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THE EFFECT OF POSITIONING ON THE FINE MOTOR ACCURACY AND COMPENSATORY BEHAVIORS OBSERVED DURING FINE MOTOR TASKS OF STUDENTS WITH CEREBRAL PALSY WHO ARE NONAMBULATORY

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THE EFFECT OF POSITIONING ON THE FINE MOTOR ACCURACY AND COMPENSATORY BEHAVIORS OBSERVED DURING FINE MOTOR TASKS OF STUDENTS WITH CEREBRAL PALSY WHO ARE NONAMBULATORY

A Dissertation APPROVED FOR THE DEPARTMENT OF EDUCATIONAL PSYCHOLOGY

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ABSTRACT

Students with motor disabilities are faced with more challenges than those faced by typical students in the educational environment. One important issue facing these students is limited fine motor accuracy which interferes with writing requirements for classroom activities. Students with motor disabilities may also have speech and language problems which intensify communication problems and make it difficult for teachers to determine student comprehension level. Standardized tests that require skilled fine motor accuracy are typically used to determine developmental levels, as well as intelligence quotients. Therefore, it is imperative that the fine motor skills these students do possess are utilized in the most efficient manner possible to ensure that learning potential is maximized.

To assure that students fully utilize their fine motor capabilities, variables that affect fine motor accuracy must be identified. Research has shown that students with motor impairments are often dependent on external positioning to facilitate their functioning. Studies of the effect of spatial orientation of students with cerebral palsy in wheelchairs have shown the upright position to be superior to reclined or semi-reclined positions. However, tilting students in their chairs continues to be a common practice, with little or no understanding of what effect tilting the chair can have on the students' overall level of functioning. In educational environments, a prevalent practice in the realm of physical therapy has been to provide positioning programs. However, little information is available regarding the influence that different positions have on areas of physical and cognitive functioning. The purpose of this study was to provide information regarding the effects of positioning on the accuracy of hand function and observed compensatory behaviors in students with cerebral palsy who are nonambulatory . More specifically, this study compared the accuracy of hand function as tested by standardized fine motor assessments and compensatory behaviors observed during fine motor assessments in three specific sitting and standing positions. Using repeated measures analysis of variance, fine motor functioning and compensatory behaviors were analyzed across several different groups. Although variability among and within the groups was strong, position did appear to impact student fine motor performance and compensatory behaviors across students and groups.

Introduction

Students with cerebral palsy are faced with many challenges in addition to those faced by typical students in the educational environment. One of these challenges is the expression of knowledge and ideas. Due to limitations in motor control, students with cerebral palsy often have difficulty with both written and verbal expression. If a student has problems with expression, it can be difficult for the teacher to reliably determine student comprehension and performance. An inaccurate assessment of student performance will decrease the likelihood of the development of appropriate educational outcomes that encourage student achievement and promotion. Fine motor accuracy is important for the classroom functioning in the classroom of all students. Students with cerebral palsy frequently have motor impairments that interfere with their ability to sit independently and manage a pen or pencil or access computers with the speed and accuracy required to complete necessary classroom assignments. In school settings, physical and occupational therapists are called upon to recommend adaptive equipment to enhance fine motor functioning to improve classroom performance of students with motor impairments. Therefore, to make germane recommendations, it is the responsibility of educators and therapists to investigate all possible variables that enhance fine motor accuracy to improve classroom performance.

Positioning for functional and therapeutic purposes is a basic part of the daily lives of students who have neuromuscular disorders that cause decreased postural control and atypical patterns of movement (Bardsley, 1984; Campbell, 1989; Campbell, Green, &

Carlson., 1977; Carrington, 1978; Connolly, Schultz, & Greer, 1982; Trefler, Hobson, Taylor, Monahan, & Shaw, 1993). Students with motor problems who are unable to maintain stable postures against gravity, are frequently placed in a variety of adaptive positioning devices designed to provide the control and stability that they lack. Most positioning devices are designed to facilitate head and trunk alignment, provide external stability, and foster improved postural control (Mac Neela, 1987; Mulcahy, Pountney, Nelham, Green, & Billington, 1988; Noronha, Bundy & Groll, 1989). In many educational programs positioning concerns occupy major portions of instructional time as therapists' recommendations are followed to place students in a variety of positions, changing each student's positions frequently (Kaufman, 1987; Laycock, 1982; Parette & Hourcade, 1986). Other authors suggest changing positions as often as every 20-30 minutes (Connolly, Schultz, & Greer, 1982; Parette & Hourcade, 1986).

The potential gains with proper positioning are numerous, and appropriate positioning throughout the day has been said to be essential for students with physical impairments to enable performance of communicative, cognitive, motor and self-help skills (Campbell, Green, & Carlson, 1977; Mac Neela, 1987; McEwen & Lloyd, 1990). Benefits of positioning proposed in the educational and therapeutic literature have been identified through experience and clinical observation, others through research. Benefits supported by observation and clinical opinion include normalization of movement patterns, prevention of deformities, improved head position and control and increased environmental awareness (Bergen, Presperin, & Tallman, 1990; Dunkel & Trefler, 1977; Fogel, Dedo, & McEwen, 1992; Hulme, Gallacher, Walsh, Niesen, & Waldron, 1987;

Scrutton, 1989). Research has found improved ability to use the hands in midline (Schultz-Hurlburt & Tervo, 1982), improved gross upper extremity function and visual orientation (Hulme, Gallacher, Niesen, & Waldron, 1987; Nwaobi, 1987), and improved ability to eat, digest and breathe (Nwaobi & Smith, 1986). The literature also supports the concept that proper positioning provides enhancement of psychosocial and cognitive development (Hundertmark, 1985), facilitation of increased gaze during parent-child interaction (Fogel, Dedo, & McEwen, 1992; Kaufman, 1987), and improved ability to listen and communicate (Bay, 1991; Hulme, Bain, Hardin, McKinnon, & Waldron, 1989; Levitt & Miller, 1973; McEwen, 1992; McEwen & Karlan, 1989; Montgomery, 1986). Additional studies have noted improvements in social interaction, eye-hand coordination, and oral motor functioning (Hulme, Poor, Schulein & Pezzino, 1983; Hulme, Shaver, Acher, Mullette & Eggert, 1987; McEwen, 1992).

Selection of adaptive equipment is only one consideration. The position of the student in the device is also critical for improved ability to function during fine motor activities. The orientation of the positioning device in space (i.e., upright, tilted backward or forward) has been shown to affect performance of students with motor impairments. Research concerning the effect of spatial orientation on students with cerebral palsy in wheelchairs has shown the upright position to be superior to reclined or semi-reclined positions (Nwaobi, 1986; Nwaobi, 1987). Tilting students in their wheelchairs however, has continued to be a common practice. Wheelchairs often are tilted backward in an attempt to allow gravity to assist with head control and decrease drooling, with little or no understanding of what effect tilting the chair could have on the students' overall level of functioning. Nwaobi (1987) found that gross upper extremity reaction time was faster when students with cerebral palsy were seated in an upright vertical position compared to when the seat of the wheelchair was tilted anteriorly and posteriorly. Nwaobi (1986) also found that excessive muscle contraction of the legs was less in the upright position than when tilted backward. He additionally found the extensor activity of the back musculature was lowest in an upright vertical position and was the highest when the wheelchair was tilted 15 degrees forward from vertical and 30 degrees backward from vertical (Nwaobi, Brubaker, Cusick, & Sussman, 1983). The positions that facilitated increased extension were considered to be problematic, in that excessive spinal extension (atypical total body extension) increased the time in which gross upper extremity movements were performed. This slower reaction time was then considered by the authors to indicate an increase in difficulty of performance. Other studies also found that changing the inclination of the seat (i.e., increasing and decreasing the angle of hip flexion of the student) of the wheelchairs of students with cerebral palsy increased back extensor activity and had no positive effect on hand function (McClenaghan, Thombs, & Milner, 1992; Seeger, Caudrey, & O'Mara 1984) . Studies by McClenaghan (1989) and Miedaner (1990) found that trunk extension of children with cerebral palsy increased when the seat was tilted anteriorly. Bendix (1984) and Brunswic (1984) found similar results with normal adults. However, in these studies spinal extension was considered to be a positive effect of positioning because the sitting postures were less slumped and students sat in a more typical erect student sitting posture. The effect of anterior tilting of the seat on hand function was not assessed by Miedaner, so comparisons cannot be made with Nwaobi's (1987) study that found slower reaction time with anterior and posterior tilting of the seat. Myhr and von Wendt (1991) found that anteriorly tilting the seat of the wheelchair improved arm and hand function.

Overall, several studies indicate that spatial orientation of a sitting position does affect spinal extension. However, other than Nwaobi's (1987) study, we have no information on how these changes in spatial orientation and spinal extension affect functional skills.

The demand for students with motor impairments to perform functional activities in assistive devices is not limited to the sitting position. Supportive standing devices are used frequently to provide students with disabilities a socially-acceptable alternative position during their school day. Most recommendations for positioning in the classroom are based upon time schedules developed by teachers and therapists to accommodate the types of positions and number of positions required by each student in a typical day (Connolly, Schultz, & Greer, 1982; Kaufman, 1987; Laycock, 1982; Parette & Hourcade, 1986). Recommendations for positioning are typically not designed based upon what tasks students must perform. A study that attempted to determine if standing is a better position than sitting for performance of certain fine motor skills, produced inconclusive results (Noronha, Bundy, & Groll, 1989). Because positioning in adaptive equipment is such a time consuming, expensive, and pervasive intervention, it is essential that we identify and maximize those positions that enhance functioning and minimize or eliminate positions that inhibit task completion. Recommendations for positioning in the educational environment must be task-specific. Related service personnel must be aware of what positions enhance and hinder specific tasks for individual student performance. Task-specific positioning can enhance and maximize student potential, save time and money, and better utilize classroom staff and related services personnel to meet students' educational needs.

In order to more effectively use adaptive equipment to meet the educational needs of students with cerebral palsy it is imperative to understand and respect the individuality of each student. In the past, attempts by therapists to understand movement of students with cerebral palsy employed a developmental or hierarchical model. This model classified students by type and amount of brain damage, atypical reflexes, movement patterns present and the developmental milestones achieved (Bobath, 1978; Brunnstrom, 1970; Knott & Voss, 1968; Rood, 1954). One of the major problems with this model is the deficit orientation. Rather than looking at what the student is capable of doing, frequently the emphasis is placed on how abnormally or atypically the student moves. An alternative theory of understanding motor behavior has been proposed which focuses on a more positive look at atypical movement (Higgins, 1991; Thelen, Kelso, & Fogel, 1987; Thelen & Ulrich, 1991). The dynamic systems theory suggests that motor behavior is the result of collective systems and subsystems self-organizing to produce movements within the context of specific tasks, regardless of abnormality of the movement. Systems involved might include physical, environmental, and motivational components. For example, dynamic systems theorists might explain the movement of reaching for an object as the result of the coordination and interaction of the musculoskeletal system, central nervous system, past experiences of the individual (i.e., weight of the object, size of the object), and gravitational pull of the environment. These systems coordinate with one another, compensate for weaknesses, and work within the constraints of the whole system to produce a functional movement or at least the best attempt possible. This reaching behavior would not be explained as a pre-programmed motor behavior controlled by the higher centers of the central nervous system (Bradley, 1994). One of the exciting concepts of this theory is that motor behavior is examined within the context of a functional task and specific to the individual attempting the task. Therefore, when observing movement of people with atypical motor behavior (e.g., children with cerebral palsy), movement can be assessed within a framework as the best attempts of that child's collective systems to achieve the task at hand, instead of abnormal movement deviating from typical standards of acceptable performance. In other words, movement typical for an individual child with cerebral palsy is assessed and measured regarding whether or not a specific task is accomplished. The organization of the child's movement within the context of specific tasks is examined to explore possible variables that affect the control and coordination of the movement. These variables that impact motor control are defined as control parameters and serve as the impetus for shifts in motor behavior (Heriza, 1991). For example, a young child who learns to walk primarily in bare feet may have difficulty walking or even be unable to walk when a pair of rigid shoes are introduced. The shoes in this scenario would be considered the control parameter or the variable shifting the motor behavior from walking to being unable to walk. The control parameter in this example is an external or environmental factor. A control parameter can also be intrinsic, such as when an infant learns to sit. One day the infant is unable to maintain independent sitting without propping with extended arms, but the next day the child can sit independently freely playing with toys. Possible control parameters could be increased strength of the gluteal muscles adequate to maintain sitting, motivation to play with the toys overcoming the fear of falling, or appropriate coordination of trunk musculature for maintaining sitting balance. In a therapeutic situation, once possible control parameters are determined, then specific activities are identified to encourage practice to improve efficiency and promote a variety of motor behaviors appropriate to meet environmental demands (Heriza, 1991).

Dynamic systems theory supports the notion that each system and subsystem is a variable that can possibly be manipulated to effect changes in motor behaviors. The idea that position is a control parameter or an environmental or external variable which influences fine motor performance provides a link to improving recommendations for adaptive equipment. If position is a control parameter of fine motor performance then therapists must make recommendations for positioning that match tasks required of the student within the context of school-life tasks.

The purpose of this study was to provide information about the effects of positioning on the accuracy of hand function in students with cerebral palsy who are nonambulatory. More specifically, this study compared the accuracy of hand function as tested by standardized fine motor assessments in three different sitting and standing positions. The three sitting positions included (1) sitting in a wheelchair with the chair back in a vertical position in space, 90 degrees from horizontal; (2) sitting in a wheelchair with the chair tilted back in space 15 degrees from the 90 degree vertical position; and (3) sitting in a wheelchair with the chair tilted forward in space 15 degrees from the 90 degree vertical position. The three standing positions involved (1) standing in a prone stander in a vertical position in space, 90 degrees from horizontal; (2) standing in a prone stander tilted forward in space 15 degrees from the 90 degree vertical position; and (3) standing in a prone stander tilted forward in space 30 degrees from the 90 degree vertical position. Student performance in this study was considered within the theoretical framework of a dynamic systems theory of motor control exploring the possibility that position was a control parameter for fine motor accuracy of children with cerebral palsy.

Chapter 2: Review of Literature

Educational programs for students with disabilities have been undergoing changes in recent years primarily due to the impact of federal legislation. The Individuals with Disabilities Education Act (IDEA), most recently amended in 1997, has historically broadened the scope of services for infants, toddlers, children and youth with disabilities and their families. The Americans with Disabilities Act (ADA), passed in 1991 and Section 504 of the Rehabilitation Act of 1973, gave civil rights protection to individuals with disabilities, ensuring access to public buildings, public education, private sector employment, and all public services, accommodations, transportation, and telecommunications. Collectively, these laws have substantially contributed to the shift in placement options for students with disabilities, with emphasis on inclusion in general education environments (Thousand & Villa, 1991; Villa, Thousand, Stainback, & Stainback, 1992). Educational demands placed upon students with disabilities are similar to those of all students in the didactic arena. However, these demands are more challenging for students with disabilities due to problems such as eye-hand coordination, mobility in the environment, and functional communication. Students with many different types of disabilities receive services in general education environments. However, cerebral palsy is a common disability, affecting two to three of every 1,000 children in the United States (Paneth & Kiely, 1984).

Cerebral palsy is defined as a non-progressive encephalopathy that occurs before, during or shortly after birth that results in a motor disturbance (Kurtz, 1992). Categorization of cerebral palsy involves defining the distribution of the involvement (i.e., the parts of the body primarily affected or less functional) and the type of movement patterns exhibited by the student (i.e., spastic, athetoid, ataxic, or hypotonic) (Nelson, 1990; Olney & Wright, 1994). Students in this study represented three types of cerebral palsy diagnosis; ataxia; athetosis; and spastic diplegia. The students in the study were categorized as follows:

(1) Ataxia is an extrapyramidal type of cerebral palsy which accounts for 5% of all types of cerebral palsy. Ataxia is classified as a cerebellar disorder involving jerky movement that resembles tremors, especially during fine motor tasks. Assisted ambulation is unsteady, shaky, and appears to have a "drunken" quality. Typically students with ataxia have total body involvement, are afraid of heights, and prefer to maintain a midline oriented position (Batshaw, Perret, & Kurtz, 1992; Eiben & Crocker, 1983; Nelson, 1990; Olney & Wright, 1994).

(2) Athetosis is an extrapyramidal type of cerebral palsy with problems emanating from the basal ganglia and involving discoordinated, involuntary movements. This type of cerebral palsy constitutes 10% of all cerebral palsy. Athetosis is characterized by total body involvement with difficulty regulating movement and maintaining posture, especially midline orientation. Stiffness appears to fluctuate and the student seems floppy at times and then at other times stiff or spastic (Batshaw, Perret, & Kurtz, 1992; Eiben & Crocker, 1983; Olney & Wright, 1994).

(3) Spastic diplegia, a pyramidal type of cerebral palsy, involves the total body, however the legs are more affected (i.e., more stiff or spastic) than the arms and typically one arm is more functional than the other. Students with spastic diplegia generally have

damage in the area of the lateral ventricles and account for 42% of cerebral palsy. Hemiplegia accounts for 36% of cerebral palsy and quadriplegia accounts for 7% of all types of cerebral palsy (Batshaw, Perret, & Kurtz, 1992; Eiben & Crocker, 1983; Nelson, 1990; Olney & Wright, 1994).

