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ABSTRACT

Two techniques to normalize muscle tone were evaluated with nine infants and young children with cerebral palsy who were enrolled in the Rural Infant Stimulation Environment (RISE) Program, near Tuscaloosa, Alabama. Electromyography (EMG) and skin temperature data were used to assess the effects of trunk rotation and slow rolling on a ball. EMG effects on muscle relaxation/contraction and thermal information collected by sensors were analyzed. Ss were treated twice a week for 6 weeks. Results indicated that changes in muscle tone, due to either trunk rotation or slow rolling, could be measured through use of EMG. The change was statistically significant when measured just prior to intervention and immediately thereafter. No significant difference was found on skin temperature readings. EMG did not discriminate between the effects of trunk rotation or slow rolling on a ball. Variables that may have influenced the results are noted, and a 12-page reference list is provided. The appendices describe two aspects of the RISE Computerized Checklist and Curriculum for the Motorically Delayed/Impaired Child (selected assessment components and selected curricular activities); the appendices also include demographic data and the Movement Assessment of Infants. (CL)

THE EFFICACY OF TWO TREATMENT TECHNIQUES FOR CHILDREN WITH SPASTIC CEREBRAL PALSY AS MEASURED BY ELECTROMYOGRAPHY AND THERMAL INFORMATION

by

DAVID MICHAEL FINN

A DISSERTATION

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CHAPTER I

INTRODUCTION

The basic premise of The Education for All Handicapped Children Act of 1975 (Public Law 94-142, November 29, 1975) is to provide a free, appropriate, public education for all handicapped children. The term "appropriate" generates a broad spectrum of intervention options especially when applied to children who are severely physically handicapped. Appropriate education, in this sense, refers to the formulation of age-appropriate objectives, implemented with age-appropriate materials, to produce age-appropriate skills (Snell, 1983). According to Anderson, Greer, and Rich (1982), educational programs for these children should address several important instructional areas. These areas include sensorimotor skills, self-care skills, functional language skills, and adaptive behavior.

One of the most prevalent physically handicapping conditions is cerebral palsy. Cerebral palsy is defined as a nonprogressive disorder of movement or posture due to neurological impairment occurring during the developmental period (Bleck & Nagel, 1982). It is characterized by abnormal muscle tone, the presence of primitive reflexes, and developmental delay (Banus, Kent, Norton, Sukiennicki, & Becker, 1979). Rutter, Graham, and Yule (1970) estimated the frequency of cerebral palsy in the school age population to be between 2.0 and 2.5 per thousand.

To confirm a diagnosis of cerebral palsy, Vining, Accardo, Rubenstein, Farrell, and Roizer (1976) suggested two criteria. The first criterion stated that no active disease should be present at the time of the diagnosis [central nervous system (CNS) neoplasia and degenerative diseases are excluded]. Second, the causative insult or injury must have taken place during the early development of the CNS (from intrauterine life through early childhood).

The age limit for a diagnosis of cerebral palsy has yet to be specifically defined. The American Academy for Cerebral Palsy (AACP) has arbitrarily assigned the age of five to be the upper age limit. Although cerebral palsy lacks a concise and a universally accepted definition, the use of that term as a diagnostic label is often critical in terms of educational placement. For example, a child's enrollment in an early intervention program may be contingent upon a medical diagnosis of cerebral palsy. A physician examining a child who exhibits hypotonicity as a precursor to the development of hypertonicity may be hesitant to diagnose a child as having spastic cerebral palsy. Although cerebral palsy is characterized as a non-progressive condition, left untreated, the developmental aspects can be devastating. Professionals concerned with the education of children who have cerebral palsy have stressed the need for early intervention. Bobath and Bobath (1967) suggested that the young child's central nervous system (CNS) is more "plastic" and amenable to intervention. They also noted that younger children may not present associated problems of contractures and deformities which may be typical with an older population.

Cerebral palsy is represented by a number of clinically diverse characteristics and is often classified in terms of neuromotor involvement. Anderson, Greer, and Rich (1982) have described five types which include spasticity, athethosis, ataxia, rigidity, and tremor.

One of the most common types of cerebral palsy is spasticity. Spasticity refers to "stiffness that varies in intensity in response to stimulation, position, or effort" (Bigge, 1982, p. 6). Athetosis is the next most prevalent type of cerebral palsy. It is characterized by involuntary writhing and twisting, in addition to fluctuating muscle tone. Athetosis is particularly evident when purposeful movements are attempted. A less frequently occurring type of cerebral palsy is ataxia. Ataxia primarily affects the child's balance and coordination. This type of cerebral palsy places the child at an increased risk for stumbling and falling. Rigidity is characterized by continuous muscle tension. Rarely seen, this type results in limited movements due to extreme stiffness. Tremor is another rare form of cerebral palsy. Affected body parts move rhythmically or vibrate uncontrollably.

The exact causes of spasticity have been evasive and have made it difficult to define spasticity in terms of etiology. In an effort to address this problem, Bishop (1977) offered a list of characteristic motor problems that may be used to help confirm the diagnosis of spasticity. First, stretch reflexes that are normally latent in the young infant often become obvious. Secondly, when a spastic muscle is tapped, the response is greater than normal. Additionally, when these muscles are stimulated by tapping, muscles other than the ones tapped usually respond.

In their review of the progression of spasticity, Bobath and Bobath (1982) noted that very few children are spastic at birth. Those children who do demonstrate congenital spasticity very early are typically severely affected and are often quadriplegic. Spasticity usually develops "gradually as the child matures and starts to react to his/her environment" (Bobath & Bobath, 1982, p. 17).

In an attempt to meet the individual needs of children who have spastic cerebral palsy, a variety of treatment techniques have been utilized. One of the earliest approaches was suggested by Phelps. In this approach, Phelps advocated treating spastic cerebral palsy through the use of massage, splinting, and exercise (Phelps, 1940). Rood (1962) suggested a sensorimotor approach. Essentially, this approach involved the use of a variety of tactile and kinesthetic experiences to encourage normal motor development. Jean Ayers (1972) advocated the use of movement experiences such as swinging and spinning in conjunction with the use of adaptive equipment to facilitate normal development. Berta Bobath (1948, 1963, 1967, 1969, 1971a, 1971b) and Karel Bobath (1959, 1966, 1971) offered a neurodevelopmental (NDT) approach in the treatment of spastic cerebral palsy. Their techniques involved the inhibition of abnormal reflexes and the facilitation of normal movement experiences.

It is difficult to select appropriate treatment strategies without empirical evidence regarding the positive effects of the various treatment approaches on specific handicapping conditions. The efficacy of one approach over another has not been supported by research findings. This lack of information often leads professionals who work with these children to a subjective selection of interventions.

Statement of the Problem

Professionals working with children who have cerebral palsy should be aware of a number of critical issues. First, the term cerebral palsy encompasses a wide range of characteristics. A number of those characteristics, such as spasticity, have been poorly defined. Second, the heterogeneity of this population, together with the relatively low incidence of each type of cerebral palsy and the complexity of differing associated disorders, have made research efforts difficult. Matching subjects by type and degree of cerebral palsy, age, IQ, and sex, contributes to the problems of formulating appropriate research designs necessary to substantiate a theoretical basis for intervention.

Third, relatively new treatment approaches, such as NDT, have been described as theoretical (Campbell, 1983a). Campbell noted that this emerging theory lacks both strong definitional components and concrete empirical evidence to support its tenets. Compounding the problem is the use of subjective observations by professionals to evaluate emerging skills of children who have spastic cerebral palsy. Verification of the efficacy of intervention strategies should be a high priority for educators who are concerned with the development of children who have motor problems. The need for studies demonstrating the efficacy of treatment techniques with this population is apparent. It was the purpose of this study to investigate the use of electromyography (EMG) and thermal information as evaluative measures to determine the efficacy of two techniques used to normalize muscle tone with children who have spastic cerebral palsy. The techniques used in this study to reduce spasticity were trunk rotation and slow rolling on a ball (see Appendix B, units 7.4 and 7.6). No efforts, thus far, have been investigated regarding the efficacy of these two treatment techniques for reducing spasticity.

Hypotheses

The following null hypotheses were developed in order to investigate the effectiveness of two techniques used to normalize muscle tone with children who have spastic cerebral palsy.

Hypothesis 1. There will be no significant interaction between groups (trunk rotation and slow rolling) and eight measures on EMG readings.

Hypothesis 2. There will be no significant difference between groups (trunk rotation and slow rolling) on EMG readings regardless of measure.

Hypothesis 3. There will be no significant difference among measures on EMG readings regardless of group membership.

Hypothesis 4. There will be no significant interaction between groups (rotation and slow rolling) and measures on skin temperature readings.

Hypothesis 5. There will be no significant differences between groups on skin temperature readings regardless of measure.

Hypothesis 6. There will be no significant difference among measures on skin temperature readings regardless of group membership.

Definition of Terms

For the purpose of this study, the following terms were defined:

Cerebral Palsy: Cerebral palsy is defined as a nonprogressive disorder of movement or posture due to neurological impairment occurring during the developmental period (Bleck & Nagel, 1982). It is characterized by abnormal muscle tone, the presence of primitive reflexes, and developmental delay (Banus et al., 1971).

Developmental Physical Management: refers to the management, positioning, and handling of the motorically involved child to insure optimal motor development and to prevent contractures and deformities (Holder, 1977).

Electromyography (EMG): measures the intensity of muscle contraction through the use of electrical impulses.

Hypertonicity: refers to excessive muscle tone.

Microvolt: refers to one-millionth of a volt. It is used in measuring electrical activity, particularly in reporting EMG data.

Motor Specialist: refers to a registered occupational or physical therapist who has been trained in neurodevelopmental treatment.

Neurodevelopmental Treatment (NDT): refers to a treatment intervention concept applied to infants and children with disorders in gross and fine motor skills and requires an interdisciplinary approach (Campbell, 1983a). The goals of NDT are to inhibit abnormal tone and abnormal positioning while facilitating normal motor patterns.

Sensor: refers to a small silver disk, usually affixed to the skin with an adhesive, and is used to collect EMG and thermal data.

Slow Rolling: refers to the placement of a child in a prone, supine, or sitting position on a large ball which is slowly and rhythmically rocked back and forth. It is suggested as a technique to reduce hypertonicity.

Spasticity: refers to increased tone of muscles causing stiff and awkward movement.

Thermal Information: refers to skin temperature information that is detected through the use of skin sensors which are connected to a thermal unit.

Trunk Rotation: refers to a technique for reducing excessive muscle tone. Using a slow, rhythmical motion, the shoulder girdle is alternately rotated in one direction while the hip girdle is rotated in the opposite direction.

CHAPTER II

REVIEW OF THE LITERATURE

This review of the literature was organized into sections which provide a description of techniques that have been used to reduce spasticity. These topics include: (a) medical interventions and strategies used to reduce spasticity, (b) plaster casting, (c) positioning devices, (d) physical and/or occupational therapeutic approaches, (e) electromyography and cerebral palsy, and (f) skin temperature applications.

Medical Interventions and Strategies Used to Reduce Spasticity

A number of medical interventions and strategies have been suggested for the treatment of spastic cerebral palsy. An important intervention technique prescribed for the treatment of this condition is drug therapy (Davidoff, 1985; Melnick & Shellenberger, 1982; Tibbs, Young, Walch, & Bean, 1981; Young & Delwaide, 1981). Davidoff (1985) stated that only a few drugs have been viable in the treatment of spasticity. Although few drugs have been effective in reducing spasticity, Young and Delwaide (1981) warned that the medications typically prescribed for reducing spasticity also tended to produce drowsiness, light headedness, and confusion. These effects result in impaired mental alertness and motor incoordination. Periods of strenuous therapy or extended mobility training could exacerbate the child's fatigue level and place him/her at risk for stumbling, falling, and incurring bodily injury. Melnick and Shellenberger (1982) cautioned that each drug should be carefully evaluated prior to selection and administration.

The drugs of choice typically prescribed for cerebral palsy are Valium, Dantrium, and Lioresal. These medications are included in a group of minor tranquilizers known as benzodiazepines. These medications are used for the reduction of anxiety, the relaxation of muscles, and sedation. These agents release the neurotransmitter gamma-amino-butyric acid (GABA) which limits the effectiveness of incoming stimuli (Tibbs et al., 1981).

Melnick and Shellenberger (1982) noted that the most commonly used medication for controlling spasticity is Diazepam (Valium). The anti-anxiety effect produced from this drug acts to reduce the level of excitement and assists in decreasing additional spasticity. The major side effect noted with the use of Diazepam is sedation.

Another drug in this group is dantrolene sodium (Dantrium). The main site of action with Dantrium is peripheral; whereas, other medications tend to focus primarily on the central nervous system (Young & Delwaide, 1981). The major mechanism of Dantrium is to "reduce the influx of calcium into the sarcoplasm, thereby reducing the force of muscle contractions" (Tibbs et al., 1981, p. 361). Weakness is the major side effect related to this agent. Other side effects of Dantrium noted by Melnick and Shellenberger (1982) include sedation, dizziness, nervousness, gastrointestinal disorders, and a feeling of inebriation. In addition to these general side effects, approximately 1% of those who receive this medication are at risk for hepatotoxicity.

Baclofen (Lioresal) is one of the more recent medications prescribed for the treatment of spasticity (Tibbs et al., 1981). Although the use of Lioresal with children remains to be approved, the effectiveness of this drug was found to be greatest when the spasticity was the result of spinal lesions (lower motor neuron dysfunction). Melnick and Shellenberger (1982) stated that persons with cerebral palsy (upper motor neuron dysfunction) are at an increased risk for developing side effects related to this agent. Therefore, the use of Lioresal in the treatment of spasticity should be approached with caution.

Davidoff (1985) noted that the practitioner may observe several different clinical patterns of spasticity depending on the area of damage (i.e., spinal cord, brainstem, or cerebrum) and the extent of injury to the CNS. The use of medications in the management of spasticity may notably alter some of the painful or disabling symptoms. However, physicians are reminded that "the diagnosis of spasticity can vary, and the medications prescribed for this population may not be equally effective in all patients" (Davidoff, 1985, p. 107). Young and Delwaide (1981) added that although the short term effects regarding the safety and efficacy of these drugs have been defined, the effects of long-term administration have not been established.

Surgical intervention is often recommended following unsuccessful pharmacologic therapy. A review of surgical options for spasticity by Tibbs, Young, Walsh, and Bean (1981) revealed that surgical treatment has been available since 1918. They noted that one of the first operative procedures was introduced by Foerster and involved the transection of a number of posterior roots. This procedure was intended to interrupt a component of the reflex arc, thereby reducing spasticity. Tibbs, Young, Walsh, and Bean (1981) summarized several other surgical procedures such as:

1. An anterior root section described by Munro in 1945. This procedure reduced spasticity but resulted in profound atrophy of the affected muscle groups.

2. A myelotomy procedure by Bischof in 1952. In this procedure he disconnected the afferent stimulus to the motor neurons and prevented generalized atrophy. Although this procedure effectively reduced spasticity in a number of cases, patients with retained voluntary corticospinal tract function were often left with an increased postoperative motor deficit.

3. An improved T-myelotomy procedure. This spared the corticospinal tract function but failed to interrupt the reflex arc at the spinal cord level.

4. A percutaneous technique described in 1974. In this technique, radio frequency-created lesions were used to destroy small unmyelinized fibers. This tedious procedure often required repetitious

treatments; however, it eliminated the potential afferent source of spasticity and preserved other sensory modalities.

Plaster Casting

Another popular technique for reducing the effects of spasticity is serial plaster casting. This is often recommended as a means of reducing the need for surgical intervention. Plaster casting is done slowly, usually requiring several readjustments. In the case of spasticity in the lower extremities, Westin and Dye (1983) suggested that the leg and foot be partially corrected to tolerance for a period of two weeks. The cast usually requires one or two additional adjustments after the initial casting. They cautioned that casting can result in muscle atrophy, knee discomfort, and disturbances in gait. Subsequent casting may also be required as the child grows. They listed two advantages for this type of medical intervention over surgery. First, surgery (heel cord or hamstring releases) usually weakens the muscle that has been lengthened. Second, surgery does not obviate the need for subsequent casting and long term follow-up. In reviewing operative procedures over a 27-year period with patients who had cerebral palsy, Westin and Dye

(1983) noted a decrease in the number of surgical interventions. Their data revealed that:

1. From 1952 to 1961, 33 surgical procedures (including gastric releases, triple arthrodeses, and tendo achilles lengthenings), were performed;

2. From 1961 to 1971, the number of operative procedures dropped to 25 (including adductor tenotomies, gastric releases, and hamstring lengthenings) and;

3. From 1970 to 1979, a reduction from 25 to 19 surgical procedures (including adductor tenotomies and plantar releases) was noted.

They attributed the reduction in required surgical interventions to the increase in successful plaster castings.

Positioning Devices

Campbell (1983b) noted that proper positioning and handling of the student with motor impairments are central to both the normalization of muscle tone and facilitation of more normal movement. She stated that the use of adaptive equipment/devices should be applied following an appropriate and individualized program of intervention designed to normalize muscle tone. Campbell further alerted the classroom teacher to several precautions when using adaptive equipment. First, adaptive equipment alone does not alter or reduce tone. Those pieces of equipment that have been well-selected and well-fitted will only "maintain" normalized muscle tone. Second, the student should be observed carefully and systematically so that a correct match can be made between the child's needs and the adapted equipment. These observations should be made over a period of time and in different situations to insure that the desired function is properly achieved. The third precaution was related to the length of time a student spends in a piece of equipment. Many of the children who need these devices may lack the ability to move and make the necessary postural adjustments in static positions. It was recommended that these children be repositioned as frequently as every 20 to 30 minutes. Failure to make these adjustments can lead to decubitus ulcers (particularly over bone promontories), additional muscle tightness, and contractions.

Campbell (1983b) emphasized that care should also be taken to prevent social isolation from the child's peers. For example, a prone board may be recommended for the child who is not able to stand independently.

The prone board allows the child to maintain an upright, therapeutic, supported standing position and prevents muscle atrophy due to disuse. It facilitates weight bearing, symmetrical body alignment, and bone density (Holder, Wells, & Cook, 1985). It also improves circulation, respiration, digestion, bowel and bladder function, socialization, and self image (Buttram & Brown, 1977). Despite the therapeutic value of this piece of adaptive equipment, most prone boards are fixed and difficult to move from one location to another. This factor may tend to exempt the child from outside activities and serve to segregate the child from even the most tangential social contacts.

