The Effects of an Adaptive Seating Device on Postural Alignment and Upper Extremity Function in Infants with Neuromotor Impairments

by

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Abstract

The Effects of an Adaptive Seating Device on Postural Alignment and Upper Extremity Function in Infants with Neuromotor Impairments

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The purpose of this study was to examine the effects of a contoured foam seat (CFS) on postural alignment and on a functional upper extremity activity of engagement with toys in infants with neuromotor impairments. Parental perceptions regarding the use and effects of the CFS at home were also assessed. The participants were four infants, ages 9 to 18 months, with diagnoses including cerebral palsy and Down syndrome who were unable to sit independently. An individualized, contoured foam seat was fabricated for each participant. A randomized, alternating treatments design was employed which included the following three interventions: 1) Treatment A was a commercial highchair; 2) Treatment B was the commercial highchair with a thin foam liner on the seat; and 3) Treatment C was the CFS used as an insert in the commercial highchair. Infants were videotaped for 5-minute observation periods, alternating Treatment A during the baseline phase and alternating Treatments B and C during the intervention phase. Using momentary time sampling, postural alignment was rated from videotapes by blinded raters using anatomical markers and visual guides placed on the highchair back. Engagement with toys was rated by recording the number of hands in contact with a toy and the number of hands or forearms in contact with the highchair tray. A semi-structured interview was conducted with mothers of the participants following three weeks of CFS use at home. Results indicated a clear, sustained effect of the CFS on improving postural alignment for all participants. The data did not support an effect of the CFS on increasing bimanual play for any participants. For two participants, increased ability to play with toys while arms were free from support of the tray was observed when using the CFS. All four mothers reported that they liked using the CFS, and that they believed the CFS had beneficial effects for themselves and their infants. These findings supported the efficacy of a low-cost seating

intervention for infants with a variety of neuromotor impairments. Suggestions for other dependent measures reflective of functional skills for infants and ideas for future efficacy studies of adaptive seating devices were described.

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DEDICATION

With love to Chris

Lindsay, Laura, and Matt

CHAPTER ONE

Statement of the Problem

For physical therapists and occupational therapists working with young children with neuromotor impairments, a primary goal of intervention is helping clients achieve the highest possible level of independence in functional skills. Children with neuromotor impairments frequently have deviations in muscle tone resulting in trunkal instability, as well as associated deficits in proprioceptive, sensory, or vestibular systems (Bobath, 1985). Therefore, providing postural stabilization for children with these impairments through a variety of positioning devices is often utilized by therapists as an adjunct to therapy intervention (Copeland & Kimmel, 1989). According to Ward (1984), there are several objectives that can be achieved through proper positioning including minimization of the effect of abnormal reflexes, promotion of symmetry, prevention or minimization of deformity, provision of stability, and facilitation of functional movement patterns. Ideally proper positioning should also serve as a means of carrying over therapeutic principles between therapy sessions (Green & Nelham, 1991).

Assistive technology is often utilized to improve functional independence for children with neuromotor impairments. Proper positioning is a crucial first step before the provision of technical aids such as augmentative communication systems, controls for power mobility devices, and computers. Adaptive seating is frequently used by therapists to improve the posture and stability of young clients with neuromotor impairments and to promote ease of caregiving by family members (Bergen & Colangelo, 1985; Trefler, 1984). Adaptive seating is the custom prescription and application of sitting support devices based on therapeutic principles (Roxborough, 1995). For children with neuromotor impairments, sitting on conventional chairs may not provide adequate stabilization to prevent fear of falling or allow them to maintain an erect posture. One of the main assumptions underlying the use of adaptive seating for persons with postural instability is that by providing increased trunk stability and improving pelvic alignment, functional use of the upper extremities will be enhanced. This concept of proximal stability as a prerequisite for postural control and functional movement is frequently referred to in the literature on treatment of children with cerebral palsy (Bly, 1994; Scherzer & Tscharnuter, 1990), as well as in the adaptive seating literature (Trefler, 1984). However, findings from some studies examining the relationship of proximal and distal motor control in typically developing infants suggest that, while proximal control and fine motor skill may be correlated, the relationship is not one of cause and effect (Case-Smith, Fisher & Bauer, 1989; Fetters, Fernandez & Cermack, 1989; Loria, 1980).

Several authors have reported a need for additional studies investigating the effectiveness of adaptive seating for children with neuromotor impairments (Harris, 1990; Mac Neela, 1987; Roxborough, 1995). However, to date there have been only a few published studies that have examined the relationship of sitting position and functional motor skills for these children. Findings from these studies are limited in their application for several reasons. First, the quality of the studies varies widely, with many demonstrating methodological problems relating to subject selection, lack of controlled conditions, choice of outcome measures, and potential confounds from other environmental variables (Roxborough, 1995). Secondly, efficacy studies on adaptive seating systems are limited almost exclusively to children two years of age and older, with few published studies examining their use specifically with infants. Additionally, outcome measures of seating studies have primarily been limited to motor goals, and few studies have examined family-focused goals such as caregiver satisfaction and the effects of adaptive seating on children's functional skills in naturalistic settings (e.g., eating meals at home). Finally, instrumentation in many studies involves the use of costly equipment or techniques such as electromyography which limits direct replication in many clinical settings.

Despite conflicting evidence as to their effectiveness and optimal design, therapists frequently utilize adaptive seating devices and anecdotally report changes in posture and head control, upper extremity use, and quality of reaching skills. One type of adaptive seating device recently developed by therapists is a contoured seat carved from medium density foam. This contoured foam seat (CFS) is intended to provide better pelvic alignment, increased postural stability, and improved somatosensory feedback. It can be used for young children with a variety of neuromuscular and musculoskeletal impairments which can negatively influence postural control. Advantages of the CFS versus other types of adaptive seating devices include its cost effectiveness, transportablility, and ease of fabrication.

The purpose of this study was to evaluate the effect of one type of adaptive seating device, a contoured foam seat (CFS), on postural alignment and functional upper extremity performance in infants with neuromotor impairments. Feedback from parents following use of the CFS at home was also obtained as a measure of social validity.

Specific research questions addressed in this study included the following:

1.) What are the effects of a CFS on postural alignment for infants with neuromotor impairments?

2.) What are the effects of a CFS on a functional upper extremity activity for infants with neuromotor impairments?

3.) How do parents perceive the use and effects of a CFS when used at home?

CHAPTER TWO

Literature Review

Introduction

The primary purpose of this literature review is to provide a rationale for the proposed research. This chapter is organized in four content areas. First, a historical perspective on the evolution of motor control theories is provided to assist the reader in understanding the rationale for current adaptive seating interventions. Second, proposed goals and clinical guidelines relating to adaptive seating are outlined to provide a framework for evaluating outcome studies. Next, an analysis of empirical studies to date that examined the effects of adaptive seating systems on dependent variables to be examined in the proposed research (i.e., upper extremity performance, postural alignment, and family-focused outcomes) is provided. Finally, the limitations of the extant literature and the need for additional research are discussed in the summary.

Motor Control Theories Applied to Adaptive Seating

Traditional theories of motor control analyzed motor development in terms of the relationship between the central nervous system and motor behavior. Early theorists such as McGraw (1943) held that a direct relationship between neural maturation and motor behavior existed, and that maturation of the central nervous system (CNS) accounted for the rapidly expanding repertoire of motor skills observed in the first year of life. McGraw (1943) described the emergence of motor milestones such as rolling, sitting, standing, and walking that appeared in a predictable sequence. These descriptions of milestones eventually became the bases of several developmental tests.

The CNS maturational theory gradually became refined to reflect the hierarchy of anatomical brain structures. In the reflex/hierarchical model of motor development, maturation of various neuroanatomical structures in the CNS results in the emergence of a set of postural reflexes that are organized hierarchically (Shumway-Cook & Woollacott, 1993). Within this model, motor development in the infant is seen to be dominated by a set of primitive reflexes mediated at the brainstem and spinal cord levels. These reflexes disappear or are integrated into more mature motor patterns as the midbrain and cerebral cortex mature. The maturation of these CNS structures is in turn manifested in the emergence of righting and equilibrium reactions.