For students with cerebral palsy, placement in general education environments often depends upon the ability of that student's team to identify strategies that improve functional independence, enhance classroom and school life participation, and prevent progression of physical problems (York, Giangreco, Vandercook & McDonald, 1992). The use of assistive technology devices for proper positioning as an effective strategy for addressing these concerns has become much more prevalent and refined over the last ten years (Bergen, Presperin, & Tallman 1990; Trefler, Hobson, Taylor, Monahan, & Shaw, 1993). Students with cerebral palsy can demonstrate problems with muscular control and coordination that inhibit independent sitting, effective communication skills, functional hand use, eating, and even breathing. As students with cerebral palsy attempt difficult tasks, especially fine motor tasks, it is common to observe compensatory movements in other parts of the body not typically required for completion of the task. It has been suggested that these associated movements or reactions can alter the motor control capabilities for the specific task actually being attempted (Stengel, Attermeier, Bly, & Heriza, 1984). Associated reactions typically observed in children with cerebral palsy involve an increase in total body stiffness (flexion or extension), drooling, fisting of the hand not involved in the task, jaw excursions, and tongue protrusion (Bobath & Bobath, 1964). Positioning equipment and other assistive technology devices are typically used to ameliorate these impairments experienced by students with cerebral palsy. The equipment can be designed to enhance functional skills or prevent physical deformities by providing support and stability for weak or ineffective muscles. The external stability provided by the use of positioning equipment can also curtail extraneous movement that interferes with the functional abilities of the student. By promoting proper body alignment and limiting unwanted movement, positioning devices are believed to promote independence in daily life activities, improve bodily functions, promote better communication skills, and prevent the emergence of secondary impairments due to the student's disability (Carlson & Ramsey, 1994). When considering the impact of positioning on the motor control of students with cerebral palsy, the importance of understanding movement and coordination is essential. The dynamic systems theory of motor control supports the concept that position is an important consideration for students with movement and coordination problems (Darrah & Bartlett, 1995).

Dynamic Systems Theory of Motor Control

The dynamic systems theory of motor control proposes a view of movement and motor coordination that suggests motor behavior is the result of the interaction of many systems. These systems include but are not limited to physical, environmental, and personal components which self-organize to complete task-specific movement. The concept that motor behavior is self-organizing conflicts with previous beliefs that all movement is prescribed and controlled in a hierarchical manner by higher centers of the central nervous system. (Darrah & Bartlett, 1995; Heriza, 1991; Horak, 1991; Thelen, Kelso, & Fogel, 1987) For example, the literature readily describes a movement pattern observed in typically developing infants, the asymmetrical tonic neck reflex (ATNR), as a motor behavior that is triggered as a predictable motor response of the central nervous system when the neck is rotated to one side. Alternatively, dynamic systems theory would suggest that the ATNR movement pattern, although stereotypic, is the result of the interaction of the combined efforts of many systems resulting in a motor behavior. However, because of limited strength, flexibility, and motor control, the movement pattern is similar among most infants (Crutchfield & Barnes, 1993).

Dynamic systems theory also encompasses the concept that each system develops at a different rate and is constrained or supported by factors that may contribute to or impede the development of new motor behaviors. At a given time in development or execution of a motor skill, certain components may be considered control parameters. Control parameters are those factors, internal and external, that must be in place for manifestation of a specific behavior (Heriza, 1991). In a study conducted by McEwen (1992), data indicated that positioning served as a control parameter of communication as the adults in the classrooms initiated more communication with the students when they were in their wheelchairs and students with the most profound multiple disabilities communicated more when given the opportunity to communicate in the supine position. Fogel, Dedo, and McEwen (1992) found that position also served as a control parameter for infants' gazing at their mothers. When the infants were placed in a supine position more gazing was noted than when the infants were placed in an upright seated position.

Another premise of dynamic systems theory suggests that internal and external components are equivalent in determining and executing functional movement

(Crutchfield & Barnes, 1993; Horak, 1991; Kelso, 1982; Thelen, Kelso, & Fogel, 1987; Thelen, Ulrich, & Jensen, 1989). For example, a child with cerebral palsy is unable to sit independently in a regular school desk because of lack of trunk control, strength, and balance. However, if the environment is manipulated by placing this student in an assistive seating system, then the student can sit without difficulty. Therefore, the environment is as important as the central nervous system or musculoskeletal system in maintaining an upright sitting posture under this condition.

Dynamic systems theory involves the understanding of coordinative structures or predictive functional synergies of movement (Thelen, 1979). The idea is that movement patterns emerge over time due to the interactive nature of physical, neural, and external factors. Therefore, movements are coordinated not because of prescribed motor pathways, but emerge from interaction of the systems, limited by the degrees of freedom over which other systems may exert control (Horak, 1991). For example, a child with athetoid cerebral palsy may have adequate muscle strength, available joint mobility, motivation, and cognitive awareness to accomplish a specific task. However, due to damage of the central nervous system, the coordination of the muscle strength and joint mobility is too poor to allow achievement of the task. Control of the movement is shifted to the motor behavior itself, so that if coordination (control parameter) is improved then the child may be able to accomplish the desired task. Therefore, the motor behavior does not only reflect a lack of neural control, but also indicates the best effort of the other systems to accomplish the task (Gordon, 1987).

Use of dynamic systems theory as a guide for practice in physical therapy is relatively new. However, Campbell (1994) suggested that the dynamical systems model focuses the therapist to concentrate on four critical approaches to practice for promoting improvements in motor control and coordination,

> (1) Search for the constraints in subsystems, such as contractures, that limit motor behavior; (2) creation of an environment that supports or compensates for weaker or less mature (rate-limiting) components of the systems that contribute to motor control; (3) attention to setting up a therapeutic environment that affords opportunities to practice tasks in a meaningful and functional context; and (4) search for control parameters, such as speed of movement, that can be manipulated in therapy to facilitate the attainment of therapeutic goals. (p. 7)

Dynamic systems theory supports the notion that each system and subsystem is a variable which can possibly be manipulated to effect changes in motor behaviors. As Campbell (1994) suggested, to enhance motor behaviors to improve functional abilities, constraints on systems and subsystems must be identified. Therapists must be able to recognize and examine possible control parameters so that appropriate intervention strategies can be implemented to improve functional performance. The possibility that position could serve as a control parameter of fine motor performance, provides potential for adaptive positioning to enhance classroom achievement of students with cerebral palsy who are nonambulatory.

Assistive Seating

Assistive seating is an external variable that has been shown to influence functional performance. Many different types of seated positioning devices have been developed to provide proper body alignment (Cristarella, 1975; Finnie, 1974; Levitt, 1982) and subsequently promote the functional manipulative skills of students with cerebral palsy (Myhr & von Wendt, 1991). The most commonly studied type of positioning device is adapted wheelchairs. Information is available, although minimal, regarding the effects of seated positioning or manipulation of the seat-to-back angle and position of the seat in space of students with disabilities in areas of communication, gross arm function, eating and digestion, breathing, visual orientation, head control, and prevention of deformity (Bay, 1991; Hulme, Bain, Hardin, McKinnon, & Waldron, 1989; Levitt & Miller, 1973; Hulme, Gallacher, Niesen, & Waldron, 1987; McEwen, 1992; McEwen & Karlan, 1989; Nwaobi, 1987; Nwaobi & Smith, 1986). The benefits of proper positioning have been discussed in the literature. However, much of the literature is based upon practice in the field and has emerged as a result of anecdotal perceptions of functional improvements of students with disabilities. The following studies have looked specifically at the effect of seated positioning on functional skills of students with disabilities.

Upright Positioning

In a study conducted by McEwen (1992), 10 students with profound multiple disabilities, 6 to 12 years of age were observed in their classrooms when positioned in their wheelchair, in sidelying, and freestyle on a mat. Data were collected regarding the number of communicative interactions initiated by the students and by the adults present in the classroom. The study found that positioning influenced communication for those students functioning at the lowest levels and that the adults in the classrooms initiated more communication with the students when they were in their wheelchairs. Students initiated more communicative interactions when offered an opportunity for communication when placed in supine on a mat on the floor.

Several other investigators determined that placing children with cerebral palsy in an upright, or more vertical than horizontal, sitting position was the most effective position for eliciting the desired responses in each study. Nwaobi (1986) found that 12 students with spastic diplegia exhibited the lowest level of abnormal activity of specific muscle groups (i.e., gastrocnemius, adductor magnus, iliocostalis lumborum) when the backs of their wheelchairs were in a vertical position. Electromyographic activity of the tested muscle groups increased when the wheelchair was tilted 30 degrees posterior to vertical alignment.

Another study indicating that the upright position was more beneficial than a tilted or reclined seating position involved 11 students with cerebral palsy ranging in age from 4 to 8 years of age (Nwaobi, Brubaker, Cusick, & Sussman, 1983). The electromyographic (EMG) activity of the lumbar erector spinae musculature was recorded while the students were tilted or reclined in seven different positions. The EMG activity was the quietest when students were in the vertical position. The EMG recordings were the highest when students were placed in a forward position with the seat-to-back angle at 0/75 degrees (tilted forward 15 degrees from upright sitting) and when reclined posterior to the vertical position with the seat-to-back angle 0/120 degrees (tilted backward 30 degrees from upright sitting).

Nwaobi (1987) also studied the effects of seating on gross upper extremity function. The study involved 13 students with cerebral palsy positioned in a chair that was placed in four positions, vertical (90 degrees from horizontal); tilted 15 and 30 degrees posterior to vertical; and tilted 15 degrees forward from vertical. In each of the four positions, the students were asked to reach toward a switch and perform a computer-activated task. Overall, reaction times were the fastest in the vertical position. McEwen and Karlan (1989) also found that placement in a stander, an adapted chair, and prone over a wedge enabled 2 students in a single-subject design study to access a communication board faster than when in a sidelying position.

Hulme, Bain, Hardin, McKinnon, and Waldron (1989) conducted a study involving eight children with cerebral palsy ages 1 to 2 years. The children were evaluated for presence of speech vocalizations. Each child was then seen in the home setting 3 months prior to receiving adapted seating devices and up to 6 months after receiving the new seating system. The children received adapted seating devices with a firm seat, head support, foot support, tray, and appropriate modifications to enable the child to assume a symmetrical upright posture. The authors did not indicate what, if any positioning equipment was used by the children prior to the study. The children were audio recorded during each visit. Data analysis revealed improvements in vocalization for 7 of the 8 subjects following placement in an upright position. Additional study by Hulme, Gallacher, Walsh, Niesen, and Waldron (1987) investigated the effect of positioning in an upright position on head control, visual tracking, sitting posture, and reach and grasp. This study involved 19 subjects (aged 1 to 6 years) also observed in their homes 3 months prior to and 6 months after receipt of the adapted seating device. Through subject observation and caregiver interview, data were collected regarding performance of activities requiring head control, visual tracking, sitting posture and reach and grasp. Results of the study indicated that head control and grasping improved. Caregiver interview information also revealed that subjects were easier to care for, take out into the community, interact with, and position. In a similar study, the effect of an adaptive seating device on eating (lip closure and tongue protrusion), self-feeding, and drinking for 11 children with motor impairments (ages 1 to 4 years) was examined. The results indicated improvement in eating and drinking, specifically due to improved head control in the upright position (Hulme, Shaver, Acher, Mullette, & Eggert, 1987).

Seat Surface Inclination

Because students with cerebral palsy often exhibit a slumped sitting posture, the effect of anteriorly tilting the seat surface of students with cerebral palsy to improve active trunk extension and decrease slumped posture has also been investigated. A slumped or kyphotic posture is manifested by a forward head, rounded shoulders and a posteriorly tilted pelvis. By anteriorly tilting the seat surface, the line of gravity in relation to the ischial tuberosities is changed. The anterior tilt of the seat causes the student to anteriorly tilt the pelvis which promotes active thoracic spinal extension and correction of the slumped posture. A study by Miedaner (1990) involved 15 children with diagnoses of developmental delay or cerebral palsy from the ages of 2 to 6 years. The children were placed in five different sitting positions. The five positions included cross-legged sitting on the floor; bench sitting with hips/knees at 90 degrees; bench sitting with bench tilted forward 20 degrees; bench sitting tilted forward 30 degrees; and sitting in the Ther Adapt Posture Chair. The Ther Adapt Posture Chair is a commercial chair allowing for adjustment of seat angle (forward), but provides support at the knees and feet. The children were asked to do nothing but sit and spinal extension was then measured by the examiners after 1 minute of sitting. Results indicated that the Ther Adapt Posture Chair and anteriorly tilted bench sitting promoted a straighter or less-slumped sitting posture.

Myhr and von Wendt (1991) studied the effect of anterior seat surface inclination on the sitting posture, head control, arm and hand function, and presence of atypical movement of 23 students with cerebral palsy ages 2 to 16 years. The students were videotaped in six different positions. The positions included sitting in their regular wheelchair; sitting in an adapted chair with an anterior seat inclination from 8 to 15 degrees; and the other four positions involved presence or removal of additional supports such as tables and abductor splints. Results of the study indicated improvement in the sitting position with the seat surface anteriorly tilted. The presence of atypical movement also decreased in this position.

In addition to studies indicating that manipulation of seat inclination of students with cerebral palsy affects hand function, several studies have found no effects. McClenaghan, Thombs, and Milner (1992) investigated the effects of seat surface inclination on postural stability and arm function of 20 students, ages 4 to 15 years. This study utilized a control group involving 10 students without cerebral palsy and 10 students with mild to moderate spastic cerebral palsy. Data were collected while students were asked to perform quiet sitting (hands on table) and then to perform upper extremity motor tasks (i.e., finger-tapping, pellet pick-up, thumb-press, and pencil-tracing). Seat surface inclinations of 0 degrees, 5 degrees anterior to vertical, and 5 degrees posterior to vertical were utilized in the study. Although differences were noted between the control and experimental groups, no changes were noted due to seat surface inclination.

McPherson et al. (1991) also investigated the effect of altering seat surface inclination on upper extremity movement. This study involved 12 subjects ranging in age from 18 to 21 years. An experimental group of 6 adults with mild to moderate cerebral palsy was compared to a control group of 6 adults with no identified neuromotor problems. Subjects were placed in four different sitting positions (i.e., vertical in a wheelchair, vertical in an adapted chair, 15 degrees forward from vertical, and 15 degrees posterior to vertical) while upper extremity movement during reaching was videotaped. The reaching was then analyzed to determine if the number of movement elements was different between groups and between positions. Differences were found between groups as the subjects with cerebral palsy had higher numbers of reaching elements, but no effect of seat surface alteration was found. In a study by Seeger, Caudrey, and O'Mara (1984), the effect of seat surface inclination was also studied relative to hand function. Involved in the study were 9 students with cerebral palsy. The students were divided into two groups, those with flexor dominant movement patterns and those with extensor dominant movement. The students were placed in a sitting position and asked to manipulate a joystick control to maintain a light on a target. The same task was then completed while maintaining a vertical position of the back and posteriorly tilting the seat of the students with extensor dominant movement and anteriorly tilting the seat of the students with flexor dominant movement. The authors concluded that seat angle alteration did not affect hand function.

Adapted Vs. Non-adapted Seating Systems

The effect of proper seated positioning on respiratory function was investigated by Nwaobi and Smith (1986). This study involved 8 students with spastic cerebral palsy, ages 5 to 12. Students were placed in a sling-seat wheelchair and a wheelchair with a firm, contoured seating system. Overall pulmonary functioning improved by at least 51% in the areas of vital capacity, expiratory time, and forced expiratory volume when the students were placed in the firm, contoured seating system. Bay (1991) also looked at the differences between a solid, adapted seating system and a sling seating system. In a single-subject design methodology involving a 37 year-old female with athetoid cerebral palsy, the effect of positioning in the adapted system and sling seating system on the subject's ability to utilize an augmentative communication device was investigated. The rate of the subject's typing on the electronic device increased each time the subject was placed in the adapted seating system. The authors concluded that for their subject, the adapted seating system improved postural control which subsequently improved functional use of an augmented communication device.

Prone Standers

Prone standing frames, which are often used as an alternative to adaptive seating, fully support the student's trunk and lower extremities while maintaining proper body alignment in standing. The prone stander has been suggested to improve postural alignment and head control, prevent deformities (i.e., hip flexion contractures, scoliosis, heelcord contractures), and provide another option for suitable positioning for students with cerebral palsy (Bergen, Presperin, & Tallman, 1990; Heuter & Blossom, 1967). In addition to prevention of deformity and promotion of postural control, other advantages to standing for students with motor impairments have been suggested. Standing has been said to contribute to improved bone density and bone growth (Jeffries, 1994; Le Veau & Bernhardt, 1984; Cusick & Stuberg, 1992), kidney function (Heuter & Blossom, 1967), prevention of hip subluxation and dislocation (Howard, McKibbin, & Williams, 1985; Phelps, 1959), and overall perception of environmental stimulation (Taylor & Saxon, 1988).

Prone Standers and Hand Function

Although relationships between certain positions and specific physical functions have been examined and identified, little objective evidence is available regarding the specific relation between the standing of students with physical impairments and fine motor tasks. A recent study by Noronha, Bundy, and Groll (1989) of 10 boys with cerebral palsy, 9 ambulatory and 1 utilizing a wheelchair, attempted to demonstrate that the added stability provided by a prone stander would enable the children to perform better on a hand function test than when they were sitting in a chair. No differences were found. However, many parameters in this study were not well-controlled or documented, such as the type of seat utilized for the sitting activities, the angle of the prone stander during standing activities, and the type and angle of the writing surface. This study also included children who were ambulatory who did not need or use prone standers. The inclusion of the ambulatory students may have also confounded results, as these students would not exhibit comparable motor control and coordination problems as those students typically needing a prone stander.

Writing surface angle

The angle of the writing surface during sitting activities in normal subjects was examined by Eastman and Kamon (1976) to determine the effect on sitting posture. No single angle was determined to be better for improving upright posture, however, differences in posture were noted between the writing surface angles. As the writing surface approached a horizontal position, subjects leaned over to use the writing surface for support. When the writing surface was positioned at an angle approaching a more vertical position, subjects sat with more erect posture. This study suggests the importance of controlling the angle of the writing surface during fine motor activities and supports the need for this control in the study by Noronha, Bundy, & Groll (1989).

