Complaint Scores**
Discussion

Cassie responded well to music as the graph above indicates. Complaints and non-cooperation scores decreased to zero in the first music session; in the second music session, there were no complaints recorded, and non-cooperation scores dropped as well. Heel scores consistently rose with music, while toe scores declined.

Music seemed to be an effective motivator for Cassie. As Cassie is a child with autism, her mood is unpredictable. In her private music therapy sessions, her music therapist is able to gradually layer sound and stimuli until Cassie engages in music. In this setting, however, time did not allow for coaxing Cassie into fully engaging with the music therapist researcher. Additionally, Cassie had only been seeing this physical therapist for the length of this study. Individuals with autism traditionally cling to routine, and two music sessions may not have adequately allowed for this child to establish a dependable routine, especially if the two music sessions are interrupted by a return to baseline conditions.

Overall, Cassie is an excellent candidate for music with physical therapy, as it did not appear to overstimulate her and provided adequate distraction from physical discomfort and appropriate reward for cooperation.

Case Study C

Diane was four months shy of four years old at the time of this study. She had been receiving PT for eight months, and had a familial history of toe-walking. Diane has a slight developmental delay. Diane has a pronounced speech impediment, and while she
chatted easily and almost constantly through the baseline session, almost all was unintelligible. Diane receives speech therapy and physical therapy at a state-supported, inclusive pre-school.

Diane received heel scores if she engaged in active stretching or allowed herself to be stretched passively. Toe scores were recorded if she refused either or compensated with other muscles to avoid activating her hamstrings or gastrocnemius.

**Baseline sessions**

Diane’s physical therapy sessions without music consisted of:

1. Both active and passive stretching of the hamstrings
2. Passive stretching of the gastrocnemius.

Diane’s passive stretches took place with her on the floor, toys placed in front of her splayed legs. The stretches became active as the PT encouraged Diane to reach forward and place objects in specific containers. The PT reported Diane would often respond to this directive by saying, “I can’t.” Only when the objects were moved close enough to reach without engaging in an active stretch would Diane complete the task.

**Music Session One**

Diane was slow to engage in music during the first portion of this session, and her PT reported she is also suddenly quiet during her turn in circle time. However, Diane gradually became more responsive, and was soon fully engaged with the music therapy researcher. She participated fully and responded to the researcher’s musical directions while remaining aware of the manipulations of her feet and legs. She did not protest or refuse to cooperate.
During the portion of the session in which Diane would normally be instructed to reach and grasp an object, actively stretching the hamstrings, the music therapy researcher inserted similar instructions into a song, and Diane responded appropriately. She did not say “I can’t” at all during this activity.

Music Session Two

Diane was “in a mood” this day, as described by her classroom teacher and PT. She was difficult to engage, and wanted to complete the standard PT routine more than she wished to participate with the music therapy researcher. The researcher was able to engage her somewhat, but she remained sullen throughout the first portion of this session. The researcher used strategically placed instruments in order to facilitate stretching of the hamstrings. Diane was instructed to reach for and grasp the shakers, which she did without complaint. She then continued to play them in all the places she was instructed, such as above her head, next to her toes, etc., stretching all muscles the PT wished to activate. The music therapy researcher stopped the music approximately three-fourths through the session, as Diane became distracted.
Discussion

Diane responded well to music during PT. Diane’s classroom teacher reports she will often become immediately quiet during her turn to speak in their circle.

While she did display some shy behavior and was sometimes slow to engage, she became
active and participatory in each music session. Even when this behavior was present, however, heel scores continued to increase, toe scores decrease, and both non-cooperation scores and complaints remained low. The introduction of music would allow her to work on communication skills while simultaneously distracting and rewarding appropriate behavior.

**Case Study D**

Edward was four years old at the time of this study, and received physical therapy twice per week. He had been receiving physical therapy for two and a half years and also received separate occupational and speech therapy. Edward has Ataxic CP, affecting his entire body. He had been fitted with Ankle Foot Orthoses (AFO’s) and had a walker. Though Edward did not walk on his toes when wearing his AFO’s, he would immediately revert to toe-walking when they were removed. Edward has poor trunk strength, flexibility and mobility.