Contemporary theories of motor control assume that understanding the development of motor skills also requires an understanding of the postural components that support movement. Bernstein's (1967) vast contributions to current motor control theory included the description of movement as "..coordination, the cooperative interaction of multiple body parts and processes to produce a unified outcome." (p. 79, Thelen, 1995). Bernstein (1967) realized that, in addition to influence from the CNS, movement is a product of the interaction of multiple factors such as biomechanical factors, the degree of environmental support, and specific task demands. More recent research has lent further support to a systems approach to motor control. Thelen and Fisher's kinematic, kinetic, and electromyographic studies (as cited in Thelen, 1995) of infant movement in the 1980s elucidated the roles gravity and biomechanical factors such as body morphology have on the acquisition of motor skills. Studies examining the development of postural control in typically developing children and adults (Woollacott & Shumway-Cook, 1989) demonstrated the influence of sensory inputs such as vision and vestibular cues on balance control.

This body of more recent research has evolved into a dynamical systems approach to motor development (Kamm, Thelen, & Jensen, 1990). Key features of a dynamical systems approach include the hypothesis that motor behaviors emerge from the interaction of a variety of neural, musculoskeletal, neuromuscular, sensory, adaptive, and anticipatory mechanisms in a task-specific context. The child's role as an active explorer of the environment is viewed as central to the development of adaptive and anticipatory mechanisms (Shumway-Cook & Woollacott, 1993). In contrast to the reflex-hierarchical model in which little emphasis is placed on experience and learning, the dynamical systems approach posits that "the child learns to predict the postural requirements associated with various tasks and environments" (Shumway-Cook & Woollacott, p. 167). The implications of this assumption for the treatment of children with neuromotor problems are apparent. By providing a child who is unable to sit independently with positioning aids (e.g., an adaptive seating device to allow upright sitting), the child is able to practice motor skills he or she would not otherwise be physically able to perform.

A proposed mechanism for how adaptive seating influences postural control has been offered by Roxborough, Fife, Story, and Armstrong (1994). The authors suggest that three biomechanical factors influence the musculoskeletal system in adaptive seating intervention—the starting conditions of the movement, the degrees of freedom of movement, and the limits of movement available. Adaptive seating devices influence the starting conditions of the movement by altering the alignment of body segments relative to each other and to the line of gravity. Postural control strategies will vary depending upon the starting position of the body. These strategies will also vary depending upon which body segments are constrained and which are free to move (i.e., degrees of freedom). By limiting the range of movements to those which the client can control, it is hypothesized that the client will have improved potential for functional movement.

Purposes and Principles of Adaptive Seating Systems

Children with neuromotor impairments frequently demonstrate difficulty balancing and stabilizing the body relative to the supporting surface. The postural control deficit can be manifested in sitting as sliding over the support and falling backwards, forwards, or sideways. Reported sequelae of postural malalignment over time include muscle contractures, pressure sores, exacerbation of tonic reflex patterns and abnormal muscle tone, and decreased functional movement (Pope, Bowes, & Booth, 1994).

The use of therapeutic positioning and adaptive seating for children with neuromotor impairments has seen dramatic growth in the past two decades. Many proposed benefits of proper seating and positioning have been described in the literature (Bergen, Presperin, & Tallman, 1990; Trefler, 1984; Ward, 1984). These proposed benefits have included prevention of deformities, facilitation of normal movement, promotion of maximal upper extremity function, and facilitation of independence in educational, social, and self-care activities. However, as pointed out by Mac Neela (1987) and Roxborough (1995) in their reviews of the literature on therapeutic positioning, many of the proposed benefits of and recommendations for various positioning techniques and devices are based on clinicians' experiences with individual clients and theoretical premises. Thus, in view of limited empirical data, these proposed outcomes should be evaluated with caution.

Key principles of proper seating for children with neuromotor impairments have been described by several authors (Cook & Hussey, 1995; Trefler, 1984; Ward, 1984). A frequently cited principle relating to postural control is that proximal (i.e., near the center of the body) stabilization facilitates movement and function of distal body segments such as the extremities. This principle is based on a normal developmental sequence in which an infant must achieve a stable base of support to maintain an independent sitting position before she can use her arms for manipulation. Without proximal stability in sitting, the infant must use her hands for propping, thus limiting functional upper extremity skills such as reaching and grasping. For children with neuromotor impairments, inability to achieve a stable base of support may be due to a variety of causes including impairments in musculoskeletal alignment, dominance of reflex patterns, muscle weakness, or deviations in muscle tone. In designing adaptive seating systems, various types of external support (e.g., custom contoured seats, seat belts, lateral trunk supports, abductor wedges) are provided to assist children who are unable to achieve a stable base independently.

Clinical guidelines for adaptive seating systems have been offered by several authors, although these recommendations appear to be based on clinical experience versus findings from empirical studies (Bergen, Presperin, & Tallman, 1990; Trefler, 1984; Ward, 1984). While each client must be evaluated on an individual basis for the most appropriate seating adaptations, several general guidelines are proposed in the literature. First, it is recommended that the pelvis be addressed first when adapting a seating position, as its position as a base of support determines the alignment of the trunk, shoulder girdle, and head (Cook & Hussey, 1995; Trefler & Taylor, 1991; Ward, 1984). For most individuals, a position of the hips flexed to approximately 90 degrees with the pelvis centered in midline is recommended to inhibit extensor tone (Cook & Hussey, 1995). Traditionally most authors agreed that the hips, knees, and ankles be positioned as close to 90 degrees as possible, with the feet supported (Bergen, Presperin, & Tallman, 1990; Ward, 1984). However, this may not always be feasible when accommodating a client's deformities in a seating system. Second, a midline position of the trunk and head are recommended when feasible to minimize the influence of abnormal reflexes and to promote symmetry. Finally, clinicians are cautioned not to provide external supports to the extent that the client is excessively restricted. Adaptive seating systems should ideally provide support while allowing active movement and postural control by the client when possible (Mac Neela, 1987).

Efficacy of Adaptive Seating Systems for Children with Neuromotor Impairments

Selection of Studies for Review

Researchers have only recently begun to explore the relationship between sitting position and functional skills to determine if adaptive seating is in fact effective in producing measurable functional improvement. Studies for this review were identified using the following methods. First, an on-line search of MEDLINE and the Cumulative Index of Nursing and Allied Health Literature (CINAHL) was conducted using the descriptors "positioning," "children," "infants," "equipment," and "adaptive seating." Second, references from articles obtained in the on-line searches were reviewed to identify additional studies. Finally, references from current rehabilitation textbooks (Campbell, 1994; Cook & Hussey, 1995) that included chapters on adaptive seating were also reviewed. Using these methods, studies were identified that examined a variety of dependent variables such as pulmonary function (Nwaobi & Smith, 1986), leg and trunk muscle activity (Myhr & von Wendt, 1993; Nwaobi, 1986), eating skills (Hulme, Shaver, Acher, Mullette, & Egger, 1987), performance on standardized tests (Miedaner & Finuf, 1993), and vocalizations (Hulme, Bain, Hardin, McKinnon, & Waldron, 1989). However, this literature review was limited to only those efficacy studies that included variables to be addressed in the present study.

Dependent variables in this study included postural alignment, upper extremity function, and caregiver feedback. Postural alignment relative to midline was chosen as a dependent variable because midline is the preferred position in the seating literature (Bergen, Presperin, & Tallman, 1990), as well as a recommended position of function for children with neuromotor impairments (Scherzer & Tscharnuter, 1990). Postural alignment was also selected based on input from clinicians currently using contoured foam seats as positioning devices. The foam seat was frequently described as having a positive effect on promoting a more erect posture. Upper extremity function was chosen as a dependent variable because, according to the proximal-distal control theory and recommendations in the adaptive seating literature, improved postural stability may be reflected in improved upper extremity function.