Prone stander angle

The angle of the prone stander during fine motor activities is important due to the amount of weight bearing directed through the upper extremities when the stander is tilted forward. Curtis (1989) found that children with cerebral palsy transmit only about 75% of their weight to their feet in all types of standers, and in prone standers the amount transmitted is even less. McCulloch, Moore, & Schenkman (1993) also found that the percentage of total body weight of children with cerebral palsy transmitted to the lower extremities when in the prone stander, tilted toward a prone position was less than when in the upright position or in a supine stander. Miedaner (1991) found in a study of 23 children with cerebral palsy, 2 to 5 years of age, that the amount of weight bearing through the lower extremities generally increased as the supported standing position moved closer to the upright or vertical position. Therefore, placing the prone stander in the most vertical position possible increases weight bearing through the lower extremities while decreasing weight bearing through the arms so they can be freed for functional activities.

Conclusions

Students with cerebral palsy who are nonambulatory generally experience problems with motor control and coordination that adversely impact classroom performance. These students are also prevalent consumers of adaptive positioning equipment. The effect of the use of positioning equipment on classroom functioning has not been well established. Therapists frequently make recommendations for students to be placed in positioning equipment during the school day without considering scheduled classroom activities. If position does influence fine motor function, then therapists must consider what positions promote optimal performance of classroom skills.

This study incorporated the suggestions of Campbell (1994) embracing the theoretical framework of dynamic systems theory. This study questioned the possibility that position is a constraint on systems and subsystems of children with cerebral palsy. This investigation also pursued a more in depth understanding of the effects of position on functional skills in order to create a more efficient environment for students with cerebral palsy. Furthermore, a better understanding of position as a possible control parameter for fine motor skills and secondary behavioral characteristics of students with cerebral palsy could be directly applied in the classroom setting to optimize classroom performance of students with cerebral palsy who are nonambulatory.

Purpose and Research Questions

The purpose of this study was to provide information about the effects of positioning on the accuracy of hand function in students who are nonambulatory with cerebral palsy. More specifically, this study compared the accuracy of hand function as tested by standardized fine motor assessments in three specific sitting and standing positions. This study also investigated typical student behaviors observed during fine motor tasks that were affected by changes in position.

Three major questions were investigated in this study:

(1) Is there a difference in the accuracy of fine motor function when students with cerebral palsy who are nonambulatory are sitting in a wheelchair and standing in a prone stander?

(2) Is there a difference in the accuracy of fine motor function when students with cerebral palsy who are nonambulatory are sitting in a wheelchair in vertical alignment and when tilted 15 degrees forward and backward from vertical alignment (90 degrees from horizontal)?

(3) Is there a difference in the accuracy of fine motor function when students with cerebral palsy who are nonambulatory are standing in a prone stander in vertical alignment and when tilted 15 and 30 degrees forward from vertical alignment (90 degrees from horizontal)?

Six additional research questions were addressed regarding observed student behaviors during fine motor tasks:

(1) Is there a difference in the control of drooling, body posture, and paper and pencil when students with cerebral palsy who are nonambulatory are sitting in a wheelchair and standing in a prone stander?

(2) Is there a difference in the control of drooling, body posture, and paper and pencil when students with cerebral palsy who are nonambulatory are sitting in a wheelchair in vertical alignment and when tilted 15 degrees forward and backward from vertical alignment (90 degrees from horizontal)?

(3) Is there a difference in the control of drooling, body posture, and paper and pencil when students with cerebral palsy who are nonambulatory are standing in a prone stander in vertical alignment and when tilted 15 and 30 degrees forward from vertical alignment (90 degrees from horizontal)?

(4) Is there a difference in the student frustration level, off task behavior, and student comments regarding position when students with cerebral palsy who are nonambulatory are sitting in a wheelchair and standing in a prone stander?

(5) Is there a difference in the student frustration level, off task behavior, and student comments regarding position when students with cerebral palsy who are nonambulatory are sitting in a wheelchair in vertical alignment and when tilted 15 degrees forward and backward from vertical alignment (90 degrees from horizontal)?

(6) Is there a difference in the student frustration level, off task behavior, and student comments regarding position when students with cerebral palsy who are nonambulatory are standing in a prone stander in vertical alignment and when

tilted 15 and 30 degrees forward from vertical alignment (90 degrees from horizontal)?

Chapter 3: Method

Students

With informed consent of parents and students, 26 school-age students with cerebral palsy who were nonambulatory participated in the study. For this study, cerebral palsy was defined as a congenital disability. No students with traumatic brain injury were included in the study. The students ranged in age from 5 to 14 years. The types of cerebral palsy for all students are described in Table 1. The definitions of the cerebral palsy diagnoses utilized for this study were derived from the; 1) literature; 2) observation of the student in the school or home environment; 3) review of available medical information from records; 4) performance on selected test items from the Peabody Developmental Motor Scales, and 5) interview with the students' primary caregiver or therapist. To summarize, of the 26 students, 3 students had ataxia; 9 students exhibited athetosis; and 14 students displayed spastic diplegia . All students were able to maneuver themselves independently in their wheelchairs by driving a power chair or pushing a standard chair (see Table 1 for wheelchair description). All students could effectively communicate either orally or through proficient use of an augmentative communication system.

Each student was screened by the investigator to determine eligibility for the study. Inclusion criteria included the ability to follow instructions and use a pen or pencil, nonambulatory status, and ability to be positioned properly in a prone stander. Ability to follow instructions and use a pen or pencil was determined by a screening test using the Peabody Developmental Motor Scales (Folio & Fewell, 1983). To be eligible for

Table 1
Student Demographics and Wheelchair Description

Student#	Age	Sex	CP Diagnosis	Wheelchair
01	5y 28d	F	Spastic Diplegia	Power Invacare Jaguar-Jay Seat/Back
02	9y 10m	F	Athetosis	Power Invacare Jaguar-Planar Seat/Back
03	12y 10m	M	Spastic Diplegia	Power Invacare Arrow-Jay Seat/Back
04	13y 7m	F	Ataxia	Everest &Jennings (E&J) Ultralite-Planar Seat/Back
05	13y 4m	F	Spastic Diplegia	Power Invacare Arrow-Contour Seat/Back
06	11y 6m	F	Spastic Diplegia	E&J Ultralite-Jay Seat/Back
07	10y 6m	F	Ataxia	Power E&J Barbie-Contour Seat/Planar Back
08	9y 1m	F	Athetosis	Power E&J Hotwheels-Jay Seat/Planar Back
09	5y 1m	M	Spastic Diplegia	Quickie-Jay Seat/Planar Back
10	12y 7m	M	Spastic Diplegia	Power E&J Hotwheels-Jay Seat/Back
11	7y 1m	F	Spastic Diplegia	Quickie-Jay Seat/Planar Back
12	6y 5m	F	Athetosis	Power E&J Hotwheels-Jay Seat/Back
13	11y 10m	M	Athetosis	Power Invacare Arrow-Jay Seat/Back
14	10y 4m	M	Ataxia	E&J Ultralite-Planar Seat/Back
15	14y 2m	F	Spastic Diplegia	Power Invacare Arrow-Jay Seat/Back
16	8y 7m	M	Spastic Diplegia	E&J Ultralite-Jay Seat/Back
17	5y 6m	F	Spastic Diplegia	Quickie-Contour Seat/Planar Back
18	13y 10m	F	Athetosis	Power Invacare Arrow-Jay Seat/Back
19	14y 9d	M	Spastic Diplegia	Invacare Rolls-Planar Seat/Back
20	14y 9d	M	Athetosis	Invacare Lightweight-Jay Seat/Back
21	7y 5m	F	Spastic Diplegia	E&J Ultralite-Jay Seat/Back
22	12y 5m	M	Athetosis	Power Invacare Arrow-Jay Seat/Back
23	6y 2m	F	Spastic Diplegia	Quickie-Planar Seat/Back
24	11y 5d	F	Athetosis	Power Invacare Arrow-Contour Seat/Back
25	5y 1d	F	Athetosis	Power Invacare Jaguar-Jay Seat/Back
26	4y 1d	M	Spastic Diplegia	Quickie-Jay Seat/Planar Back

Note. CP=cerebral palsy.

participation in the study, students needed to obtain a score of 1 or 2 on items from the fine motor portion of the test requiring students to draw straight horizontal and vertical lines, a circle, intersecting lines, trace a line, and draw a line connecting two dots. Nonambulatory status was determined by use of a wheelchair and a gross motor age equivalent of 12-14 months or less on the Peabody Gross Motor Scales (unable to walk functionally). Forty-five students were screened for the study and 19 were ineligible based upon poor performance on the Peabody Fine Motor Scale items. Other student information was collected to enable a more robust description of the sample such as age, sex, medical diagnoses, and history. Each student's wheelchair was also evaluated to determine if modifications were necessary to provide an appropriate seated position (see Table 1 for seating description). Positioning principles followed in this study were according to recommended guidelines (Bergen, Presperin, & Tallman, 1990; McEwen & Lloyd, 1989; Trefler et al., 1993). See Table 1 for demographic information, student diagnoses, and type of wheelchair used for each participant in the study. Students were selected from: (1) J.D. McCarty Center in Norman, Oklahoma and (2) Tulsa Public School District in Tulsa, Oklahoma. In addition to the participating schools, many students were nominated for the study by family or individual therapists. Participants were from the following other geographic sites in Oklahoma (See Figure 1 for state map):

(1)	Oklahoma City	(2)	Norman	(3)	Pauls Valley
(4)	Wynnewood	(5)	Sulphur	(6)	Ada
(7)	McAlester	(8)	Checotah	(9)	Sperry
(10)	Broken Arrow	(11)	Tulsa	(12)	Edmond
(13)	Enid	(14)	Lahoma		

These sites represent large urban areas, suburban areas, rural areas, and very rural areas of Oklahoma.

Independent Variable: Position

The independent variable of the study was the position in which students were placed. The students sat in their own wheelchairs for each of the three sitting positions, with the exception of one student who was awaiting the arrival of a new power wheelchair. This student borrowed a power wheelchair from another student that met all positioning guidelines. An angle of 90 degrees between the seat and back was maintained in each of the three sitting positions. The wheelchairs were tilted 15 degrees forward and backward from 90 degrees using a wooden wedge placed beneath the front or back wheels of the wheelchair. The students stood in a Mulholland prone stander for each of the standing positions. The prone stander was adjustable in height and was easily tilted in the desired positions. The tray on the prone stander was also adjustable so that it could be maintained in a horizontal position at all times. Fifteen degree increments of tilt were chosen for the testing positions in this study, based on Nwaobi's study of the effect of seating orientations on gross upper extremity function and extensor activity (Nwaobi, 1987; Nwaobi, Brubaker, Cusick & Sussman, 1983). The following is a list of the six positions in which students were placed;

(1) Sitting in a wheelchair in a vertical position in space, the back 90 degrees from horizontal (W-1);

(2) Sitting in a wheelchair tilted forward in space 15 degrees from the 90 degree vertical position (W-2);

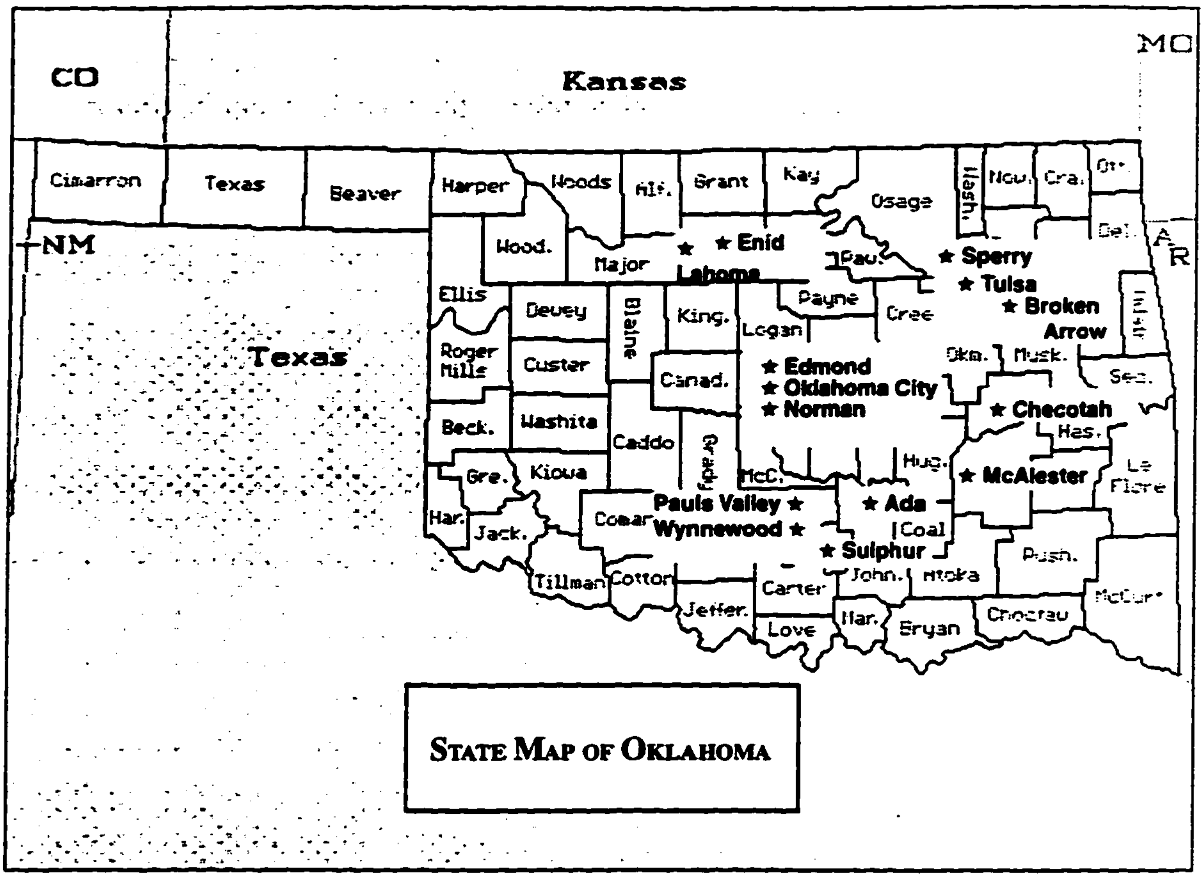

Figure 1. ★ = Location of Research Sites

(3) Sitting in a wheelchair tilted back in space 15 degrees from the 90 degree vertical position (W-3);

(4) Standing in a prone stander in a vertical position, 90 degrees from horizontal (P-1);

(5) Standing in a prone stander tilted forward 15 degrees from the 90 degree vertical position (P-2); and

(6) Standing in a prone stander tilted forward 30 degrees from the 90 degree vertical position (P-3).

Dependent Variables

Fine Motor Accuracy

One of the dependent variables which was examined in this study was fine motor accuracy. The term fine motor accuracy was defined in terms of performance on four standardized tests which assess fine motor function.

Tests 1-3: Visual-Motor Control Subtest (Items 2-4). The Visual-Motor Control Subtest is a standardized subtest from the Bruininks-Oseretsky Test of Motor Proficiency (Bruininks,1978). The Bruininks-Oseretsky Test of Motor Proficiency yields age equivalency scores, standard scores, and percentile ranks. The Visual-Motor Control Subtest is composed of eight items. The three items chosen for this study were items 2, 3 and 4 which required the student to draw a line through a straight path; draw a line through a curved path; and draw a line through a crooked path. This test was normed on 765 4 1/2 to 14 1/2 year old subjects from differing geographic regions and community sizes across the nation based on the 1970 census. Test-retest reliability coefficients for the Visual-Motor Control Subtest are .80 for second graders and .70 for sixth graders.

Tests were scored based upon the number of mistakes made by each student on each test. Each time the student's line was drawn outside of the printed test lines one mistake was tallied. For each quarter inch the student's drawn line remained outside of the printed lines additional mistakes were documented (see Appendix A for sample scored tests).

Test 4: Motor Accuracy Test- Revised. The Motor Accuracy Test-Revised (MAC) is a standardized subtest from the Southern California Sensory Integration Test (Ayres, 1980). This test required the student to use a pencil to trace a printed, curved, black line shaped somewhat like a butterfly or dog bone. A test-retest correlation of .92 was obtained in a sample of 41 pairs of MAC scores of children with neuromuscular disorders including cerebral palsy, traumatic brain injury, and meningomyelocele. On 50 MAC tests selected at random, the interscorer reliability coefficient was .998 (Western Psychological Services, 1980). No description of the expertise or training of the scorers was available. Scoring of the MAC involved use of a line measure tool provided with test. The wheel of the line measure was run on the printed black line or broken lines along the portions of the test where the student's drawn line was off of the printed line. When the student's drawn line returned to the printed line, the line measure wheel was removed from the paper. The total distance the student's drawn line was off of the printed lines was calculated as the total number of mistakes for Test 4 (Western Psychological Services). See Appendix A for sample of scored tests.