Research demonstrating the therapeutic effects of positioning devices has resulted in mixed findings. Mathiowetz, Bolding, and Trombly (1983) noted that "there is a continuing controversy in the literature and in clinical practice about whether positioning devices are effective in decreasing spasticity and, if so, which types are most effective" (p. 247). To test that hypothesis, Mathiowetz et al.(1983) investigated the immediate effects of positioning devices on the normal and spastic hand. Their subjects included eight normal and four hemiplegic individuals who ranged from

25 to 40 years of age. Subjects with hemiplegia had moderate to severe spasticity in the impaired wrist and fingers. Four different treatment conditions were tested and involved the use of a volar resting splint, a finger spreader, and a firm cone. The fourth condition involved the absence of devices. Flexor muscle activity was measured by EMG instrumentation. Results indicated that neither the volar splint, the finger spreader, nor the cone significantly reduced flexor muscle activity. Thus, Mathiowetz, Bolding, and Trombly (1983) questioned the efficacy of these devices to decrease spasticity and recommended further study.

In another study involving positioning devices, Smith (1985) investigated the effects of adaptive seating on the speech intelligibility of children who had cerebral palsy. Ten children between the ages of 3 years, 6 months and 9 years, 8 months who had cerebral palsy were selected for this study. Recorded speech samples were collected from each of the 10 children under one of two treatment conditions. The first condition referred to a situation where children were seated, unsupported, in a standard wheelchair. The second condition had each child in a seating simulator. The children were then prompted to make single word responses through administration of the picture test portion of the Arizona Articulation Proficiency Scale: Revised (AAPS-R) (Fudala, 1974). Language samples were collected from each child in both seating options. Results of this study failed to demonstrate a significant difference between the two treatment conditions. However, six of the children made "notable" (an increase of 10% of more as defined by Smith) gains in terms of speech intelligibility. The inconclusive results of the studies by Mathiowetz, Bolding, and Trombly (1983) and Smith (1985) failed to demonstrate the efficacy of positioning devices. These findings underscore the lack of effective treatment techniques with children who have spastic cerebral palsy.

Physical/Occupational Therapeutic Approaches

One of the earliest treatment regimes suggested for children with spastic cerebral palsy was offered by Winthrop M. Phelps (1940). His techniques were developed as a result of conventional treatment techniques used in the management of poliomyelitis. This method was primarily concerned with protecting flaccid and weak muscles from stretching. Selective techniques were used such as massage, splinting, and careful exercise (walking) (Phelps, 1940). Phelps felt that spasticity was a fixed and irreducible state where relaxation was impossible (Bobath, B., 1963). Spasticity, in particular, was managed by bracing, stretching, and strengthening opposing muscle groups (Gillette, 1969). A study conducted in 1950 by Crosland investigated the effects of the Phelps approach on 34 children. These subjects ranged in age from 4 to 11 and had diagnoses of spastic paraplegia, spastic tetraplegia [sic], athetoid tetraplegia, and ataxia. Average length of treatment was 20 months. The author reported motoric gains for all subjects, yet he cautioned that age may have been an intervening variable in terms of normal acquisition of developmental milestones. Two limitations related to these findings focused on the lack of specific treatment conditions and the selection of subjects. Crosland (1950) reported that subjects for this study were selected because they appeared "to offer the possibility of a good response to treatment" (p. 93). As a result of a lack of random sampling and the absence of specific treatment methods, cautious interpretation of those results is indicated.

Using reportedly similar intervention strategies, Zuck and Johnson (1952) evaluated 36 subjects to determine if intelligence and type of cerebral palsy were related to the success of the Phelps approach. The progress of each subject was plotted against a slope (1.0) of normal development. Following 10 months of treatment, all subjects demonstrated progress. However, this progress was not enough to change their overall rate of development, and the authors suggested that the children could have done as well without treatment. The results of this study suggested that subjects with spasticity progressed at a more rapid rate than those with athetosis, and subjects with IQ scores above 70 demonstrated greater gains than those with IQ scores of less than 70. Inconclusive findings regarding the effectiveness of this approach failed to support this technique as a current treatment option.

The Doman-Delacato approach, often referred to as the Fay-Doman or patterning approach, was one of the most controversial approaches used with children who had severe brain injury. This system was based on neurological organization and focused on the injured central nervous system (Doman, Spitz, Zucman, Delacato, & Doman, 1960). Doman et al. (1960) suggested that motor development in humans is similar to the evolutionary progression from fish to anthropoids. Treatment methods in this approach developmentally replicated the motor patterns of these species (i.e., swimming, cross creeping, etc.) in an effort to reach higher functioning levels.

Doman et al. (1960) suggested an approach that focused on three components:

1. Permitting the child to experience normal developmental movement patterns in areas where the responsible brain level was undamaged,

2. Externally imposing the bodily patterns of activity that were the responsibility of damaged brain levels, and

3. Utilizing additional factors to enhance neurological organization.

To test this theory, a two-year study was conducted by Doman et al. (1960) using 76 children who were brain injured. All children were treated bi-monthly and were required to be in treatment for a minimum of six months. Pre and post-test evaluations rated the subjects on a motor performance scale from 1 (rolling) to 13 (walking in a cross pattern). The findings of this study revealed that of the 20 children who were unable to move, eight were creeping in a cross pattern and 12 were ready to walk (cruising, walking-holding on). Ten of the children who could walk initially did not improve their mobility competence by one level; however, the other 29 children improved their ability by one or more levels. Although motor gains were reported for almost all subjects, the heterogeneity of the population, and the possibility of normal motoric maturation leave the findings of this study inconclusive.

In a similar study, Sparrow and Ziegler (1978) found somewhat differing results. Their findings were based on 45 severely retarded children who were provided with exhaustive patterning exercises. Their final report suggested that "loving care and concern were just as effective as were the complex and structured patterning methods" (Bleck & Nagel, 1982, p. 82).

A variety of techniques using cutaneous stimuli have been suggested to reduce spasticity (Twist, 1985). Perhaps the best known therapist who recommended this approach was Rood (1954, 1956). She felt that brushing, stroking, and sounds presented in a slow, maintained, and rhythmical fashion tended to relax the voluntary musculature. Rood also selectively recommended the use of warm or cold applications to reduce spasticity. Wrapping extremities with down comforters, or icing the oral musculature were some of Roods' techniques. The goal of her treatment was to effectively activate or inhibit affected musculature through sensory receptors to facilitate the emergence of a sequence of developmental patterns. In reviewing the theory and practice of Rood's techniques, Twist (1985) noted that it was not so much the warmth of the stimuli that created muscular change, but the activation of C-fiber sensory receptors. These receptors are typically found in hairy skin and, when stimulated, facilitate autonomic nervous system (ANS) responses. It is the activation of these ANS responses that decrease muscle tone.

To test the effects of C-fiber stimulation, Twist (1985) studied four adults who had upper extremity hypertonicity. Baseline data were collected using manual goniometers to assess each subject's pre-test passive range of motion (PROM). Measurements were taken at all joints of the affected upper extremity except for the fingers. Subjects then had their spastic upper extremity wrapped with two 4 inch elastic wrap bandages. The hand was covered with two gloves:

an isotoner glove and a polyester glove. Gloves and wrappings were worn for three hours. After three hours the wrappings were removed and post-test measurements were taken. Subjects were wrapped three times a week on alternating days for four weeks. The results indicated a significant difference ($p < .01$) for all subjects and all motions (PROM). All subjects also subjectively reported a marked reduction in pain after three weeks.

Another approach emphasizing a form of sensory stimulation was postulated by Jean Ayres, an occupational therapist and educational psychologist. Her goal was "to provide controlled sensory input that would improve the basic organization of central nervous system mechanisms and, thereby, enhance the child's adaptive and learning processes (Ayres, 1972). She advocated vestibular stimulation to enhance learning and motor responses. She provided this stimulation through the use of swings, spinning apparatus, scooters, and other adapted equipment.

Perhaps the most widely-accepted intervention strategy applied today is the neurodevelopmental treatment approach (NDT) (Harris, 1981). This approach has been developed and modified over the last several decades by Berta Bobath, a physical therapist, and Karel Bobath, a physician. The Bobaths noted that "cerebral palsy reveals itself both in a developmental and a pathological deviation from normal motor behavior" (Bobath & Bobath, 1967, p. 1039). These deviations are represented in the persistance of primitive reflexes, abnormal posturing and motor patterns, and a general poverty of movement. In the NDT approach, the aims of treatment for cerebral palsy are:

1. To develop normal postural reactions and postural muscle tone against gravity for support and control of movements,

2. To counteract the development of abnormal postural reactions and abnormal postural tone,

3. To give the child, by means of handling and play, the functional patterns used for feeding, dressing, washing, and self-care, and

4. To prevent the development of contractures and deformities (Bobath, B., 1963, 1967, 1969; Bobath & Bobath, 1967, 1972).

Early intervention with the NDT approach is stressed for a number of reasons. First, the infantile brain is more plastic and has optimal adaptibility to cerebral damage. Secondly, since the acquisition of movement skills is predicated on sensorimotor learning, the time spent relearning or correcting abnormal motor patterns will delay the appearance of normal movement patterns. The third reason for early intervention is that deprived sensorimotor experiences can lead to mental retardation (Bobath, K., 1966). Fourth, the young child who has cerebral palsy demonstrates persistent primitive reflexes which can lead to abnormal postural activity and tone. The prevention of persistent asymmetry or internal rotation of an extremity, resulting in permanent contractures and deformities, obviously presents a strong case for early intervention.

Berta Bobath (1967) reported that the treatment for the child who has spasticity requires a great deal of movement and inhibition of abnormal postural reflexes. She also recommended a variety of sensory stimulation activities. These activities, when carefully provided, encourage more normal development and inhibit abnormal reactions. Further, these activities should provide the child with diverse opportunities for normal movement patterns. Once the child has been allowed to feel normal movement patterns, Bobath recommended a gradual increase in the speed and range of movement. The emphasis for treatment goals for children with spasticity is qualitative rather than quantitative. For example, a therapist might wish to introduce the child to riding an adaptive tricycle. Not only does this objective provide the child with an entertaining activity, but also an occasion to feel a reciprocal motor pattern in the lower extremities. This treatment modality stresses active and qualitative movement. Evaluative criteria focuses on observing a smooth alternating pattern rather than a stated objective such as, "the child will be able to ride an adaptive tricycle unassisted for two minutes." Bobath further noted that static postures should be avoided. She stated that passive movements and stretching of individual muscles are useless (p. 376).

Several studies have investigated the efficacy of the neurodevelopmental treatment (NDT) approach. One study by Tyler and Kahn (1976) explored the effectiveness of NDT with a child who had athetoid cerebral palsy in a home-treatment program. Intervention strategies focused on feeding techniques and adaptations of the child's playing and sleeping positions. Treatments were conduced for 28 days, six and a half hours per day. Post-evaluation results revealed improvements in muscle tone and movement patterns. A diminished Galant reflex, the emergence of the Landau and righting reactions, and more normal head and trunk control were noted. Additionally, the child was able to tolerate more stimulation, sleep respiration was markedly improved, and gains in speech and feeding were reported.

Wright and Nicholson (1973) studied 47 children under the age of 6 who participated in an NDT program with somewhat different results. The children were randomly assigned to one of three treatment groups. Group One received the Bobath approach for 12 months (7 subjects); Group Two received no treatment for 12 months (31 subjects); and Group Three received no therapy for six months followed by therapy for the last six months (9 subjects). A one year follow-up study reported no significant difference among any of the groups. Commenting on this study, Bleck and Nagel (1982) noted that this was one of the "rare" attempts to assess the efficacy of physical therapy with children who have cerebral palsy.

Scherzer, Mike, and Olson (1976) conducted a double-blind study with 24 infants investigating the efficacy of NDT principles. Subjects in this study were all less than 18 months old. Children in the experimental group received a neurophysiological program designed to improve certain developmental milestones. The control group received only passive range of motion activities (PROM) twice a week. Gains in motor and social domains were evidence by the experimental group at school. However, results revealed that no significant difference existed between the experimental and control groups in the home setting. The greatest improvements in the school setting were made by those subjects who were older and of higher intelligence.

In planning intervention strategies for children who have spastic cerebral palsy, the interdisciplinary team must consider the heterogeneity of population characteristics; the diversity of available treatment modalities to manage these manifestations; and the lack of sound, empirical data to support the efficacy of one approach over another. This has influenced several professionals to adopt or develop an eclectic approach to treatment. Twist (1985) noted that the adoption of the eclectic approach "often results in the endorsement of many different forms of treatment with variable results" (p. 299).

A number of investigations have focused on defining and/or quantifying the results of the eclectic approach. Carlsen (1975) stated that "little attention has been paid to the actual value of each approach in facilitating a child's total development" (p. 268). Carlsen investigated a facilitative approach to determine if it was more effective than a functional occupational therapy treatment program. A facilitative approach was described as including "activities that are geared toward sequential normalization of postural tone, gross coordination, and sensorimotor interaction with the environment" (p. 268). This approach was an adaptation of treatment modalities suggested by Bobath and Bobath (1967, 1972), Rood (1954), and Ayres (1972). The functional approach reflected a more "traditional" position to pediatric occupational therapy. The latter approach relegated the development of gross motor skills to the physical therapist and allowed the occupational therapist to focus on specific, fine-motor-adaptive and self-care skills. This study included 12 children who were in regular attendance at the United Cerebral Palsy Association (UCP) of Central

Florida. The subjects, one to five years old, were evaluated using the Denver Developmental Screening Test (DDST) and the Bayley Motor Development Scale (BMS). Efforts were made to match the children according to their developmental age, chronological age, and type and degree of cerebral palsy. The children were randomly assigned to one of the two treatment conditions. Treatment programs were implemented for a period of six weeks and included daily home programs. At the mid-point of the treatment phase, a meeting was held with the mothers and therapists to discuss the successes and failures of the program. The results from this meeting were used to upgrade the remaining three weeks of treatment. At the termination of the treatment phase, the children were re-evaluated on the DDST and BMS. Findings from this study suggested that those children who were given the facilitative approach tended to demonstrate greater improvement in all areas of development as measured by the DDST and the BMS. As a result of these findings, the author concluded that children between the ages of one and five who have cerebral palsy should concentrate on gross sensorimotor activities.

Another study concerning the efficacy of an eclectic approach was investigated by Norton (1975). This study examined the nine-month effects of a combined neurodevelopmental (Bobath) and sensory integration (Ayres) program with three children who were profoundly mentally retarded and multiply handicapped. The children in this study were all less than five years old and received their intervention via a mother-administered, clinic-supervised program. Physical therapists initially evaluated each child with an assessment developed by Bobath. Eight monthly follow-up assessments were conducted during the course of the study using an adapted form of a scale developed by Milani-Comparetti and Gidoni. Each mother was asked to provide 60 minutes of treatment to her child daily. Ten to 15 minutes of individually prescribed activities were provided when the child awakened in an effort to begin the child's day with normal movement experiences. The remainder of intervention was provided by the mother for several minutes each time the diapers were changed. Careful monitoring of the mothers' activities was conducted three times a week by both physical and occupational therapists. Modifications to the mothers' handling of their children were made during that time, if necessary. Results of this nine-month study revealed higher developmental levels (postural, emotional, perceptual, and cognitive) in children who had limited opportunities to move or interact with their environment from birth or early infancy as a result of profound retardation and multiple handicaps. The author of this study recommended that this approach should be examined further with expanded samples and a control group.

One of the most recent treatment approaches suggested to ameliorate the diverse problems associated with cerebral palsy was Developmental Physical Management (DPM). DPM, as explained by Buttram and Brown (1977), reflects an eclectic approach abstracted from the theories of Rood, Ayres, and the Bobaths. "It encompasses a total approach concerning the specific care and handling of the multi-disabled infant both in the classroom and in the home" (p. 3). This approach assumes that dysfunction of sensory integration can be treated by using two different techniques. The first technique encourages a bombardment of stimuli to the child. It is felt that this overstimulation normalizes the threshold of responses, allowing the child to decode incoming stimuli and respond appropriately. Secondly, this approach provides the child with purposeful sensorimotor activities. These activities provide feedback to the child relating to motor performance. These motor activities serve to organize sensory input and facilitate sensory integration. DPM is practiced with the following assumptions:

1. Assessment and treatment follow the normal developmental sequence. Treatment is done proximally to distally.

2. Reflex maturation is encouraged. The integration of the vestibular mechanism is initially emphasized.

3. Abnormal muscle tone is dealt with prior to positioning and movement patterns to promote the maintenance of straight body alignment.

4. Initial stimulation is provided to the less involved side of the body (Buttram & Brown, 1977, p. 7).

Of particular interest in this approach are those techniques which have been suggested to reduce muscle tone. Several authors (Buttram & Brown, 1977; Holder, Wells, & Cook, 1985) maintain that addressing the child's muscle tone is an initial therapeutic activity, and allows the child the maximum benefit from positioning and movement activities. In an effort to operationalize DPM activities for the handling, positioning, and management of children with motor impairments, a computerized checklist and curriculum was developed (see Appendix A for assessment items and Appendix B for curricular activities).

Electromyography and Cerebral Palsy

Westin and Dye (1983) stated that no methods currently exist to measure the exact degree of spasticity. Harris (1981) supported the claim that few techniques were available for assessing muscle tone. In studying the effects of neurodevelopmental therapy on motor performance of infants with Down's Syndrome, she noted the following:

> One of the main aims of neurodevelopmental therapy is the facilitation of normal postural tone, but it is extremely difficult, clinically and objectively, to assess precise degrees of postural tone. With the exception of electromyographic procedures, which are too costly and complicated for the average pediatric treatment setting, there are no well-quantified, objective procedures for measuring changes in muscle tone. (p. 481)

Several authors (Asato, Twiggs, & Ellison, 1981; Basmajian, 1978, 1981; Neilson & McCaughey, 1982; Steiner & Dince, 1981) have suggested the use of EMG in various settings. It has been used by physical and occupational therapists as an assessment tool in gait analysis, shoulder subluxations, strokes, epilepsy, and in the treatment of cerebral palsy. Perhaps the most common uses are for stress management and the treatment of migraine headaches.

Electromyography (EMG) has been defined as the measurement of the intensity of electrical impulses. More specifically, it measures:

> electrical impulses from muscles which synapse (connect) at the neuromuscular or myoneural junction. Action potentials are transmitted from the cerebral cortex down through the spinal cord via a complex series of nerve pathways to individual motor units in the muscles. When a significant number of action potentials are generated in a particular time period over a given area, contraction of the muscle occurs. Conversely, muscle relaxation represents a decrease in the firing or electrical discharge of motor nerves (Fischer-Williams, Nigle, & Sovine, 1981, p. 102).