Parental feedback was included as a dependent variable as a form of cross-validation for the seating intervention, and as a measure of social validity. Systematic collection of data from parents may be the most efficient way for clinicians to gather information on the effects of adaptive seating devices in naturalistic settings. With the mandate of Public Law 99-457, therapists must direct their intervention efforts to include family-focused outcomes. Some authors (Schwartz & Baer, 1991) have stressed the importance of gathering feedback from consumers regarding the acceptability of early intervention practices. However, variables such as time, energy, and cost of interventions for caregivers have often not been addressed in early intervention efficacy studies to date.

Thus, three criteria were employed to select studies for this review: 1) subjects were children with neuromotor impairments; 2) dependent variables included postural alignment, upper extremity function, or caregiver feedback; and 3) adaptive seating was an independent variable. Thirteen studies met these criteria and were included in this review.

A summary of the included studies is provided in tabular format (see Table 1). The table provides relevant information relating to study design, participants, independent and dependent variables, outcome measures, and findings. To organize the discussion of findings, studies were arranged in the table by headings that described the most typical independent variables explored as possibly affecting postural alignment or upper extremity function. These independent variables included specific types of adaptive seating devices, seating orientations in space, and pelvic alignment and angle of hip flexion.

Studies Evaluating Specific Types of Trunk Support

Studies in this group were designed to evaluate the hypothesis that proximal control (i.e., support provided to the trunk) as provided by adaptive seating is related to functional control of the upper extremities, among other variables. Colbert, Doyle and Webb (1986) examined the effect of a molded, vacuum-formed seating system on functional status, defined as the child's upper extremity function and ability to relax. Twelve children with severe cerebral palsy, ages 18 months to eight years, were selected as subjects. A team comprised of the child's parents, physiatrist, orthotist and physical or occupational therapist met to decide upon the child's optimal position for comfort and function prior to fabrication of the seating system. After approximately one year of use, efficacy of the seating system was evaluated via a questionnaire sent to each child's parents, fabricating team and primary therapists. The questionnaire, which used a Likert Scale format, requested a subjective assessment of the seat's ability to enhance the child's overall relaxation and upper extremity function, and included questions relating to satisfaction with cosmesis and length of fit. Four of the six parents responding strongly agreed that the seat increased their child's ability to relax, and five of six parents felt the seat improved upper extremity function. Primary therapists were more critical of the seat's effectiveness. Only four of eleven therapists strongly agreed that the seat increased the child's ability to relax, and three of twelve therapists strongly agreed that the seat improved the child's upper extremity function. The fabricating team reported improved upper extremity function in eight of eleven subjects, seven of whom were now able to manipulate a standard joystick on a motorized wheelchair.

The above study presented a series of case studies and does not qualify as an experimental design. The lack of a control group and controlled variables limited the probability that improvements were due solely to the provision of the seat. Because the intervention period of one year was quite long, and the subjects were young, history and maturation were potential confounds to the effects of the adaptive seating device on manipulation skills. A more objective method of measuring dependent variables would also have strengthened this study.

A type of seating system in which the child straddles the seat (i.e., saddle seat) has been recommended for children with cerebral palsy (Finnie, 1974; Stewart & McQuilton, 1987). The use of the Seating and Mobility (SAM) system for children with severe spastic quadriplegia was evaluated in a longitudinal study by Pope, Bowes, and Booth (1994). The subjects, ten children ages two and one half to nine years, were fitted with the SAM system, comprised of a saddle seat with a mechanical base and a customized molded support. Outcome measures included body symmetry documented by angles measured from photographs, postural ability assessed using levels of sitting ability, upper limb control and dexterity on two prescribed tasks with cubes, mobility, and activities of daily living (ADL) as recorded by parents. Children were initially assessed when the SAM system was issued, and annually thereafter for three years.

The authors reported improvements in mobility and postural ability, with little change noted in upper limb performance. Subjective feedback from parents indicated that the children were easier to handle, appeared less disabled when in the SAM system, showed improved feeding skills and functional performance, and were easier to transport. Regarding cosmesis, some parents reported that their children became a focus of attention when seated in the SAM system as opposed to being ignored when they were in a wheelchair. Reported negative aspects included the weight of the system and increased drooling in some children. Several threats to internal validity were mentioned by the authors including maturation, surgical procedures, lack of a control group or baseline data, varying lengths of time the SAM system was used at home, and cooperation level during assessments. Single subject designs were suggested as a possible alternative for limiting methodological problems in future studies.

A study by Gross (1989) demonstrated no effect of adaptive seating on upper extremity control for children with spastic cerebral palsy. The six subjects, ages 2 to 10 years, were instructed to reach as fast as possible to a target in supported and unsupported sitting positions. Unfortunately, the specific type of support provided was not described in this abbreviated research report. Using videotapes, the wrist in each frame was digitized to compute wrist velocity, the number of changes in wrist trajectory, and relative length of reach. No significant differences ($p < .05$) were found for any variables between the two conditions using the Wilcoxon matched-pairs ranked sums test. The author suggested that, for children placed in a new seating device, a period of motor learning may be necessary before improvements in upper extremity performance are achieved. Limited information regarding the independent variables and methodology limit replicability and application of the findings from this study.

A longitudinal study by Hulme, Gallacher, Walsh, and Niesen (1987) used direct observation by examiners and parent questionnaire to evaluate the effectiveness of adaptive seating devices in a) improving positioning and the amount of time spent in functional positions; b) producing positive behavioral changes in head control, visual tracking, reach and grasp; c) improving social interactions within the community; and d) providing increased freedom and support for the caregiver.

The subjects included 19 children ranging in age from 16 months to 3 years 9 months. Eight subjects had spasticity, three had hypotonicity, four had mixed tone, three had severe mental retardation, and one had a genetic disorder. None of the children were able to walk independently. Each child had an adaptive seating device designed and fabricated for their individual positioning and transportation needs. Specifics of design elements were not provided by the authors other than a statement that each client had trunk support, hip stabilization, thigh support, foot support and a tray provided by the seating devices, which were constructed from a variety of materials. The subjects served as their own controls with behaviors observed prior to use of the adaptive seating devices compared with behaviors observed while using the equipment. Parents filled out questionnaires during the first and last visits, and the childrens' behaviors were observed using a coded rating scale developed for the study. The subjects were observed in their homes seven times with six-week intervals between each visit. During each visit, ten trials of each skill were observed and results recorded. Five examiners assessed performance, achieving at least 80 percent agreement throughout the study.

Analysis of variance and post hoc analysis were used to analyze rating scale data for head control, sitting posture, visual tracking, reach, and grasp. Analysis of the data revealed that head control and alignment of trunk, hip, knee and ankles improved significantly ($p < .01$). Functional improvements were seen in grasp, but not in visual tracking or reach. Descriptive data from the parent questionnaire indicated that they could feed, play, and travel with the client more easily with than without the use of the adaptive seating devices.

The fact that this study was conducted in a naturalistic setting of the clients' homes as opposed to a clinical setting strengthened the external validity. However, most subjects were concurrently receiving training programs in sitting balance, head control, visual tracking, reach and grasp during the study. Use of a control group participating in the training programs but not receiving adaptive seating devices would have been helpful in limiting possible confounds from the training programs. The length of the intervention period (i.e., approximately one year) also added maturation as a confound to the effects of the seating devices.

Studies Examining Orientation of the Body in Space

Adaptive seating has also been utilized to provide clients with a variety of seating orientations relative to upright, or 0 degrees vertical. Variations in seating orientation are typically achieved by tilting the entire seating system. Studies of seating orientation comprise the largest group of efficacy studies relating to adaptive seating; however, agreement regarding the most optimal orientation is lacking. In a study investigating the effect of seating orientation on upper extremity skills, Nwaobi (1987) examined performance time of a reaching task in four different seating orientations (i.e., 0 degrees in the vertical plane, 30 and 15 degrees posterior to the vertical plane, and 15 degrees anterior to the vertical plane). Thirteen children with cerebral palsy, ages 8 to 16 years, participated in this study. Subjects were placed in a multi-adjustable seating system with hips, knees, and ankles maintained at 90 degrees flexion. The subjects were asked to move their arm from a prescribed starting position on a laptray to activate a switch at midline. Upper extremity function was monitored via an Apple computer and a video monitor, which provided visual cues to initiate movement. Mean performance times were the lowest at the 0-degree orientation, with the author concluding that orientation in space affects upper extremity function and recommending the fully upright position for seating. Lower mean performance times on retest trials suggested the influence of a practice effect on reaching skills.