Edward’s scores were recorded as heel when he allowed himself to be stretched, walked on the treadmill without throwing his feet and while taking small, balanced, controlled steps. Additional heel scores were recorded if he maintained balance during stand-to-sit exercises. Toe scores were recorded if at any time Edward toe-walked, lost his balance, did not engage in stretching, or walked on the treadmill with uncontrolled steps.

**Baseline sessions one and two**

Edward’s baseline sessions consisted of:
1. Passive stretching of the gastrocnemius

2. Walking on a treadmill, approximately _ mile

3. Stand-to-sit exercises, focusing on shifting the weight from back to front, then standing safely losing balance.

Edward had great difficulty during the stand-to-sit exercises, and would fall most of the time when attempting to perform this activity. In addition to increased functionality, the stand-to-sit exercises promoted trunk control and strength.

Edward’s treadmill walking was usually the most stressful part of the sessions for both patient and PT. Edward would often lose interest in this activity and begin to pay less attention to his movements. This would produce poor locus of control in the head and trunk, and often his feet would “get away from him”. This resulted in Edward being supported by the physical therapist, who maintained close proximity at all times. In fact, he would often end up in a prone position, with his feet elevated by the PT in an effort to keep him from falling. Edward tried his PT’s patience, resulting in frustration on both behalves, and decreasing the efficacy of the treadmill exercise. Edward’s PT assured the music therapy researcher behavior was his most consistent obstacle to a healthier gait.

Music Session One

A task-analysis was performed for Edward’s stand-to-sit exercise, and an original song composed to assist him in learning to stand from this seated position. During Edward’s stand-to-sit exercises, instruments were strategically placed, requiring Edward to reach for them by standing, then slowly sit down with the instrument in hand.

During the walking portion, the music researcher played music of a march-like feel, and matched the tempo to that set by the PT for Edward’s heel-strike impetus. Live
music was crucial during this session. The music therapy researcher had to make tempo adjustments as the PT adjusted the speed of Edward’s gait. The addition of music engaged Edward, and the PT had to redirect him much less frequently. He remained cooperative throughout the entire treadmill exercise.

Music Session Two

The music therapy researcher again matched the tempo of live music to the gait determined by the PT. Edward was able to participate both in the music and treadmill exercise, and the number of prompts and/or redirection was given by the PT was greatly reduced.

During this session, Edward practiced walking with the aid of parallel bars approximately three feet in height. These were placed on either side of the child, and Edward was instructed to walk both forward and backward. Edward’s PT instructed him to take small, controlled steps, and the music therapy researcher played music of slow tempo and soft dynamic level.

The stand-to-sit exercises utilized music via rhythm instruments. Edward was instructed to reach up for the instrument, and when he stood to retrieve it successfully, a song was played as reward and Edward accompanied with the instrument.
Results

Figure 4.0 Edward’s Heel and Toe Scores Per Session

Figure 4.1 Edward’s Non-Cooperation and Complaint Scores Per Session

Discussion

The above graph shows the efficacy of added music during Edward’s PT routine. While the number of heel scores rose during both music sessions, the number of toe scores decreased in each as well. Additionally, Edward’s complaints and non-cooperation scores were greatly reduced. In the first music session alone, Edward’s non-
cooperation scores dropped from 2.35% to zero, and his complaints dropped from 7.64% to 1.87%.

Music proved to be an excellent contingency for Edward. When the PT told Edward he must cooperate or the music therapy researcher must leave the room, he did so immediately. Edward maintained cooperation during the treadmill sessions, and the rhythm instruments proved to be an adequate, desirable stimulus for Edward to perform the activity in a controlled manner. Edward was consistently able to maintain tempo and walk with the researcher’s rhythm. Edward’s PT reported to the researcher that his body responded quite well to the music by relaxing when appropriate and performing in sync with the music as well. In addition, the music did not distract him, and he was able to concentrate both on his movements while participating with the music therapy researcher.