In an effort to examine previous applications of EMG technology with this population, a review of the literature revealed 10 references dating back to 1967. However, a majority of these studies used electromyographic information as a major component of biofeedback. Biofeedback was defined by Basmajian (1978) as:

> the technique of using electronic equipment to reveal to human beings some of their internal physiological events, normal and abnormal, in the form of visual and auditory signals in order to teach them to manipulate their otherwise involuntary or unfelt events by manipulating the displayed signals. (p. 1)

A study conducted by Asato, Twiggs, and Ellison

(1981) demonstrated the use of EMG biofeedback successfully with a client who was profoundly retarded and had spastic cerebral palsy. The subject was a 29 year old woman whose expressive communication was limited to two and three word utterances. Her physical status was characterized by left shoulder adduction and internal rotation, elbow hyperextension, forearm pronation, wrist and finger flexion, and wrist ulnar deviation. This subject was described as having a short attention span, lacking motivation, and having a low tolerance for frustration. The initial goal of treatment was to improve finger extension through biofeedback. EMG apparatus were attached to her finger and, when extension was detected, an electronic biofeedback device activated music as a reinforcement. Through the use of EMG biofeedback training, the subject was finally able to hyperextend her fingers. Wrist flexion and wrist ulnar deviation were also improved through EMG biofeedback training.

Other findings by Neilson and McCaughey (1982), revealed similar results. This study involved four young adult subjects who had cerebral palsy. The subjects were given two goals. The first goal was to reduce contractures and decrease reflex sensitivity.

The second goal was to increase the subjects' flexion level. Through the use of EMG biofeedback, achievements were rewarded by playing a cassette tape of the subjects' favorite music. All four subjects learned to self-regulate spasticity and to regulate the contraction level. Mathiowetz et al. (1983) used EMG instrumentation to investigate the immediate effects of positioning devices on the normal and spastic hand. Their subjects included eight normal and four hemiplegic individuals who ranged from 25 to 40 years of age. Subjects with hemiplegia had moderate to severe spasticity in the impaired wrist and fingers. Four different treatment conditions were tested and involved the use of a volar resting splint, a finger spreader, and a firm cone. The fourth condition involved the absence of devices. Flexor muscle activity was measured by EMG instrumentation. Results as measured by EMG indicated that neither the volar splint, the finger spreader, nor the cone significantly reduced flexor muscle activity.

Basmajian (1978) in a review of related literature, noted over 1,300 international studies which demonstrated the positive effects of EMG biofeedback with some type of rehabilitation. These articles addressed the issue of evaluation or efficacy of intervention as they related to electromyography in which subjects were required to cognitively reduce tone. Yet, for many children who are multi-handicapped, this activity is often beyond their physical or intellectual capabilities.

The efficacy of electromyography in biofeedback training is often paired with mixed results. Steiner and Dince (1981) noted that results with EMG biofeedback are often disappointing when used in isolation. Allen (1983), a biofeedback therapist who used electromyography to change a variety of client behaviors, further added that when used to ameliorate some type of undesirable behavior, it is rarely used alone. For this reason, he suggested the pairing of EMG data and other measures to detect physiologic change as a result of treatment techniques.

Skin Temperature Applications

The second strategy used to measure physiological change involved the use of distal thermal information (skin temperature). With a spastic muscle, there is a decrease in blood flow (Adams & Imms, 1983; Allen, 1983). This is often most notable at distal sites (fingers and toes). As the muscle relaxes and the blood flow assumes a more normal state, one would expect an increase in the peripheral skin temperature. Skin temperature readings are simple to collect and are basically non-invasive to the child. Studies that involve skin temperature typically focus on measuring autonomic responses such as blood pressure, blood flow, and peripheral skin temperature before and after treatment. The use of skin temperature data in evaluating the effectiveness of treatment techniques has been suggested by a number of investigators (Janman & Daniels, 1983; Kluger, Jamner, & Tursky, 1985; Suter & Loughry-Machado, 1981). However, similar to EMG studies in which the effects of various types of treatment were investigated, skin temperature data are often used with biofeedback to ameliorate some type of disease or dysfunction. Kewman and Roberts (1980) attempted to confirm the efficacy of finger-warming training in the treatment of migraine headaches. Their study involved 34 subjects who had migraine headaches. Eleven were taught to increase the temperature of their hands; 12 were trained to reduce their hand temperature; and 11 control subjects were not trained but maintained records of migraine activity. All subjects were female and ranged in age from 21 to 75, with a mean age of 40 years. The experimental per od lasted 21 weeks and was divided into three phases. Phase One consisted of a six-week pretreatment period for the collection of baseline data. In Phase Two, the two experimental groups were trained to either raise or lower their hand temperature for approximately nine weeks. Phase Three involved a six-week period of post-treatment data collection. Results of this study failed to support the premise that hand-warming biofeedback techniques could demonstrate a reduction in migraine activity.

The use of skin temperature biofeedback with children has increased over the last 10 years. Suter, Fredericson, and Portuesi (1983) reported on three experiments designed to explore the capacity of children to use thermal biofeedback for self-regulation. Children in these experiments ranged from 6 to 12 years of age and were asked to perform either hand-warming or hand-cooling activities using mental imagery. Conflicting findings regarding the efficacy of skin temperature regulatory functions with that age group indicated that further research is warranted.

Skin temperature data have also been used to assess the effects of various wheelchair cushions and the prevention of decubitus ulcers. In their study, Seymour and Lacefield (1985) investigated the effects of eight wheelchair cushions with 20 subjects. Ten of the subjects were described as able-bodied and 10 subjects had spinal cord injury. Several objective and subjective factors were studied. Objective factors included the area of first light, pressure, tuberosity, and thigh temperatures. The subjective factors included the subjects' opinions of cosmesis, handling ability, and purchase of wheelchair cushions. No significant difference was found among cushions regarding area of first light, cosmesis, handling ability, or purchase. Temperature differences among cushions were not significant; however, the alternating pressure and foam cushions tended to produce consistently higher temperatures. The authors concluded their findings by stating that the use of cushions for patients should be modified on the basis of initial and periodic assessments.

Rattenbury and Donald (1982) reported on a number of studies that used both EMG and thermal information to assess changes in muscular tension. Their study investigated forearm tension and changes in finger temperature. Ten university students between the ages of 19 to 25 comprised the study sample. Using EMG biofeedback, subjects were asked to maintain an EMG output of five microvolts or less. Subjects were then asked to perform a tonic contraction of the forearm for three minutes. EMG and skin temperature readings were collected following each contraction period. The results indicated that an increase in tonic forearm EMG activity produced a decrease in skin temperature.

In another study, Kibler and Rider (1983) investigated the effects of muscle relaxation on finger temperature. Subjects in this study were three sections (76 students) of an introductory music class. Each section received either sedative music (M), progressive muscle relaxation (PMR), or both (M+PMR) as treatment for 15 minutes. Significant increases in skin temperature readings were noted for all groups immediately after treatment.

Summary

The preceding review of the literature provides a description of research investigating the effectiveness of techniques used to reduce spasticity in children. This review also reports on two techniques used to quantify physiological change as a result of those treatment techniques. The following conclusions highlight those findings:

First, a variety of approaches exist for use in remediating problems for children who have spastic cerebral palsy. These treatment approaches can be divided into four main categories: (a) medical interventions and strategies used to reduce spasticity, (b) plaster casting, (c) positioning devices, and (d) physical and/or occupational therapeutic approaches. Secondly, this review of the literature described two techniques that have been used to assess physiologic changes. These techniques included electromyography (EMG) and skin temperature readings.

Conflicting results have emerged from investigations of the efficacy of differing medical approaches in the treatment of spasticity. The use of medications is one of the most common alternatives to reduce spasticity. Although several prescription drugs such as Valium, Dantrium, and Lioresal have proven effective in the reduction of spasticity, companion side effects inherent with this treatment approach have been noted. Drowsiness, lightheadedness, and confusion are typical side effects that obviously inhibit optimal cognitive and motor performance in the classroom. In reviewing the effects of different medications used to reduce spasticity, Davidoff (1985) and Young and Delwaide (1981) urged practitioners to exercise caution when prescribing medications.

The use of plaster casting is another treatment modality used to ameliorate the effects of spastic cerebral palsy. Westin and Dye (1983) noted that although plaster casting had several potential negative side effects (muscle atrophy, knee discomfort, and gait disturbances), it can be used effectively in reducing the effects of spasticity. They further noted that plaster castings are less invasive than surgical techniques and may result in fewer follow-up treatments.

Another strategy frequently used in the treatment of spasticity involves the use of positioning devices (Campbell, 1983b). These methods included the use of prone boards (Holder, Wells, & Cook, 1985); splints, finger spreaders, and cones (Mathiowetz, Bolding, & Trombly, 1983); and adaptive seating devices (Smith, 1985). Inconclusive results have been reported in recent investigations regarding the efficacy of these devices (Mathiowetz et al., 1983; Smith, 1985).

The use of physical/occupational therapeutic approaches in the treatment of spastic cerebral palsy has been extensive in the last 45 years. The differing effects of approaches within this group of methods have been noted. For example, the efficacy of the Phelps approach as reported by a number of researchers has not been conclusively demonstrated (Crosland, 1950; Zuck & Johnson, 1952). Research investigating the effects of the Doman-Delacato approach (Doman, Spitz, Zucman, Delacato, & Doman, 1960) was reported with similar results. Sparrow and Zeigler (1978) noted that loving care and concern was just as effective as the time-consuming Doman-Delacato approach.

Two relatively recent approaches involving sensory stimulation suggested for children who have spastic cerebral palsy were offered by Rood (1962) and Ayres (1972). However, research investigating the Rood and Ayres techniques did not substantiate the efficacy of these treatment approaches.

Harris (1981) noted that the neurodevelopmental treatment (NDT) approach is, perhaps, the most popular set of strategies used today in treating children who have spastic cerebral palsy. This approach was originally developed by Bobath and Bobath (1967), and has been modified over the last several years. Investigations concerning the efficacy of this approach are beginning to emerge with promising results (Tyler &

Kahn, 1976; Scherzer, Mike, & Olson, 1976; Wright & Nicholson, 1973).

A common alternative to the adoption of a specific treatment regime has been the development of eclectic approaches (Twist, 1985). Several authors (Carlsen, 1975; Norton, 1975) have demonstrated significant gains with an eclectic approach. However, replication of similar gains with a heterogenous population remains to be documented.

The Developmental Physical Management approach (Holder, 1977) suggested a similar eclectic mode of intervention. However, research examining this modality is not yet available.

"Appropriate" treatment techniques have been selected based on subjective assessment information and have been applied using unproven theoretical constructs. Many of these approaches lacked the empirical verification needed to demonstrate the actual effectiveness of intervention. One method of evaluating the effectiveness of these approaches included electromyography. Traditional applications of EMG usually require some component of cognitive participation on the part of the child, and are not practical with severely involved children. It is apparent that further research is needed to quantify the use of EMG as a means of evaluating the effectiveness of intervention strategies with children who have spastic cerebral palsy.

The use of distal thermal information may prove to be a reliable technique in assessing the effects of intervention. However, research demonstrating the effects of skin temperature data in the assessment of various treatment techniques remains to be established.

It is apparent that further research is needed in establishing the efficacy of current treatment techniques with children who have spastic cerebral palsy. Martin and Epstein (1976) observed:

> the best known therapeutic 'schools' in cerebral palsy typically rely on 'semiobjective anecdotal case reports or simple outcome studies' to recommend specific physical therapy techniques to the therapist. These studies may have indicated that 'something' did or did not work, yet failed to isolate the effective treatment variables. (p. 285)

CHAPTER III

PROCEDURES

The efficacy of two treatment techniques frequently utilized for reducing hypertonicity in children who have spastic cerebral palsy was explored in this study. Electromyography and skin temperature data were used to assess the effects of trunk rotation and slow rolling on a ball. This chapter includes the sample selection, instrumentation, data collection, and design and data analysis.

Sample Selection

Prior to implementation of this investigation, approval was secured from The University of Alabama to use human subjects (see Appendix H). The sample for this study consisted of infants and young children who were enrolled in the Rural Infant Stimulation Environment (RISE) Program. RISE is described as a comprehensive program for physically handicapped and other health impaired infants from the Tuscaloosa, Alabama area. It typically serves 40 children from birth to three years who are delayed in motor development. Infants served at RISE include those who have been diagnosed as having cerebral palsy, spina bifida, hydrocephaly, and developmental delay. Ten infants (8 months to 35 months) who had been diagnosed as having spastic cerebral palsy and who were in regular attendance at RISE were selected for this study.

Basic demographic data were collected on each subject to further characterize the sample. This information included the child's weight, height, and head circumference. A composite summary of each child's assessment findings are described in Appendix C.

Following the determination that a child had met the study criteria, the parent(s)/legal guardian(s) were contacted and the study was described to them. After receiving verbal approval from the parent(s)/ legal guardian(s) of the children, a letter describing the study, forms for written consent, and releases of information were mailed with a self-addressed, stamped return envelope (see Appendix D).

Instrumentation

The motor specialist employed in this study assessed each child using three assessment instruments. They included: (a) the RISE Computerized Checklist Physical Management subcomponent (RCC-PM) (Holder, Wells, & Cook, 1985); (b) the Movement Assessment of Infants (MAI) (Chandler, Andrews, & Swanson, 1980); and (c) the Bayley Scales of Infant Development (BSID) (Bayley, 1969).

The RISE Computerized Checklist (RCC) was designed to assess the development of children who are motorically impaired/delayed. It was developed to be used with children who (a) motorically function between the ages of birth and 18 months; (b) have been diagnosed as developmentally delayed; (c) exhibit hypotonia (low muscle tone) or hypertonia (excessive muscle tone); and/or (d) have abnormal movement patterns (e.g., cerebral palsy). It examines four developmental areas which include Physical Management, Reflex Integration, Reflex Development, and Oral Motor Development. The Physical Management section assesses: (a) positioning and handling techniques; (b) precautionary measures used with particular handicapping conditions (i.e., hydrocephalus or epilepsy); and (c) equipment. The Reflex Integration section examines those reflexes which are normally present at birth and are later integrated into movement patterns that lead to higher level responses. The Reflex Development section is based on those reflexes described by Fiorentino (1974). These reflexes typically appear from one to 18 months of age. The Oral Motor section assesses the child's oral reflex development and feeding patterns. The RCC-PM was used in this study to confirm the presence of hypertonicity. It was also used to determine the side of the body that was most involved for the placement of sensors. As a companion tool to the RCC, a computerized curriculum cross-references assessment items from the RCC to therapeutic classroom activities and objectives (see Appendix A). These include the two treatment techniques of trunk rotation and slow rolling on a ball. Administration of the RCC must be conducted by a registered physical or occupational therapist.

The Movement Assessment of Infants (MAI) is a non-standardized assessment of specific motor behaviors of infants up to 12 months of age (Chandler, Andrews, & Swanson, 1982). This assessment tool addresses four areas: tone, primitive reflexes, automatic reactions, and volitional movement. The Muscle Tone section was used to provide detailed and systematic appraisal of tone difficulties with a high-risk score that indicates the severity of involvement. Out of a possible high-risk score of 10 (a score of 0-2 is normal), the children in the study scored 8, 9, or 10 high-risk points in the Muscle Tone section. This test was used to support the diagnosis of spasticity.

The Bayley Scales of Infant Development (BSID) was designed to provide information regarding a child's developmental status during the first two and one-half years of life (Bayley, 1969). Three scales comprise the BSID: a Mental Scale, a Motor Scale, and an Infant Behavior Record. The BSID was standardized on a sample of 1,262 infants. Holden (1972) noted that this sample was representative of the United States with respect to major geographic areas, sex, and race in each age group.

Two sections of the BSID were administered to subjects in this study. The Mental Development Index (MDI) yielded a standard score of the child's mental development. The Psychomotor Development Index (PDI) provided a standard score measurement of the child's motor development. According to Bayley (1969), the Mental Scale was designed to:

> assess sensori-perceptual acuities, discrimination, and the ability to respond to these; the early acquisition of object constancy, memory, learning, and problem solving ability; vocalizations and the beginnings of verbal communication; and early evidence of the ability to form generalizations and classifications, which is the basis of abstract thinking. (p. 3)

Reliability coefficients for the Mental Scale ranged from .81 to .93, with a median value of .88 (Bayley, 1969).

The Motor Scale provided "a measure of the degree of control of the body, coordination of the large muscles, and finer manipulatory skills of the hands and fingers" (Bayley, 1969, p. 3). Statistics relating to reliability coefficients for the Motor Scales ranged from .62 to .92, with a median value of .84 (Bayley, 1969). Standard scores for both the MDI and PDI have a mean score of 100 and a standard deviation of 16. Children with a standard score between 70 and 130 are reported to be within normal limits. Standard scores of less than 70 or greater than 130 indicate that the child is "at risk." Scores less than 50 or greater than 150 indicate exceptionalities. The BSID was used to describe the subjects. This information was helpful in illustrating the characteristics of the study sample.

Pilot Study

After the 10 subjects who met the criteria of the study were determined, two infants were randomly selected and placed in one of two treatment groups to test the methodology. The child in Group 1 (Subject

"C") received trunk rotation, and the child in Group 2 (Subject "D") received slow rolling on a ball. The purposes of the pilot study were to test the functionality of the side-lying position, placement of the sensors, and data collection procedures.

Pilot study data were collected three times a week, for two weeks with both subjects. Although the EMG and thermal data points were invalid for a number of reasons, considerable information was gained in terms of the methods and procedures. For example, it was found that the side-lying position was inappropriate and could not be tolerated by either of the subjects. It was decided, instead, to use a therapeutic sitting position. Behaviorally, the children seemed to tolerate this position better. As a result of the pilot study, another change in the methods involved the placement of the thermal sensor. Originally, it was designed to be attached with adhesive tape to the big toe on the most involved side. After many attempts, the investigator found this to be an awkward placement and the sensor kept coming off the toe. After consultation with two EMG specialists (Dr. Vernon Pegram, Director, Alabama Sleep Disorders Center; and Mr. Jan Hoover, President, J. & J., Inc., a distributor of EMG and thermal equipment), it was decided to move the placement of the sensor to the midpoint of the superior surface of the foot. One of the children was terminated from the study for several reasons. First, the child had difficulty tolerating all activities during the study. His persistent crying, movements, and attempts to remove the sensors precluded the collection of valid data. His hypertonicity and skin temperature pretest measures were highly exaggerated as a direct result of his kicking and crying behaviors. It was then decided to reduce the sample size to nine instead of 10. Although it may have been possible to locate another appropriate subject within a reasonable geographic area, repeated movement of both the EMG and thermal units to another location to collect data on another child could have resulted in artifact data (Hoover, 1984). Furthermore, this would have precluded controlling the environmental variables described in this study.

Data Collection

All data were collected in a small room adjacent to the RISE program. The treatment room was in close proximity to the classroom from which subjects were selected. A hallway and storage room helped to insulate the treatment room from environmental noises. Ordinarily, the room was illuminated by two six foot florescent tubes. However, florescent lighting can also be artifact in collecting sensitive EMG data. Therefore, a small shaded table lamp with a 60 watt bulb was used to provide illumination. No other electrical devices were operated during data collection.