In contrast to a vertical seating position, Myhr and von Wendt (1991) recommended a forward-tipped position. They designed a functional sitting position (FSP) in which the head, trunk, and upper extremities were positioned in front of the fulcrum of the ischial tuberosities, with the seat sloped forward an average of 8 degrees (range 0 - 15 degrees). While in this position, the client sat leaning forward, with the pelvis tipped forward and supported by a backrest. Twenty-three children with cerebral palsy ages 2 to 16 years were photographed and videotaped in six different sitting positions, including the FSP designed by the authors. Outcome measures included duration of head control, frequency of pathological movements (i.e., spastic or tonic reflex patterns), and postural control. Postural control was measured using an observational tool, the Sitting Assessment Scale, developed for the study to rate head, trunk, and foot control, as well as arm and hand function.

Differences in median scores for head, trunk, and foot control, and arm and hand function were significantly different ($p < 0.001$) when five sitting positions were compared with the FSP. Frequency of pathological movements was also least in the FSP. The authors concluded that both the position of the pelvis and the inclination of the seating system relative to vertical were important factors in promoting postural control for children with cerebral palsy, and suggested that the line of gravity anterior to the fulcrum of the ischial tuberosities was a prerequisite for a functional sitting position. Results from a follow-up study of ten children with spastic diplegia who were introduced to a FSP and assessed using the Sitting Assessment Scale five years later indicated that eight of the ten subjects who sat in a FSP showed slight but significant ($p < .05$) improvement. The two children who did not sit in a FSP demonstrated a loss of postural control (Myhr, von Wendt, Norrlin, & Radell, 1995).

The effects of various sitting positions and an adaptive seat on active trunk extension and postural alignment were evaluated by Miedaner (1990). The study was also aimed at identifying an objective and reliable method (the Modified Schober Measurement of Spinal Extension) for assessing changes in trunk position. Fifteen children between the ages of 2 and 6 years who had diagnoses of developmental delay and/or cerebral palsy, as well as documented weakness of trunk musculature, were tested. A rating scale was developed to assess trunk control, with the subjects' average sitting skill reported as the ability to maintain bench sitting for up to two minutes, with spinal kyphosis and a posteriorly rotated pelvis. Each subject was asked to assume each of five sitting positions in a randomized order, and to maintain a quiet sitting posture for one minute. The five positions included tailor sitting on the floor; bench sitting with hips and knees at 90 degrees flexion; bench sitting with a 20 degree forward tip; bench sitting with a 30 degree forward tip; and sitting in a commercial chair (i.e., Ther Adapt Posture Chair) with an anteriorly tipped seat and knee blocks. After one minute the amount of spinal extension was measured using the Modified Schober Measurement. A randomized complete block design and Tukey's multiple comparisons test were used to identify significant means of differences among sitting positions.

For all subjects, the Ther Adapt Posture Chair was found to provide the best trunk extension when compared to the other positions. Group differences were significant at the

.01 level between the Ther Adapt chair and the floor sitting positions, and at the .05 level between all angled bench sitting positions and floor or level bench sitting. The author concluded that sitting in an anteriorly tipped position was the preferred position to promote active trunk extension and reduce spinal kyphosis. This study was limited by the fact that the rater was not blinded to the seating condition, and by a failure to report interrater reliability data for the outcome measure. An interesting follow-up study would be the examination of the relationship between spinal extension and functional upper extremity skills.

McClenaghan, Thombs, and Milner (1992) investigated the relationship of seating orientation on postural alignment, force, and functional use of the upper extremities. Ten non-impaired children and 10 children with spastic cerebral palsy, ages 4 to 15 years, were participants. Postural alignment data consisted of mean displacement of selected body segments, while force measures included the location and variability of the center of pressure. Data for these variables were collected using a video digitizing system, and analyzed statistically using a 2 x 2 x 3 factorial analysis of variance. Upper extremity performance was evaluated using performance measures for tasks such as finger tapping, picking up pellets, turning pegs, thumb pressing on a switch, and pencil tracing of figures. Experimental conditions consisted of seating orientations of 0 degrees, 5 degrees anterior tilt, and 5 degrees posterior tilt. Significant differences were observed on most dependent measures between the two groups. Seat inclination did not affect most dependent measures of postural stability or upper extremity motor performance for either group.

However, anteriorly tilting the seat decreased postural stability for some children with cerebral palsy as evidenced by increased head movement during quiet sitting. The authors concluded that, due to high inter-subject variability in the performances of children with cerebral palsy, the identification of a universal seating position was not practical. Possible factors contributing to the results included the relative high functional levels of the subjects with cerebral palsy (described as having the ability to sit independently and ambulate with or without mobility aids) and the small gradations in seat orientations (i.e., 5 degrees).

Studies Investigating Pelvic Alignment and Angle of Hip Flexion

The importance of pelvic alignment for maximum stability and facilitation of extremity mobility is frequently mentioned in the literature on adaptive seating (Bergen & Colangelo, 1985; Trefler, 1984). In their guidelines for evaluation of clients requiring adaptive seating, Trefler and Taylor (1991) note that optimal positioning begins with support at the pelvis, since proper alignment of the pelvis dictates what is happening in the rest of the body. A neutral pelvic position has been recommended for children with muscle tone disorders, as a posterior pelvic tilt tends to pull a child backward (Finnie, 1974). The child may then compensate by rounding the upper trunk forward, with resultant hyperextension of the head and neck. The posterior pelvic tilt may result in poor body alignment, which in turn may decrease upper extremity performance. While these recommendations are provided in the adaptive seating literature, to date there are few empirical studies providing support for them.

McCormack (1990) studied the effects of keyguard use and pelvic positioning on typing speed and accuracy in an 8-year-old boy with athetoid and spastic cerebral palsy. The keyguard consisted of a plexiglass grid which embedded each key. This allowed the subject to rest his forearm on the keyguard and restricted his tendency to inadvertently strike keys. The subject was positioned in his three-wheel scooter with his pelvis either in a neutral position (90 degrees hip flexion) or in a posterior tilt (65-70 degrees hip flexion). Data collection occurred twice weekly for four weeks, and a computer program was used to measure speed and accuracy. While typing accuracy increased with the use of the keyguard, pelvic positioning did not have a significant effect on either speed or accuracy. These findings did not support the author's hypothesis that therapeutic positioning of proximal pelvic alignment (i.e., neutral alignment with 90 degrees hip flexion) may facilitate distal fine motor skills. However, the author did not indicate how pelvic positioning was obtained or maintained during data collection, thus introducing a possible source of measurement error.

The relationship between variations in seat angle which alter the degree of hip flexion and hand function was measured by Seeger, Caudrey, and O'Mara (1984). The subjects were nine children over the age of five years and young adults with cerebral palsy who demonstrated rudimentary ability to control a joystick. Each subject was rated for severity and frequency of hip flexor spasticity and hip extensor spasticity, and placed in one of two groups. The first group included six subjects whose extensor spasticity was greater than flexor spasticity, and the second group included three subjects who had equal scores for flexor and extensor spasticity. Subjects were asked to direct and maintain a light on a target with a joystick control. The task was attempted with the subjects seated in positions of 90, 100, 110, and 120 degrees of hip flexion. Each subject was tested at all seat angles on four consecutive days. Recordings of the time taken to produce a successful target match (response time), as well as the number of incomplete matches (errors) were made for each subject in each position. Results demonstrated that the seat angle did not alter the subjects' ability to direct the light accurately. The authors concluded that degree of hip flexion did not affect performance on a prescribed fine motor task. However, angles of hip flexion less than 90 degrees were not assessed in this study.