**Case Study E**

Francis was four years old at the time of this study, and had been diagnosed with Angelman’s Syndrome at age three and a half. This syndrome is a genetic disorder, and has often been confused with autism. The symptoms consistently include movement or balance disturbance, functionally severe developmental delay, and speech disorder. Speech may be delayed or non-existent, but receptive language is more developed than communicative language. The child with Angelman’s Syndrome maintains a happy demeanor nearly all the time, and smiles and laughs almost constantly. In addition, symptoms may include drooling, wide mouth and spaces in between the teeth, heat sensitivity, fascination with water, and occipital abnormalities. The child with Angelman’s Syndrome often has light hair and eyes, regardless of familial traits.
Francis has a flat occiput, wide mouth, and widely spaced teeth. Francis demonstrated he understood commands, but was only able to say “Mama,” and then only randomly. While Francis was unable to effectively verbalize, he often showed comprehension, such as placing his arms in front of the PT in order to prevent her from stretching his hamstrings. This was scored as non-cooperation, as was the time during walking portions when Francis rested with his parent.

Francis received a heel score if he walked with a heel-toe gait, allowed himself to be stretched, and maintained balance. Toe scores were recorded if he pulled away during stretching, lost his balance as he performed the stand-to-sit exercises, or walked on his toes.

**Baseline sessions one and two**

Francis’ PT without music consisted of:

1. Passive stretching of the hamstrings
2. Passive stretching of the gastrocnemius
3. Stand-to-sit exercises
4. Walking from PT to parent with assistance.

Francis had been fitted with AFO’s, and wore them at all times. During the walking portion of the session, the PT would first assist Francis with stand-to-sit exercises, verbally cuing him to sit as she pressed down on Francis’ hips. She would then aid him in walking to his parent by providing posterior support. The PT would release Francis about five feet from his mother, whereupon Francis would attempt to walk unaided; however, Francis would usually simply fall toward the outstretched arms of his parent.
PT was usually difficult for Francis as he would constantly cry and often scream during the hamstring stretches. His PT felt the stretches were not painful, but that Francis had sensory input issues and simply did not want to be touched in this way. Francis demonstrated some receptive language skills, and would often stand before the verbal prompt. However, he showed a consistent unwillingness to walk unassisted.

**Music Session One**

Francis responded well to music during the stretching portion of this session. The PT reported she was able to stretch him longer and with much less protest than without music.

During the walking portion of the session, the music therapy researcher attempted to provide a conditioned response using paired association. As the PT commanded Francis to sit, one song was played, another during the stand portion, and yet another still during the walking portion. Francis began to respond to the appropriate music as the researcher played it, without having been cued by his PT. During this portion of the session, Francis’ PT allowed him much less “rest time” with his mother.

**Music Session Two**

During the walking portion of this session, Francis was placed on a treadmill. He babbled and complained significantly less with the music. In addition, the music therapy researcher was able to match tempo to Francis’ gait, providing him with motivation and music as a reward.

The stretching was similarly successful with Francis engaging in playing the rhythm instruments for a significant amount of time. Francis’ mother reports he is unwilling to hold objects for longer than a few seconds, yet he showed interest in the
rhythm instruments, and wanted to both hold and play them. He responded to the music therapy researcher by playing when directed. In fact, Francis even touched the researcher’s guitar and strummed the strings, amazing both his mother and PT.

Results

Figure 5.0  Francis’ Heel and Toe Scores

Figure 5.1  Francis’ Non-Cooperation and Complaint Scores
Discussion

The graph above indicates a clear reduction in Francis’ complaints, with each music session reducing complaints by half from the previous baseline session. Toe scores also decreased during each music session. The only anomaly appears to be the non-cooperation score in the last music session, and even then the numbers rose only slightly. When Francis was allowed less rest time, complaints were still decreased.

Francis was significantly distracted by music during his PT sessions. During the treadmill portion especially, music was stopped during his complaint, and he immediately became quiet. Stretching with music was equally successful, allowing the PT a fuller stretch while decreasing anxiety on the parts of patient, parent, and PT. Additionally, this part of the session allowed for vestibular stimulation via the rhythm instruments (a possible link to sensory defensiveness) while remediating Francis’ toe-walking.

Case Study F

Gretchen was four years old at the time of this study, and had been diagnosed with diplegic spastic CP; she also wore AFO’s, and walked with an assistive cane. Gretchen also received both occupational and aquatic (Hippo) physical therapy.