Based on each child's size and sitting balance, two adaptive seating options were used. For those children who lacked sufficient head and trunk control for independent sitting, a small Tumble Forms Deluxe Floor Sitter was used. (Available from J. A. Preston Corporation, 60 Page Road, Clifton, NJ 07012, #PC4542 B.) These chairs were specifically designed for positioning children with severe handicaps. It consisted of a soft and washable plastic and had a contoured shape for both comfort and correct posture. It also had an integral leg abductor and hip positioning belt. A separate wedge with velcro fasteners was used to hold the seating unit in an upright position and small pillows were used to provide proper foot support. For those children who demonstrated adequate sitting posture or who were too large for a floor sitter, a Rifton Toddler chair was used. (Available from Rifton, Route 213, Rifton, NY 12471, #E77.)

At the north end of the room a small table was used for the EMG unit, thermal unit, and supplies. Supplies needed for this study included:

1. A box of facial tissues,
2. An air tight container for cotton balls,
3. Alcohol for removing bandage residue and sensor gel,
4. A can of "Static Guard," anti-static spray,
5. Electrodes,
6. Adhesive discs for attaching electrodes to the skin,
7. A tube of JE-22 conductivity gel,
8. "Snoopy Strip" brand bandages for attaching thermal sensors to the top of the foot,
9. Scissors for trimming bandages,
10. Extra pens/pencils for data collection,
11. Data summary sheets (see Appendix G),
12. A "West Bend" brand triple timer (#40000), and
13. A 20 inch diameter (53cm) gymnastic ball.

(Available from The Equipment Shop, P. O. Box 33, Bedford, MA 01730, #SBO.)

The children were positioned in the adaptive chairs facing south, away from the equipment. Due to the size of the room, timing of procedures, and the dual channel capability of the EMG and thermal units, two children were typically involved in data collection at the same time. The chairs were placed on a 4' by 4' shag rug. An anti-static spray mist was used on the rug because static electricity was a source of possible data contamination, particularly with EMG data (Hoover, 1984).

The device used to collect EMG data was a Dual Channel EMG, model M-53. (Available from J. & J. Inc., 22797 Holgar Ct., N.E., Poulsbo, WA 98370; see Appendix I). The purpose of this model was to measure electrical information sent from the brain and spinal cord to the muscles and to measure the electrical impulses that caused the muscle fibers to contract. These electrical impulses move through the neuromuscular network and terminate in groups of muscle fibers known as motor units. When enough motor units are repeatedly stimulated in a certain area, muscle contraction occurs. Relaxation of the muscle occurs when the number and rate of stimulations decrease below the level initially required for contraction.

EMG activity is reported in terms of microvolts (millionths of a volt). According to the Instruction Manual included with the EMG unit, the level of microvolts is determined by three variables:

1. the number of motor units firing,
2. the rate of those firings, and
3. the proximity of the motor units to instrument electrodes.

This motor unit activity is averaged over a short period of time prior to display on the instrument meter. The higher the microvolt level, the greater the muscular tension or contraction. Conversely, the lower the microvolt level, the more relaxed the muscle (J. & J. Inc., no date). This particular instrument was powered by four nickel-cadmium rechargeable batteries. Prior to each treatment session, the power level was checked using the check button located on the unit. Weak batteries were either replaced or recharged prior to operation. Several pieces of additional equipment and supplies were used to collect the EMG data. These accessories are described below:

1. Isolation Preamplifier (#1P-5): EMG electrodes were attached into the preamplifier. The preamplifier eliminated the interference "antenna"

effect of attached equipment. The plug on the other end of the preamplifier attached to the rear of the EMG unit.

2. Electrode Leads (#EC-18): Three wires (leads) composed this essential piece of equipment. On one end of each lead there was a snap connector for cup electrodes. The other ends had pin-plugs which were plugged into the preamplifier. As suggested by J. & J. Inc., the leads were twisted together in a braided fashion and secured with paper tape.

3. Silver/Silver Chloride Electrodes: Three of these cup electrodes were attached to the lead wires. Depending on the size of the child's gastrocnemius (calf muscles), two different cup electrodes were used. These included an 18mm housing (#SE-40) and a 23mm housing (#SE-25).

4. Adhesive Attachment Discs (#AD-25): These discs had an adhesive material on both sides and were used to attach the electrode to the skin surface.

5. Electrode Contact Medium (EJE-201): This electrically conductive gel facilitated electrode contact with the skin. A small amount of the gel was placed in the cup of the electrode prior to attaching it to the skin.

The following directions in the Instruction Manual (J. & J. Inc., no date) were used to attach the electrodes to the skin:

1. Visually inspect the site for attachment (middle of the gastrocnemius) for general cleanliness. Abrading the skin was not necessary with this equipment.

2. Remove one of the attachment discs from its backing to expose the adhesive surface.

3. Holding one of the electrodes cup side up, apply the exposed adhesive surface of the disc to the electrode housing, assuring that the hole in the disc is centered over the cup.

4. Fill the electrode cup with contact medium so that it slightly overfills the cup. Using the backing of the adhesive disc, scrape off the excess electrode gel so that the remaining gel is flush with the top of the cup.

5. Remove the backing paper from the other side of the attachment disc, exposing the adhesive surface which will be attached.

6. Apply the electrodes to the selected sites.

7. Place the white electrodes in a parallel fashion to the middle of the gastrocnemius. Place the

green electrode over the knee (a boney prominence), or halfway between the two white electrodes.

The device used to collect thermal information (skin temperature readings) was a J. & J. thermal model T-63 (see Appendix I). The J. & J. thermal model T-63 measured the tissue temperature of the skin located under the thermal sensor. It provided an "indirect measurement" of peripheral cardiovascular activity and, in turn, sympathetic nervous system arousal. The vessels (arterioles) which supply blood to the periphery are surrounded by smooth vessels which are innervated by the sympathetic branch of the autonomic nervous system. With sympathetic arousal or activation, the muscles in the vascular beds constrict (vasoconstriction) resulting in a reduction in peripheral blood flow and, ultimately, a reduction in tissue temperature. With decreased sympathetic activity, the muscles in the vascular beds relax (vasodilation), resulting in an increase in peripheral blood flow and, ultimately, an increase in tissue temperature (J. & J. Inc., no date). This thermal unit was powered by four nickel-cadmium batteries. This device also had the capability of checking the strength of the power supply. A button located on the front, lower-right corner of the unit could be pressed to test the power supply. Batteries were either recharged or replaced, when needed. The only additional equipment needed to collect skin temperature data were the sensors. The sensors were described as highly sophisticated integrated circuits which were reported to be highly sensitive to fluctuations in temperature. Placement of electrodes and sensors on the most affected body side was done in an effort to observe the greatest change in skin temperature.

Upon arrival, the child's clothing was removed, with the exception of diapers, so that his/her body temperature could adjust to the ambient temperature of the room. This also allowed for placement of the electrodes and sensors. Staff members at RISE assisted in checking the child's diaper and bringing them to the treatment room at the appointed time. Parents or favored staff members were allowed to accompany the child into the treatment room in order to reduce the child's anxiety. However, most children quickly adapted to the new regime. Upon entering the treatment room, each child was positioned in one of the two seating options (floor sitter or toddler chair). Proper positioning was checked by the motor specialist employed in this study. EMG electrodes and the thermal sensor were attached to the appropriate site of the most affected leg and foot. The sticky portion of a standard adhesive bandage was used to attach the sensor to the superior surface of the foot. The beginning time and ambient room temperature were recorded on the Data Summary Sheet (see Appendix G). The triple timer was set so that pre-treatment data could be precisely recorded at -15, -10, -5, and -2½ minutes prior to intervention. A subjective evaluation of the child's behavior was also recorded at each interval.

The subjects were provided with quiet activities such as story-telling during pre- and post-intervention sessions. After data were collected at -2½ minutes, the EMG leads were disconnected (the electrodes stayed on the child's leg), and the thermal sensor was removed. The timer was then set for five minutes of intervention. The motor specialist provided all of the intervention. Intervention consisted of either trunk rotation or slow rolling on a ball.

Trunk rotation was administered to subjects in Group 1 and is a technique that has been suggested to reduce muscle tone (Holder, Wells, & Cook, 1985). The child was placed in a prone position across the therapist's lap. The child was held at the pelvis, with the right hand placed under the child's right hip joint and the left hand placed under the child's shoulder girdle for stability. The therapist then rotated the hips toward her while rotating the shoulders in the opposite direction. The therapist next rotated the hips away from her while rotating the shoulder girdle in the opposite direction. This procedure was continued in a slow, rhythmical, and alternating pattern for five minutes.

Slow rolling, which was administered to Group 2, is another activity which has been suggested for reducing muscle tone (Holder, Wells, & Cook, 1985). In this activity, the child was placed prone over a large ball and held at the hips. A towel was placed on the ball for added comfort. The child was then slowly, and rhythmically rocked forward, backward, and to each side on the ball. This procedure was provided to children in Group 2 for five minutes.

At the end of intervention, the child was returned to his/her adapted seat. The position was checked by the motor specialist and the electrodes and sensors were reconnected. The children were again provided with quiet activities for the remainder of the data collection. Post-treatment data were collected at $+2\frac{1}{2}$, +5, +10, and +15 minutes after intervention. The time of day and ambient room temperature were recorded at the end of the session. The child was then returned to his/her classroom for the remainder of the day. Following all intervention sessions, the electrodes were cleaned with warm water and stored for the next day. Electrodes were discarded after approximately 50 uses. Battery levels were checked daily and were either charged or changed, if necessary.

Design and Data Analysis

After all data were collected on the Data Summary Sheets, the information was transferred to a computer disk file at The University of Alabama for analysis. The independent variable identified in this study was the treatment condition (either trunk rotation or slow rolling on a ball). The first dependent variable involved electromyography microvolt readings from the area over the gastrocnemius. The second dependent variable involved skin temperature readings obtained from the superior surface of the foot.

All hypotheses were analyzed using an analysis of variance (ANOVA) for a split-plot. A split-plot design consists of a between-subjects factor and a within-subjects factor (Kennedy, 1978). In this study, the between-subjects factor was the treatment condition (i.e., trunk rotation or slow rolling). The within-subjects factor of repeated measures consisted of either electromyographic (EMG) or skin temperature readings. The primary analysis was accomplished using the ANOV77 program of the Behavioral Sciences Program Library (Barker & Barker, 1977).

CHAPTER IV

RESULTS

This chapter reports the research findings for each of the six hypotheses investigated in this study. Statistical tests of hypotheses and their associated assumptions are presented in detail in the following sections.

Tests of Hypotheses for Eight Measures

Tests of Assumptions

Prior to using the ANOVA procedure for testing the hypotheses, appropriate assumptions associated with the design were tested. First, the assumption of homogeneity of variance was tested using Hartley's (1950) *F*max procedure. Values for calculating *F*max were obtained using the BREAKDOWN procedure contained in the Statistical Package for the Social Sciences (SPSS) (Nie, Hull, Jenkins, Steinbrenner, & Bent, 1975). The second assumption of additivity was tested using the RELIABILITY procedure of SPSS (Hull & Nie, 1981). The means and standard deviations for both groups on the eight measures of EMG and skin temperature are presented in Table 1.

When the analysis revealed significant differences

Table 1

Group Means of Eight Intervals for Two Different Treatment Approaches

MEASURE	GROUP 1 ROTATION				GROUP 2 SLOW ROLLING			
	EMG		ST		EMG		ST	
	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD
-15 Minutes	3.30	.93	88.48	4.11	4.43	3.74	89.05	1.46
-10 Minutes	3.80	1.37	88.32	4.38	4.45	4.07	89.17	2.00
- 5 Minutes	3.94	1.32	88.48	4.44	4.02	2.75	89.45	2.12
-2½ Minutes	4.08	1.97	88.54	4.44	3.87	2.89	89.40	2.27
INTERVENTION								
+2½ Minutes	3.12	1.62	89.18	2.76	2.72	1.81	88.87	2.20
+ 5 Minutes	3.04	1.44	89.10	2.98	2.57	1.19	89.05	2.31
+10 Minutes	3.08	1.75	89.28	3.23	2.82	1.85	89.20	2.12
+15 Minutes	3.00	1.26	89.16	3.36	2.20	.86	89.45	2.20

among measures, Tukey's Honestly Significant Difference was employed as an appropriate follow-up procedure. The following sections present analyses involving eight repeated measures. These include results of tests of assumptions, analysis of variance, and appropriate follow-ups.

The assumption of homogeneity of variance was tested separately for EMG and skin temperature readings. For EMG, the obtained Hartley statistic (F_{max} = 22.05) was compared to the Hartley table value. Based on these results, there was insufficient evidence to indicate that this assumption had been violated. Using the same procedure with skin temperature findings, the obtained Hartley statistic (F_{max} = 9.23) was also compared to the Hartley table value. As with the EMG findings, there was insufficient evidence to indicate that the assumption of homogeneity of variance on skin temperature findings had been violated.

The assumption of additivity within each group was tested separately for EMG and skin temperature. For Group 1 (subjects receiving trunk rotation), the obtained F for nonadditivity on EMG readings (F = .29) was compared to the critical value (F = 4.22, $p < .05$). In this case there was insufficient evidence to indicate that this assumption had been violated. For this same group, the obtained *F* for nonadditivity on skin temperature readings ($F = 20.42$) exceeded the critical value ($F = 4.22$, $p < .05$), thus violating the assumption of additivity. In Group 2 (subjects receiving slow rolling), the obtained *F* for nonadditivity on EMG readings ($F = 104.8$) exceeded the critical value ($F = 4.35$, $p < .05$). This finding clearly indicated that this assumption of additivity had been violated. The obtained *F* for nonadditivity on skin temperature readings ($F = .26$) with this same group, was also compared to the critical value ($F = 4.35$, $p < .05$). For these findings, there was insufficient evidence to indicate that this assumption had been violated. Analyses were conducted as planned despite violations of additivity assumptions in two cases (skin temperature measures with Group 1, and EMG readings with Group 2). The analysis of variance procedures are robust against these violations, particularly when the assumptions are not grossly violated (Glass, Peckham, & Sanders, 1972; Kennedy, 1978).

Analysis of Variance Findings for Eight Measures

The analysis of variance procedure was employed to test null hypotheses 1, 2, and 3 as they related to eight measures of EMG. The results of the analysis of variance for EMG are presented in Table 2.

Table 2

ANOVA Summary Table for EMG Readings in Microvolts-Two (Groups) X Eight (EMG Measures) with Repeated Measures

SOURCE	SS	df	MS	F
Between Groups	.02	1	.02	.00
Error (between)	196.22	7	28.03	
Total (between)	196.24	8		
Between Measures	23.42	7	3.35	4.01*
Groups X Measures	6.24	7	.89	1.07
Error (within)	40.91	49	.83	
Total (within)	70.57	63		

*$p < .05$

The obtained F value for the interaction between groups (rotation and slow rolling) and EMG measures ($F = 1.07$) did not exceed the critical value ($F = 2.22$, $p < .05$). Hypothesis 1 stated that there would be no significant interaction between groups (rotation and slow rolling) and eight measures on EMG readings.

Thus, there was insufficient evidence to reject the first hypothesis. These findings indicated there was no significant interaction between the two groups.

Hypothesis 2 predicted that there would be no significant difference between groups (trunk rotation and slow rolling) on EMG readings regardless of measure. The obtained F value for the difference between groups (F = .00) failed to reach significance in that it did not exceed the critical value (F = 5.59, p < .05). Due to the lack of statistically significant differences between groups regardless of measure, there was insufficient evidence to reject Hypothesis 2.

Hypothesis 3 stated that there would be no significant difference among measures on EMG readings regardless of group membership. The obtained F value for the difference among measures (F = 4.01) exceeded the critical value (F = 2.22, p < .05). Since the obtained F value exceeded the critical F, Hypothesis 3 was rejected at the .05 level.

Using Tukey's HSD as a follow-up procedure, the difference between all possible pairs of means ($\bar{X}$'s) was compared to the critical HSD value of 1.94 (p < .05). These obtained differences are found in Table 3.

None of the differences reached statistical

Table 3

Table of Differences Between Pairs of EMG Means for Both Groups

EMG MEASURES	2 4.09	4 3.99	3 3.98	1 3.80	7 2.97	5 2.94	6 2.83	8 2.64
(EMG 2) 4.09	----	.1	.11	.29	1.12	1.14	1.26	1.44
(EMG 4) 3.99		----	.01	.19	1.02	1.04	1.16	1.34
(EMG 3) 3.98			----	.18	1.01	1.03	1.14	1.33
(EMG 1) 3.80				----	.83	.86	.97	1.16
(EMG 7) 2.97					----	.02	.13	.32
(EMG 5) 2.94						----	.11	.30
(EMG 6) 2.83							----	.199
(EMG 8) 2.64								-----

significance. It can therefore be assumed that only the largest difference, that between EMG 2 and EMG 8, was significant. Practical significance of the results using eta square (N^2) revealed that 33% of the variability was due to the measure.

The analysis of variance procedure was used to test null hypotheses 4, 5, and 6 as they related to eight measures of skin temperature. The results of the analysis of variance for skin temperature are summarized in Table 4.

Table 4

ANOVA Summary Table-Two Groups X Eight Measures of Skin Temperature

SOURCE	SS	df	MS	F
Between Groups	2.86	1	2.86	.04
Error (between)	520.05	7	74.29	
Total (between)	522.91	8		
Between Measures	3.09	7	.44	.53
Groups X Measures	3.64	7	.52	.62
Error (within)	41.02	49	.84	
Total (within)	47.75	63		

*$p < .05$

The obtained F value for the interaction between groups (rotation and slow rolling) and skin temperature measures (F = .62) did not exceed the critical value (F = 2.22, $p < .05$). The fourth hypothesis stated that there would be no significant interaction between groups (rotation and slow rolling) and measures on skin temperature readings. Thus, there was insufficient evidence to reject Hypothesis 4.

The obtained F value for the difference between groups (F = .04) failed to reach statistical significance (critical F = 5.59, $p < .05$). Hypothesis 5 stated that there would be no significant difference between groups on skin temperature readings regardless of measure. A failure to reject Hypothesis 5 was attributed to a lack of sufficient evidence supporting a statistical difference between those two groups.

Hypothesis 6 predicted that there would be no significant difference among measures on skin temperature readings regardless of group membership. The obtained F value for the difference among measures (F = .53) did not reach the critical value (F = 2.22, $p < .05$). As a result of these findings, there was insufficient evidence to reject Hypothesis 6.