In contrast to the findings of McCormack (1990) and Seeger et al. (1984), other researchers found significant differences in upper extremity function related to degree of hip flexion. Nwaobi, Hobson, and Trefler (1986) evaluated ten children with cerebral palsy who were seated in an upright position in randomly ordered positions of 50, 70, 90, and 110 degrees of hip flexion. Subjects were asked to perform ten trials of horizontal shoulder adduction to activate a switch, and the average movement time was calculated for each hip flexion position. Mean movement time was fastest in the 90 degree position, and slowest in the 50 degree position. A Fisher Multiple Comparisons showed a significant difference ($p < .05$) between the 90 degree position and the other three positions. These findings suggest that for selected clients in an upright seating position, hip flexion angle affects upper extremity movement time.

In one of the few studies including infants as subjects, Dilger and Ling (1986) examined the effects of posterior wedge sitting on postural kyphosis. The subjects were 16 children from 8 to 36 months of age with a variety of diagnoses including Down syndrome, cerebral palsy, and congenital paraplegia. The sitting posture of all subjects was characterized by a spinal kyphosis, a posterior pelvic tilt, and lower extremity flexion, abduction, and external rotation. Using rubber darts as markers on the vertebrae, the subjects were videotaped in the sagittal plane while sitting on a mat and on foam wedges with 15 and 25 degree posterior inclines. Using stop frame analysis, measurements of spinal extension were taken by drawing vectors between vertebral markers and comparing these to baseline data while the children were seated on the mat. Results indicated that postural kyphosis was reduced during sitting on the wedges, with overall postural alignment more improved during sitting on the larger incline. The authors proposed several possible mechanisms including vestibular, biomechanical, and righting reactions for the improved posture during wedge sitting. In discussing biomechanical factors, the authors suggested that sitting on a posteriorally inclined surface released tension in the hamstrings by decreasing the angle of hip flexion. This in turn decreased the posterior pelvic tilt, and facilitated weight bearing on the ischial tuberosities and a more perpendicular alignment of the pelvis in relation to the support surface.

Summary

The studies in this review included a variety of subjects, measurement techniques, and research questions, and reflect the difficulties inherent in conducting controlled studies with a population as diverse as children with neuromotor impairments. Some evidence in the literature suggests that adaptive seating systems may have beneficial effects for children with neuromotor impairments and their family members. However, the following are preliminary findings of the effects of adaptive seating that will require further research for confirmation. Findings have been summarized according to the dependent variables in the present study.

1.) Postural alignment/control. Improvements in postural alignment as a result of adaptive seating devices have been reported by some authors (Dilger & Ling, 1986; Hulme et al., 1987; Miedaner, 1990; Myhr & von Wendt, 1991). Treatment effects were measured using rating scales or procedures developed for the individual studies, with interrater reliability not always reported. However, other studies suggest that variables such as seat inclination (McClenaghan et al., 1992) and a specific adaptive seating device (Pope et al., 1994) do not effect postural alignment.

2.) Upper extremity function. The effects of various seating systems on upper extremity function are controversial. There is some evidence to suggest that upright (Nwaobi, 1987) and forward-tipped (Myhr & von Wendt, 1991) seating systems improve performance of functional upper extremity tasks for children with neuromotor impairments. However, several other authors reported no significant change in upper extremity performance with independent variables including angle of hip flexion (McCormack, 1990; Seeger et al;. 1984), seat inclination (McClenaghan et al., 1992), and specific types of adaptive seating systems (Gross, 1989; Pope et al., 1994).

3.) Caregiver feedback: Data relating to this variable are very limited. Reported benefits of adaptive seating according to parents include increased ease in feeding, transporting, and caring for their children (Colbert et al., 1986; Hulme et al., 1987; Pope et al., 1994). Reported negative aspects of an adaptive seating system included the weight of the system and increased drooling (Pope et al., 1994).

It is evident that there are conflicting findings relative to adaptive seating efficacy, and that further research is needed to determine the effects of adaptive seating for individual clients. Age, type of neuromotor impairments, and severity of neuromotor dysfunction may all be factors in determining which adaptive seating devices are appropriate for specific clients. As recommended in previous studies (McClenaghan et al., 1992), a major consideration in the design of future studies should be the inter-subject variability typically seen in children with neuromotor impairments. Single subject designs rather than group designs may be more appropriate in addressing this methodological issue.

The research questions asked in this study have not been answered in the current body of literature. To date there is little research examining the efficacy of adaptive seating devices for improving postural stability and functional motor performance of infants. With the exception of the studies by Colbert et al. (1986), Dilger and Ling (1986), and Hulme et al. (1987), few of the studies in this review included any subjects younger than two years. Similarly, there is limited information on the effects of adaptive seating devices commonly provided by therapists when used in naturalistic versus clinical settings. Most of the reviewed studies were laboratory-based, and investigated seating systems that were expensive and thus not typically available for many clients. Feedback from caregivers regarding functional outcomes (e.g., community accessibility, time, and energy expenditure) related to the use of adaptive seating is also very limited.

Further research examining the effects of adaptive seating devices is clearly warranted. This study examined the effects of a contoured foam seat (CFS) on postural alignment and upper extremity function in infants with neuromotor impairments. The CFS was developed to provide better pelvic alignment, increased postural stability and improved sensory feedback for children with neuromotor impairments. It is inexpensive to fabricate and is custom-fitted for each client. Anecdotal reports from physical and occupational therapists have indicated that the foam seats are advantageous for children with neuromotor impairments. Improvements in postural alignment, feeding skills, reaching and grasping, and tolerance for upright sitting have been reported (G. Pinder, personal communication, July 14, 1995). To date no studies demonstrating the effectiveness of the CFS have been published. This study was conducted to provide objective documentation of the effects of a currently used adaptive seating intervention for infants.

TABLE 1. Selected Efficacy Studies of Adaptive Seating for Children with Neuromotor Impairments

Evaluations of Specific Types of Adaptive Seating Devices						
Reference	**Design**	**Participants**	**Independent Variable**	**Dependent Variable**	**Outcome Measure**	**Results**
Colbert et al. (1986)	Case studies	12 children with cerebral palsy; 18 mos. to 8 yrs.	Molded, vacuum-formed seating system	Upper extremity function, overall relaxation, cosmesis	Questionnaire (Likert Scale)	Parental assessment was generally more positive than fabricating teams' and therapists'
Hulme et al. (1987)	Repeated measures (Longitudinal: 1 yr.)	19 children with various disabilities; 16 mos. to 3.9 yrs.	Use of individualized adaptive seating devices	Positioning, head control. visual tracking, reach and grasp, community access, ease of caregiving	Parent questionnaire and direct observation by raters	Improvements in postural alignment and functional grasp. No improvement in reach or visual tracking. Increased ease of caregiving reported.
Gross (1989)	Two-period crossover	6 children with cerebral palsy; 2.9 yrs. to 10.5 yrs.	Unsupported and supported sitting	Upper extremity control	Digitized video-tapes to compute wrist velocity, trajectory, and length of reach	No significant differences ($p < .05$) for any variables between conditions
Pope et al. (1994)	Repeated measures (Longitudinal: 3 yrs.)	10 children with severe cerebral palsy; 2.5 to 9 yrs.	Saddle seat with customized molded support	Trunk symmetry, mobility, postural ability, upper limb control (2 tasks), activities of daily living (ADLs)	Angles measured from photos, rating scales, parental report of ADLs	Improvements in mobility and postural ability; little change in upper limb control. Parents reported improved functional skills (e.g. feeding) and ease of caregiving

TABLE 1 (continued)