Student Compensatory Behaviors During Fine Motor Tasks

The additional dependent variables examined in this study included the following behaviors observed during student completion of fine motor tasks: (1) adjusting paper/pencil; (2) adjusting body position; (3) commenting on the position; (4) drooling; (5) frustration regarding the task; and (6) off task behavior. These behaviors were chosen following observation of students in the pilot study. Due to the possible effects that the compensatory behaviors may have on postural control and subsequently effect fine motor performance, a videocamera was used to document each student's movement and behavior during testing. The compensatory behaviors were then coded and entered into the computer using the Micro-Analytic Data Analysis Package (MADAP) (Kienapple, 1986). The behaviors of altering body posture, adjusting pen and paper, and drooling were observed to determine if changing position affected the presence of these behaviors. Off-task behaviors, comments regarding specific positions, and student behaviors indicating frustration were also documented to detect if these behaviors affected fine motor performance. The student behaviors were coded continuously according to the real time of a digital clock on the videotape. When coding, the coder would note the beginning and ending time in minutes and seconds of the behavior being exhibited. Drooling was coded as occurring or not occurring. Coding continued in this manner for each subject documenting each behavior during all four fine motor tests across all six positions. Table 2 summarizes the behaviors that were coded and their definitions.

Procedures

Students were placed in each of the six positions and received all four fine motor tests. All positioning was performed according to best practice guidelines available in the literature (Bergen, Presperin, & Tallman, 1990; McEwen & Lloyd, 1989; Trefler, Hobson, Taylor, Monahan, & Shaw, 1993). The order of the positions was

Table 2

Definitions For Coding Behaviors

Adjust Paper/pencil		
1	None - Subject is not adjusting paper or pencil	
2	Adjustment - Subject adjusts position of paper on tray; adjusts position of pencil in hand; picks up pencil off paper during task	
3	Excess Time - Administrator is changing tests, working with the video camera, or other action that takes up time other than what is needed for the subject to complete the test	
Adjust Body Position		
1	None - Subject performs task without atypical changes of body position	
2	Adjustment - While performing task, subject displays associated body movements not typically required for completion of the task; such as widely opening mouth, hyperextending neck, uncontrolled movement of non-dominant arm and/or hand; this does not include actions necessary for completion of the task such as moving an arm out of the way or adjusting the paper	
Comments		
1	None - Subject does not speak about how the position feels	
2	Comments - Subject mentions how he/she feels (nervous, scared, in pain, comfortable, stronger) or any positive or negative comments regarding the general position	
Drooling		
1	None - Subject does not drool during task	
2	Drooling - Subject drools during task; specifically moves mouth to keep from drooling	
Frustration		
1	None - Subject concentrates on task without sign of dissatisfaction	
2	Frustrated - Subject is dissatisfied with his/her work or the situation at hand; actions include wanting to stop, trying to erase, stopping to throw pencil down, sighing, grabbing head or hair	
On/Off Task		
1	On Task - Subject is concentrating on task at hand	
2	Off Task - After administrator has asked the subject to start, subject is distracted from the task by an external source; stops to rest, play, or visit	

counterbalanced within and across students to control for possible effects of order. The fine motor tests were administered in the same order for each student in all positions. The tests were administered in a manner progressing from the least challenging to the most challenging (1) drawing a line through a straight path; (2) drawing a line through a curved path; (3) drawing a line through a crooked path; and (4) the Motor Accuracy Test. No student was tested in more than two positioning devices in one day (i.e., one sitting and one standing position). This procedure required a total of three different sessions with each student. Each student was observed as close to the same time of day as possible to control for any individual or environmental effects that time of day may produce. A 15-minute time period was allowed between testing in the two positions. Each session with each subject was videotaped with the subject's permission and knowledge.

Reliability

Fine Motor Test Scores

One student assistant was trained by the investigator to administer and score each of the four fine motor tests. Following parental and student consent, three students at the J.D. McCarty Center not involved in the study participated as pilot subjects in the training sessions for the student assistant. The four tests were administered in each of the six positions. The tests were then scored by the student assistant and re-scored by the principal investigator until interrater reliability of at least .80 was achieved. Strict guidelines were defined for when a mistake occurred on each of the four tests. Standard procedure involved ceasing to grade a test when the occurrence of a mistake on a test was questioned. When this happened, both the student assistant and principal investigator graded the test together, jointly deciding upon the mistakes for that test.

To determine interrater reliability and assure that acceptable reliability was maintained throughout the data collection, 20% of the samples of the test scores (6 subjects in 2 positions across all four tests) were scored by both the principal investigator and the student assistant. The intraclass correlation coefficient (ICC) was used to calculate interrater reliability for scoring of the fine motor tests. Portney and Watkins (1993) describe the ICC as "a reliability coefficient that is calculated using variance estimates obtained through an analysis of variance, therefore reflecting both a degree of correspondence and agreement among ratings" (p.509). Six different types of ICC are classified based upon descriptions of Shrout and Fleiss (1979). The six different equations are based upon the "purpose of the reliability study, the design of the study, and the type of measurements taken" (p. 510). The model most appropriate for this study was model 3, equation 1 which used a repeated measures analysis of variance design, single vs. mean ratings, and the tested raters were considered the only raters of interest. The ICC was calculated using the following equation:

$$ICC = \frac{BMS - EMS}{BMS + (k\text{-}1)EMS}$$

BMS was the between-subjects mean square from the analysis of variance, EMS was the error mean square, and k the number of ratings for each subject (Portney & Watkins, 1993). ICC values range from 0.00 to 1.00. The closer the value is to 1.00, the stronger the reliability. Portney and Watkins (1993) suggest guidelines of values above .75 indicating good reliability and values below .75 as poor to moderately reliable.

The ICC values obtained for scoring the four fine motor accuracy tests ranged from .95 to .99, which is interpreted as strong reliability between raters. These high ICC values are indicative of the standard protocol used for grading each test.

<u>Test 1 (draw a line through a straight path)</u>. For Test 1, the ICC value was .95. Although .95 is considered a high reliability value, it was the lowest of the four values obtained on the fine motor accuracy tests. This was surprising as the line through the straight path seemed the most simple to score. The discrepancies noted here, although mild, may be due to the perceived idea that this was an easy test to score and concern regarding making mistakes was generally low.

<u>Test 2 (draw a line through a curved path)</u>. The ICC value obtained for Test 2 was .99. This test was difficult to score due to many errors by most subjects. As the results of this study indicated, the curved path was one of the two most difficult tests for the subjects. The high reliability might be accounted for by the multiple checks and re-checks by the student assistant and principal investigator.

<u>Test 3 (draw a line through a crooked path)</u>.The ICC value of .99 was calculated for Test 3. Like Test 2, the crooked path was difficult to score due to the high number of errors committed by most subjects. Again, this high reliability can be explained by the constant discussions between the principal investigator and the student assistant.

<u>Test 4 (trace a curved, black line shaped like a butterfly)</u>. Test 4, the Motor Accuracy Test-Revised was the most complicated of the four tests to score. A line-measure wheel was used to determine the length of the student's drawn line that did not follow or was out of acceptable boundaries of the curved, black line established by dotted

or broken lines. First, the line-measure wheel was set at 0 and then run along the solid black line along the sections where the student's line was off of the main line. This value was then recorded. Next, the distance of the student's line that went outside of the dotted lines was then measured and recorded. This procedure was completed two more times recording the amount of the student's line drawn outside of the short-dashed and then the long-dashed lines. The student's final score on Test 4 was the combined score of all four measures, or the total distance the student's line was off of the main, curved line. The ICC value obtained for Test 4 was .99.

Compensatory Behaviors (Except Drooling)

Twenty percent (6 subjects in 2 positions) of the subjects' compensatory behaviors were coded by both the principal investigator and the student assistant. Cohen's Kappa was used to determine interobserver agreement of these nominal data. Cohen's Kappa determines the proportion of observed agreements, and also considers the proportion of agreements expected by chance (Portney & Watkins, 1993). Cohen's Kappa represents an average rate of agreement for sets of observations and is appropriately used with the nominal data representing the codes classifying the compensatory behaviors.

The Kappa values for interobserver agreement for each of the six subjects coded for reliability are shown in Table 3. Kappa values listed for each position are the mean of the reliability of that behavior across each of the four fine motor tests. The mean Kappa value reported at the bottom of Table 3 is the total mean for that behavior for each position.

Overall, mean reliability values for the compensatory behaviors coded in this

Table 3

Cohen's Kappa Inter-observer Agreement on Compensatory Behaviors of 6 Subjects in 2 Positions

Student	AP	BP	CM	FR	TK
01	P-1 =.91	P-1=.96	P-1=1.0	P-1=1.0	P-1=1.0
	W-1=.91	W1=.92	W-1=1.0	W-1=1.0	W-1=1.0
02	P-2=.86	P-2=.94	P-2=.94	P-2=1.0	P-2=.96
	W-2=.91	W-2=.90	W-2=.99	W-2=1.0	W-2=.93
05	P-1=.89	P-1=.87	P-1=.95	P-1=1.0	P-1=.95
	W-2=.87	W-2=.96	W-2=.96	W-2=1.0	W-2=.96
06	P-2=.91	P-2=.91	P-2=.96	P-2=1.0	P-2=.96
	W-1=.91	W-1=.93	W-1=.93	W-1=1.0	W-1=.96
09	P-3=.91	P-3=.87	P-3=.91	P-3=1.0	P-3=.91
	W-3=.92	W-3=.88	W-3=.95	W-3=1.0	W-3=.96
13	P-3=.97	P-3=.97	P-3=.98	P-3=1.0	P-3=1.0
	W-1=.87	W-1=.98	W-1=.99	W-1=1.0	W-1=.99
M	P=.91	P=.92	P=.96	P=1.0	P=.96
	W=.90	W=.93	W=.97	W=1.0	P=.97

Note. AP=adjusting paper/pencil; BP=adjusting body position; CM=commenting on the position; FR=frustration regarding the task and TK=off task behavior. P-1= standing upright; P-2=standing tilted 15 degrees forward; P-3=standing tilted 30 degrees forward; W-1=sitting upright; W-2=sitting tilted 15 degrees forward; and W-3=sitting tilted 15 degrees backward. M=Mean; P=standing mean and W=sitting mean.

study ranged from .86 to 1.0. When examining the data coded for reliability the interobserver agreement was off only by time of observation (often only 1 or 2 seconds), not by observation of the behavior exhibited by the student. The reliability values might be accounted for by two major factors. The pilot study (3 subjects) provided preliminary training for the student assistant to initiation of the actual study. The close working relationship between the principal investigator and the student assistant was crucial to maintaining ongoing reliability checks throughout the study. Standard procedure included stopping any videotaped segment when a question arose regarding the possibility of a student exhibiting a compensatory behavior. That videotape would then be reviewed by both the principal investigator and the student assistant to determine documentation of a compensatory behavior.

For the compensatory behaviors of commenting on the position, frustration, and off task behavior, mean coefficients were between .96 and 1.0. These three compensatory behaviors did not occur most often, especially frustration with the task and off task behavior. Possibly, with fewer behaviors to observe, reliability was higher.

Adjusting pencil/paper. For the compensatory behavior adjusting pencil/paper agreement ranged from .86 to .97 in the standing positions with an average agreement of .91. In the seated positions agreement ranged from .87 to .92 with an average of .90 across all six subjects.

Adjusting body position. Kappa values for the compensatory behavior of adjusting body position ranged from .87 to .97 in the standing positions with an average agreement of .92. An average agreement of .93 was obtained for the seated positions with

Kappa values ranging from .88 to .98. for the six subjects coded for reliability analysis.

Commenting on the position. Average agreement for commenting on the position in the standing positions was .96, with Kappa values ranging from .91 to 1.0. For the seated positions values ranged from .93 to 1.0, with an average agreement of .97.

Frustration regarding the task. For the compensatory behavior, frustration regarding the task, average agreement was perfect in both the standing and seated positions. Kappa values equaled 1.0 across all six subjects, for each test, in all positions coded for reliability.

Off task behavior. Values ranged from .91 to 1.0 for off task behavior in the standing positions, with an average agreement of .96. In the seated positions, an average agreement of .97 was obtained with values ranging from .93 to 1.0.

Drooling

Reliability for the compensatory behavior drooling was determined using percentage of agreement, which was 100% for 50% of the subjects (13) in the study. Drooling was coded by observing if the subject drooled in any of the six positions. Thirteen subjects were double-coded, nine of the subjects drooled and four subjects did not.

Data Analysis

Data were analyzed utilizing SAS statistical package. Simple repeated measures analysis of variance (ANOVA) by the general linear models procedure (GLM) was used for analysis of the variables to obtain an overall F-value with Dunn and Tukey critical values used for post hoc analysis of main effects for multiple comparisons of all variables. This procedure assumes that sphericity is met. Sphericity for repeated measures designs assumes equality of variances of differences of observations for all possible pairs of levels of the repeated factor. Assuming that sphericity is met in a repeated measures analysis is typically not a safe assumption. Often the sampling distribution of F is not well fit by the usual F distribution and the statistic is not robust (Toothaker, 1991). Therefore, two-correlated-sample t tests were also implemented for post hoc analysis to safeguard for the assumption of sphericity. Data were analyzed using an alpha level of $\leq .10$, indicating that the probability of a Type I error was 10% or less. This decision was made based on the belief that the probability of committing a Type II error, or not identifying an important finding, would be more detrimental than identifying an erroneous effect. Rothstein (1990) states, "...the smaller the p value, the more likely the finding is true, not the more meaningful the finding" (p. 535). Due to the lack of substantiated interventions for students with cerebral palsy, the use of an alpha level of $\leq .10$ allowed an acceptable error rate of 10%.

The Micro-Analytic Data Analysis Package (MADAP) (Kienapple, 1986) was utilized for entering coded data and merging all behavior categories for each session. Transcripts of the timed sequence of behaviors during each session were produced which contained frequency, rate, and duration calculations for each coded behavior. The frequency of each coded behavior was then entered into the data base which was analyzed with SAS using repeated measures ANOVA.

The data were analyzed by dividing the subjects into several groups to examine all possible effects of the study. The data were classified into the following groups:

(1)	CP Diagnosis	Group = Ataxia	Table 1	n=3
		Group = Athetosis	Table 1	n=9
		Group = Diplegia	Table 1	n=14
(2)	Age	Group = Young (7yr & under)	Table 4	n=9
		Group = Old (8yr & over)	Table 5	n=17
(3)	Gender	Group = Female	Table 6	n=16
		Group = Male	Table 7	n=10
(4)	Score on Test 2	Group = Low (0-10)	Table 8	n=4
		Group = Mid (11-30)	Table 9	n=19
		Group = High (> 30)	Table 10	n=3
(5)	Score on Test 4	Group = Low (0-60)	Table 11	n=7
		Group = Mid (61-125)	Table 12	n=14
		Group = High (> 125)	Table 13	n=5

Age

The study population was divided into groups by age, young (7 years and under) and old (8 years and over). The division between the age of 7 and 8 years was determined based on information in the literature regarding the development of hand preference and graphomotor (drawing and writing) skills (Murray,1995; Ziviani, 1995). Recent studies have shown that although handedness begins as early as 12-13 months, and is stable in most children by 3 to 4 years of age, the degree of handedness increases over time and is consistent by age 7 to 8 years (McManus et al., 1988). Ziviani (1995) concluded that until the age of 8 years, children are unable to fully take into account all aspects of visual perspective and object position and orientation for integration into consistently legible and accurate handwriting.

Gender

Another comparison made within the sample population involved classifying the students by gender. It should be noted that this study did not support the natural incidence

Table 4

Age Group of Young Students 4 to 7 years (N=9)

STUDENT#	AGE	SEX	CP DIAGNOSIS
01	5y 28d	F	Spastic Diplegia
09	5y 1m	M	Spastic Diplegia
11	7y 1m	F	Spastic Diplegia
12	6y 5m	F	Athetosis
17	5y 6m	F	Spastic Diplegia
21	7y 5m	F	Spastic Diplegia
23	6y 2m	F	Spastic Diplegia
25	5y 1d	F	Athetosis
26	4y 1d	M	Spastic Diplegia

Note. CP=cerebral palsy.

Table 5

Age Group of Old Students 8 to 14 years (N=17)

STUDENT#	AGE	SEX	CP DIAGNOSIS
02	9y 10m	F	Athetosis
03	12y 10m	M	Spastic Diplegia
04	13y 7m	F	Ataxia
05	13y 4m	F	Spastic Diplegia
06	11y 6m	F	Spastic Diplegia
07	10y 6m	F	Ataxia
08	9y 1m	F	Athetosis
10	12y 7m	M	Spastic Diplegia
13	11y 10m	M	Athetosis
14	10y 4m	M	Ataxia
15	14y 2m	F	Spastic Diplegia
16	8y 7m	M	Spastic Diplegia
18	13y 10m	F	Athetosis
19	14y 9d	M	Spastic Diplegia
20	14y 9d	M	Athetosis
22	12y 5m	M	Athetosis
24	11y 5d	F	Athetosis

Note. CP=cerebral palsy.

Table 6

Gender Group of Female Students (N=16)

STUDENT#	AGE	SEX	CP DIAGNOSIS
01	5y 28d	F	Spastic Diplegia
02	9y 10m	F	Athetosis
04	13y 7m	F	Ataxia
05	13y 4m	F	Spastic Diplegia
06	11y 6m	F	Spastic Diplegia
07	10y 6m	F	Ataxia
08	9y 1m	F	Athetosis
11	7y 1m	F	Spastic Diplegia
12	6y 5m	F	Athetosis
15	14y 2m	F	Spastic Diplegia
17	5y 6m	F	Spastic Diplegia
18	13y 10m	F	Athetosis
21	7y 5m	F	Spastic Diplegia
23	6y 2m	F	Spastic Diplegia
24	11y 5d	F	Athetosis
25	5y 1d	F	Athetosis

Note. CP=cerebral palsy.