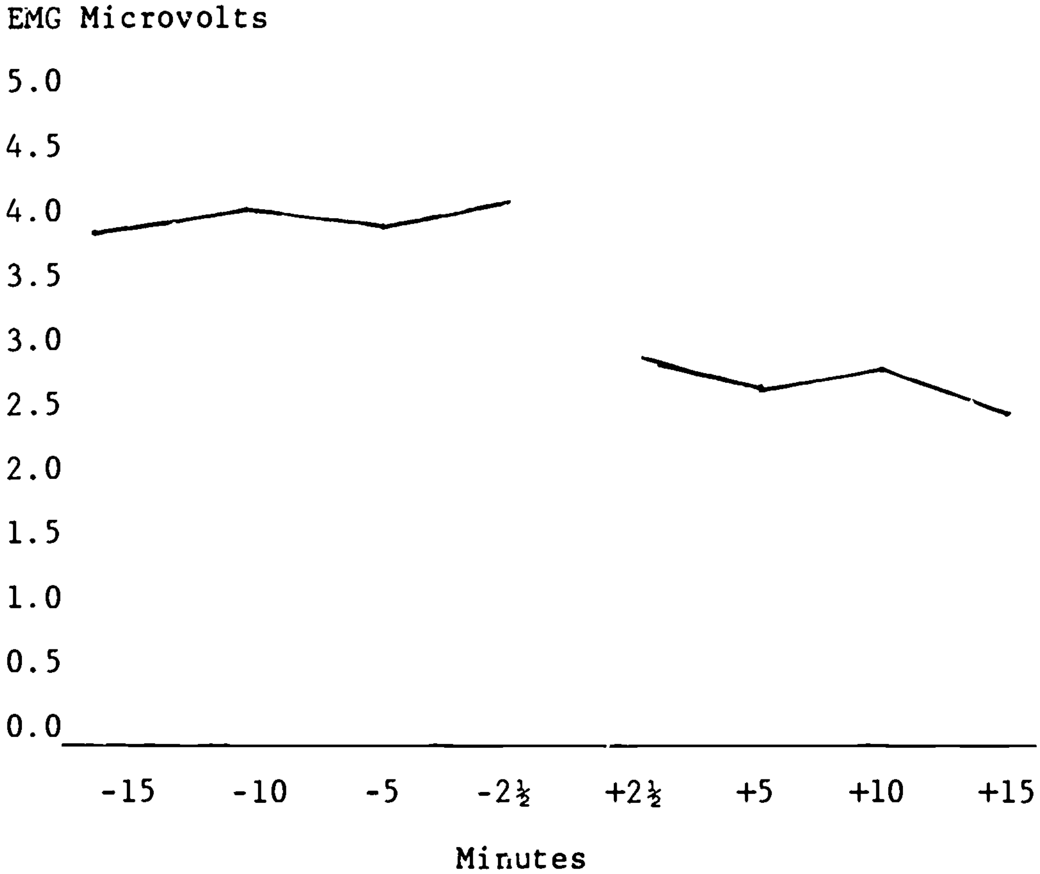
Analyses Using Two Repeated Measures

Tests of Assumptions

The following section presents an analysis involving two EMG measures. Specifically, these measures occurred at 2½ minutes prior to intervention and 2½ minutes following intervention. It should be mentioned that these findings are not directly related to the hypotheses that were previously stated. However, it was decided to include these results based on the relative usefulness of these findings. Figure 1 illustrates EMG microvolt pre- and post-treatment results. Those data were obtained by averaging EMG microvolt readings over 12 treatment sessions for both groups at each measure. Investigation of those findings was pursued in an effort to further conceptualize the effects of trunk rotation and slow rolling. Tests of assumptions and the analysis of variance results are included for this post hoc investigation.

The assumption of homogeneity of variance was tested separately for EMG measures and skin temperature readings. For the EMG measures, the obtained Hartley statistic ($F_{max} = 3.17$) was compared to the Hartley table value. Based on these results, there was

Figure 1. Pre- and post-treatment microvolt readings for two groups.



insufficient evidence to indicate that this assumption had been violated. The same procedures were used with skin temperature findings. The obtained Hartley statistic (F_{max} = 4.09) was compared to the Hartley table value (F_{max} for four groups, four degrees of freedom, and $p < .01$ is greater than 49). Similar to the results reported on the EMG findings, there was insufficient evidence to indicate that the assumption of homogeneity of variance with skin temperature had been violated.

The assumption of additivity within the two groups was tested separately for EMG measures and skin temperature findings. For subjects receiving trunk rotation (Group 1), the obtained *F* for nonadditivity on EMG readings ($F = .30$) was compared to the critical value ($F = 10.10$, $p < .05$). Thus, there was no reason to believe that this assumption had been violated. With this same group, the obtained *F* for nonadditivity on skin temperature readings ($F = 27.19$) exceeded the critical value ($F = 10.10$, $p < .05$). This finding clearly indicated that the assumption of additivity had been violated.

For those subjects who received slow rolling (Group 2), the obtained *F* for nonadditivity on EMG readings ($F = 4.31$) did not reach the critical value ($F = 18.51$, $p < .05$), which suggested that the assumption of additivity was not violated. Upon examining the obtained *F* for nonadditivity on skin temperature readings ($F = .06$) against the critical value ($F = 18.51$, $p < .05$), there was insufficient evidence to indicate that this assumption had been violated. Although there was a violation of additivity with Group

1 on skin temperature readings, the robust nature of the analysis of variance procedures permitted further investigation.

Analysis of Variance Findings for Two Measures

The analysis of variance procedure was used to examine the interaction and main effects for two treatment techniques (trunk rotation and slow rolling) as measured by electromyography. The results of the analysis of variance for EMG measures are presented in Table 5.

Table 5

ANOVA Summary Table-Two Groups X Two EMG Measures

SOURCE	SS	df	MS	F
Between Groups	.40	1	.40	.05
Error (between)	55.42	7	7.92	
Total (between)	55.82	8		
Between Measures	4.91	1	4.91	6.06*
Groups X Measures	.04	1	.04	.05
Error (within)	5.67	7	.81	
Total (within)	10.62	9		

*$p < .05$

The obtained *F* value for the interaction between groups (trunk rotation and slow rolling), and the two EMG measures ($F = .05$) did not exceed the critical value ($F = 5.59$, $p < .05$). Therefore, this interaction was not statistically significant. The obtained *F* value for the difference between groups ($F = .05$) failed to reach significance in that it did not exceed the critical value ($F = 5.59$, $p < .05$). The obtained *F* value for the difference between measures ($F = 6.06$) exceeded the critical value ($F = 5.59$, $p < .05$), clearly indicating a statistically significant difference between EMG measures. A measure of practical significance of these results was obtained by calculating eta square. The findings revealed that 46% of the variability was due to the measure. The analysis of variance procedure was used to examine the interaction and main effects for two treatment techniques as measured by skin temperature. The results of the analysis of variance for skin temperature are presented in Table 6.

The obtained *F* value for the interaction between groups (trunk rotation and slow rolling) and the two skin temperature measures ($F = 1.58$) failed to reach the critical value ($F = 5.59$, $p < .05$). Based on these

Table 6

ANOVA Summary Table-Two Groups X Two Skin Temperature Readings

SOURCE	SS	df	MS	F
Between Groups	.35	1	.35	.02
Error (between)	132.82	7	18.97	
Total (between)	133.17	8		
Between Measures	.07	1	.07	.08
Groups X Measures	1.50	1	1.50	1.58
Error (within)	6.65	7	.95	
Total (within)	8.22	9		

$^{*}p < .05$

findings, there was insufficient evidence to support the notion that there was a significant interaction between groups and two measures of skin temperature.

The obtained F value for the difference between groups (F = .02) did not exceed the critical value (F = 5.59). Therefore, there was no statistically significant difference between those subjects in Group 1 (rotation) and those in Group 2 (slow rolling). The obtained F value for the difference between measures

(F = .08, p < .05) failed to reach the critical value (F = 5.59, p < .05). Thus, this finding was not statistically significant.

Summary

Six hypotheses were tested in the present study. The first three hypotheses investigated the effects of trunk rotation and slow rolling with children who had spastic cerebral palsy. Changes in muscle tone were evaluated through the use of EMG measurements.

The first hypothesis predicted that there would be no significant interaction between groups (trunk rotation and slow rolling) and eight measures on EMG readings. The results of this particular investigation indicated a lack of statistically significant interaction. This lack of statistically significant evidence failed to reject Hypothesis 1.

The second hypothesis stated that there would be no significant difference between groups (trunk rotation and slow rolling) on EMG readings regardless of measure (-15 minutes to +15 minutes). Results of this investigation failed to demonstrate a significant difference between treatment groups.

Hypothesis 3 predicted that there would be no significant difference among measures on EMG readings regardless of group membership. Statistical findings resulted in the rejection of this hypothesis at the .05 level. Practical significance of these results using eta square revealed that 33% of the variability was due to the measure.

Hypotheses 4, 5, and 6 investigated the effects of trunk rotation and slow rolling on a ball in reducing muscle tone in children who have spastic cerebral palsy. The effects of those treatments were assessed through the use of skin temperature readings.

Hypothesis 4 stated that there would be no significant interaction between groups (trunk rotation and slow rolling) and measures of skin temperature readings. Results of this investigation indicated a lack of statistical evidence to reject this hypothesis.

The fifth hypothesis stated that there would be no significant difference between groups on skin temperature readings regardless of measure (-15 minutes to +15 minutes). Results of this investigation revealed that there was no statistical difference between groups. Thus, there was insufficient evidence to reject Hypothesis 5.

The sixth hypothesis stated that there would be no significant difference among measures of skin temperature readings regardless of group membership. No significant differences were found among skin temperature measures for either treatment group.

A post hoc analysis was conducted on two particular EMG measures. These measures were at 2½ minutes prior to intervention and 2½ minutes following intervention. Group membership for this investigation was disregarded. The obtained *F* value for this analysis (*F* = 6.06), exceeded the critical value (*F* = 5.59, $p < .05$). This finding clearly indicated a significant difference between those two measures. The practical significance of those results was obtained by calculating eta square. The findings revealed that 46% of the variability was due to the measure.

In conclusion, the results of this study indicated that changes in muscle tone, due to either trunk rotation or slow rolling, could be measured through the use of EMG. More specifically, this change is statistically significant when measured just prior to intervention (-2½ minutes) and immediately thereafter (+2½ minutes). No significant difference was found on skin temperature readings.

CHAPTER V

DISCUSSION

The purpose of this study was to investigate the effects of trunk rotation and slow rolling with children who had spastic cerebral palsy. The effects of those two techniques were measured by electromyography (EMG) and thermal information (skin temperature readings). This chapter is divided into a discussion of the results, conclusions, limitations, and recommendations for future research.

Discussion of the Results

The subjects for this study included nine children who were in regular attendance at the Rural Infant Stimulation Environment (RISE) program at The University of Alabama. All of the children were described as having spastic cerebral palsy. The muscle tone of children who have spastic cerebral palsy is characteristically excessive or hypertonic. The presence of hypertonicity was confirmed through administration of the Movement Assessment of Infants (MAI) (Chandler, Andrews, & Swanson, 1982). One of the components of this instrument is designed to assess the status of muscle tone. Results from the muscle tone section of the MAI are ranked from 1 to 10, with a score of 10 indicating excessive muscle tone. All children in this study rated a score of 8, 9, or 10.

The RISE Computerized Checklist-Physical Management subcomponent (Holder, Wells, & Cook, 1985) was used to determine the severity of involvement and the side of the body that was most involved. The Bayley Scales of Infant Development (BSID) (Bayley, 1969) was used to further characterize each child.

The subjects were randomly assigned to one of two treatment groups (trunk rotation or slow rolling on a ball). After being placed in a therapeutic seating position, two EMG electrodes and a skin temperature sensor were attached to the child's most involved leg and foot. Pre-treatment data were collected at -15, -10, -5, and -2½ minutes. A motor specialist provided five minutes of treatment. The child was then returned to his/her seat and post-treatment data were collected in a reverse fashion (+2½, +5, +10, and +15 minutes). Each child was treated twice a week for six weeks.

A split-plot research design was utilized in this study to ascertain the effects of trunk rotation or slow rolling o the dependent variables of EMG microvolt readings and skin temperature measures. The data were analyzed using an analysis of variance with repeated measures.

Basmajian (1978) has stated that EMG is a relatively new technique used to assess the status of muscle tone. Harris (1981) noted that EMG instrumentation is one of the few techniques available to study the effects of treatment strategies.

Studies investigating the use and effects of EMG are replete in the literature (Basmajian, 1978, 1981; Steiner & Dince, 1981; Asato, Twiggs, & Ellison, 1981; Neilson & McCaughey, 1982). However, a majority of the studies that utilized EMG data used it as a component of biofeedback training. Biofeedback training requires the subject to cognitively alter internal physiological events (Basmajian, 1978). This study proposed a departure from the typical applications of EMG and utilized that technology to evaluate changes in spastic musculature but did not require active participation on behalf of the subject.

Six hypotheses were used to study the effects of two treatment techniques used to reduce hypertonicity in children who had spastic cerebral palsy. The first three hypotheses concerned the effects of trunk rotation and slow rolling on a ball as measured by electromyography (EMG).

The dependent variable of EMG microvolt readings was analyzed to determine the effects of trunk rotation and slow rolling with children who had spastic cerebral palsy. Three hypotheses were investigated to detect the presence of interaction between groups and measures, differences between groups, and differences among measures.

The results of an analysis of variance with repeated measures indicated that no significant interaction existed between treatment groups and EMG measures. When data were analyzed for differences between groups, no significant difference was revealed for either trunk rotation or slow rolling.

However, when the effects among EMG measures were analyzed, a significant difference among those measures was obtained. Tukey's HSD served as an appropriate follow-up procedure to examine all possible pairs of EMG means. Since this technique failed to reveal any statistically significant difference, it was assumed that the largest difference between EMG 2 (4.09) and EMG 8 (2.64) was significant (a difference of 1.44).

To further clarify those finding , a post hoc analysis of variance was employed to test the immediate effects of trunk rotation and slow rolling as measured by EMG. A statistically significant difference between EMG observations immediately before and after intervention supported the therapeutic recommendations of Buttram and Brown (1977) and Holder, Wells, and Cook (1985). Thus, both trunk rotation and slow rolling on a ball appear to be effective methods of reducing excessive muscle tone as measured by EMG. The practicality of these findings was supported by further statistical validation through the use of eta square and revealed that 33% of the variability was due to the dependent variable.

Findings supporting the use of skin temperature data to evaluate physiologic changes as a result of trunk rotation or slow rolling on a ball were not evident. A lack of statistically significant data failed to reject all null hypotheses that investigated the use of skin temperature measures to detect physiologic changes. Although trunk rotation or slow rolling on a ball are suggested as techniques to reduce hypertonicity (Buttram & Brown, 1977; Holder, Wells, & Cook, 1985), skin temperature measures did not prove to be effective indicators of the effectiveness of these techniques in the reduction of excessive muscle tone in children who have spastic cerebral palsy.

The changes measured by electromyography did not indicate a difference between the two treatment techniques. The dependent variable of skin temperature readings also failed to discriminate between treatment techniques. Furthermore, skin temperature data, as employed in this study, failed to reveal physiological changes in skin temperature as a result of either treatment techniques. If these techniques produced a generalized relaxation of the musculature, including those surrounding the blood vessels, then one would expect to see an observable difference in peripheral blood flow, resulting in a change in skin temperature. However, the results of this study failed to demonstrate those vascular changes through the use of skin temperature measures.

Several factors may have affected the results of this study. These factors included variables that were child related and variables that were related to the data collection.

Child-Related Variables

Child's Age

One factor that may have influenced the results of this study was related to the child's age. As previously stated, the use of EMG with children has been limited. Basmajian (1978) has stated that a majority of EMG studies are used with biofeedback investigations. Biofeedback studies, by design, require a certain degree of cognitive participation by the subject. Since the subjects in this study were all between the ages of birth and three years of age, it would have been unrealistic to expect them to respond to EMG feedback. Compounding this problem was the non-traditional use of EMG in this research. Although children were not required to cognitively attend to the EMG data or respond to stimuli, their inability to sit quietly when asked to do so, as a result of their age, may have been artifact when collecting EMG data.

Skin temperature studies have also reported a lack of consistent results with children (Suter, Fredericson, & Portuesi, 1983). For example, in their review of skin temperature biofeedback results with children, the subjects used in four studies were all between the ages of six and 12. They noted when children were provided with a thermistor (skin temperature sensor), standard instructions, and feedback, one could not predict, with any confidence, what would ensue (p. 582). They concluded that the use of skin temperature data with children, as opposed to adults, may be premature, based on results obtained from adults who may be able to more fully understand the exact nature of the study requirements.

Degree and Type of Involvement

Another variable that may have had an effect on the results found in this study was related to the degree and type of spastic cerebral palsy each subject manifested. Cerebral palsy is usually classified by using one of three nosologies. The first describes cerebral palsy according to degree of severity (Umbreit, 1983). These types are typically known as mild, moderate, and severe. The second manner of describing cerebral palsy is known as the physiologic classification. It includes spasticity, athetosis, rigidity, tremor, and mixed types. The other classification distinguishes cerebral palsy according to limb involvement (a topographic classification). These types include hemiplegia, paraplegia, diplegia, and quadriplegia. Although these three classification systems overlap in terms of describing various forms of cerebral palsy, considerable discrepancy still exists in describing this population. Umbreit (1983) added that this heterogenous population is also at risk for a number of associated disorders. These associated problems can include visual, auditory, perceptual and cognitive limitations, and seizure activity. These secondary deficits are exhibited in varying degrees and further expand the parameters of this population. For example, a three-year old child who is described as having left hemiplegia could still differ significantly from a three-year old child who has right hemiplegia.

Banus et al. (1971) noted one of the characteristics of cerebral palsy includes the presence of primitive reflexes. One of the most common and persistent primitive reflexes is the asymmetrical tonic neck reflex. Fiorentino (1974), in describing this reflex, noted that it can be elicited by the position of the head. Children who have a persistent asymmetrical tonic neck reflex are bound by this obligatory response. When the head is turned to one side, the arm and leg on that same side will extend (increase in muscle tone) while the contralateral side will flex (decrease in muscle tone). The possibility of eliciting this reflex during EMG data collection can influence the general musculature of the child. Consider the hypothetical situation with a child who has quadriplegic spastic cerebral palsy who also demonstrates an obligatory asymmetrical tonic neck reflex (ATNR). Each time the child's head is turned to the right, the muscles on the left side of the body will flex and the right side will extend with an overall increase in tone. Should this child be involved with EMG data collection with an electrode attached to the right side, EMG data gathered from that side will reflect an increase in muscle tone due to the child's ATNR.