Evaluations of Seating Orientations in Space

Reference	Design	Participants	Independent Variable	Dependent Variable	Outcome Measure	Results
Nwaobi (1987)	Group comparison; repeated measures	13 children with cerebral palsy; 8 to 16 yrs.	Adjustable seating system at 4 different positions relative to upright	Upper extremity function on switch-activating task	Analysis of performance times	Mean performance times lowest in upright position (0 degrees in vertical plane)
Miedaner (1990)	Repeated measures	15 children with developmental delay and/or cerebral palsy	5 sitting positions (one including adaptive seat)	Trunk extension	Modified Schober Method	Most trunk extension found in adaptive seat with anterior sitting position
Myrh & von Wendt (1991)	Group comparison; repeated measures	23 children with cerebral palsy; 2 to 16 yrs.	6 sitting positions including forward-tipped (i.e. functional sitting position designed by authors)	Head, trunk, and foot control; arm and hand function; pathological movements	Observational techniques (i.e. rating scale) for analyzing videotapes	Significant ($p<.001$) differences between forward-tipped position and other 5 positions. Fewer pathological movements in forward-tipped position
McClenaghan et al. (1992)	Group comparison; repeated measures	10 non-impaired children and 10 children with cerebral palsy; 4 to 15 yrs.	3 seating orientations-- vertical, forward, and backward tilt	Postural alignment, force and upper extremity performance	Digitized videotapes for alignment and force; functional measures for upper extremity performance	No effect of seat inclination on most measures of postural alignment and upper extremity performance for either group
Myhr et al. (1995)	Repeated measures (Longitudinal: 5 yrs.)	10 children with spastic diplegia; 7 to 10 yrs. at follow-up	Functional sitting position (FSP) with seat tipped forward and abduction orthosis	Head, trunk, and foot control; arm and hand function	Observational techniques (i.e. rating scale) for videotapes	8 children who used FSP showed significant ($p<.05$) improvement on rating scale; 2 children not demonstrating FSP deteriorated

TABLE 1 (continued)

Evaluations of Pelvic Alignment and Angle of Hip Flexion

Reference	Design	Participants	Independent Variable	Dependent Variable	Outcome Measure	Results
Seeger et al. (1984)	Group comparison; repeated measures	9 children and young adults with cerebral palsy	Adjustable seat with 4 hip flexion angles	Hand function during target-matching task	Analysis of response time and error rate	No difference in response time for different seat angles for most participants
Nwaobi et al. (1986)	Repeated measures	10 children with cerebral palsy; ages not reported	Adjustable seat with 4 hip flexion angles	Upper extremity function during switch-activating task	Average movement time calculated for each hip-flexion position	Movement time was fastest for 90 degrees hip flexion; significant differences ($p<.05$) between 90 degrees and other positions
McCormack (1990)	Single subject	1 child with cerebral palsy; 8 yrs.	Pelvic positioning (neutral vs. posterior)	Upper extremity function during typing task	Calculation of typing speed and accuracy	No significant effect of pelvic positioning on typing speed or accuracy
Dilger & Ling (1986)	Repeated measures	16 children 8 to 36 mos. with variety of diagnoses	Foam wedges with posterior incline	Degree of postural kyphosis	Angle of spinal extension drawn from vertebral markers	Improved spinal extension with posterior wedge sitting

CHAPTER THREE

Method

Participants and Settings

Four infants with various neuromotor impairments participated in this study. All participants met the following inclusion criteria:

1.) Were between the ages (corrected for prematurity) of 9 and 24 months. This age range was selected because a) there are few studies examining the effects of an adaptive seating device on children younger than two years of age, b) adaptive seating devices are commonly recommended for children in this age range, and c) it was representative of the most typical ages for children to be positioned in a highchair.

2.) Were currently receiving physical and/or occupational therapy services for neuromotor impairments. Participants were not limited to a specific diagnosis such as cerebral palsy because a) typical caseloads now inclde a more heterogeneous group of children, and b) some infants who are appropriate candidates for an adaptive seating device may not have received a specific diagnosis.

3.) Were recommended as an appropriate candidate for a CFS by their treating physical or occupational therapists. This criterion insured that the intervention in this study was clinically relevant for each participant.

4.) Demonstrated a level of sitting of 3, 4, or 5 as assessed on the Level of Sitting Scale (Roxborough at al., 1994). (See Appendix A: Level of Sitting Scale.) This was included to provide some criteria for the degree of head and trunk control needed by participants to sit in a highchair.

5.) Demonstrated the ability to reach out and grasp a toy (i.e., the Red Rings toy) presented at midline with either hand when held in supported sitting on an adult's lap. This criterion was included to provide some homogeneity in terms of the upper extremity function of participants.

6.) Had no significant fixed deformity of the hips (e.g., hip dislocation) or pelvis as assessed by their treating therapists. This criterion was included to provide some homogeneity in terms of severity of involvement.

7.) Had no evidence of a visual impairment as reported by their treating therapists. This criterion was included to control for visual impairment as a factor influencing upper extremity function.

8.) Had parents who agreed to bring their children in, or permitted the investigator to come to the home, for data collection a minimum of twice weekly. This criterion was included to facilitate timely data collection and to minimize maturation as a confounding variable.

9.) Had parents who agreed to use a CFS for a minimum period of three weeks at home following the videotaped data collection period. This criterion was included to insure that parents had adequate experience with the CFS to enable them to respond to questions regarding the device.

Participants were recruited from a university affiliated infant-toddler program, a non-profit organization providing home-based physical and occupational therapy services, and from two local developmental centers. Data collection occurred at the site where the participant received therapy services, or in the home, depending upon parental preference. Descriptions of individual participants (with pseudonyms) are included below.

Participant 1: Lucas

Lucas was an 18-month-old African American infant with a diagnosis of spastic quadriplegia. He had more spasticity in the lower extremities than the upper extremities. Lucas tended to grasp more frequently with his left hand, but also occasionally used both hands for manipulation. His level of sitting at the start of data collection was rated a "3" (i.e., required support of the trunk and pelvis to maintain a sitting position on a bench.) Lucas was the only participant who had previous experience sitting in a highchair and using a CFS. His mother had used a CFS as an insert in his highchair, but felt he had outgrown it. Lucas received center-based occupational therapy services twice weekly. Data collection with Lucas was conducted three times weekly at the facility where he received early intervention services, and participated in full-day childcare.

Participant 2: David

David was a Caucasian infant who was 11 months 22 days of age at the start of data collection. He had a diagnosis of Down Syndrome with multiple medical complications including a severe mitral valve leak, pulmonary hypertension, congestive heart failure, and failure to thrive. He was fed via a nasogastric tube which was placed at seven months of age. David's level of sitting at the start of data collection was rated a "3" (i.e., required support of the trunk and pelvis to maintain a sitting position on a bench.) When well supported at the trunk, he was able to manipulate toys bimanually, but demonstrated a preference for using his left hand. Prior to enrollment in the study, he was positioned for drip feedings in a semi-reclined infant seat, and had no previous experience sitting in a highchair or using a CFS. David received home-based occupational therapy services once weekly. Data were collected three times weekly in his home.

Participant 3: Colin

Colin was a Caucasian infant who was born prematurely at 35 weeks gestation. He had a diagnosis of hypotonic cerebral palsy secondary to cytomegalo virus. His age (corrected for prematurity) at the start of the study was exactly nine months. Colin had low muscle tone of the trunk and all four extremities. The rating of his level of sitting fluctuated, depending on his behavioral state. At times, Colin's level of sitting was rated a "4" (i.e., required support only at the pelvis to maintain a sitting position on a bench). However, he occasionally pushed back into hip extension and required additional support at the trunk to maintain a sitting position (i.e., level of sitting = "3"). Colin used both hands for manipulating toys when postural support was provided (i.e., when lying on his back or when sitting semi-reclined in his swing). His therapy consisted of once weekly center-based physical therapy. He had no previous experience sitting in a highchair or using a CFS prior to the study. Data were collected five times weekly in Colin's home.