Table 7

Gender Group of Male Students (N=10)

STUDENT#	AGE	SEX	CP DIAGNOSIS
03	12y 10m	M	Spastic Diplegia
09	5y 1m	M	Spastic Diplegia
10	12y 7m	M	Spastic Diplegia
13	11y 10m	M	Athetosis
14	10y 4m	M	Ataxia
16	8y 7m	M	Spastic Diplegia
19	14y 9d	M	Spastic Diplegia
20	14y 9d	M	Athetosis
22	12y 5m	M	Athetosis
26	4y 1d	M	Spastic Diplegia

Note. CP=cerebral palsy.

Table 8

Test 2 Low Score Group (score= 0-10 or good performance on tracing curved path) (N=4)

STUDENT#	AGE	SEX	CP DIAGNOSIS
03	12y 10m	M	Spastic Diplegia
04	13y 7m	F	Ataxia
18	13y 10m	F	Athetosis
19	14y 9d	M	Spastic Diplegia

Note. CP=cerebral palsy.

Table 9

Test 2 Mid score Group (score 11-30 or average performance on tracing curved path) (N=19)

STUDENT#	AGE	SEX	CP DIAGNOSIS
01	5y 28d	F	Spastic Diplegia
02	9y 10m	F	Athetosis
05	13y 4m	F	Spastic Diplegia
06	11y 6m	F	Spastic Diplegia
07	10y 6m	F	Ataxia
08	9y 1m	F	Athetosis
09	5y 1m	M	Spastic Diplegia
10	12y 7m	M	Spastic Diplegia
11	7y 1m	F	Spastic Diplegia
12	6y 5m	F	Athetosis
14	10y 4m	M	Ataxia
15	14y 2m	F	Spastic Diplegia
16	8y 7m	M	Spastic Diplegia
17	5y 6m	F	Spastic Diplegia
20	14y 9d	M	Athetosis
21	7y 5m	F	Spastic Diplegia
23	6y 2m	F	Spastic Diplegia
24	11y 5d	F	Athetosis
26	4y 1d	M	Spastic Diplegia

Note. CP=cerebral palsy.

Table 10

Test 2 High Score Group (score > 30 or poor performance on tracing curved path) (N=3)

STUDENT#	AGE	SEX	CP DIAGNOSIS
13	11y 10m	M	Athetosis
22	12y 5m	M	Athetosis
25	5y 1d	F	Athetosis

Note. CP=cerebral palsy.

Table 11

Test 4 Low Score Group (score = 0-60 or good performance on tracing motor accuracy butterfly) (N=7)

STUDENT#	AGE	SEX	CP DIAGNOSIS
03	12y 10m	M	Spastic Diplegia
04	13y 7m	F	Ataxia
06	11y 6m	F	Spastic Diplegia
07	10y 6m	F	Ataxia
16	8y 7m	M	Spastic Diplegia
19	14y 9d	M	Spastic Diplegia
24	11y 5d	F	Athetosis

Note. CP=cerebral palsy.

Table 12

Test 4 Mid Score Group (score = 61-125 or average performance on tracing motor accuracy butterfly) (N=14)

STUDENT #	AGE	SEX	CP DIAGNOSIS
02	9y 10m	F	Athetosis
05	13y 4m	F	Spastic Diplegia
08	9y 1m	F	Athetosis
09	5y 1m	M	Spastic Diplegia
10	12y 7m	M	Spastic Diplegia
11	7y 1m	F	Spastic Diplegia
12	6y 5m	F	Athetosis
13	11y 10m	M	Athetosis
14	10y 4m	M	Ataxia
15	14y 2m	F	Spastic Diplegia
18	13y 10m	F	Athetosis
21	7y 5m	F	Spastic Diplegia
22	12y 5m	M	Athetosis

Note. CP=cerebral palsy.

Table 13

Test 4 High Score Group (score > 125 or poor performance on tracing motor accuracy butterfly) (N=5)

STUDENT#	AGE	SEX	CP DIAGNOSIS
17	5y 6m	F	Spastic Diplegia
20	14y 9d	M	Athetosis
23	6y 2m	F	Spastic Diplegia
25	5y 1d	F	Athetosis
26	4y 1d	M	Spastic Diplegia

Note. CP=cerebral palsy.

cited by Gilroy and Meyer (1979) that the proportion of boys with cerebral palsy is slightly higher than girls (1.4:1). In this study, 16 subjects were girls and 10 were boys.

Scores on Tests 2 & 4

The decision to divide the study population into groups based upon the scores on Test 2 (drawing a line through a curved path) and Test 4 (tracing a curved, black line shaped like a butterfly) was made following post hoc analysis of the data which found these two tests to be the most sensitive to changes in position. Test 1 (drawing a line through a straight path) and Test 3 (drawing a line through a crooked path) did not vary by position. This finding also matched the investigator's observations during the testing procedures. Following post hoc analysis, the scores on Tests 2 and 4 were plotted using a stacked, scatter-plot method (see Figures 2 and 3). Student scores were averaged across the six positions to obtain one score for performance on Tests 2 and 4. Upon examining the scatter-plots, division into three distinct groups (low, mid, & high score values) was possible. At this point in the analysis, data were examined to identify if one group might be more sensitive to changes in position than the other two groups. The investigator questioned the possibility that the low-score group (fewest mistakes) might do well in all positions and the high-score group (most numerous mistakes) might do poorly in all positions, leaving the mid-score group most vulnerable to effects of changes in position.

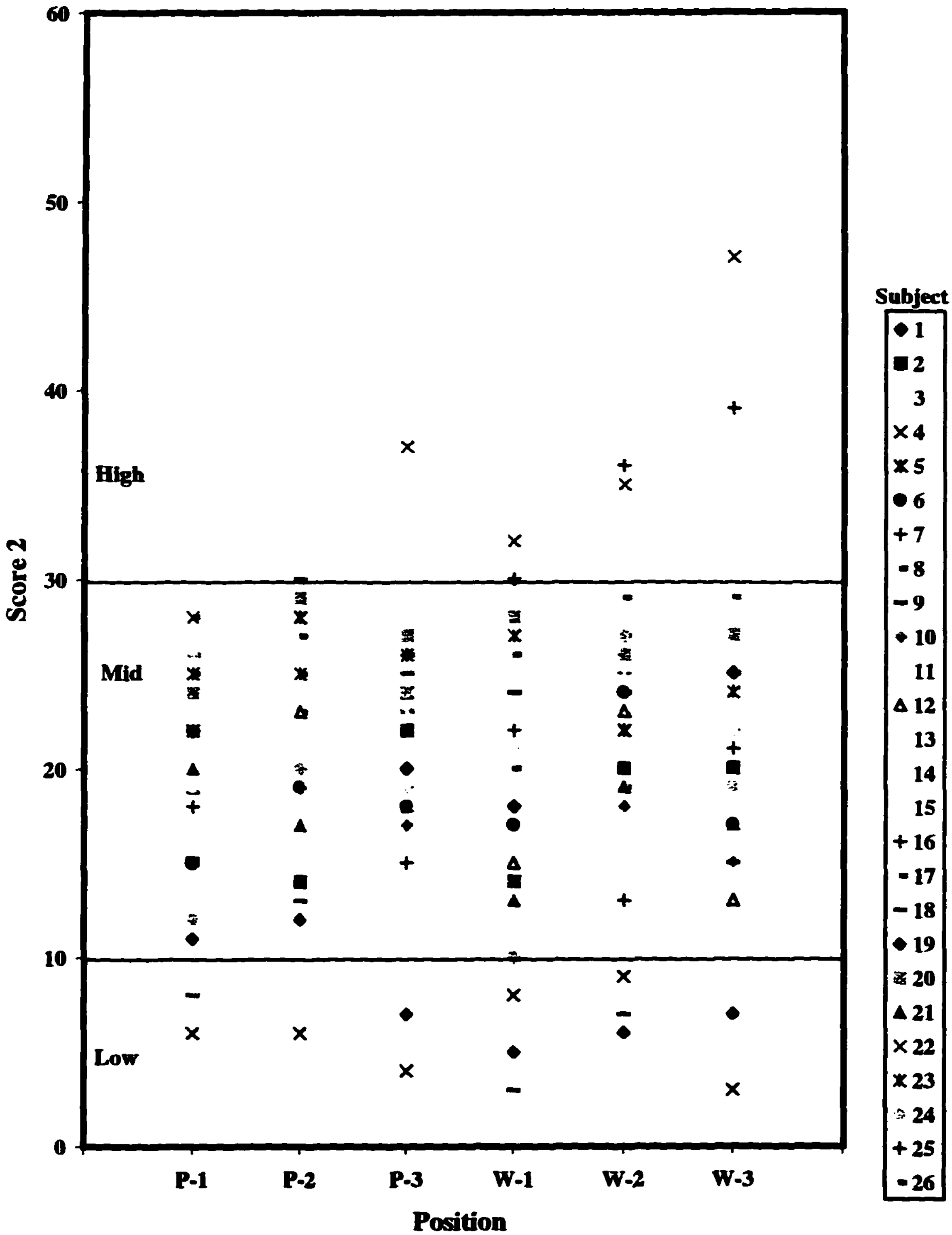

Figure 2. Score 2 grouped by low, mid, & high values.

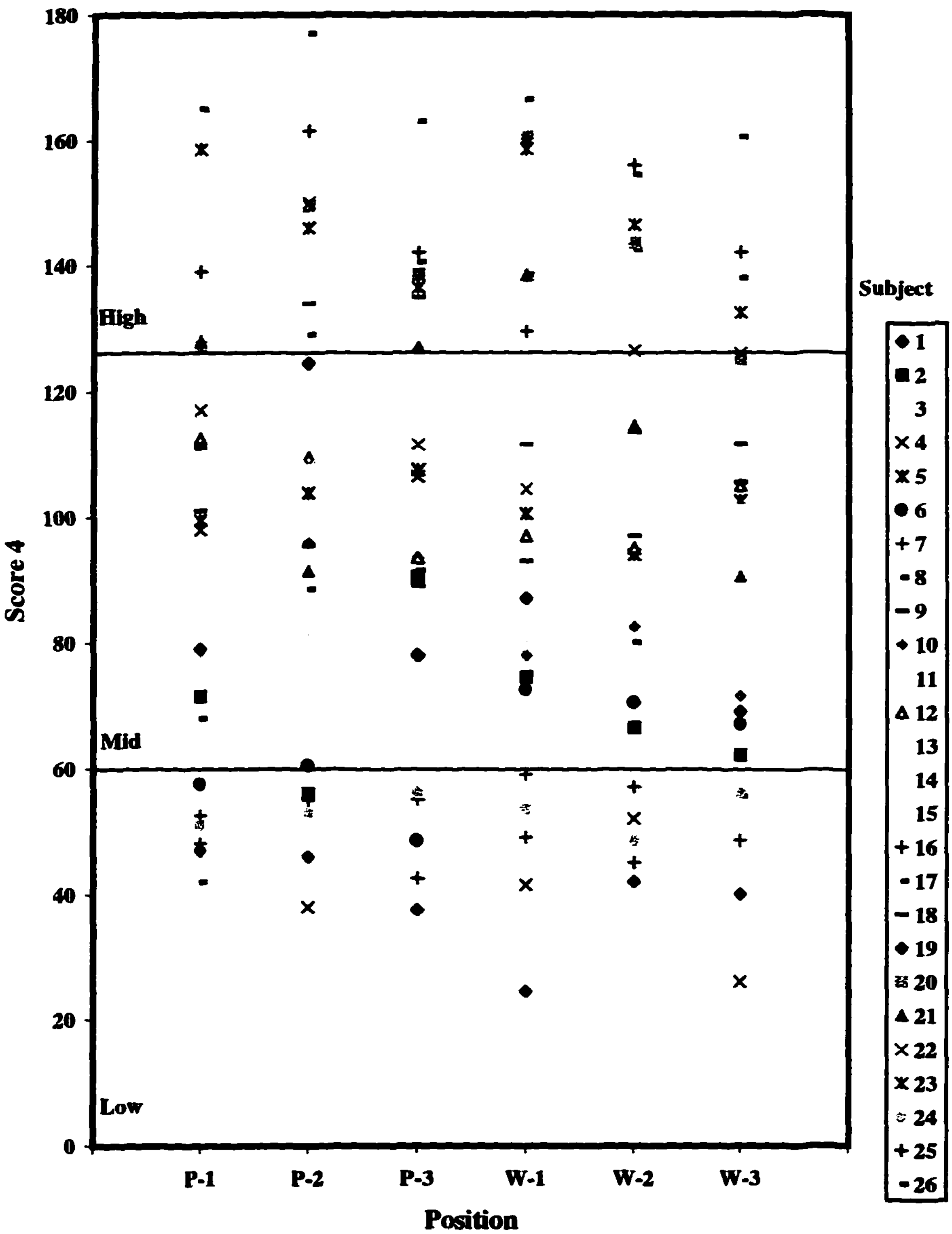

Figure 3. Score 4 grouped by low, mid, & high values.

Chapter 4: Results

The effect of position (independent variable) on fine motor accuracy (dependent variable) was measured by student performance on four fine motor tests. For all subjects and groups, scores on Test 1 (drawing a line through a straight path) and Test 3 (drawing a line through a crooked path) did not vary by position. Scores on Test 2 (draw a line through a curved path) and Test 4 (trace a curved, black line shaped like a butterfly) did vary by subject, group, and position; differences are discussed later in the text. The additional dependent variables examined in this study included the following compensatory behaviors observed during student completion of fine motor tasks:

(1) adjusting paper/pencil;

(2) adjusting body position;

(3) commenting on the position;

(4) drooling;

(5) frustration regarding the task; and

(6) off task behavior.

The effect of position on the student compensatory behaviors varied across subjects and groups.

All Students

All subjects were placed in six different positions. The following is a list of the positions used in this study.

(1) Sitting in a wheelchair with the chair in a vertical position in space, the back 90 degrees from horizontal (W-1).

(2) Sitting in a wheelchair with the chair tilted forward in space 15 degrees from the 90 degree vertical position (W-2).

(3) Sitting in a wheelchair with the chair tilted back in space 15 degrees from the 90 degree vertical position (W-3).

(4) Standing in a prone stander in a vertical position in space, 90 degrees from horizontal (P-1).

(5) Standing in a prone stander tilted forward in space 15 degrees from the 90 degree vertical position (P-2).

(6) Standing in a prone stander tilted forward in space 30 degrees from the 90 degree vertical position (P-3).

Effect of Position on Fine Motor Accuracy

All positions were analyzed to determine if any position emerged as the overall best position for all students for fine motor functioning. On Test 2, no position was the best position, however, position W-1 [M=19.58], sitting in a wheelchair with the chair in a vertical position in space with the back 90 degrees from horizontal, did result in better performance on Test 2 than the following positions:

P-2: Standing in a prone stander tilted forward in space 15 degrees from the 90 degree vertical position [(M=21.73), (p=.095), (SD= 6.33)].

P-3: Standing in a prone stander tilted forward in space 30 degrees from the 90 degree vertical position [(M=21.69), (p=.086), (SD= 6.04)].

W-3: Sitting in a wheelchair with the chair tilted back in space 15 degrees from the 90 degree vertical position [(M=22.27), (p=.014), (SD= 5.22)].

On Test 4, for all subjects, no position was the best position for fine motor functioning. Scores on Test 4 in position W-3 [M=88.98], sitting in a wheelchair with the chair tilted back in space 15 degrees, were better than in the following positions:

W-1: Sitting in a wheelchair with the chair in a vertical position in space, the back 90 degrees from horizontal [(M=95.38), (p=.053), (SD= 13.13)].

W-2: Sitting in a wheelchair with the chair tilted forward in space 15 degrees from the 90 degree vertical position [(M=95.06), (p=.028), (SD= 6.08)].

P-2: Standing in a prone stander tilted forward in space 15 degrees from the 90 degree vertical position [(M=100.11), (p=.001), (SD= 15.53)].

P-3: Standing in a prone stander tilted forward in space 30 degrees from the 90 degree vertical position [(M=98.27), (p=.039), (SD= 21.73)].

Effect of Position on Student Compensatory Behaviors

No differences were observed across all subjects for the compensatory behaviors of adjusting body position, commenting on the position, frustration regarding the task, or off-task behavior. Students adjusted their paper and pencil less in position P-2, standing tilted forward 15 degrees, [M=10.12] than in position P-3, standing tilted forward 30 degrees, [(M=12.69), (p=.083), (SD= 7.29)]. Across all students, drooling occurred less in position P-3, standing tilted forward 30 degrees, [M=.15] than in positions P-2, standing tilted forward 15 degrees, [(M=.31), (p=.043), (SD= .368)], W-1, sitting upright, [(M=.35), (p=.022), (SD= .402)], and W-2, sitting tilted forward 15 degrees, [(M=.31), (p=.043), (SD= .368)]. Drooling also occurred less in position W-3, sitting tilted backward 15 degrees, [M=.19] than in position W-1, sitting upright [(M=.35), (p=.103), (SD= .464)].

Cerebral Palsy Diagnosis

Students with three types of cerebral palsy were included in this study; 3 had ataxia, 9 had athetosis, and 14 had spastic diplegia (Table 1).

Effect of Position on Fine Motor Accuracy

Using a 3 x 6 (diagnosis by position) ANOVA with position as a within-subjects factor, of the three groups of cerebral palsy diagnosis no group emerged as having an overall better or worse fine motor accuracy performance on Test 2 [$F(2, 23) = 1.81$, $p = .284$] or Test 4 [$F(2, 23) = .69$, $p = .513$] across all positions . Similarly no one position was the overall best or worst position for fine motor functioning on Test 2 [$F(2, 23) = .90$, $p = .484$] or Test 4 [$F(2, 23) = 2.02$, $p = .091$]. Although this p value indicates that a position effect existed on Test 4, when multiple comparisons were performed at an alpha level $\leq .10$, no significant differences were found. No position by group interaction was noted on Test 4 [$F(2, 23) = 1.26$, $p = .270$]. However, on Test 2 (drawing a line through a curved path), a position by group interaction effect [$F(2, 23) = 1.81$, $p = .066$] was distinguished. The students with ataxia [$M = 15.33$] and spastic diplegia [$M = 19.43$] scored lower, indicating better performance in position P-3 (standing tilted forward 30 degrees) than the students with athetosis [$M = 27.33$].