Gretchen received a heel score if she allowed herself to be stretched and maintained balance during activities. Toe scores were recorded if she pulled away during stretching, lost her balance during an activity, or walked on her toes.
Baseline sessions

Gretchen’s PT routine without music consisted of:

1. Passive hamstring stretches
2. Seated balance activities on a therapy ball
3. Activities designed to practice bending over from a standing position, actively stretching both the hamstrings and gastrocnemius muscles
4. Walking unassisted, either in combination with another activity or on the treadmill.

While Gretchen was a very agreeable child, she complained during the hamstring stretches. Her face was tense, her speech forced, high-pitched, and strained. Gretchen and her PT would engage in a counting game to occupy time during this stretch, and the stretching was complete when they counted to 20. While this game distracted her, she would often count in a whine and cry in between numbers.

Gretchen was an energetic and curious child, and much time was wasted during redirection and allowing Gretchen play time during activities. Additionally, Gretchen was very aware she was entertaining, and would often entertain the entire room, distracting from others’ PT as well as her own.

Music Session One

Gretchen was very excited about music, and engaged easily during the stretching portion of the music. She did not complain or cry during the first part of her stretch, and responded to the musical instructions appropriately. However, she then requested a song of a fast tempo, and this song provided too much stimulation. She began to cry and say she did not want music. When her PT pressed Gretchen to clarify, she responded she did
not want to be stretched, but then counted with musical accompaniment until the end of the routine. She recovered easily and was eager to go on to the next portion of her session.

Rhythm instruments were placed on the floor in different locations, and Gretchen was instructed to walk to the instruments, bend to retrieve them, return to an upright position, then walk back to the designated area. A song was then played with the instrument she had retrieved. This proved to be an effective motivator, and Gretchen was so curious about the song the instrument had in store that she was much more on task during this activity than the baseline sessions, in which toys were used. It was not necessary to remove the music at all during this time.

**Music Session Two**

During the stretching portion of this session, Gretchen did not cry at all. She remained engaged in the music but aware of the stretches, and responded appropriately to the researcher’s musical instructions. While Gretchen would become more aware of the manipulations during transition between songs, she was able to fully engage in the new song. She did not count at all this day during stretching, and was in fact surprised when her PT told her she was finished stretching both legs.

Gretchen walked on the treadmill during this session, and was very successful. The researcher was able to match Gretchen’s heel-strike tempo with guitar and singing, and she participated fully in the music during this time. She walked a significant amount of time, and her PT reported she usually was unwilling to walk such a long distance on the treadmill. Gretchen’s mood remained positive, and she did not tire until the treadmill
was stopped and she was allowed to rest. Again, she seemed surprised the activity was complete.

Results

Figure 6.0  Gretchen’s Heel and Toe Scores

Figure 6.1  Gretchen’s Non-Cooperation and Complaint Scores
Discussion

As the above graph indicates, music allowed Gretchen’s heel scores to increase, while her toe scores simultaneously declined. The most significant difference in sessions, however, was during the stretching portion. Without music, Gretchen cried, complained, and squirmed during stretching; with the addition of music, she was music calmer. While she occasionally complained during this portion, the number of complaints dramatically dropped. Between the first non-music and music sessions, Gretchen’s non-cooperation scores dropped during each music session as well. Gretchen’s decreased non-cooperation meant less redirection from her PT. In addition, Gretchen’s PT was more relaxed without her complaints, and the overall mood of the sessions with music was consistently pleasant.

Music proved to be an effective motivator and reinforcer for Gretchen. Music allowed her to be stretched with little or no complaint, and facilitated a longer period of walking on the treadmill. In addition, it prevented her from stalling her PT by entertaining, as she was motivated to continue the music. This allowed for more physical therapy exercises during her session.

Case study G

Harry was a six-year-old energetic child with severe diplegic spastic CP, and could be classified as severe quadriplegic spastic CP as well. According to his PT, Harry sometimes had control over all his limbs, and sometimes had control over only his arms. He had been receiving PT almost his entire life, beginning at two and a half months of age. Harry had undergone surgery to release his adductors and heel-cords approximately
six months ago, and had only recently begun to ambulate with the assistance of a walker. Harry faced forward in a walker, which had a back brace allowing him to maintain an upright position, and ankle straps to control the spastic scissoring of the ankles. Turning the walker was Harry’s biggest challenge, as he did not yet have the motor control or physical strength necessary to turn it.