Participant 4: Shanti

Shanti was born prematurely at 34 weeks gestation in Fiji, Pacific Islands. She had a diagnosis of asymmetrical spastic quadriplegia, with more involvement in the right extremities. At the beginning of the study her age was 12 months 15 days (corrected for prematurity.) Her spontaneous play with toys was limited to use of her left hand only. There was marked spasticity of the right arm, which was usually held in a flexed position with a fisted hand. Shanti did not spontaneously use her right hand for grasping, and she had sensory deficits in the right upper extremity. On occasion Shanti would use her right hand to stabilize a toy while she manipulated it with her left hand. Her level of sitting was rated a "3" (i.e., required support of the trunk and pelvis to maintain a sitting position on a bench.) Shanti received home-based occupational therapy services once weekly. Prior to her enrollment in the study, Shanti had no previous experience sitting in a highchair or using a CFS. Data collection occurred two to three times weekly in her home.

Research Design

The objectives of this study were threefold: 1) to examine the effects of a CFS on postural alignment in infants with neuromotor impairments, 2) to examine the effects of a CFS on the performance of a functional upper extremity activity for infants with neuromotor impairments, and 3) to assess parental perceptions regarding the use and effects of a CFS following home use. To address the first two objectives, a time series, randomized alternating treatments design was selected. The conditions in this design included the following three interventions. Treatment A consisted of videotaped observations while the infant was seated in a standard highchair. Treatment B was observations while the infant was seated in the highchair with a thin (i.e., one eighth inch) foam liner on the seat. The foam liner provided a non-slip surface as compared to the vinyl surface of the highchair. This intervention was included to control for the effects of the texture of the seating surface on the dependent variables. Treatment C was observations of the infant using the CFS as an insert in the highchair. During all treatment conditions, participants were provided with toys to manipulate.

This design was selected as the most appropriate for several reasons. First, having each infant serve as his or her own control addressed the problem of comparing heterogeneous subjects. Second, the effects of the alternative treatments were compared relatively quickly, thus controlling for maturation and fluctuations due to behavioral states and performance across days. Because the intervention of the CFS was expected to show immediate effects and have little or no carryover when it was removed, alternating treatments also appeared to be an appropriate design. Finally, if a given treatment was shown to be effective, it did not need to be withdrawn from a participant for any extended period, thus minimizing ethical constraints (Kazdin, 1982).

To answer the third research question, semi-structured interviews were conducted with the parent who served as the primary caregiver of each participant. Interviews occurred after the CFS had been used in the home for a minimum period of three weeks following the videotaped data collection phases. Sample questions from the interview are included in Appendix B: Parent Interview Guide.

Description of Variables

Independent Variables. The independent variables in this study were a standard highchair (i.e., Treatment A), the highchair with a foam seat liner (i.e., Treatment B), and the highchair with a CFS used as an insert (i.e., Treatment C). All participants used the same highchair (Graco Model #3306L) during data collection. Following fabrication of the CFS, steps were taken to standardize conditions (e.g., height of highchair tray, placement of anatomical markers) throughout data collection.

Dependent Variables. The first dependent variable referred to in the first research question was "postural alignment". As described by Shumway-Cook and Woollacott (1995), alignment refers to "the arrangement of body segments to one another, as well as the position of the body with reference to gravity and the base of support" (p. 191). For purposes of this study, "postural alignment" was defined as "the arrangement of upper body segments over the pelvis to allow midline positioning in the coronal plane while sitting." Measurement of postural alignment relative to midline was chosen because midline is the preferred position in the seating literature (Bergen & Colangelo, 1985), as well as a recommended position of function for children with neuromotor impairments (Scherzer & Tscharnuter, 1990). Rating of postural alignment in the coronal plane from videotapes was done using anatomical markers and visual guides placed on the highchair back as described in the Data Collection and Videotaping Procedures section.

The second dependent variable was engagement with toys, a functional upper extremity activity developmentally appropriate for infants ages 9 to 24 months of age. Since very young children are typically not able to follow verbal instructions, the measurement of a prescribed upper extremity task was not felt to be appropriate. The developmentally appropriate activity selected was engagement with toys defined as "manipulation of a toy with either or both hands". Examples of manipulation included instances when an infant was playing with a toy while resting hands or forearms on the highchair tray, banging a toy on the highchair tray, or bringing a toy to the mouth. For each 10-second interval, raters viewing videotapes recorded the following two types of data: 1) the number of hands in contact with the toy, and 2) the number of hands or forearms in contact with the tray. These data were chosen to reflect functional hand use (i.e., unilateral versus bilateral manipulation) and degree of arm support (i.e., propping on highchair tray with one, two, or no hands or forearms) required for a functional play activity when additional trunk support was provided by the CFS.

The third dependent variable was parents' perceptions of the CFS following its use at home for a minimum period of three weeks. Perceptions were assessed via a semi-structured interview.

Control Variables. Control variables in this study included the age of the participants, their therapy status, their level of functional sitting ability, their musculoskeletal status relative to hip mobility, and their vision status. Since tray height may have an influence on an infant's ability to manipulate toys, the highchair tray height was also controlled across treatments. Texture of the seating surface was controlled by inclusion of Treatment B, a thin foam liner stretched across the vinyl highchair seat.

Procedures

Stage 1: Recruitment and Screening of Participants

The study was approved by the Institutional Review Board of the University of Washington and by the directors of participating early intervention centers. Following an inservice with therapists during which inclusion criteria were described by the investigator, parents of potential participants were approached by their infant's physical or occupational therapist and given a copy of an information sheet explaining the purpose and procedures of the study. Interested parents gave authorization for the investigator to telephone them. After consulting with each prospective participant's therapist, the investigator screened each infant to insure that all inclusion criteria were met. The infants were assessed by the investigator using the Level of Sitting Scale (Roxborough et al., 1994). Upper extremity function was measured by presenting each infant with the reaching task described in the inclusion criteria. Informed consent was obtained from each participant's parent prior to inclusion in the study.

Stage 2: Fabrication of Contoured Foam Seat (CFS) and Measurement of Infants

A customized CFS was fabricated for each participant by a pediatric physical therapist (NH) with six years clinical experience in the use of CFSs. The fabricating therapist also taught workshops for pediatric therapists in the design and fabrication of CFSs. The infant was held in supported sitting on a block of medium density foam that was four inches in depth and approximately 15 inches square. A symmetrical tracing was made with a marker around the infant's buttocks and thighs, and an electric knife was used to carve out the depressions of the seat. For carving the tracing around the buttocks and thighs, the knife was held at approximately a 45 degree angle to create a sloped, nested effect around the pelvis. The angle of the pelvic depression was modified slightly for each participant, depending on the tendency for the participant to sit with the pelvis in an anterior or posterior tilt. The foam was carved out with the area for the buttocks slightly deeper than the area for the thighs, placing the infant in approximately 100 degrees of hip flexion. Participant 4 was seated in slightly more hip flexion (i.e., 110 degrees) to control her strong pattern of hip extension. For all participants, a foam abduction wedge was left in place to provide additional stability.

To facilitate upright posture, lateral trunk support was provided by adding 4-inch foam cubes to both sides of the CFS. In a clinical setting, the height of the foam side supports vary depending on the child's level of sitting ability. However, for purposes of this study the foam side supports needed to be below the level of the highchair tray so that they were hidden from the raters' view. Following fabrication, the CFS was trimmed to fit inside the seat of the highchair.

The following procedures and measurements were completed with each infant to prepare for data collection sessions. First, the acromion process on both shoulders was palpated by the investigator and marked with an indelible marker on the infant's skin. The distance between the two points was measured, and this distance equaled the infant's trunk width. A vertical dowel was secured to the back of the chair to mark the midline of the chair. The highchair back was divided into five sections marked with colored tape. The middle section of the highchair back (left untaped) was referred to as "midline", and the width of this section equaled the infant's trunk width plus two inches on both sides. The other four sections were marked on the sides of the highchair back with 1 1/2 inch wide colored tape. The two segments closest to the midline of the highchair were marked with yellow tape and the two outside segments marked with black tape. The taped sections on the right side of the highchair back were referred to as "right +1" for the yellow tape, and "right +2" for the black tape. Similar references (i.e., "left +1" and "left +2") were made for the taped sections on the left side of the highchair back. During videotaping, adhesive circular markers were placed over the marks on the infant's acromion processes, and raters scored the position of the markers relative to the five sections on the highchair back. Scoring grids for rating postural alignment relative to midline paralleled the five sections on the highchair back (see Appendix C: Rater's Scoring Sheet).