Behavior

Another important variable that may have influenced the results of this study was the child's behavior during data collection and treatment. Substantial information is available from the results of this study to support this observation. Factors related to this variable include the child's cognitive level of functioning, movement reactions of children who have spasticity, and mother-child separation. First, scores on the Bayley Scales of Infant Development-Mental Development Index (Bayley, 1969) for this study sample ranged from 50 to 145. Therefore, some of ths children in this study may not have been able to understand the treatment procedures or the novelty of EMG and thermal data collection. As a result of that misunderstanding, those children might have developed an undesirable affective response. A subjective evaluation of each child's behavior was made at each data collection interval. It was observed that the behavior of several subjects varied, during sessions, from sitting quietly to crying.

Similar behaviors may also be attributed to the child's spasticity. Children who have spastic cerebral palsy often do not feel comfortable when they are moved. This is due to their lack of body control and inability to react to changes of positions in space.

One of the subjects (Subject "B") had considerable difficulty separating from his mother. This separation problem resulted in the subject's crying and moving in his chair to get out. Eventually, this subject learned to tolerate the separation, yet his early anxious behaviors obviously played a definite role in affecting his musculature, EMG, and thermal results.

No statistical analyses were performed with the subjective behavioral data. However, those behaviors constituted variables that may have affected the results.

Variables Related to Data Collection

Day of the Week

Frequently discussed, yet rarely reported, is the day of the week that a child is seen in treatment. Teachers involved in this study subjectively reported that it was more difficult to reduce a child's muscle tone on Monday than on other days of the week. This factor may be attributed to the lack of treatment, since these children typically do not receive treatment on weekends. The RISE program encourages parental involvement in the treatment of children with developmental delays; however, the typical daily responsibilities of those parents, unrelated to the care of their child, may have precluded the implementation of a thorough and consistent weekend treatment regime. As a result, the difference between entering tone on Monday mornings could have been significantly different than entering tone on Friday mornings.

Time of Day

Although children selected to participate in this study were in regular attendance at the RISE program, their arrival time was not consistent. For that reason, children were scheduled to participate as they arrived each day. In an effort to insure the consistency of treatment, one therapist provided all treatment activities; consequently, she could only treat one child at a time. Treatment sessions ranged from 8:30 a.m. to early afternoon. Some children were treated early in the morning while other children were treated later in the day. Those children who were treated later in the day may have participated in activities that could have affected their general muscle tone. Thus, the time of day when treatment was offered may have been a factor that affected the results reported in this study.

Variables Related to Instrumentation

Timing of Intervals

Another variable that may have influenced these results included the timing device that indicated the intervals for data collection. At each interval, a repetitive "beep" was produced. This auditory stimulus could have triggered primitive reflexes in these developmentally delayed children. For example, a moro or startle reflex could have been initiated by the "beep," resulting in a generalized pattern of extension (increased muscle tone). Children in this study may have acclimated to the "beeps" during the pre-treatment phase. Following treatment, the child may have had to readjust to that auditory stimuli. Although statistical results indicated that there was a significant change in muscle tone immediately after treatment as measured by electromyography, this result might have been different had a silent indicator of interval times been employed. Methods that employ the use of an inaudible signal to indicate data collection intervals possibly could control for reflex movements that may be triggered through an auditory stimulus.

EMG Instrumentation

The EMG unit used in this study displayed readings on a meter with a needle that fluctuated with changes in microvolts. Obtaining readings from a scale with an almost constantly fluctuating needle is obviously less accurate than one that provides microvolt readings via a digital display. Although extreme care was exercised during these data collection procedures, precise measurements were tedious due to the constant movements of the EMG needle that indicated the level of microvolts expressed at the electrode site. A device has recently become available that interfaces between the EMG unit and a computer. This device records the exact microvolt output from the site at given intervals and displays or prints the data for future analysis. The collection of more precise data can now be ensured with the development of computer-read data.

Ambient Room Temperature

Differences in the beginning and ending ambient room temperature suggested another variable for discussion. Variations as much as 15 degrees were noted between several pre- and post-treatment sessions. Taub and School (1978) have suggested elaborate conditions for controlling the ambient room temperature. When employed in the environment for skin temperature studies, those suggestions insure that the room temperature does not vary more than 1.5° (F) during sessions. Those conditions included: lining the walls of the clinical setting with three inches of fiberglass insulation covered with burlap; altering the air flow through a combination of floor and ceiling air ducts; and installing a "false" ceiling with an empirically designed system of baffles and air filters. These procedures were cost prohibitive; however, in this study, every effort was made to avoid drafts, and to monitor and adjust the room temperature as needed.

Conclusions

The statistical results of this study indicated that the effects of trunk rotation and slow rolling on a ball can be measured through the use of electromyography. Skin temperature readings were not judged to be effective in measuring physiologic change as a result of two intervention strategies. More specifically, the following conclusions were warranted:

1. The use of EMG appears to be an effective measure of evaluating the effects of trunk rotation and slow rolling on a ball with children who have spastic cerebral palsy. The validation of EMG as an evaluative measure of treatment strategies was statistically significant when examining EMG data points prior to and immediately after treatment (EMG 4, -2½ minutes; and EMG 5, +2½ minutes). These data suggest that both of the treatment techniques employed in this study were effective in reducing hypertonicity. The reduction of excessive muscle tone, for even a brief period of time during each day, may help to reduce the chances of contractures and deformities for this population.

2. EMG did not discriminate between the effects of trunk rotation or slow rolling on a ball with children who had spastic cerebral palsy. According to an analysis of EMG data, both techniques used in this investigation were effective in reducing excessive

tone, albeit brief. When a child's excessive muscle tone is effectively reduced, regardless of duration, those tone-reducing activities allow the child to feel normal postures and movements and reduce the probability of contractures and deformities. These findings support the suggestions by Buttram and Brown (1977) and Holder, Wells, and Cook (1985) that trunk rotation and slow rolling can reduce excessive muscle tone.

3. No significant difference existed among skin temperature measures for children with spastic cerebral palsy who had been provided with five minutes of trunk rotation or slow rolling on a ball. It was concluded that further research needs to be conducted concerning the validity of EMG and skin temperature measurements as evaluative techniques commonly used with childrer who have spastic cerebral palsy.

Limitations

Several limitations characterized this study. These limitations effect the generalizations that may be made to other samples. The limitations of this research are as follows:

1. The number of children who participated in the data collection procedures in this study was limited to

nine. Although less traditional research designs investigating a number of variables with heterogenous populations have been suggested (Tawney & Gast, 1984), the replicable strength of treatment techniques with this population depended on consistent findings among large numbers of subjects. This relatively small sample size is due, in part, to the sensitivity of EMG and skin temperature instrumentation when moved from site to site, thus precluding the participation of additional youngsters from other sites.

2. The sample used in this study was described as typically heterogenous in relation to the total population of children who have spastic cerebral palsy. An examination of sample characteristics reflected a great deal of variability in terms of degree and type of involvement and cognitive level of functioning even when several population controls were implemented.

3. Maintaining a constant ambient temperature was a major limitation of this study. Often, the ambient room temperature was judged to be excessive at the start of treatment sessions (89.0° F). At other times, the ending ambient temperature was recorded at 71.8° F. Variations among individual treatment sessions varied as much as 5.7° F. As a result, the relationship

between tone reducing activities and skin temperature measures could not be determined.

4. Some of the children who were involved in the study at the start of the day were compared to children who, while waiting their turn for inclusion in the study for that day, were engaged in activities in their classroom that may have affected their musculature.

Recommendations for Future Research

This study investigated the therapeutic effects of trunk rotation and slow rolling on a ball for children who had spastic cerebral palsy. Changes in the child's physiology as a direct result of the two treatment techniques were measured by electromyography and thermal information (skin temperature readings). As a result of the findings of this study, a number of recommendations are offered for future research.

The first recommendation relates to the ages of the subjects. The ages of subjects in this study were restricted to birth through three years; a period of time encompassing a wide, yet normal range of developmental changes. The wide-range of skills that typically occur with this sample provides a limited basis to generalize research findings to other populations. Perhaps the use of an older population that could tolerate and respond to verbal commands would assist in: (a) the verification of these tone-reducing techniques as appropriate intervention strategies, and (b) the efficacy of using EMG and skin temperature collection procedures to evaluate those changes. Additionally, these procedures should be verified with a number of age groups rather than confining the age limit to one particular chronological level.

Secondly, this study made no attempt to control for the children's intelligence. Children included in this study demonstrated considerable divergence on their performance on the Bayley Scales of Infant Development-Mental Development Index (50 to 145). Future studies should investigate the effects of these treatment activities with an array of individuals who function on a number of different, yet defined, cognitive levels.

Third, the population of children who have spastic cerebral palsy are at risk for a number of associated disorders, including seizures. Several of the children involved in this study had brief petit mal and/or grand mal seizures during data collection. EMG readings obtained immediately after those periods of convulsant behavior were not true measures of tone-reducing activities alone. It is suggested that children selected for future studies be seizure-free, or that seizures at least be controlled by medication.

The fourth recommendation involves both the time of day that intervention is provided and the day of the week that it is offered. An ideal situation is one in which intervention would be provided at the same time each day. It is further recommended that treatments preceed other classroom activities that might influence the child's musculature. Similarly, providing those intervention activities on the same day of the week would strengthen research findings.

Fifth, intervention strategies provided in this study were limited to five minutes per session. Future studies might consider altering this variable to study any differences that might be obtained from varying the length of treatment.

The sixth recommendation concerns the timing device that was used to indicate data collection intervals. This study employed the use of a three-stage timer that indicated intervals with an audible "beep." The use of a silent device would help to eliminate the possibility of triggering primitive reflexes that may be elicited through auditory stimuli.

The seventh recommendation suggests an alteration of the device used to collect EMG data. Since the completion of this study, newer, more technically advanced EMG instrumentation has become available. These EMG units now have the capability of interfacing with computers for the expressed purpose of collecting data that is free from experimenter bias through the use of objective computer-read information from electrode sites.

The eighth recommendation involves greater control over the ambient room temperature. Sensitive thermal units are greatly affected by changes in temperature, and the elimination of fluctuations in the ambient room temperature might strengthen future designs and encourage better results.

The ninth recommendation concerns the anatomical site of the thermal sensors. The site for collection of thermal data in this study was selected to prevent the removal of the sensor by the subject. Future investigations might involve the study of skin temperature changes from alternative and more traditional sites such as the hand or a finger.

The final recommendation suggests that the evaluative techniques employed in this study should be tested with other intervention strategies used to reduce excessive muscle tone. These strategies might include positioning or physical/occupational therapeutic approaches.

Summary

This study investigated the use of electromyography and skin temperature data to measure the efficacy of trunk rotation and slow rolling as strategies to reduce muscle tone with children who had spastic cerebral palsy. The subjects were 10 children who were between the ages of birth and three years who were in regular attendance at the Rural Infant Stimulation Environment (RISE) program at The University of Alabama in Tuscaloosa. Due to the attrition of one subject, the final data analyses were conducted with nine children. All of the children had the diagnosis of spastic cerebral palsy supported by a muscle tone score of 8, 9, or 10 on the Movement Assessment of Infants (Chandler, Andrews, & Swanson, 1982). The child's side of greatest involvement was determined by the motor specialist through administration of the RISE Computerized Checklist-Physical Management subcomponent. Subjects were randomly placed in one of two treatment groups. Children in Group 1 received trunk rotation and children in Group 2 received slow rolling on a ball. Both intervention strategies were provided by a motor specialist who had received specialized training in these treatment techniques. Subjects were involved in treatment twice a week for six weeks. Each child was placed in a therapeutic seating position that was monitored by the motor specialist. Once the child was placed in his/her seat, EMG electrodes were attached to the child's leg over the gastrocnemius on the most involved side. A thermal sensor was also attached to the superior surface of the child's foot on the same side as the electrode. Data points were collected at 15, 10, 5, and 2½ minutes prior to intervention. Electrodes and sensors were then disconnected from the child and each subject was provided with five minutes of intervention. Following intervention, the child was returned to his/her therapeutic seating and the electrodes and sensors were reattached. Post-treatment data were collected from both sites at 2½, 5, 10, and 15 minutes.

A split-plot research design was utilized in this study to determine the effects of trunk rotation and slow rolling with children who had spastic cerebral palsy. Statistical results indicated that the muscle tone for children in both treatment groups was immediately reduced as measured by electromyography. No differences was noted between the two treatment techniques. Skin temperature measurements did not indicate physiologic changes.

A number of critical questions have been raised as a result of this study. Further investigation is warranted to address unanswered questions to determine appropriate and effective treatment strategies for this population.

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APPENDIX A

SELECTED ASSESSMENT COMPONENTS FROM THE RISE COMPUTERIZED CHECKLIST AND CURRICULUM FOR THE MOTORICALLY DELAYED/IMPAIRED CHILD

UNIT NO.	DEVELOP-MENTAL AGE IN MONTHS	UNIT DESCRIPTION	EQUIP-MENT	EXPLANATION OF ADMINIS-TRATION OF ASSESSMENT ITEM	OBSERVED RESPONSES
PM 007	N/A	HYPERTONIC (MUSCLE TONE IS TOO HIGH)	MAT	THE HYPERTONIC (MUSCLE TONE IS TOO HIGH) SECTION IS RECOMMENDED FOR THE CHILD WHO EXHIBITS ANY OF THE OBSERVED RESPONSES: A. THE CHILD IS POSITIONED SUPINE AND THE FOLLOWING POSTURAL CHARACTERISTICS ARE OBSERVED:	1A. RESISTANCE TO PASSIVE RANGE OF MOTION IN THE NECK, EXTREMITIES, AND/OR TRUNK. 2A. A POVERTY OF MOVEMENT DUE TO INCREASED MUSCLE TONE. 3A. POSTURING OF THE HEAD IN HYPEREXTENSION. 4A. THE UPPER EXTREMITIES ARE INTERNALLY ROTATED AND EXTENDED. HANDS MAY BE FISTED. 5A. THE TRUNK ARCHES IN EXTENSION. 6A. THE LOWER EXTREMITIES ARE EXTENDED, ADDUCTED, AND INTERNALLY ROTATED WITH THE FEET IN PLANTAR FLEXION.

UNIT NO.	DEVELOP-MENTAL AGE IN MONTHS	UNIT DESCRIPTION	EQUIP-MENT	EXPLANATION OF ADMINISTRATION OF ASSESSMENT ITEM	OBSERVED RESPONSES
PM 007	N/A	HYPERTONIC (MUSCLE TONE IS TOO HIGH) (CONTINUED--)	MAT	THE HYPERTONIC (MUSCLE TONE IS TOO HIGH) SECTION IS RECOMMENDED FOR THE CHILD WHO EXHIBITS ANY OF THE OBSERVED RESPONSES:	
				B. THE CHILD IS POSITIONED PRONE AND THE FOLLOWING POSTURAL CHARACTERISTICS ARE OBSERVED:	1B. THE CHILD ARCHES USING EXTREME TRUNK EXTENSION.
					2B. FLEXION HAS NOT DEVELOPED ACROSS THE UPPER TRUNK, CREATING AN INABILITY TO PROP ON FOREARMS AND/OR EXTENDED ARMS. HANDS MAY BE FISTED.
					3B. INCREASED EXTENSION IN THE TRUNK THROUGH THE LOW BACK AND ACROSS THE PELVIS, RESULTING IN AN INABILITY TO ACTIVELY FLEX HIPS AND KNEES.
				C. THE CHILD IS POSITIONED IN SUPPORTED SITTING OR ALLOWED TO ASSUME INDEPENDENT SITTING AND THE FOLLOWING CHARACTERISTICS ARE OBSERVED:	1C. THE HEAD IS POSITIONED FORWARD TOWARD THE CENTER OF GRAVITY AS THE CHILD ATTEMPTS TO MAINTAIN AN UPRIGHT POSITION.

UNIT NO.	DEVELOP-MENTAL AGE IN MONTHS	UNIT DESCRIPTION	EQUIP-MENT	EXPLANATION OF ADMINISTRATION OF ASSESSMENT ITEM	OBSERVED RESPONSES
PM 007	N/A	HYPERTONIC (MUSCLE TONE IS TOO HIGH) (CONTINUED--)	MAT	THE HYPERTONIC (MUSCLE TONE IS TOO HIGH) SECTION IS RECOMMENDED FOR THE CHILD WHO EXHIBITS ANY OF THE OBSERVED RESPONSES:	
				C. THE CHILD IS POSITIONED IN SUPPORTED SITTING OR ALLOWED TO ASSUME INDEPENDENT SITTING AND THE FOLLOWING CHARACTERISTICS ARE OBSERVED.	2C. A TENDENCY TO PUSH BACKWARD WHILE SUPPORTED IN SITTING.
					3C. THE INABILITY TO MAINTAIN LONG SITTING DUE TO POSTERIOR PELVIC TILT AND/OR INCREASED HIP AND KNEE FLEXION.
					4C. POSTURING IN LONG SITTING WITH KYPHOTIC TRUNK DUE TO PELVIC IMMOBILITY.
					5C. SITTING PREFERENCE TO ONE SIDE DUE TO ASYMMETRICAL INVOLVEMENT.
					6C. CONSISTENT SITTING IN REVERSE TAILOR FASHION (W-SITTING).

UNIT NO.	DEVELOP-MENTAL AGE IN MONTHS	UNIT DESCRIPTION	EQUIP-MENT	EXPLANATION OF ADMINIS-TRATION OF ASSESSMENT ITEM	OBSERVED RESPONSES
PM 007	N/A	HYPERTONIC (MUSCLE TONE IS TOO HIGH) (CONTINUED--)	MAT	THE HYPERTONIC (MUSCLE TONE IS TOO HIGH) SECTION IS RECOMMENDED FOR THE CHILD WHO EXHIBITS ANY OF THE OBSERVED RESPONSES:	
				D. THE CHILD IS ALLOWED TO PULL TO STAND INDEPENDENTLY OR WITH SUPPORT AND THE FOLLOWING CHARACTERISTICS ARE OBSERVED:	1D. A TENDENCY TO USE INCREASED TONE IN THE UPPER EXTREMITIES AND TRUNK FOR BALANCE DURING STANDING. MAY POSTURE WITH THE SHOULDERS ELEVATED AND EXTERNALLY ROTATED AND THE ELBOWS FLEXED IN THE "HIGH GUARD" FASHION.