On Test 2, within group position differences also were discovered, as indicated in Table 14. Students with ataxia displayed more accurate fine motor functioning in position P-3 (standing tilted forward 30 degrees) than in positions W-1 (sitting upright) and W-2 (sitting tilted forward 15 degrees). Students with athetosis demonstrated better fine motor accuracy in positions P-1 (standing upright) and W-1 (sitting upright) than in positions P-3 (standing tilted forward 30 degrees) and W-3 (sitting tilted backward 15 degrees). Students with athetosis also exhibited better test performance in position W-1 (sitting upright) than in position W-2 (sitting tilted forward 15 degrees). The students with spastic diplegia also revealed differences within their group, with students performing better on Test 2 in positions P-3 (standing tilted forward 30 degrees) and W-1 (sitting upright) than in position P-2 (standing tilted forward 15 degrees). See Table 14 for data.

On Test 4, students with ataxia scored better in position W-3 (sitting tilted backward 15 degrees) than in positions W-1 (sitting upright) and W-2 (sitting tilted forward 15 degrees). Students with athetosis were more accurate in positions P-1 (standing upright), W-2 (sitting tilted forward), and W-3 (sitting tilted backward) than in position P-2 (standing tilted forward 15 degrees). Students with spastic diplegia had better scores on Test 4 in position W-3 (sitting tilted backward) than in positions P-2 (standing tilted forward 15 degrees), W-1 (sitting upright), and W-2 (sitting tilted forward). See Table 15 for numerical values.

Effect of Position on Student Compensatory Behaviors

Across the students with three types of cerebral palsy, no effect of position was found on compensatory behaviors. A position effect [$F(2, 23) = 1.99$, $p = .085$] was determined for drooling across the cerebral palsy groups, but on further examination of the data by multiple comparisons, no significant position effect for drooling was noted. However, students with ataxia did emerge as the group most influenced by position. In positions W-1 (sitting upright) and W-3 (sitting tilted backward 15 degrees) students with

Table 14
Cerebral Palsy Within Group Differences on Test 2

Group	Position	M	SD	p≤.10
Ataxia	P-3	15.33[a]		
	W-1	18.66	.577	.010*
	W-2	19.66	2.082	.069*
Athetosis	P-1	21.89[a]		
	P-3	27.33	7.038	.050*
	W-3	27.33	8.338	.086*
	W-1	21.11[a]		
	P-3	27.33	8.273	.054*
	W-2	26.00	5.578	.030*
	W-3	27.33	5.652	.011*
Diplegia	P-3	19.43[a]		
	P-2	21.29	3.009	.038*
	W-1	18.79[a]		
	P-2	21.29	4.146	.042*

Note. *p value of ≤ .10. [a]Lower score denotes best performance. P-1= standing upright; P-2=standing tilted 15 degrees forward; P-3=standing tilted 30 degrees forward; W-1=sitting upright; W-2=sitting tilted 15 degrees forward; and W-3=sitting tilted 15 degrees backward.

Table 15
Cerebral Palsy Within Group Differences on Test 4

Group	Position	$\underline{M}$	$\underline{SD}$	$\underline{p} \leq .10$
Ataxia	W-3	62.00[a]		
	W-1	73.00	4.272	.047*
	W-2	80.00	8.846	.072*
Athetosis	P-1	100.67[a]		
	P-2	114.44	15.639	.030*
	W-2	103.17[a]		
	P-2	114.44	11.980	.022*
	W-3	101.33[a]		
	P-2	114.44	14.452	.026*
Diplegia	W-3	86.82[a]		
	P-2	97.60	17.777	.041*
	W-1	95.75	15.982	.057*
	W-2	93.07	10.720	.048*

Note. *$\underline{p}$ value of $\leq .10$. [a]Lower score denotes best performance. P-1= standing upright; P-2=standing tilted 15 degrees forward; P-3=standing tilted 30 degrees forward; W-1=sitting upright; W-2=sitting tilted 15 degrees forward; and W-3=sitting tilted 15 degrees backward.

ataxia adjusted their body position less than the students with athetosis. Students with ataxia made more comments regarding their positioning than students with athetosis in positions P-3 (standing tilted forward 30 degrees) and W-1 (sitting upright). Students with ataxia also made more comments than students with spastic diplegia in positions P-3 and W-1 (as above), and also in position W-3 (sitting tilted backward 15 degrees). See Table 16 for numerical values.

In position P-1, standing in a prone stander in a vertical position, students with ataxia demonstrated more frustration than students with athetosis and spastic diplegia. More off-task behavior was also noted for students with ataxia than those students with athetosis or spastic diplegia in positions P-1 (standing upright), W-1 (sitting upright), and W-3 (sitting tilted backward 15 degrees). See Table 17 for numerical values.

In position P-1, standing upright [$F(2, 23) = 2.53$, $p = .102$], students with spastic diplegia ($M = 7.786$) adjusted their paper and pencil less than the students with athetosis ($M = 17.667$).

Age

Students were divided into two groups by age, students ages 7 and younger and those 8 years of age and older. The age 7 and younger group was comprised of 9 students, 7 females and 2 males. The age 8 and older group included 9 female and 8 male students.

Effect of Position on Fine Motor Accuracy

A 2 x 6 (age by position) ANOVA with position as a within-subjects factor was used to analyze the data by age group. No group [$F(1, 24) = 1.43$, $p = .244$], position [$F(1, 24) = 1.15$, $p = .337$], or position by group interaction effect [$F(1, 24) = .22$, $p = .945$] of age

Table 16

Cerebral Palsy Group Effects of Position on Student Compensatory Behaviors of Adjusting Body Position and Commenting on Position

Comparison	Behavior	Position	M	F(2,23)	p≤.10
Ataxia*[a]	**adjusting body**	**W-1**	**1.667**	**3.50**	**.048**
Athetosis			7.778		
Ataxia*	**adjusting body**	**W-3**	**2.000**	**3.50**	**.048**
Athetosis			7.333		
Ataxia*	**comments**	**P-3**	**5.000**	**3.19**	**.060**
Athetosis			.333		
Diplegia			.071		
Ataxia*	**comments**	**W-1**	**7.000**	**3.19**	**.060**
Athetosis			.111		
Diplegia			.071		
Ataxia*	**comments**	**W-3**	**1.000**	**3.19**	**.060**
Diplegia			.071		

Note. *Denotes significant comparisons at p value of ≤ .10 [a]Bold type indicates fewest body adjustments and most comments on position. P-1= standing upright; P-2=standing tilted 15 degrees forward; P-3=standing tilted 30 degrees forward; W-1=sitting upright; W-2=sitting tilted 15 degrees forward; W-3=sitting tilted 15 degrees backward.

Table 17

Effects of Position on Student Compensatory Frustration and Off-Task Behavior

Comparison	Behavior	Position	M	F(2,23)	p≤.10
Ataxia*[a]	**frustration**	**P-1**	**1.667**	**2.33**	**.080**
Athetosis			.111		
Diplegia			.357		
Ataxia*[b]	**off-task**	**P-1**	**5.000**	**2.41**	**.073**
Athetosis			.444		
Diplegia			.357		
Ataxia*	**off-task**	**W-1**	**2.333**	**2.41**	**.073**
Athetosis			.333		
Diplegia			.429		
Ataxia*	**off-task**	**W-3**	**4.667**	**2.41**	**.073**
Athetosis			.222		
Diplegia			1.071		

Note. *Denotes significant comparisons at p value of ≤ .10 [a]Bold type indicates most frustration. [b]Bold type denotes most off-task behavior. P-1= standing upright; P-2=standing tilted 15 degrees forward; P-3=standing tilted 30 degrees forward; W-1=sitting upright; W-2=sitting tilted 15 degrees forward; W-3=sitting tilted 15 degrees backward.

was ascertained on Test 2. However, on Test 4 (tracing a curved, black line shaped like a butterfly), a group effect [$F(1, 24) = 10.33$, $p = .004$] was detected. The students in the 8 years of age and over group exhibited lower (better) scores in all positions (Table 18). No position [$F(1, 24) = 1.82$, $p = .113$] or position by group interaction effects [$F(1, 24) = .43$, $p = .827$] were noted on Test 4.

On Test 2 and Test 4 position differences within the groups were also noted. On Test 2, students in the 8 years of age and over group performed better in position W-1 (sitting upright) than in positions P-2 (standing tilted forward 15 degrees), W-2 (sitting tilted forward 15 degrees), and W-3 (sitting tilted backward 15 degrees). On Test 4, the older students also performed better in position W-3 (sitting tilted backward 15 degrees) than in positions P-2 (standing tilted forward 15 degrees), P-3 (standing tilted forward 30 degrees), and W-2 (sitting tilted forward 15 degrees). See Table 19 for statistical results. On Test 4, the students in the 7 years of age and younger group performed better in position W-3 [($M = 116.00$), ($p = .082$), ($SD = 20.81$)] than in position P-2 [$M = 129.78$].

Effect of Position on Student Compensatory Behaviors

Drooling was the only student compensatory behavior where a group effect [$F(1, 24) = 3.80$, $p = .063$] of age was observed. No position [$F(1, 24) = 1.31$, $p = .267$] or position by group [$F(1, 24) = 1.31$, $p = .267$] effects for age were detected. Students in the 8 years of age and older group [P-2 $M = .471$; W-1 $M = .471$] drooled more in positions P-2 (standing tilted forward 15 degrees) and W-1 (sitting upright) than did the students in the 7 years of age and younger group [P-2 $M = .111$; W-1 $M = .111$].

Among students within the 8 years of age and older group, differences by position

Table 18
Age Group Means on Test 4 by Position

	7 years and younger	8 years and older
P-1*	117.111	80.794[a]
P-2*	129.778	84.406
P-3*	122.833	85.265
W-1*	125.389	79.500
W-2*	121.000	81.324
W-3*	116.000	74.676

Note. *Denotes comparisons significant a p value ≤.10. [a]Lower score indicates better performance. P-1= standing upright; P-2=standing tilted 15 degrees forward; P-3=standing tilted 30 degrees forward; W-1=sitting upright; W-2=sitting tilted 15 degrees forward; and W-3=sitting tilted 15 degrees backward.

Table 19
8 Years of Age and Over Within Group Differences on Test 2 and Test 4

Test	Positions	M	SD	p≤.10
2	**W-1**	**17.88**[a]		
	P-2	20.71	.5.823	.063
	W-2	20.24	4.911	.066
	W-3	21.12	5.629	.031
4	**W-3**	**74.68**[a]		
	P-2	84.41	12.425	.005
	P-3	85.26	23.813	.085
	W-2	81.32	14.375	.075

Note. [a]Lower score indicates better performance. P-1= standing upright; P-2=standing tilted 15 degrees forward; P-3=standing tilted 30 degrees forward; W-1=sitting upright; W-2=sitting tilted 15 degrees forward; and W-3=sitting tilted 15 degrees backward.

did emerge. The students within the 8 years of age and older group drooled less in position P-1 (standing upright) than P-2 (standing tilted forward 15 degrees) and W-1 (sitting upright). The older students also drooled less in positions P-3 (standing tilted forward 30 degrees) and W-3 (sitting tilted backward 15 degrees) than in positions P-2, W-1, and W-2 (Table 20). Within the group of students ages 8 years and older, students adjusted their pencil and paper more in positions P-1 (standing upright) [(M=13.24), (p=.073), (SD= 6.70)] and P-3 (standing tilted forward 30 degrees) [(M=14.06), (p=.099), (SD= 9.29)] than in position W-2 (sitting tilted forward 15 degrees) [M=10.12].

Students in the 7 years of age and younger group adjusted their body position more frequently in position W-2 [M=6.22] than in positions P-1 [(M=3.77),(p=.087), (SD= 3.71)] and P-3 [(M=4.33), (p=.040), (SD= 2.36)]. No age effects were noted for the other student compensatory behaviors of commenting on position, frustration with the task, or off-task behavior.

Gender

Students were also divided into groups by gender. The female group consisted of 16 students and the male group was comprised of 10 students. A 2 x 6 (gender by position) ANOVA with position as a within-subjects factor was used to analyze the data by gender.

Effect of Position on Fine Motor Accuracy

No overall group [Test 2: $F(1, 24) = .75$, $p = .396$]; [Test 4: $F(1, 24) = 0.00$, $p = .958$], position [Test 2: $F(1, 24) = 1.37$, $p = .241$]; [Test 4: $F(1, 24) = 1.57$, $p = .174$], or position by group [Test 2: $F(1, 24) = 1.35$, $p = .247$]; [Test 4: $F(1, 24) = 0.70$, $p = .625$] interaction

Table 20
8 Years of Age and Over Within Group Differences on Drooling

Difference	Position	M	SD	p≤.10
1	**P-1**	**.294[a]**		
	P-2	.471	.393	.083
	W-1	.471	.393	.083
2	**P-3**	**.235[a]**		
	P-2	.471	.437	.041
	W-1	.471	.437	.041
	W-2	.412	.393	.083
3	**W-3**	**.235[a]**		
	P-2	.471	.437	.041
	W-1	.471	.437	.041
	W-2	.412	.393	.083

Note. [a]Lower score indicates better performance. P-1= standing upright; P-2=standing tilted 15 degrees forward; P-3=standing tilted 30 degrees forward; W-1=sitting upright; W-2=sitting tilted 15 degrees forward; and W-3=sitting tilted 15 degrees backward.

effects were noted on Test 2 or Test 4. However, on Test 2 where no effects were determined, female students [M=18.63] did score significantly lower in position P-1, standing upright, than did the male students [M=24.10]. Upon analyzing the data further by individual group, still no effects were detected. However, within both groups, position differences within gender were detected. On Test 2, female students were more accurate in positions P-1(standing upright) [(M=18.63), (p=.090), (SD= 5.38)] and W-1 (sitting upright) [(M=18.69), (p=.088), (SD= 5.20)] than in position W-3 (sitting tilted backward 15 degrees) [M=21.06]. Male students displayed more accuracy in position W-1 [M=21.00] than in positions P-1 [(M=24.10), (p=.102), (SD= 5.38)] and W-3 [(M=24.20), (p=.099), (SD= 5.49)]. Male students also demonstrated better performance in position P-3 (standing tilted forward 30 degrees) [(M=21.70), (p=.069), (SD= 3.84)] than in W-3 (sitting tilted backward 15 degrees) [M=24.20].

On Test 4, female students performed more accurately in position W-3 (sitting tilted backward 15 degrees) [M=86.44] than in positions P-2 [(M=98.15), (p=.017), (SD= 17.51)], P-3 [(M=100.94), (p=.032), (SD= 24.50)], W-1[(M=96.03), (p=.022), (SD= 14.95)], and W-2 [(M=95.16), (p=.012), (SD= 12.24)]. Male students demonstrated better fine motor accuracy in positions P-1[(M=94.55), (p=.071), (SD= 13.43)], P-3 [(M=94.00), (p=.060), (SD= 13.59)], and W-3 [(M=93.05), (p=.030), (SD= 12.55)] than in position P-2 [M=103.25].

Effect of Position on Student Compensatory Behaviors

Group effects for adjusting paper and pencil were distinguished when analyzing the student compensatory behaviors for effects [$F(1, 24)$ =5.04, p=.034] of gender.

Female students[(P-2: M=12.36),(P-3: M=16.63)] adjusted their pencil and paper more than male students [(P-2: M=6.50),(P-3: M=6.40)] in positions P-2 and P-3, standing tilted forward 15 and 30 degrees respectively. Also, within the group of female students position P-3 [M=16.63] emerged as the position where more adjusting of pencil and paper occurred than in positions P-2 [(M=12.38), (p=.048), (SD= 7.88)], W-2 [(M=12.19), (p=.070), (SD= 9.11)], and W-3 [(M=12.69), (p=.048), (SD= 7.31)]. Female students also stated more comments in position P-2 [(M=1.25), (p=.081), (SD= 2.54)] than in position W-2 [M=.063].

For the drooling behavior, group [F(1, 24) =5.34, p=.030] and position [F(1, 24) =2.59, p=.031] effects were ascertained with the female students [(W-1: M=.188), (W-2: M=.125)] drooling less than the male students (W-1: M=.600), (W-2: M=.600)] in positions W-1 (sitting upright) and W-2 (sitting tilted forward 15 degrees).

Within the group of male students, differences were also noted. Male students adjusted their body position less in W-1, sitting upright, [(M=3.50), (p=.026), (SD= 2.15)] than in P-1, standing upright [M=5.30]. Male students also drooled more frequently in positions W-1 [(M=.600), (p=.081), (SD= .483)] and W-2 [(M=.600), (p=.081), (SD= .483)] than in positions P-3, standing tilted forward 30 degrees, [M=.300] and W-3 sitting tilted backward 15 degrees [M=.300].

<u>Score on Test 2 and Test 4 by Group</u>

Following post hoc analysis, students were divided into groups based upon the score they obtained on Tests 2 and 4. Student's scores were averaged for performance across the six positions. The groups were delineated into low, mid, and high values for each test and are defined in Tables 8-13. A 3 x 6 (score by position) ANOVA with position as a within-subjects factor was used to analyze the data by score.