Heel scores were recorded for Harry if he allowed himself to be stretched and walked in a controlled manner in his walker. Toe scores were recorded if he was unable to begin walking, required assistance walking, or walked on his toes.

Baseline sessions

Harry’s non-music physical therapy sessions consisted of:

1. Passive stretching of the hamstrings
2. Ambulation in the walker with instruction from the PT.

Music Session One

Harry arrived at the clinic with his mother and younger brother. Harry had requested music by a popular female artist, and the music therapy researcher instructed Harry’s mother in tambourine playing to the impetus of the song Harry requested. Unfortunately, Harry’s mother allowed his brother to use the tambourine, and the child was unable to maintain a consistent rhythm. Harry’s brother also played with toys that made a significant amount of noise during the session. This combined with the presence of another physical therapist observing Harry’s session proved to be overstimulating for him. While he was excited to engage in the music, cooperated fully and smiled a great deal, he was often unable to respond to simple commands given by his physical therapist. While the music therapy researcher attempted softer, more calming music it was drowned
out by the conversation of others in the room. Harry’s physical therapist reported his tone increased during this music session, but she did not want to stop the music because Harry was so enjoying the session.

**Music Session Two**

Before this session began, Harry’s family was asked to wait outside the PT room. This allowed them to hear Harry, but eliminated the distraction of his younger brother.

Stretching proved easy for Harry, and he enjoyed participating in the music that accompanied it. After this was complete, Harry was instructed to crawl to a bench and climb upon it. From this seated position he was to remain as upright as possible and stand upon the PT’s instruction. The music therapy researcher played music with cues the PT used to remind Harry to sit up as straight as possible, and to remain upright once he was standing. Harry consistently corrected his posture when cued by the music therapy researcher.

Using the walker was also enjoyable for Harry. He was often able to maintain heel-strike tempo with the researcher, and the PT assisted by clapping with the beats. However, if Harry stopped at any time during his walk, he would become distracted. Harry was also distracted during this portion because he would stop walking to sing along with the music.

One of Harry’s major issues in using the walker was in planning when to turn. That is, he would often come to the end of the hallway or room, have forgotten to begin turning, and be unable to reverse the walker. During this session, the music therapy researcher instructed Harry to begin turning when he heard specific music, and he was able to do so. This allowed Harry to receive a non-verbal cue, then successfully plan
when and how to turn on his own. Harry almost ran in his walker during this session, and walked for a long period of time. The end of this session showed Harry to be tired, and he did not want any more music. Harry’s PT reported when he tires he often refuses to participate at all.

Results

Figure 7.0 Harry’s Heel and Toe Scores

Figure 7.1 Harry’s Non-Cooperation and Complaint Scores
Discussion

Harry loved music, and the addition of it to his PT session seemed to be enjoyable. Music assisted him in training his legs to move as he wished, and provided an effective cue to plan his movements. However, he was easily overstimulated. Harry responded best when either music or his family was present, but both proved to be too much. If music is to be used with Harry in future PT sessions, it should accompany only certain portions of the session to avoid overstimulation and quick fatigue.
RESULTS

The effect of music with physical therapy in children who toe-walk was assessed in this study. All seven subjects participated in an ABA_B_ design, with A=Baseline (Physical Therapy alone) and B=Contingent Music with Physical Therapy. Each child received music only when they were cooperative and not complaining. Data were collected from videotapes made during each session using a five-second observe, five-second record format. Within each period, a child could have a heel, toe, non-cooperation, and complaint score, or any combination of the four. Reliability was computed with the assistance of a Graduate Music Therapy student who viewed 25% of the videotapes independently. A reliability of 92% was achieved.

A one-way analysis of variance (ANOVA) was performed on the heel, toe, non-cooperation, and complaint scores taken from the videotapes to determined whether significant differences existed in any of these categories during baseline and music treatments.