APPENDIX B

SELECTED CURRICULAR ACTIVITIES FROM THE RISE COMPUTERIZED CHECKLIST AND CURRICULUM FOR THE MOTORICALLY DELAYED/IMPAIRED CHILD

NAME: DATE:

CURRICULUM	RISE COMPUTERIZED CURRICULUM (RCC)
AREA	PHYSICAL MANAGEMENT
UNIT	PM 007 - HYPERTONIC (MUSCLE TONE IS TOO HIGH)

ACTIVITY	EVALUATION
MUSCLE TONE REFERS TO THE STATUS OF THE MUSCLE. A HIGH PERCENTAGE OF CHILDREN WITH MOTOR DELAYS/IMPAIRMENTS HAVE MUSCLE TONE THAT IS TOO HIGH OR HYPERTONUS. HYPERTONUS MAY VARY FROM MODERATE RESISTANCE TO PASSIVE MOVEMENT; TO EXTREME SPASTICITY WITH CONSTANT ABNORMAL POSTURING. A SMALL PERCENTAGE OF THESE CHILDREN MAY HAVE FLUCTUATING MUSCLE TONE (ATHETOSIS) WITH A PREDOMINANCE OF EITHER HYPER OR HYPOTONUS. THE FOLLOWING ARE SUGGESTED ACTIVITIES TO NORMALIZE MUSCLE TONE, HOWEVER, THOSE TECHNIQUES SPECIFIC TO MANAGEMENT OF ATHETOSIS, WILL BE DETERMINED BY THE THERAPIST. 7.1 ACTIVITIES THAT NORMALIZE MUSCLE TONE SHOULD BE INITIATED PRIOR TO POSITIONING CHILDREN OR WORKING ON MOVEMENT PATTERNS. 7.2 IN GENERAL, SLOW RHYTHMICAL MOVEMENTS DECREASE MUSCLE TONE. THE CHILD SHOULD BE IN A THERAPEUTIC POSITION WITH MOVEMENT GRADED ACCORDING TO THE CHILD'S TOLERANCE LEVEL. 7.3 DO NOT FORCE AN EXTREMITY INTO A POSITION. NORMALIZE MUSCLE TONE BY UTILIZING ROTATION AND GENTLY MOVING THE EXTREMITY TO THE DESIRED POSITION. 7.4 ROTATION IS A TECHNIQUE WHICH CAN BE UTILIZED TO DECREASE MUSCLE TONE. ROTATION SHOULD BE THE FIRST ACTIVITY OF THE DAY AND SHOULD BE REPEATED WHENEVER AN INCREASE IN MUSCLE TONE IS NOTED. ROTATION MAY BE IMPLEMENTED IN THE FOLLOWING POSITIONS: PRONE: PLACE THE CHILD IN PRONE POSITION ACROSS AN APPROPRIATE SIZED BALL. (THE BALL PROVIDES A MOVEABLE SURFACE FROM WHICH HEAD AND TRUNK RIGHTING AGAINST GRAVITY CAN ALSO BE FACILITATED.) HOLD THE CHILD AT THE PELVIS WITH YOUR RIGHT HAND	

NAME:	DATE:
CURRICULUM	RISE COMPUTERIZED CURRICULUM (RCC)
AREA	PHYSICAL MANAGEMENT
UNIT	PM 007 - HYPERTONIC (MUSCLE TONE IS TOO HIGH)

ACTIVITY	EVALUATION
7.4 Continued-- UNDER THE CHILD'S RIGHT HIP JOINT. AS THE BALL IS SLOWLY ROLLED TOWARD THE RIGHT, GRADUALLY RAISE THE CHILD'S RIGHT HIP OFF THE BALL AND MAINTAIN AT MID-LINE, AS THE BALL IS ROLLED FURTHER TO THE RIGHT (BY PUSHING THE CHILD AND THE BALL WITH YOUR LEFT HAND), THE RIGHT LEG SHOULD EXTEND AND THE LEFT LEG SHOULD FLEX AS THE LOWER TRUNK IS ROTATED. HOLD THE POSITION FOR A FEW SECONDS AND SLOWLY RETURN TO PRONE. REPEAT THIS PROCESS INITIATING THE MOVEMENT FROM THE LEFT HIP. THIS PROCEDURE CAN BE USED WHEN ROTATING THE CHILD PRONE ON A ROLL OR ON YOUR LAP. FOR THE INFANT, TRUNK ROTATION CAN BE INCORPORATED WHILE HANDLING IN PRONE (REFER TO ITEM PM 003.2). SUPINE: PLACE THE CHILD IN A SUPINE POSITION WITH A SMALL PAD BEHIND THE HEAD AND SHOULDER TO FACILITATE NECK FLEXION AND TO INHIBIT SHOULDER RETRACTION. THIS POSITION BREAKS UP TOTAL EXTENSION. IF THE CHILD HAS TIGHTNESS IN THE ADDUCTOR MUSCLES, PLACE YOUR HANDS JUST ABOVE AND BEHIND THE KNEES, SEPARATE THE LEGS AND MOVE THE HIPS IN A SEMICIRCULAR MOTION. IF THE CHILD IS TIGHT IN THE ABDUCTOR MUSCLES, PLACE YOUR HANDS JUST ABOVE THE KNEES, MOVE THE LEGS TOWARD MIDLINE OR TO A NEUTRAL POSITION, AND MOVE THE HIPS IN A SEMICIRCULAR MOTION. WHEN ROTATING IN THE SUPINE POSITION, HAVE ADEQUATE SEPARATION OF THE LEGS AND MAINTAIN SEPARATION DURING ROTATION. A QUALIFIED THERAPIST OR MOTOR SPECIALIST SHOULD DETERMINE THE DEGREE OF SEPARATION NEEDED FOR THE INDIVIDUAL CHILD.	

NAME:

DATE:

CURRICULUM	RISE COMPUTERIZED CURRICULUM
AREA	PHYSICAL MANAGEMENT
UNIT	PM 007 - HYPERTONIC (MUSCLE TONE IS TOO HIGH)

ACTIVITY	EVALUATION
7.5 HANDLING A) FOR THE HYPERTONIC INFANT WHO LACKS ADEQUATE HEAD CONTROL, ROTATION MAY BE IMPLEMENTED WHILE HOLDING THE CHILD IN A THERAPEUTIC SITTING POSITION (REFER TO ITEM PM 003.2). SUPPORT IS PROVIDED WITH ONE HAND UNDER THE LEGS AND THE OTHER HAND HOLDING THE UPPER TRUNK. THE CHILD'S TRUNK IS ROTATED BY TWISTING THE UPPER TRUNK AND THE LOWER TRUNK IN OPPOSITE DIRECTIONS.	
SUPPORTED SITTING B) FOR THE CHILD WHO LACKS ADEQUATE TRUNK CONTROL, ROTATION MAY BE IMPLEMENTED IN A SITTING POSITION, UTILIZING THERAPEUTIC EQUIPMENT TO PROVIDE ADDITIONAL SUPPORT. POSITION THE CHILD IN SUPPORTED SITTING ASTRIDE AN APPROPRIATE SIZED ROLL. MAINTAIN UPRIGHT, STRAIGHT ALIGNMENT OF HIS/HER TRUNK BY SUPPORTING THE CHILD'S CHEST. POSITION BOTH SHOULDERS FORWARD WITH THE ARMS EXTENDED. TWIST THE CHILD'S TRUNK FROM SIDE-TO-SIDE BY APPLYING SLIGHT PRESSURE AGAINST THE CHILD'S ARM WITH THE BACK OF YOUR HAND AS THE OTHER HAND IS POSITIONED ACROSS THE CHILD'S LAP TO MAINTAIN HIS/HER LEG POSITION. ROTATE TO BOTH SIDES.	
SIDELYING C) POSITION THE CHILD ON HIS/HER SIDE ON A FLOOR OR A MAT. WHILE USING ONE HAND TO STABILIZE THE CHILD AT THE SHOULDER, PLACE THE OTHER HAND ON THE CHILD'S HIP. GENTLY MOVE THE UPPER TRUNK IN ONE DIRECTION WHILE MOVING THE LOWER TRUNK IN THE OPPOSITE DIRECTION. THE PROCEDURE SHOULD BE REPEATED TO THE OTHER SIDE.	

NAME:	DATE:
CURRICULUM	RISE COMPUTERIZED CURRICULUM (RCC)
AREA	PHYSICAL MANAGEMENT
UNIT	PM 007 - HYPERTONIC (MUSCLE TONE IS TOO HIGH)

ACTIVITY	EVALUATION
7.5 Continued-- INDEPENDENT SITTING — D) FOR THE CHILD WHO HAS ADEQUATE HEAD AND TRUNK CONTROL AND CAN MAINTAIN INDEPENDENT SITTING USING THERAPEUTIC EQUIPMENT (REFER TO ITEM PM 002.5) ROTATION MAY BE ACCOMPLISHED IN A SITTING POSITION. POSITION THE CHILD IN INDEPENDENT SITTING ACROSS A ROLL OR ON A THERAPY BALL OF AN APPROPRIATE SIZE. THE HIPS AND KNEES SHOULD BE POSITIONED AT 90° ANGLES WITH THE FEET POSITIONED FLAT ON THE FLOOR. THERAPEUTIC POSITIONING OF THE LEGS SHOULD BE MONITORED. THE CHILD SHOULD BE ENCOURAGED TO ACTIVELY ROTATE HIS/HER TRUNK IN THE SITTING POSITION. BY POSITIONING TOYS OR ACTIVITIES ON EACH SIDE OF THE THERAPEUTIC EQUIPMENT, ALLOW THE CHILD TO REACH TO EACH SIDE, ROTATING THE TRUNK, AS HE/SHE ENGAGES IN THE ACTIVITY. USE OF AN APPROPRIATE SIZED THERAPY BALL WILL ALSO PROVIDE A MOVEABLE SURFACE TO INCORPORATE THE DEVELOPMENT OF BALANCE AND EQUILIBRIUM RESPONSES (REFER TO RD 014.2) AS NORMALIZED TONE IS APPROXIMATED. 7.6 POSITION THE CHILD PRONE ON A BALL AND ROLL HIM/HER SLOWLY IN ALL DIRECTIONS.	

APPENDIX C

SUBJECT DEMOGRAPHICS

Subject "A", at the beginning of the study (September 1, 1984), was described as a 15 month old, white female. At the time of her birth, she was initially admitted to the Neonatal Intensive Care Unit for respiratory distress and prematurity. Gestational age was 33 weeks by date and examination. (Apgar scores were 2 at 1 minute, 3 at 5 minutes, and 5 at 7 minutes). Her final discharge summary noted the following diagnosis:

1. Preterm newborn female infant.
2. Perinatal asphyxia.
3. Rule out placental abruption.
4. Hyaline membrane disease.
5. Acute renal failure.
6. Seizure disorder.
7. Anemia of prematurity.
8. Feeding problem.

On December 3, 1984, she weighed 20 pounds, 10 ounces; was 31½ inches long (recumbant), with a head circumference of 46 cm.

The results of the RISE Computerized Checklist-Physical Management subcomponent (RCC-PM), administered on October 5, 1984, revealed developmental delay with a predominance of hypertonicity. She was quadrapedal with good head and trunk control. Her reflex maturation revealed that her residual basic reflexes appeared to be integrated. Her righting reactions, protective extension, and equilibrium reactions were developing. Her functional status showed that she crawled in a reciprocal fashion with adequate quality, pushed from quadrapedal to reverse tailor sitting but could long sit with adequate quality, and pulled to stand using upper extremities. She postured in a standing position with her feet in plantar flexion. The Movement Assessment of Infants (MAI) was administered on October 5, 1984. It revealed a Muscle Tone score of 10 which is indicative of greater than normal muscle tone, and with this child, particularly, in the lower extremities. On November 19, 1984, the Bayley Scales of Infant Development (BSID) disclosed a Mental Developmental Index (MDI) of 78, and a Psychomotor Development Index (PDI) of 61.

Subject "B" was described at the onset of the study as an 18 month old, white male who was born three months premature. Following birth, he remained hospitalized due to the question of placental abruption and periods of apnea that required respiratory support. He was diagnosed has having delayed motor development, probably secondary to prematurity and cerebral palsy. On December 3, 1984, he weighed 26 pounds, measured 32½ inches (recumbant) and had a head circumference of 45 cm. On October 22, 1984, the RCC-PM revealed delayed development with a predominance of hypertonicity, with good head control and fair trunk control. His reflex maturation was delayed with residual basic reflexes and equilibrium reactions. Righting reactions and protective extension were noted to be developing. Functionally, this child exhibited increased tone in the extremities and lower trunk with more tone in the legs than arms. Mobility was attained by sliding in prone (commando crawl). He pushed from prone-lying to reverse tailor sitting (W-sitting). He could sit for brief periods with a kyphotic back and increased hip and knee flexion. Standing was accomplished by fixing with increased tone in the lower extremities, adduction and crossing of the legs with his feet plantar flexed.

The MAI revealed a Muscle Tone score of 10 which indicated greater than normal muscle tone in all four extremities with higher tone in the arms than in the legs. The Bayley Scales of Infant Development showed a MDI of 145 and a PMI of 38 as of May 15, 1984.

Subject "C" was described as a 24 month old, black female. Birth history revealed that she was admitted to the Neonatal Intensive Care Unit for respiratory distress, prematurity, prolonged rupture of fetal membranes, and maternal fever. The hospital's discharge diagnosis additionally noted moderate prenatal asphyxia, hyaline membrane disease, physiologic hyperbilirubinemia, and a feeding problem. On December 3, 1984, she weighed 22 pounds, 10 ounces; measured 31 inches in recumbant length; and had a head circumference of 46 cm. On October 4, 1984, the RCC-PM subcomponent described her as having spastic, quadraplegic cerebral palsy. She was apedal, had a predominance of hypertonicity, and had poor head and trunk control. Her residual basic reflexes, righting reactions, protective extension, and equilibrium reactions were delayed. An examination of her functional status noted a predominance of hypertonicity in the extremities and trunk. Head control, although poor, was beginning to develop. She was able to raise her head against gravity when in a prone position with elbows flexed, but tended to shift her upper extremity weight with asymmetry. In a prone position, she typically postured with her legs extended and feet plantar flexed.

Her performance that same day on the MAI revealed a Muscle Tone score of 10, indicating hypertonicity. The BSID was administered to this child on December 3, 1984. Both the MDI and PDI sections of that assessment revealed scores of 50.

Subject "D" was described as 10 month old, white male. The discharge summary from the local High Risk Nursery noted that he was a term infant and was characterized by severe perinatal asphyxia, pulmonary edema, and seizures due to cerebral hypoxia. His Apgar scores at 1 minute was 0, at 5 minutes was 1, and at 15 minutes was 4. Delivery was complicated by placental abruption with loss of fetal heart tones for 10 to 15 minutes prior to an emergency Cesarean section. On December 3, 1984, he weighed 18 pounds, measured 28 inches (recumbant), and had a head circumference of 43 cm.

The RCC-Physical Management subcomponent revealed quadraplegic cerebral palsy with a predominance of hypertonicity. At the time of the assessment, October 4, 1984, he was apedal with fair head control and poor trunk control. Residual basic reflexes and righting reactions were delayed and both his protective extension and equilibrium reactions were not developed.

His functional status exhibited a strong hypertonus upon active movement with fluctuations to hypotonicity. He had strong postural asymmetry that was usually initiated with head movement. He was unable to sit when propped or prop prone on forearms with symmetry and head control. Passive range of motion (PROM) was within normal limits at all joints.

An MAI Muscle Tone score on October 24, 1984, of 9 indicated hypertonicity in both upper and lower extremities. The BSID, administered in December 3, 1984, revealed scores of less than 50 for both the MDI and PDI sections.

Subject "E" was described as a 15 month old, white male. Gestational history up to delivery was unremarkable. Delivery was premature with a spontaneous breech presentation. During a well baby visit to his pediatrician at four months of age, chart notes revealed that increased muscle tone was noted. As of December 3, 1984, he weighed 32 pounds, 12 ounces; was 31½ inches in recumbant length; and had a head circumference of 47 cm. An RCC-Physical Management subcomponent administered on September 25, 1984, described him as having cerebral palsy with a predominance of hypertonicity. He had good head control and fair to good trunk control. Residual basic reflexes and righting reactions were delayed, and both his protective extension and equilibrium reactions were not developed. A review of his functional status found that he postures with his upper extremities in external rotation, flexion, and shoulder elevation. His legs were typically extended and adducted, with the feet plantar flexed. He propped prone on his forearms with inconsistent fisting. "E" was able to roll to both prone and supine positions using an extension pattern and increased tone. Further, he exhibited mild to moderate hypertonus with more tone in the arms than legs.

An MAI Muscle Tone score of 9 on October 10, 1984, demonstrated greater than normal tone and hypertonicity in both the upper and lower extremities. The BSID was given on December 3, 1984. Both portions of this assessment rated less than 50.

Subject "F" was described as a 29 month old, white male. A medical evaluation in April of 1983 described him as having static encephalopathy with secondary left spastic hemiparesis. His weight as of December 3, 1984, was 32 pounds, 12 ounces; and he measured 36½ inches tall. Head circumference at the same time was an unremarkable 47 cm. On September 28, 1984, the RCC-PM subcomponent confirmed the diagnosis of left himiplegic cerebral palsy. Predominant muscle tone on the left side was hypertonic. He was bipedal with good head and trunk control. His residual basic reflexes appeared to be integrated whereas his righting reactions, protective extension, and equilibrium reactions were all delayed to the left side.

An MAI Muscle Tone score of 9 on September 28, 1984, was indicative of greater than normal tone on the left side. The Bayley Scales of Infant Development revealed an MDI of 106 and a PDI of 60 on December 3, 1984.

Subject "G" was described as a 35 month old, black male. The discharge summary from the local Neonatal Intensive Care Unit revealed an initial diagnosis of severe perinatal asphyxia, placental eruption, consumption coagulopathy, a seizure disorder due to hypoxic encephalopathy, acute renal failure, and hypotonia. His weight as of December 3, 1984, was 22 pounds and he measured 34½ inches in recumbant length. Head circumference was measured at 40 cm. The diagnosis of hypotonia had reversed by the time "G" was evaluated with the RCC-PM assessment on November minute and 7 at five minutes. At nine days of age she began to have feeding problems and became lethargic. Laboratory tests revealed that she had group B beta hemolytic streptococcus and she was treated with Penicillin and Gentamicin. Ultrasound of the head on December 9, 1983, revealed a bilateral bleed with enlargement of the lateral ventricular system. She was discharged to the High Risk Follow-up Clinic in Tuscaloosa, Alabama. On December 3, 1984, she weighed 21 pounds, measured 30½ inches (recumbant) and had a head circumference of 44 cm.

The RCC-PM assessment on September 19, 1984, noted developmental delay and a predominance of hypertonicity. She was further described as apedal with good head control and poor trunk control. Her status at the time of reflex testing showed that her residual basic reflexes appeared to be integrated, and her righting reactions, protective extension, and equilibrium reactions were developing. The RCC-PM assessment summary noted increased muscle tone in her trunk and extremities, with more tone in her legs than in her arms. Her heelcords were tight bilaterally, but could be ranged to neutral. At the time of the evaluation, her only means of mobility was rolling. She did not push up on extended arms in prone, but was able to reach out and grasp for a toy in the prone position.