Effect of Position on Fine Motor Accuracy

Score on Test 2. Within group position differences were detected on Test 2. The low value group, scoring 0-10 mistakes on Test 2, showed no differences across position. The students scoring in the mid value group on Test 2 (11-30 mistakes) performed better in position W-1 (sitting upright) [M=20.21] than in positions P-2, standing tilted forward 15 degrees [(M=23.05), (p=.005), (SD= 3.82)], P-3, standing tilted forward 30 degrees [(M=22.26), (p=.070), (SD= 4.65)], and W-3, sitting tilted backward 15 degrees [(M=22.05), (p=.068), (SD= 7.31)]. The students in the mid value group also scored better in position P-1, standing upright [M=21.37], than position P-2, standing tilted forward 15 degrees [(M=23.05), (p=.078), (SD= 3.93)] . The students in the high value group on Test 2 (scores over 30 mistakes) performed better in position W-1, sitting upright [M=33.33], than positions W-2 [(M=37.33), (p=.057), (SD= 1.73)] and W-3 [(M=42.67), (p=.099), (SD= 5.51)], sitting tilted forward and backward 15 degrees respectively. Students in the high value group also performed better in position P-3 (standing tilted forward 30 degrees) [M=33.00] than W-3 [(M=42.67), (p=.041), (SD= 3.51)].

Score on Test 4. Within group position differences were detected for Test 4. Students in the low value group (i.e., the best scores) performed more accurately in position W-3, sitting tilted backward 15 degrees [M=42.71], than in position P-2, standing tilted forward 15 degrees [(M=48.64), (p=.100), (SD= 8.06)]. The group of students scoring in mid values performed better in position W-3 [M=94.04] than in positions P-1 [(M=100.86), (p=.102), (SD= 14.52)], P-2 [(M=107.10), (p=.023), (SD= 19.04)], and P-3 [(M=103.93), (p=.094), (SD= 20.47)]. The high value group also scored more accurately in position W-3 [M=139.60] than in position P-2 [(M=152.60), (p=.088), (SD= 12.95)].

Effect of Position on Student Compensatory Behaviors

Score on Test 2. A position effect [F(2, 23) =2.52, p=.033] for drooling was detected among groups on Test 2. In position P-1, the students in the high value (most mistakes) group [M=1.00] drooled more than students in the mid [M=.105] or low [M=.250] value groups. Within group position differences were also discovered among students in the mid value group on Test 2. Students in the mid value group on Test 2 drooled more in position W-1, sitting upright [M=.263], than in positions P-1, standing upright [(M=.105), (p=.083), (SD= .375)] and P-3, standing tilted forward 30 degrees [(M=.105), (p=.083), (SD= .375)]. These students also drooled more in positions P-1 [(M=.105), (p=.083), (SD= .375)] and P-3 [(M=.105), (p=.083), (SD= .375)] than in position W-2 [M=.263].

Position [F(2, 23) =1.97, p=.089] and position by group interaction effects [F(2, 23) =2.92, p=.003] were determined for the compensatory behavior of adjusting pencil and paper. However, no position or group was identified with significant values. Upon investigating the data further using multiple comparisons, no significant values were obtained. Within group position differences were noted for students in the mid and high value scores for adjusting pencil and paper. Students in the high value group on Test 2 adjusted their pencil and paper less in position P-2 (standing tilted forward 15 degrees) [M=11.00] than when sitting upright in position W-1 [(M=14.33), (p=.010), (SD= .577)]. Students in the mid value group adjusted their pencil and paper less in position P-2 [(M=9.21), (p=.067), (SD= 8.13)] than positions P-1 [M=12.84] and P-3 [M=12.63].

A group effect [F(2, 23) =3.95, p=.034], position effect [F(2, 23) =2.61, p=.028], and position by group interaction effect [F(2, 23) =2.80, p=.004] for commenting on positioning was determined for students on Test 2. In positions P-2 [(low: M=3.50), mid: M=.368)], P-3 [(low: M=4.25), mid: M=.526)], and W-1 [(low: M=5.25), mid: M=.105)], students in the low value group commented more frequently than did students in the mid value group. Also in position P-2, students in the low value group [M=3.50] commented more frequently than students in the high value group [M=0.00].

Score on Test 4. On Test 4, a position by group interaction effect [F(2, 23) =1.69, p=.092] for drooling was noted, with students in the mid value group [M=.571] drooling more than the students in the high value group [M=0.00] when sitting upright in position W-1. Within group position differences were also noted on Test 4, within the mid value group. Students in the mid value group on Test 4 drooled more in position W-2, sitting tilted forward 15 degrees, than in positions P-3, standing tilted forward 30 degrees, and W-3, sitting tilted backward 15 degrees. The mid value group students also drooled more in position P-2 (standing tilted forward 15 degrees) than in positions P-3 and W-3 and more in position W-1 than when standing upright in position P-1 and sitting tilted backward 15 degrees in W-3 (Table 21).

No other group, position, or interaction effects were noted across any of the

Table 21

Mid Value Within Group Differences on Test 4 for Drooling Behavior

Position	M	SD	$p \leq .10$
P-2	.428[a]		
P-3	.214	.426	.082
W-3	.214	.426	.082
W-1	.571[a]		
P-1	.286	.469	.040
W-3	.214	.497	.019
W-2	.429[a]		
P-3	.214	.426	.082
W-3	.214	.426	.082

Note. [a]Higher value denotes more drooling. P-1= standing upright; P-2=standing tilted 15 degrees forward; P-3=standing tilted 30 degrees forward; W-1=sitting upright; W-2=sitting tilted 15 degrees forward; and W-3=sitting tilted 15 degrees backward.

additional student compensatory behaviors on Test 4. However, differences within groups were detected for adjusting paper and pencil, adjusting body position, frustration, and off-task behavior. Students in the low value group on Test 4 adjusted their paper and pencil less frequently in position W-3 [M=11.86] than in positions P-3 [(M=19.29), (p=.065), (SD= 8.73)] and W-1 [(M=17.57), (p=.090), (SD= 7.48)]. Students in the mid value group on Test 4 adjusted their paper and pencil fewer times in position W-2 [M=8.21] than in positions P-1 [(M=11.14), (p=.090), (SD= 5.98)] , W-1 [(M=11.64), (p=.045), (SD= 5.79)], and W-3 [(M=10.50), (p=.092), (SD= 4.70)]. The high value group made fewer paper and pencil adjustments in position P-2 [(M=7.40), (p=.053), (SD= 1.48)] than in position P-1 [M=9.20]. Students in the mid value group on Test 4 adjusted their body position less frequently in position P-3 [M=4.36] than in positions P-1 [(M=6.21), (p=.044), (SD= 3.12)] and W-1 [(M=5.50), (p=.076), (SD= 2.21)].

Students in the low value group on Test 4 (fewest mistakes) exhibited more behaviors indicating frustration in position W-1 [(M=1.14), (p=.103), (SD= .787)] than in position P-1 [M=.571] and more off-task behavior in position W-2, sitting tilted forward 15 degrees, [(M=1.57), (p=.084), (SD= 1.46)] than in P-2, standing tilted forward 15 degrees [M=.429]. Students in the high value group on Test 4 experienced more off-task behavior in position W-3, sitting tilted backward 15 degrees [(M=.600), (p=.071), (SD= .548)] than when sitting upright in position W-1 [M=0.00].

Chapter 5: Discussion

The effect of position on the fine motor performance and compensatory behaviors of the 26 students in this study substantiates the importance of the "I" in the IEP, the Individualized Educational Program for students with disabilities. This study contributes to existing evidence that no one position is best for all students (Campbell, 1977; McEwen, 1992; McEwen & Karlan, 1989; Nwaobi, 1987). Although fine motor functioning and compensatory behaviors were analyzed across several different groups, variability among and within the groups was strong. Even though students' individual performance was variable, position did appear to affect student fine motor performance and compensatory behaviors across students and groups.

Position as a Control of Fine Motor Accuracy

Although no position emerged as superior for student fine motor accuracy, individual effects among students and groups were found. Students' performance on Tests 1 (drawing a straight line) and 3 (drawing a crooked path) did not vary by position for any group or student. Differences by position were found for Tests 2 (drawing a curved line) and 4 (tracing a large butterfly-shaped figure). Overall, Test 4 seemed to be most sensitive to changes in position. When compared to Test 2, Test 4 required more time to complete, so required a longer period of concentration on the part of the student. Test 4 also required more active upper extremity movement than Test 2. The butterfly-shaped figure, Test 4, covered the entire desk-top. To complete Test 4, students had to reach to the farthest corners of their desks, move the paper closer to them, or request that the paper be moved for them. If students did not have the available arm movement required for the task, then paper adjustments were required to complete the test. Due to the requirement of using more upper extremity movement and available range of motion, it is reasonable to assume that more body adjustments were also inherent on Test 4 across all positions.

All Subjects

When analyzing data across all subjects on Test 2, the students performed better when sitting upright in their wheelchairs compared to three other positions, sitting tilted backward (W-3), and standing tilted forward 15 and 30 degrees (P-2 and P-3). This finding supports the literature as sitting upright was cited in several studies as the position where student performance was most desirable (Hulme, Gallacher, Walsh, Niesen, & Waldron 1987; Nwaobi, 1986; Nwaobi, 1987; Nwaobi, Brubaker, Cusick, & Sussman, 1983). On Test 4 across all subjects W-3, sitting tilted backward 15 degrees, emerged as the position where significantly better performance occurred than in four of the other five test positions: W-1, sitting upright; W-2, sitting tilted forward; P-2, standing tilted forward 15 degrees, and standing tilted forward 30 degrees. This was a surprising finding. Scores on Test 4, the most difficult test, requiring the most upper extremity function and student concentration were significantly better when students were tilted backward in their wheelchairs 15 degrees. Upon analyzing all of the data further, this emerged as a strong trend throughout the study across all groups. On Test 4, among all groups, sitting tilted backward 15 degrees emerged as the position or one of the positions for better fine motor performance. This position required students to actively lean forward to reach the horizontal tray on their wheelchairs and maintain this position while completing the test activity. Research has shown that upright positioning was the most effective for the desired response (Hulme, Gallacher, Walsh, Niesen, & Waldron; Nwaobi; Nwaobi; Nwaobi, Brubaker, Cusick, & Sussman), that anterior seat inclination improved sitting posture (Miedaner, 1990; Myhr & von Wendt, 1991), or that seat inclination had no effect on upper extremity function (McClenaghan, Thombs, & Milner, 1992; McPherson et al., 1991; Seeger, Caudrey, & O'Mara, 1984). However, none of these studies required a fine motor activity equal to the degree of difficulty or length of time required for completion of Test 4. The combination of the level of intensity of Test 4 and the requirement of the students to actively lean forward and maintain a flexed position to reach the tray may have resulted in the best effort of students yielding better fine motor performance when tilted backward in the sitting position because students were physically unable to totally lean on the tray. Possibly keeping their heads held off of the tray surface, improved fine motor performance.

Type of Cerebral Palsy

Test 2. Results on Test 2 varied among and within all groups of students. The only group effect of cerebral palsy occurred on Test 2 where students with ataxia and spastic diplegia performed better in position P-3, standing tilted forward 30 degrees, than the students with athetosis. Considering the nature of each of these types of cerebral palsy, it is not surprising that the students with athetosis would perform poorly in position P-3, standing tilted forward 30 degrees. In this position, students would experience the greatest influence of gravity due to being tilted so far forward. Of the three types of cerebral palsy, students with athetosis would experience the most difficulty with gravitational effects. Students with athetosis experience fluctuations in movement, poor midline orientation and control and increased extensor tone. When tilted forward 30 degrees, gravitational effects would make it very difficult to hold the head upright without using excess extensor tone which would then impact the entire body, and especially influence fine motor performance. Few within group trends were found by type of cerebral palsy. The only exception was that the students with athetosis performed better in positions W-1, sitting upright, and P-1, standing upright, than in positions W-2 (sitting tilted forward), W-3 (sitting tilted backward), and P-3 (standing tilted forward 30 degrees). Gravitational effects would be the least influential in positions W-1 and P-1. Sitting and standing upright may have enabled the students to use their available fine motor control without excessive extraneous movements due to gravitational influence.

Test 4. No group effects were detected on Test 4. However, as mentioned previously, when examining within group differences performance in position W-3, sitting tilted backward, was the best position for students in the groups of ataxia and spastic diplegia. Position W-3, was also one of the best positions for students with athetosis.

Age

Test 2. No group effects of age were detected on Test 2. However, the students in the older student group, age 8 years or over, performed better in position W-1, sitting upright, than in positions W-2 (sitting tilted forward), W-3 (sitting tilted backward), and P-2 (standing tilted forward 15 degrees). As stated previously, when position W-1, sitting upright emerged as the best position, this was consistent with the literature (Hulme, Gallacher, Walsh, Niesen, & Waldron 1987; Nwaobi, 1986; Nwaobi, 1987; Nwaobi, Brubaker, Cusick, & Sussman, 1983). It was interesting that the older students scores demonstrated better performance when sitting upright and no differences were found within the younger group on Test 2. The older students may have established a preferred sitting position (i.e., upright sitting) simply due to the fact that they have used wheelchairs longer than the younger students or learned to compensate better as they aged.

Test 4. A group effect of age was detected on Test 4. The students in the older age group, 8 years of age and over, performed better in all positions than the students in the younger group, 7 years of age and under. These results indicate that Test 4 is a sensitive measure, probably due to the level of difficulty and amount of concentration required for test completion. Older students should perform better than younger students on this fine motor task. Older students should have better fine motor coordination and control than younger students. Continuing with the trend of better performance in position W-3, sitting tilted backward, within group differences were noted on Test 4. Both groups, older and younger students, performed better in position W-3 than in other positions. It appears that the combination of the time, concentration, and student effort required for completion of Test 4 yielded improved fine motor performance when tilted backward while sitting.

Gender

Test 2 and 4. No group effects of gender were noted on Test 2. The only notable within group differences detected on Test 2 involved position W-3, sitting tilted backward. For both boys and girls, performance was worse on Test 2 and best on Test 4 in position W-3. Again, the time and concentration required on Test 2 is much less than that required on Test 4, therefore, students may have not exerted as much effort yielding poorer scores on Test 2.

Scores on Test 2 and Test 4

Test 2. The groups were specifically delineated by score (low, mid, and high values) to see if differences in fine motor functioning within the groups could be detected. Of interest when examining within group differences, was that students with the best fine motor performance (low value group) showed no effect of position changes, while students in the mid and high value groups were sensitive to position changes. This lack of influence of position on the students with better fine motor performance may indicate that students with the best fine motor control can generally use their control regardless of the position in which they are placed to perform the task, whereas students with poorer fine motor control are affected by positional changes and must be assessed more carefully when determining positioning for fine motor tasks. Therapists must be knowledgeable about a student's ability to perform fine motor tasks which require concentrated effort for a considerable amount of time (i.e., not just reaching for a switch or batting an object) comparable to completion of Test 4, the large butterfly, prior to making recommendations for alternative positioning during the school day.

Test 4. On Test 4, students in all three groups performed better in position W-3, sitting tilted backward, than in other positions. Position W-3 emerged as the only position in all three groups where a difference was noted. This supports the trend that fine motor behavior was enhanced on Test 4 when students were tilted backward in their wheelchairs.

Position as a Control of Student Compensatory Behaviors

Across all student groups, no compensatory behavior was controlled or strongly influenced by changes in position. A few exceptions did occur. The compensatory behaviors of students with ataxia were most influenced by changes in position. However, caution must be used when interpreting the results due to the size of the group with ataxia. Of the 26 students, only 3 students had ataxia. Although this group was small, they were representative of the typical incidence of ataxic type cerebral palsy. The three students in the group also demonstrated characteristic ataxic cerebral palsy. The other trend that emerged across compensatory behaviors was that the drooling behavior across and within all groups was the behavior that was affected the most by positional changes.

All Subjects

Effects of position across all subjects were noted for two behaviors, adjusting paper and pencil and drooling. Students adjusted their pencils and paper less in position P-2 (standing tilted forward 15 degrees) than in position P-3 (standing tilted forward 30 degrees). Gravitational effects of position P-3 are the strongest. Students had to work harder to hold up their heads and shifting their weight up off of their arms to effectively use their pencils may have caused more adjustments of pencil and paper. Drooling occurred less in position P-3, standing tilted forward 30 degrees than when in position P-2, standing tilted forward 15 degrees and W-1, sitting upright, and W-2, sitting tilted forward 15 degrees. Considering the effects of gravity, these results are ironic. It seems that students would drool less in positions when they were tilted backward (W-3) and more in positions when they were tilted forward (W-2, P-2, and P-3). However, these results indicated students drooled less in the position where they were tilted the farthest forward. These results may also be explained by gravitational effects. Suppose drooling was increased when the student was tilted forward, but due to the increased amount of saliva present in this position, the student became more aware of the behavior and made a concerted effort to keep their mouth closed and to swallow. Another possibility is observer error. In position P-3, many of the students were extremely flexed forward on the tray while completing their fine motor tasks. When coding the videotapes, examiners could have possibly missed the drooling behavior because of difficulty observing the students' faces.

Type of Cerebral Palsy

Group effects for cerebral palsy were noted on four of the five compensatory behaviors. Students with ataxia adjusted their bodies less than students with athetosis in positions W-1, sitting upright, and W-3, sitting tilted backward. Due to the nature of the disability of the types of cerebral palsy, this finding was not surprising. Students with athetosis move more than students with ataxia. Athetosis is characterized by fluctuations in movement and associated involuntary motor behaviors that can be almost constant in some students. In contrast, students with ataxia, although they do have characteristic tremor-like movements, move much less. Students with ataxia are usually sensitive to being out of the midline position and are particularly uncomfortable in positions up off the ground (i.e., standing in a prone stander).