Table 2.0  Summary of One-Way Analysis of Variance Test on Heel Scores

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between</td>
<td>1647.76</td>
<td>3</td>
<td>549.25</td>
<td>10.17</td>
<td>0.000383</td>
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<tr>
<td>Within</td>
<td>972.24</td>
<td>18</td>
<td>54.01</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td>SS/Bl</td>
<td>820.27</td>
<td>6</td>
<td>/</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td>Total</td>
<td>3440.27</td>
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</table>
A significant difference was found, with $P<.05$. A Tukey HSD Test was performed on this data to determine where differences occurred. This test compared the mean of each sample to each other. Significant differences of $P<.01$ occurred in heel scores between the first baseline and first music sessions, first baseline and last music sessions, return to baseline and first music sessions, and return to baseline and second music sessions.

Table 2.1  Mean of Heel Scores

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>Music</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1</td>
<td>79.23</td>
<td>94.85</td>
</tr>
<tr>
<td>B3</td>
<td>79.48</td>
<td>94.54</td>
</tr>
</tbody>
</table>

Table 2.2  Summary of Tukey HSD Test on Heel Score Data

<table>
<thead>
<tr>
<th>Mean of Session</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1 vs. M2</td>
<td>$P&lt;.01$</td>
</tr>
<tr>
<td>B1 vs. B3</td>
<td>Not significant</td>
</tr>
<tr>
<td>B1 vs. M4</td>
<td>$P&lt;.01$</td>
</tr>
<tr>
<td>M2 vs. B3</td>
<td>$P&lt;.01$</td>
</tr>
<tr>
<td>M2 vs. M4</td>
<td>Not significant</td>
</tr>
<tr>
<td>M2 vs. M4</td>
<td>$P&lt;.01$</td>
</tr>
</tbody>
</table>

B1=Mean of Baseline Session 1   M2=Mean of Music Session 2

Table 2.3  Summary of One-Way Analysis of Variance Test on Toe Scores

<table>
<thead>
<tr>
<th>Source</th>
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<th>MS</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
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<td>Between</td>
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<td>942.93</td>
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<td>Within</td>
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<td>18</td>
<td>82.42</td>
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<td>SS/Bl</td>
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<td></td>
<td>766.49</td>
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<td>/</td>
<td>/</td>
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</tr>
<tr>
<td>Total</td>
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<td>27</td>
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</tbody>
</table>
This ANOVA revealed a significant difference in the number of toe scores between baseline and music sessions. Significant differences of $P < .01$ were found between the first baseline and first music sessions, first music and return to baseline, and between the first and second music sessions. A significance of $P < .05$ was found between the first baseline and second music sessions.

Table 2.4  Mean of Toe Scores

<table>
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<tr>
<th>Baseline</th>
<th>Music</th>
<th>Baseline</th>
<th>Music</th>
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</thead>
<tbody>
<tr>
<td>35.37</td>
<td>14.13</td>
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<td>18.63</td>
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</table>

Table 2.5  Summary of Tukey HSD Test on Toe Score Data

<table>
<thead>
<tr>
<th>Mean of Session</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1 vs. M2</td>
<td>$P &lt; .01$</td>
</tr>
<tr>
<td>B1 vs. B3</td>
<td>Not significant</td>
</tr>
<tr>
<td>B1 vs. M4</td>
<td>$P &lt; .05$</td>
</tr>
<tr>
<td>M2 vs. B3</td>
<td>$P &lt; .01$</td>
</tr>
<tr>
<td>M2 vs. M4</td>
<td>Not significant</td>
</tr>
<tr>
<td>M2 vs. M4</td>
<td>$P &lt; .01$</td>
</tr>
</tbody>
</table>

B1=Mean of Baseline Session 1  M2=Mean of Music Session 2

Table 2.6  Summary of One-Way Analysis of Variance Test on Non-Cooperation Scores

<table>
<thead>
<tr>
<th>Source</th>
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<th>df</th>
<th>MS</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
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<td>Within</td>
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<td>/</td>
</tr>
<tr>
<td>SS/Bl</td>
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<td>/</td>
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</tr>
</tbody>
</table>

Total 1982.14  27

This ANOVA showed no significant difference among complaint scores between baseline and music sessions.
Table 2.7  Summary of One-Way Analysis of Variance Test on Complaint Scores