The results of her Muscle Tone score in the MAI on October 10, 1984, was 9, indicating greater than normal muscle tone in the lower extremities. The BSID was given on December 3, 1984. Both scales on that administration were reported below 50.

Subject "I" was described as a 35 month old, white male. A review of his hospital discharge summary from the local High Risk nursery revealed a pre-term (36 weeks) infant who has severe hydrocephalus. A ventriculoperitoneal shunt was inserted on the 22nd day. Basic demographics were collected on December 3, 1984. At that time, he weighed 31 pounds, measured 36 inches (recumbant), and had a head circumference of 52.5 cm.

His RCC-PM assessment of October 5, 1984, described him as having cerebral palsy and hydrocephalus. His predominant muscle tone was hypertonic with fair head and trunk control. His overall reflex maturation was delayed but he exhibited marked development in the areas of righting reactions and protective extension. Functionally, "I" was able to sit independently for short periods of time if

26, 1984. This is typical in the development of spasticity. That assessment characterized him as having severe, spastic quadraplegic cerebral palsy. His functional level was described as apedal with poor to fair head control and poor trunk control. Both his residual basic reflexes and righting reactions were delayed, while his protective extensive and equilibrium reactions were not yet developed. A review of his functional status revealed severe hypertonus in all extremities and trunk with limitations in hip, knee, and elbow extension. He further exhibited structural kyphotic posturing of the upper trunk with the shoulders protracted, upper extremities flexed, and limited mobility of the spine.

An MAI Muscle Tone score of 10 on October 10, 1984, was indicative of hypertonicity. His performance on both scales of the BSID on December 3, 1984, were less than 50.

Subject "H" was described as a nine month old, black female at the time of the study. This preterm baby was 31 weeks old at birth by date, and 35 weeks by examination. Partial placental abruption, mild perinatal asphyxia, and transient respiratory distress complicated her delivery Apgar scores were 6 at one provided with a wide base of support. He was able to push up from prone on his forearms and extended arms with adequate head control for short periods of time.

On October 5, 1984, his Muscle Tone score of 8 on the MAI evidenced greater than normal muscle tone in both the upper and lower extremities. The BSID was administered on May 5, 1984. Both indexes on the Bayley were less than 50.

Subject "J" was described as an eight month old, black male. He was admitted to the Neonatal Intensive Care Unit following delivery, due to a lack of spontaneous respiration. His hospital course was complicated with cardiac and respiratory arrest, diarrhea, an ocular staph infection, and a seizure disorder. On December 3, 1984, he weighed 17 pounds, 6 ounces; measured 28½ inches (recumbant); and had a head circumference of 43 cm.

An RCC-Physical Management assessment was conducted on September 7, 1984. He was described as developmentally delayed with a seizure disorder. His predominant muscle tone was noted to be hypertonic with tightness at the proximal joints and ankles. Head and trunk control were both described as poor. His reflex maturation was significantly delayed.

On October 11, 1984, his performance on the MAI Muscle Tone section rated him a score of 8, which indicated greater than normal muscle tone in both the upper and lower extremities. The BSID was administered on December 3, 1984. Performance on both the PMI and MDI sections of the BSID were below 50.

APPENDIX D

LETTERS OF SUPPORT

THE UNIVERSITY OF ALABAMA
UNIVERSITY ALABAMA 35486

COLLEGE OF EDUCATION
AREA OF SPECIAL EDUCATION

P O BOX 2592

PROGRAMS IN

EMOTIONAL CONFLICT
GIFTED AND TALENTED
HEARING IMPAIRED
LEARNING DISABILITIES
MENTAL RETARDATION
ORTHOPEDICALLY HANDICAPPED-
OTHER HEALTH IMPAIRED
SPECIAL EDUCATION
ADMINISTRATION

February 29, 1984

Mr. David M. Finn
P.O. Box 2592
University, AL 35486

Dear Mr. Finn:

This is to inform you that your request to utilize infants at the Rural Infant Stimulation Environment (RISE) program for your research study has been reviewed and approved. It is with great pleasure that I extend this invitation to you to work with our program. The efficacy of early intervention strategies with the multihandicapped population has yet to be demonstrated in the recent literature. I feel that this study will be of major importance in lending support to the existence of therapeutic intervention programs for children who have cerebral palsy.

My staff will look forward to working with you in any way possible to facilitate data acquisition for your study. Best wishes for continued success in your endeavors.

Sincerely,

Loreta F. Holder, Ph.D.
RISE Project Director

LFH/nb

THE UNIVERSITY OF ALABAMA
UNIVERSITY ALABAMA 35486

COLLEGE OF EDUCATION
AREA OF SPECIAL EDUCATION

P O BOX 2592

PROGRAMS IN

EMOTIONAL CONFLICT
GIFTED AND TALENTED
HEARING IMPAIRED
LEARNING DISABILITIES
MENTAL RETARDATION
ORTHOPEDICALLY HANDICAPPED-
OTHER HEALTH IMPAIRED
SPECIAL EDUCATION
ADMINISTRATION

February 16, 1984

Mr. Jan Hoover
J & J
22797 Holgar Ct., NE
Poulsbo, WA 98370

Dear Mr. Hoover:

This letter is in reference to our phone conversation on Friday, February 10, 1984. I sincerely appreciate your generous offer to loan some of your equipment for my study. As you remember, I am going to investigate the use of EMG and thermal measurement with treatment techniques used with children who have spastic cerebral palsy.

The equipment we discussed was the Dual Channel EMG Model M-53 and a Thermal Model 63 (or Model 68). As I mentioned previously, the equipment will not be needed until September 1, 1984, but, due to federal grant deadlines I need to tie down all of my costs by March 1.

I have contacted my insurance company and they suggested that since the equipment will be kept at a local program, that I take out a short-term policy with their insuror. I have contacted the director of this program and they are to contact me shortly concerning the cost.

If you would be so kind as to send me a "letter of support" stating your intention to loan me the above mentioned equipment, I would be most appreciative. Please include any reasonable costs this may include such as postage, handling, insurance, etc. This letter of support must be included in the March 1 materials if at all possible.

Mr. Jan Hoover

February 16, 1984

I honestly feel that this project will help to verify some of the techniques we are using with these children and I thank you, in advance, for your support.

With deep appreciation, I remain,

Sincerely,

David M. Finn.
Graduate Assistant

DMF/jt

APPENDIX E

LETTER TO PARENTS, CONSENT TO PARTICIPATE, AND RELEASE OF INFORMATION FORM

THE UNIVERSITY OF ALABAMA
UNIVERSITY, ALABAMA 35486

COLLEGE OF EDUCATION
AREA OF SPECIAL EDUCATION

P O BOX 2592

PROGRAMS IN

EMOTIONAL CONFLICT
GIFTED AND TALENTED
HEARING IMPAIRED
LEARNING DISABILITIES
MENTAL RETARDATION
ORTHOPEDICALLY HANDICAPPED-
OTHER HEALTH IMPAIRED
SPECIAL EDUCATION
ADMINISTRATION

Dear Parents:

The Area of Special Education at the University of Alabama is proposing a research study involving children who have motor delay. This letter is to provide a description of the study and to request permission for your child to participate.

The effectiveness of certain treatment techniques with children who have motor delay has not been clearly demonstrated in previous studies. This study will compare two techniques, slow rolling and rotation, which are used at the RISE program. These techniques are used to normalize muscle tone. Techniques will be evaluated by assessing the child's skin temperature and muscle tension. To measure each of these areas, a simple "band-aid" type sensor is placed on the child's finger and/or toe; and one is placed over the child's leg muscle. Neither measure will be harmful to the child in any way.

Measures have been taken to assure that privacy and confidentiality of the findings will be maintained. The study will be supervised by Dr. Loreta Holder, Chairperson of programs in Orthopedically Handicapped/Other Health Impaired at the University of Alabama. Participation of your child in this important study will require a half-hour a day, twice a week, for six weeks.

Your permission to allow your child to participate in this study will generate valuable information which will improve the quality of services to children with motor delay. We need your help. Please complete and return the attached form. A self-addressed stamped envelope is provided for your convenience.

Sincerely,

Loreta F. Holder

Loreta F. Holder, Director
RISE

David M. Finn
Doctoral Candidate

Attachment

Dear Mr. Finn:

I have read the letter regarding the research study comparing treatment techniques with children who have motor delay.

	YES	NO
My child may participate.	_____	_____
You may have access to my child's records.	_____	_____
I have some questions and would appreciate you calling me.	_____	_____

______________________________ ______________
Parent's Signature Date

____
Child's Name

APPENDIX F

MOVEMENT ASSESSMENT OF INFANTS

Scoring Sheet
for
MOVEMENT ASSESSMENT OF INFANTS

Name____________________ Date of exam________________

Birth date________________

Case number____________________ Chronological age________________

Gestational age________________

Examiner____________________ Corrected age________________

MUSCLE TONE

Items 1-6, 9, and 10 should be coded by the scale below.
Code items 7 and 8 as explained in the instructions for those items in the manual.

0 - Item omitted
1 - Hypotonic
2 - Greater than hypotonic but less than normal
3 - Normal
4 - Greater than normal but less than hypertonic
5 - Hypertonic
6 - Fluctuating, variable

		Distribution Variations		Asymmetries		
		Upper	Lower	Left	Right	
____	1. Consistency	____	____	____	____	1.
____	2. Extensibility	____	____	____	____	2.
____	3. Passivity	____	____	____	____	3.
____	4. Posture in Supine	____	____	____	____	4.
____	5. Posture in Prone	____	____	____	____	5.
____	6. Posture in Prone Suspended	____	____	____	____	6.
____	7. Asymmetry					
____	8. Distribution Variation					
____	9. Summary of Tone - Extremities	____	____	____	____	9.
____	10. Summary of Tone - Trunk	____	____	____	____	10.

PRIMITIVE REFLEXES

Items 1-12 should be coded by the scale below.
Code items 13 and 14 as explained in the instructions for those items in the manual.

0 - Item omitted
1 - Integrated or not elicited
2 - Incomplete response
3 - Complete response
4 - Dominant

		Asymmetries		
		Left	Right	
____	1. Tonic Labyrinthine Reflex in Supine	____	____	1.
____	2. Tonic Labyrinthine Reflex in Prone	____	____	2.
____	3. Asymmetrical Tonic Neck Reflex - Evoked	____	____	3.
____	4. Asymmetrical Tonic Neck Reflex - Spontaneous	____	____	4.
____	5. Moro	____	____	5.
____	6. Tremulousness	____	____	6.
____	7. Palmar Grasp	____	____	7.
____	8. Plantar Grasp	____	____	8.
____	9. Ankle Clonus	____	____	9.
____	10. Neonatal Positive Support	____	____	10.
____	11. Walking Reflex	____	____	11.
____	12. Trunk Incurvation (Galant)	____	____	12.
____	13. Asymmetry			
____	14. Summary of Primitive Reflexes			

AUTOMATIC REACTIONS

Items 1-14 should be coded by the scale below.
Code items 15 and 16 as explained in the instructions for these items in the manual.

0 - Item omitted
1 - Complete and consistent response
2 - Incomplete or inconsistent response
3 - Partial response
4 - No response

		Asymmetries Left	Asymmetries Right	
____	1. Head Righting - Lateral	____	____	1.
____	2. Head Righting - Extension	____	____	2.
____	3. Head Righting - Flexion	____	____	3.
____	4. Landau	____	____	4.
____	5. Rotation in Trunk	____	____	5.
____	6. Equilibrium Reactions in Prone	____	____	6.
____	7. Equilibrium Reactions in Sitting	____	____	7.
____	8. Equilibrium Reactions in Vertical Suspension	____	____	8.
____	9. Downward Parachute	____	____	9.
____	10. Protective Extension - Forward	____	____	10.
____	11. Protective Extension - Side	____	____	11.
____	12. Protective Extension - Backward	____	____	12.
____	13. Placing of Feet	____	____	13.
____	14. Placing of Hands	____	____	14.
____	15. Asymmetry	____	____	15.
____	16. Summary of Automatic Reactions	____	____	16.

VOLITIONAL MOVEMENT

Items 1-23 should be coded by the scale below.
Code items 24 and 25 as explained in the instructions for these items in the manual.

0 - Item omitted
1 - Complete and consistent response
2 - Incomplete or inconsistent response
3 - Partial response
4 - No response

		Asymmetries Left	Asymmetries Right	
____	1. Hearing	____	____	1.
____	2. Visual Following	____	____	2.
____	3. Peripheral Vision	____	____	3.
____	4. Vocalization	____	____	4.
____	5. Head Centering	____	____	5.
____	6. Head Position - Anterior/Posterior	____	____	6.
____	7. Head Balance	____	____	7.
____	8. Active Weight Bearing Through Shoulders	____	____	8.
____	9. Open Hands	____	____	9.
____	10. Hands to Midline	____	____	10.
____	11. Large Grasp	____	____	11.
____	12. Small Grasp	____	____	12.
____	13. Reaches Out	____	____	13.
____	14. Combines	____	____	14.
____	15. Transfers	____	____	15.
____	16. Back Straight in Sitting	____	____	16.
____	17. Active Use of Hips	____	____	17.
____	18. Rolling	____	____	18.
____	19. Prone Progression	____	____	19.
____	20. Sits When Placed	____	____	20.
____	21. Coming to Sit	____	____	21.
____	22. Coming to Stand	____	____	22.
____	23. Walking	____	____	23.
____	24. Asymmetry	____	____	24.
____	25. Summary of Volitional Movement	____	____	25.

APPENDIX G

DATA SUMMARY SHEET

DATA SUMMARY SHEET

CHILD'S NAME: ____________________ DATE: ____________________

TREATMENT CONDITION: _____ ROTATION _____ SLOW ROLLING INTERVENTIONIST ____________

TIME BEGIN: ____________________ TIME END: ____________________

AMBIENT TEMPERATURE BEGIN: __________ AMBIENT TEMPERATURE END: __________

************************************ DATA ************************************

		PRE EMG	PRE THERMAL	PRE BEHAVIOR*			POST EMG	POST THERMAL	POST BEHAVIOR*
-15	1.)				+2½	5.)			
-10	2.)				+ 5	6.)			
- 5	3.)				+10	7.)			
-2½	4.)				+15	8.)			

(I N T E R V E N T I O N)

****

*BEHAVIOR CODE: (C) CRYING, (Q) QUIET, (S) SLEEPING (O) OTHER-NOTE

COMMENTS: ____

____

____

Rev. 10-14-84

APPENDIX H

AUTHORIZATION FOR USE OF HUMAN SUBJECTS

THE UNIVERSITY OF ALABAMA

INSTITUTIONAL REVIEW BOARD FOR THE PROTECTION OF

HUMAN SUBJECTS

TO: Johnny Rogers
Loreta Holder
David Finn

FROM: Ronald Rogers, Chairperson

DATE: June 4, 1984

SUBJECT: IRB ACTION

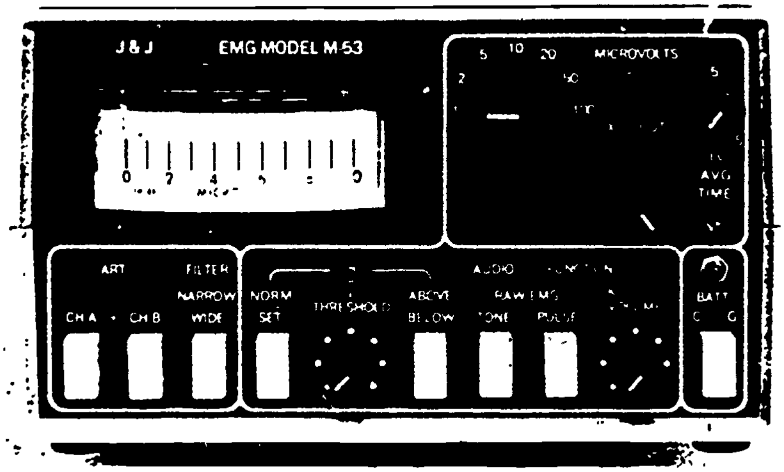
The University of Alabama's Institutional Review Board for the Protection of Human Subjects has reviewed the research proposal entitled

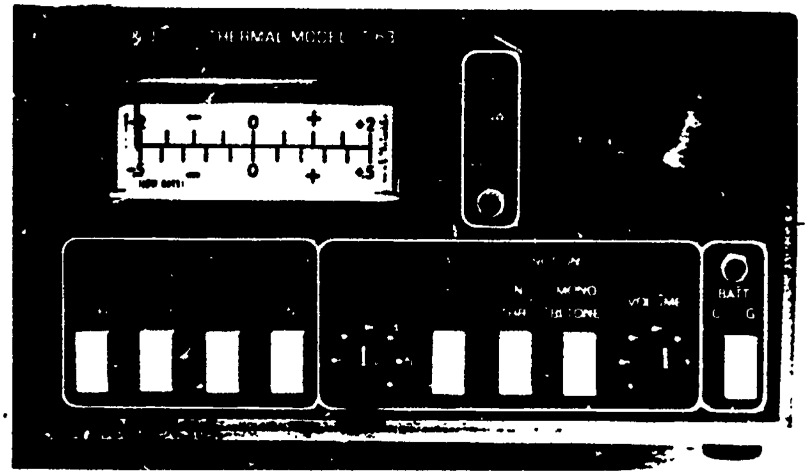
"A comparison of two treatment techniques for children with spastic cerebral palsy as measured by EMG and thermal information"

The proposal complies with University and federal regulations for the Protection of Human Subjects (45 CFR Part 46).

APPENDIX I

PHOTOGRAPHS OF EMG AND THERMAL UNITS


J & J
EMG MODEL M-53
MICROVOLTS
AVG
TIME
ART
FILTER
NARROW
CH A
CH B
WIDE
NORM
SET
ABOVE
BELOW
AUDIO
RAW EMG
TONE
BATT


THERMAL MODEL
BATT

1 on skin temperature readings, the robust nature of the analysis of variance procedures permitted further investigation.

Analysis of Variance Findings for Two Measures

The analysis of variance procedure was used to examine the interaction and main effects for two treatment techniques (trunk rotation and slow rolling) as measured by electromyography. The results of the analysis of variance for EMG measures are presented in Table 5.

Table 5

ANOVA Summary Table-Two Groups X Two EMG Measures

SOURCE	SS	df	MS	F
Between Groups	.40	1	.40	.05
Error (between)	55.42	7	7.92	
Total (between)	55.82	8		
Between Measures	4.91	1	4.91	6.06*
Groups X Measures	.04	1	.04	.05
Error (within)	5.67	7	.81	
Total (within)	10.62	9		

*$p < .05$