The students with ataxia commented more about positional changes than students with athetosis in positions P-1 and W-1 and more than students with spastic diplegia in positions P-3, W-1, and W-3. Upon examining the individual comments made by students in each of the groups, this finding supports the idea that students with ataxia were typically more sensitive or uncomfortable when placed in positions that were out of midline or unfamiliar to them. The comments made in positions P-1, P-3, and W-3 were comments that indicated fear, anxiety, or requests to be taken out of the position. Comments in position W-1, were comments indicating relief, or happiness with being back in a comfortable position. For example, when student 4 was placed standing upright in the prone stander (P-1) she stated, "Get me out of this thing. I don't like it way up here." When the same student was tilted backward 15 degrees in her wheelchair she stated, "I want to be straight. This feels very strange." When student 14 was placed in position P-1, he indicated with manual signs that he wanted down off the prone stander immediately.

In position P-1, standing upright in the prone stander, students with ataxia demonstrated more frustration and off-task behavior than the students with athetosis and spastic diplegia. This was consistent with the previous observations of the students with ataxia, indicative of fear, anxiety, or a general feeling of uncomfortableness when placed in the standing position. If a student is uncomfortable in a particular position then more frustration with the task and off-task behavior could be expected.

<u>Age</u>

A group effect of age was detected for the compensatory behavior of drooling.

Students in the older group, age 8 years and over, drooled more than the younger students, age 7 years and under, in positions P-2 (standing tilted forward 15 degrees) and W-1 (sitting upright). When looking at within group differences, older students drooled more in position P-2 than four of the other positions. Determining why the drooling behavior occurred more often in these positions for older students is difficult. Possibly, the students in the older group have more motor control problems that contribute to the drooling behavior.

Gender

Group effects of gender were detected for the compensatory behaviors of drooling and adjusting paper and pencil. Female students adjusted their paper and pencil less than the male students in positions P-2 and P-3 (standing tilted forward 15 and 30 degrees respectively). The female students drooled less than the male students in positions W-1 (sitting upright) and W-2 (sitting tilted forward). No plausible explanation easily emerged for these differences. Differences could have been detected by chance, circumstance, or impact of individual students on group effects.

Score on Test 2 and Test 4

Test 2. Group effects among low, mid, and high value groups were also detected for the drooling behavior. The students in the high value group drooled more in position P-1, standing upright, than the students in the mid and low value groups. The high value group for Test 2 was comprised of only three students, all of which had a diagnosis of athetosis. Because of the pervasive motor control problems experienced by students with athetoid type cerebral palsy, drooling is more common in students with athetosis than in those students that have ataxia or spastic diplegia. Caution must be used when accepting this explanation as a possible cause for this finding. No group effect for cerebral palsy for the drooling behavior was detected, therefore this finding could also have been detected because of chance. The only within group differences detected for the Test 2 group occurred within the mid value group. Students in the mid value group drooled more in position W-1 than in positions P-1 and P-3. These same students also drooled more in positions P-1 and P-3 than in W-2. The only interesting information this finding offered is that the mid and high value groups were also more sensitive to position changes when looking at fine motor accuracy. This supports the theory that students with poorer fine motor control were influenced more by changes in position than students with better fine motor accuracy.

Test 4. In the group divided by their scores on Test 4, a group effect for drooling was detected. The students in the mid value group drooled more than the students in the high value group in position W-1, sitting upright. Due to the size of the groups, findings are strongly influenced by individual behavior within the groups. Two of the three students in the high value group on Test 2 moved to the mid-value group on Test 4. Both of the students drooled during fine motor tasks. These students had athetosis and drooled considerably during fine motor tasks in all positions. These particular students caused the effect detected between the groups. On Test 4, the within group differences were also detected on the mid value group with drooling occurring less in positions P-3 (standing tilted forward 30 degrees) and W-3 (sitting tilted backward). These behaviors have previously been explained, with more conscious effort exerted in position P-3 due to increased amounts of drool because of gravitational effects. Less drooling would be expected when students are tilted backward in their wheelchairs due to the influence of gravity on the head and neck with more passive swallowing occurring. Various within group differences were detected across compensatory behaviors, but no implication of these results can be derived.

<u>Position as a Control Parameter in a Dynamic System</u>

The results of this study support the idea that position is a control parameter for fine motor functioning and student compensatory behaviors. However, the results also strongly indicate that individual students are influenced by positional changes to varying levels of intensity. From a dynamic systems perspective, each student brings strengths, problem areas, and past experiences to a specific task. These internal factors then combine with environmental elements to produce the motor behavior exerted by the student to accomplish a specific task. During the study manipulation of the environment (i.e., changing student positions) influenced student their fine motor functioning and compensatory behaviors with the exception of the students in the low value group on Test 2. The students in low value group exhibited the best performance and fine motor behavior was not impacted by positional changes. Also, student fine motor performance on Test 4 was generally enhanced when in position W-3, sitting tilted backward 15 degrees. Dynamic systems theory would support the notion that the characteristics of Test 4 (i.e., level of difficulty, length of test, size of test) and the internal motor control qualities brought to the task by each student combined with the posteriorly tilted sitting position to collectively produce the best effort or performance of the students for that specific task. The intrinsic qualities exhibited by students combined with their individual reactions to modifications of the external environment produced significant variability in the performance even when students were placed in homogeneous groups.

Limitations of the Study

The heterogeneity of students with cerebral palsy is difficult to control in any study. This study did represent a rather large sample size compared to other clinical studies of students with cerebral palsy. Due to the size of the sample (26 students), it was possible to group the students into more homogeneous subgroups. However, as the results indicated, even though the groups were divided into subgroups, substantial variability remained among the students.

Procedurally, the study ran smoothly. The decision to maintain the writing surface at a horizontal level across all positions may have affected the results of the study. Especially since position W-3, sitting tilted backward 15 degrees, emerged as a position where student performance on Test 4 was better than other positions. If the tray had been placed at a more upright angle so students weren't required to lean so far forward in position W-3, the results of the scores on Test 4 may have been different. However, it is interesting to consider that fine motor performance may be enhanced by requiring specific students to exert active flexion when completing a difficult fine motor task simply by tilting the wheelchair posteriorly 15 degrees. Students that typically placed their heads on their trays were unable to do so in the posteriorly tilted position. This idea is contrary to research and popular practice, but may provide insight for future research activities.

The tests used to measure fine motor functioning may have not been the best choice to measure fine motor performance. When considering the results of the study, Test 4 was the most sensitive measure used to discern changes in fine motor performance when positions were altered. The simple Tests 1 (straight line), 2 (curved line), and 3 (crooked path) lacked sensitivity to position changes. When considering future research, activities that take a substantial amount of time to complete and that require concerted student effort may be more beneficial when measuring fine motor functioning and the impact of positional changes on fine motor performance. The task of completing an assignment on a computer keyboard might provide more meaningful information relative to actual student performance in the classroom.

Implications of the Study and Recommendations for Future Research

The results of this study strongly suggest that student fine motor performance is affected by changes in external positioning. However, these results also indicated that individual student performance varied and that no particular positions emerged as the best or worst positions for all students or groups of students. The finding that position W-3, sitting tilted backward 15 degrees, was the overall best position for fine motor performance on Test 4 was unexpected and not supported by the literature. However, this finding did support the theory of dynamic systems as a means to explain motor behavior of students with cerebral palsy. Previous research on the posteriorly tilted sitting position (Nwoabi, 1987) indicated that motor performance was worse when students were tilted posteriorly than when in an upright position. However, the task required of the students was to reach toward a switch and perform a computer-activated task. The task did not require the amount of time, concentration, or motor control that was required of the students in this study on Test 4. Future research of the effect of positioning on fine motor performance should include tasks requiring substantial time, effort, and motor control to maximize sensitivity of the measures to changes in position. Examples include, but are not limited to buttoning and unbuttoning a shirt or jacket, completing math or spelling assignments (i.e., worksheets, lists), or typing a list of words on a computer keyboard. These are activities that require student concentration and effort, require more than a few seconds for successful completion, and are functional activities that could be required of students during a typical day.

The finding that the students with ataxia were the most influenced by changes in position for compensatory behaviors was not surprising. Although this group was small (only 3 students), they were typical of students with ataxia. The influence of unfamiliar or uncomfortable positions on students with ataxia is well-known to most therapists with experience working with students with ataxia (Batshaw, Perret, & Kurtz, 1992; Eiben & Crocker, 1983; Nelson, 1990; Olney & Wright, 1994). In uncomfortable or unfamiliar situations, students with ataxia can panic, freeze, or exhibit aberrant behaviors indicating anxiety which would interfere with fine motor functioning. Clinical application of this information may indicate the need for introduction of alternative positioning early in the lives of students with ataxia (i.e., early intervention programs).

Perhaps the most important consideration of the findings of this study is the effect of changes in position on fine motor performance and compensatory behaviors of individual students. As indicated in the results, many different positions emerged as the better position across students and within groups. However, this variability in student response could also indicate that student performance was so variable that position did not affect fine motor outcomes. Future research may prove to be more meaningful using single- subject design methodology typified in the study by McEwen and Karlan (1989). This study examined the effect of positioning on individual students' abilities to access a communication board.

The results of this study support the reality that positioning for students with cerebral palsy is a complicated process and students react to different positions in a unique manner. Practical application of these findings would support a close working relationship between therapists and classroom teachers to identify fine motor tasks required of the student throughout the day and the positions in which the student demonstrates the best performance. Although alternative positioning may provide benefits not associated with classroom performance such as bone ossification and growth, (Cusick & Stuberg, 1992; Jeffries, 1994; Le Veau & Bernhardt, 1984), kidney function (Heuter & Blossom, 1967), and prevention of hip subluxation and dislocation (Howard, McKibbin, & Williams, 1985; Phelps, 1959), the primary focus of the therapist and teacher should be on enhancing student performance in the classroom. Therapists making recommendations for positioning in the classroom must take into account the impact of the change in position on the student's ability to participate successfully in classroom activities.

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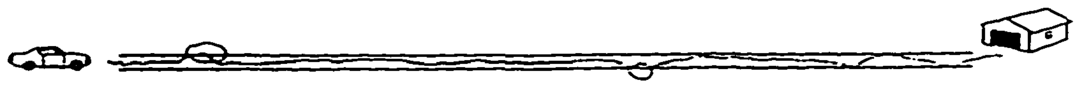
APPENDIX

TESTS 1-4

Test 1

Drawing a Line Through a Straight Path with Preferred Hand



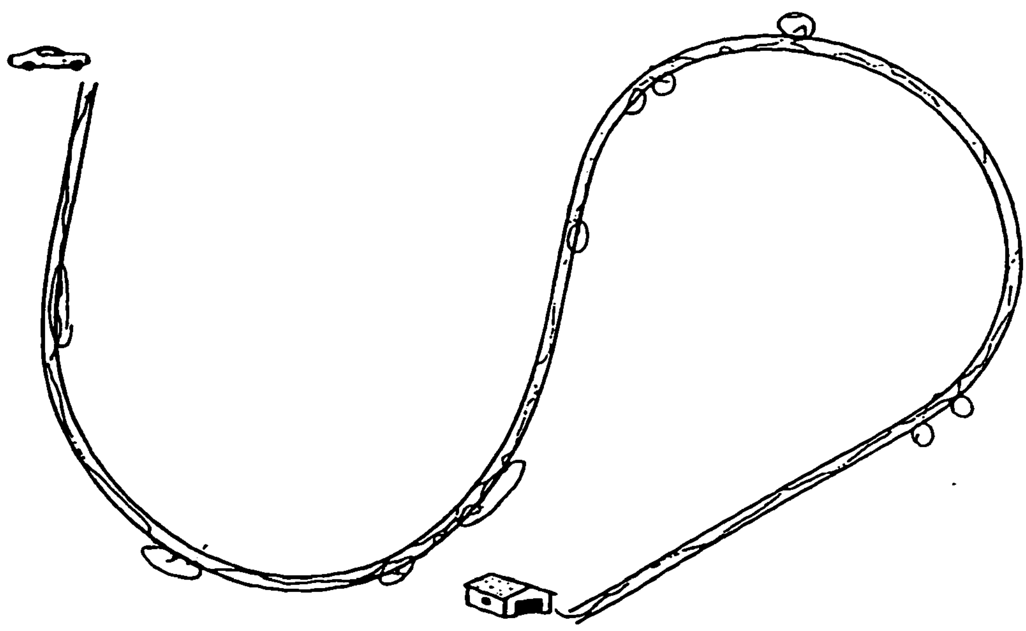
START

Number of Errors 2

Test 2

Drawing a Line Through a Curved Path with Preferred Hand

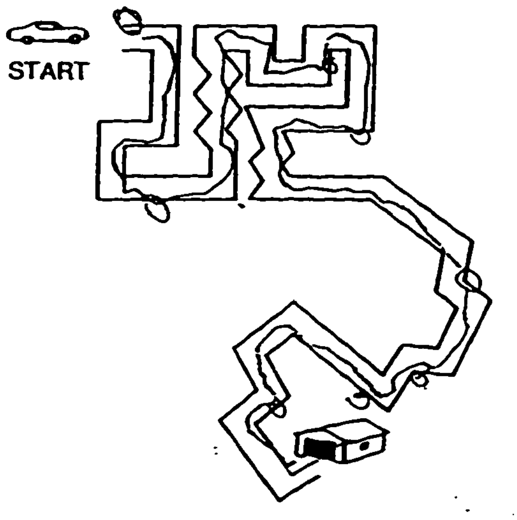
START



Number of Errors 10

Test 3

Drawing a Line Through a Crooked Path
with Preferred Hand



Number of Errors 6

Test 4

Sensory Integration

SIPT

and Praxis Tests

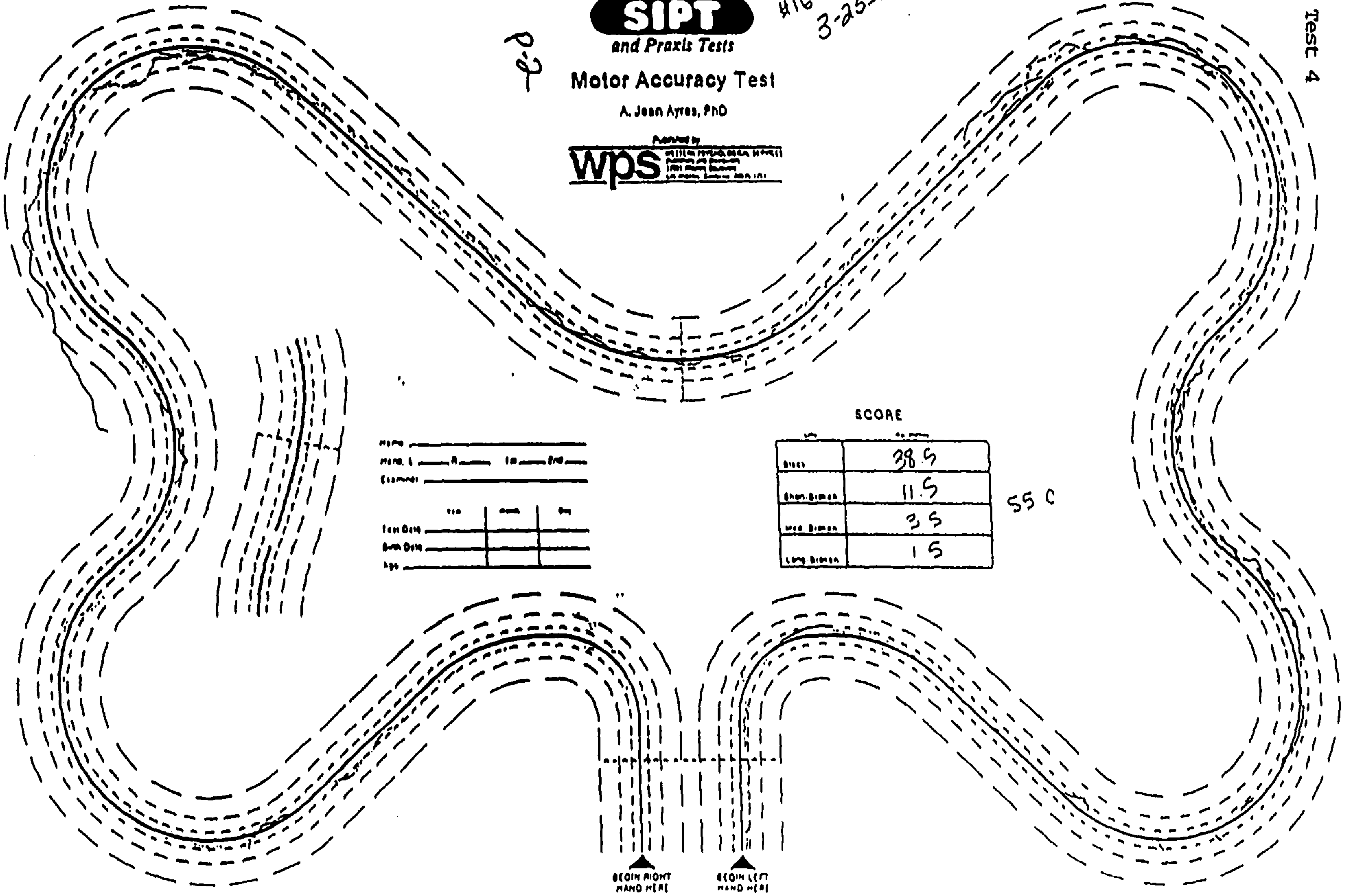
P-7

#16 3-25-93

Motor Accuracy Test

A. Jean Ayres, PhD

Published by
WPS



SCORE

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[illegible]	1.5

55 C