<table>
<thead>
<tr>
<th>Source</th>
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<th>df</th>
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<th>F</th>
<th>P</th>
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</thead>
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<td>Within</td>
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<td>SS/Bl</td>
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<td>6</td>
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<td>/</td>
<td>/</td>
</tr>
<tr>
<td>Total</td>
<td>2276.49</td>
<td>27</td>
<td>/</td>
<td>/</td>
<td>/</td>
</tr>
</tbody>
</table>

This ANOVA showed no significant difference among complaint scores between baseline and music sessions.
DISCUSSION

Results of this study showed a significant difference in the amount of stretching muscles required to walk on the heels or number of times the heel actually struck the ground during locomotion in PT sessions with live music. The children involved in this study were aged two to six, and received physical therapy specifically for the remediation of toe-walking. This PT treatment may have involved stretching, strengthening, and/or actual locomotion during the session. Diagnoses of participants varied, but included CP, developmental delay, autism, and Angelman’s Syndrome.

Music was added to each session contingent upon the child’s cooperation and non-complaint. When the child cried or complained, the music was immediately stopped until s/he was quiet again, and then the music quickly resumed. This was also true if the child refused to cooperate in ways such as pulling the foot away from the PT, refusing to walk as instructed, or not following instructions.

While statistical analysis revealed only significant differences in heel and toe scores between baseline and music sessions, the overall mood of the music sessions was quite different from those without. All parents were eager to have music in their child’s session, and the children were interested and excited to see musical instruments. Without fail, all children participated in singing and playing rhythm instruments. Only one session was stopped completely because the child was distracted by the music, and this only had to be done in the last quarter of the session.
Several factors among the children may have contributed to their diverse reactions to music. The first of these is musical exposure. The child who most responded to music during PT had parents who played music in the home almost all the time, and one parent was in a band who rehearsed and performed regularly. Another child knew many of the folk songs most children do not know because his mother sang them to him as they drove to his many doctor and therapy appointments. This child would often stop walking to sing along with the music therapy researcher.

The second variable possibly influencing reaction to music is functional level. For example, the children with autism and developmental delay did not engage as easily during new music. However, children with no known developmental delay were excited to hear new music, and remained interested and on-task until the conclusion of the song.

Additionally, the great amount of attrition in this study must be noted. Prior to beginning research, a survey of the community was conducted to determine the number of available subjects. Over ten were found. When research began, however, many of the music therapy researcher’s phone calls were unreturned, and two children had developed severe medical problems, rendering them unable to participate in PT. Additionally, one child canceled PT three times sequentially, with as little as 30 minutes’ notice each time. Unfortunately, from the sessions he did complete, this child seemed to benefit significantly from added music during PT. Another child completed three of the four sessions, but developed a seizure disorder after the third. As this child began new medications requiring constant adjustment, he no longer attended the preschool providing PT, and was unable to complete the study.
While music with PT and music with children have both been documented, music with children receiving PT has not been as thoroughly explored. However, the above-mentioned attrition factors must be taken into account. While the need for further research is indicated by the positive results of this study, this research would most effectively be conducted at a facility with a large number of children who toe-walk. Additionally, while each child may have made considerable changes between baseline and music sessions, statistical tests are invalid with such small groups. Graphs, therefore, are the only way to show the differences among individual patients.

Music combined with physical therapy appears to be an effective combination in terms of meeting the physiological and psychological needs of the patient. The positive results of this study indicate a need for further research.
APPENDIX A

FSU HUMAN SUBJECTS COMMITTEE APPROVAL LETTER

Florida State University
Office of the Vice President for Research
Tallahassee, Florida 32306-2763
(850) 644-3260 • FAX (850) 644-4392

APPROVAL MEMORANDUM
from the Human Subjects Committee

Date: June 24, 2002
From: David Quadagno, Chair
To: Penny Roberts
Dept: Music Therapy
Re: Use of Human subjects in Research
Project entitled: The Effect of Contingent Music with Physical Therapy on Children Who Toe-Walk

The forms that you submitted to this office in regard to the use of human subjects in the proposal referenced above have been reviewed by the Human Subjects Committee at its meeting on June 13, 2002. Your project was approved by the Committee.

The Human Subjects Committee has not evaluated your proposal for scientific merit, except to weigh the risk to the human participants and the aspects of the proposal related to potential risk and benefit. This approval does not replace any departmental or other approvals which may be required.

If the project has not been completed by June 12, 2003, you must request renewed approval for continuation of the project.

You are advised that any change in protocol in this project must be approved by resubmission of the project to the Committee for approval. Also, the principal investigator must promptly report, in writing, any unexpected problems causing risks to research subjects or others.

By copy of this memorandum, the chairman of your department and/or your major professor is reminded that he/she is responsible for being informed concerning research projects involving human subjects in the department, and should review protocols of such investigations as often as needed to insure that the project is being conducted in compliance with our institution and with DHHS regulations.

This institution has an Assurance on file with the Office for Protection from Research Risks. The Assurance Number is IRB00000446.

APPLICATION NO. 02.309
cc: Jayne Standley, Ph.D
Dear Parent:

I am a graduate student under the direction of Professor Jayne Standley, Ph.D., in the Department of Music Therapy at Florida State University. I am conducting a research study to determine the efficacy of pairing music with physical therapy in the treatment of toe-walking.

Your child’s participation will involve his/her normally scheduled physical therapy session, with added music. Both the researcher and the physical therapist will be present, with the physical therapist directing activity. Your child will be asked to perform the exercises previously prescribed by the physical therapist, first without music, and then with your child’s preferred music. This will take place two times, with two additional sessions without music. Videotapes will be made of each session, and viewed only by the researcher and independent party. These videotapes will be analyzed, and destroyed on or before December 31, 2004.

Your participation, as well as that of your child, in this study is voluntary. If you or your child choose not to participate or to withdraw from the study at any time, there will be no penalty, and it will not affect your child’s treatment. The results of the research may be published, but your child’s name will not be used.

Although there may be no direct benefit to your child, the possible benefit of your child’s participation is increased effectiveness of physical therapy sessions.

If you have any questions concerning this study or your child’s participation in the study, please call me at 850-322-3139, or e-mail me at toewalking@hotmail.com.

Sincerely,

Penny Roberts

_______________________________________________________________________

I give consent for my child ______________________________________ to participate in the above study, and be videotaped.

Parent’s Name:____________________________________________________
Parent’s Signature:______________________________________ Date:_____________

If you have any questions about your rights as a subject/participant in this research, or if you feel you have been placed at risk, you can contact the Chair of the Human Subjects Committee, Institutional Review Board, through the Vice President for the Office of Research at (850) 644-8633. You may also contact my professor, Jayne Standley, at (850) 644-4565.
APPENDIX C

DEMOGRAPHIC INFORMATION FORM

Subject:______________________________________________________________

Facility location/Physical Therapist:______________________________________

Confidentiality Number:__________________________________________________

Age:______________

Sex:______________

DOB:___________

Race:___________

Number of months in physical therapy:_______________________________

Sessions per week/month:_____________________________________________

Referred by:___________________________________________________________

Age physical therapy began:_____________________________________________

Additional Comments:
APPENDIX D

SONGS USED

Songs included but were not limited to:

You are My Sunshine  Winnie the Pooh
The Ants Go Marching  Three Little Birds
Hello, Everyone  Wherever, Whenever
Goodnight, Sweetheart  Get the Party Started
The Exercise Song  Yellow Submarine
Roll the ball  Stars and Stripes
Twinkle, Twinkle  Turn, Turn, Turn
The Bear Went Over the Mountain  Get this started
Old McDonald  Wherever, Whenever
If You’re Happy and You Know It  Are you ready?
Shake My Sillies Out  When you Wish Upon a Star
Shake, Rattle & Roll
The Bumble Bee Song
Six Little Ducks
Five Green & Speckled Frogs
Under the Sea
Kick that Ball!
So long, Farewell
APPENDIX E

DATA COLLECTION FORM

Pt. Id ___________
Session #________
Observer________

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<th>NC</th>
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APPENDIX F

RAW DATA

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REFERENCES


BIOGRAPHICAL SKETCH

Name: Penny A. Roberts

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