With the infant seated in the CFS in the highchair, a measurement of the distance from the top of the highchair tray to the infant's sternal notch was taken. Since the CFS raised the infant's pelvis up, height of the highchair tray was kept constant across seating interventions by the use of Styrofoam inserts placed beneath the highchair seat when the CFS was not being used. A fabric drape was hung from the outer lip of the highchair tray so that raters were blind to the seating intervention. Mothers were interviewed regarding their infants' current toy preferences. Six visually appealing toys, selected based on parental input, the infant's developmental level, and potential for both unilateral and bimanual manipulation, were chosen for each infant.

<u>Stage 3: Data Collection and Videotaping Procedures</u>

Data collection occurred at the site where the participant received therapy services or in the home, depending on parental preference. For each participant, all data collection sessions occurred at approximately the same time of day, and were scheduled to accommodate the infant's nap and feeding times. During videotaping sessions, efforts were made to keep potentially distracting environmental stimuli, such as noise, at a minimum. The highchair tray and seatbelt were in place during all data collection sessions throughout the study. Circular anatomical markers (i.e., adhesive stickers) were placed over the acromion processes which had previously been marked with an indelible marker. For each data collection session, the investigator kept a written log. Information on the infant's behavioral state, order of seating interventions and toy presentations, and general comments regarding the infant's posture and reaching skills were recorded. Participants were videotaped from an anterior view with the camera positioned approximately ten feet in front of the highchair. All intervals during videotaping were timed by the investigator with a stopwatch. The following conditions were in effect during data collection sessions.

Phase 1: Baseline. The purpose of a baseline phase in an alternating treatments design is to document the subject's initial function and provide a basis for prediction of future performance (Ottenbacher, 1986). During baseline data collection sessions, each participant was videotaped for two 5-minute periods while seated in the highchair (i.e., Treatment A). The infant was placed in the highchair and given a 2-minute free play period to accommodate to the seating condition. Following the 2-minute accommodation period, the investigator positioned the infant in midline (i.e., aligning the infant's nose with the vertical dowel). Videotaping of the first 5-minute observation period began immediately following presentation of an age-appropriate toy placed at midline on the highchair tray. The order of presentation of toys was randomized prior to the first videotaping session. The randomized sequence of toys was used throughout data collection to insure that each infant had equal opportunity to interact with each toy. If an infant did not visually attend to a toy, or have it in contact with one or both hands within a maximum period of 20 seconds, the toy was replaced with the next toy in the randomly ordered sequence. If a toy was dropped on the floor after the infant secured it, a new toy was presented. In order to match the conditions of Phase 2: Alternating Treatments, the infant was removed from the highchair for approximately two minutes, and then seated in the highchair for a second 2-minute accommodation period. Following this, the same toy was again presented at midline on the tray, and videotaping of the second 5-minute observation period began. The following is a schedule of conditions during baseline data collection:

Accommodation to Seat (Freeplay)	- 2 minutes
Alignment and Engagement (Videotape)	- 5 minutes
Break	- 2 minutes
Accommodation to Seat (Freeplay)	- 2 minutes
Alignment and Engagement (Videotape)	- 5 minutes
Total Data Collection time	- 16 minutes (approx.)

Information regarding the infant's behavioral state was recorded for all sessions using a 3-point rating scale. If an infant's postural alignment appeared to be making the infant uncomfortable (e.g., the infant cried for longer than 10 seconds), the infant was repositioned in midline by the investigator, and the frequency of this intervention was recorded. Parents were told that if they felt that their infant could not complete the videotaping session due to fatigue or discomfort, the session would be terminated and rescheduled within three days. No data collection sessions were stopped for this reason. Baseline data were collected on a minimum of three occasions, or until baseline data were stable.

Phase 2: Alternating Treatments. Phase 2 of the study began with introduction of the alternating treatments, with use of the highchair with the foam seat liner being Treatment B, and use of the CFS as an insert in the highchair as Treatment C. Since any effects of the CFS were expected to be immediate and not carry over once the CFS was removed, both treatments were administered consecutively on the same day. Procedures for accommodation periods and presentation of toys in Phase 2 were identical to those employed during Phase 1. The sequence of Treatments B and C was randomized by flipping a coin to control for order effects. Each participant was observed for a 5-minute period with both treatments, with each treatment condition preceded by a 2-minute freeplay period during which the infant had an opportunity to accommodate to the seating condition. Total time for data collection during Phase 2 was approximately 16 minutes per session, excluding time to set up the camera. The baseline condition of Treatment A (i.e., the highchair without either adaptation) was inserted once randomly in the last three sessions of Phase 2. This was done to provide data on the potential influence of maturation of the infant on outcome variables, and to minimize maturation as a threat to internal validity of the study.

Phase 3: Home Intervention. After all videotaping sessions were completed, the CFS was sent home for the parents to keep. Parents were asked to use the CFS for a minimum of three weeks. During this time, each participant's mother was contacted by the investigator to answer any questions or address any problems that might arise from use of the CFS. None of the mothers reported any difficulties. After three to five weeks, a semi-structured interview was conducted with each mother (See Appendix B: Parent Interview Guide.) The interview was audiotaped so that an accurate record of the mothers' responses could be kept.

Stage 4: Rating of Videotapes

To allow for potential adjustments in the study protocol and to insure that interrater reliability could be obtained, rating of videotapes was done throughout the data collection phase. Three physical therapists volunteered to serve as raters in this study. Rater 1 scored all data for Participants 1 and 2, with Raters 2 and 3 scoring the other two participants' data respectively. Two of the raters were pediatric physical therapists, and the third rater worked in home health care with adults. Prior to scoring videotapes of participants, each rater participated in a training session with the investigator to achieve interrater reliability.

Raters were blind to the seating intervention by having a fabric drape attached to the lower rim of the highchair tray which obscured their view of the seating condition. Momentary time sampling was used for scoring each 5-minute videotape, with beeps at 10-second intervals signaling data recording. Thus for each 5-minute observation session, 30 data points were recorded. Raters viewed each 5-minute videotape twice, the first time to record postural alignment and a second time to rate engagement with toys. The scale for rating postural alignment was a 5-point scale to represent the position of the anatomical markers relative to the midline of the highchair back. The five points corresponded to the five segments of the highchair back as marked by the colored tape. Raters were instructed to score an omit for any interval where the anatomical markers were obscured by a toy or the infant's head. Two types of data were recorded when rating engagement with toys (see Appendix C: Rater's Scoring Sheets). First, the rater recorded whether the infant had one, both, or no hands in contact with the toy. Second, the rater recorded how many hands or forearms the infant had in contact with the tray.

Data Analysis

Data for the dependent variables of postural alignment and engagement with toys were analyzed separately for each participant, with all raw data prepared in table form. (See Appendix D: Percent of Intervals in Midline and Appendix E: Percent of Intervals Hands on Tray and Toy.) For three of the infants, it was noted that when they deviated from a midline position, they often slumped so that anatomical markers were aligned with the colored zones that were the farthest to the right or left sides of the highchair back. As there were minimal data for deviation to the inner colored zones, data for both levels (e.g., R+1 and R+2) of sideways deviation from midline to either side were combined. Postural alignment data, presented as percent of intervals in midline, were then presented in graph form and analyzed visually for level and trend differences across treatments. For each participant, data for engagement with toys were presented in two formats. First, graphs were prepared which showed the percent of intervals during which an infant was engaged in bimanual play with toys. Bimanual play with toys was selected as a more functional and mature type of manipulation than unilateral or no engagement with toys. Data were then presented in graph form which showed the percent of intervals during which an infant did not have forearms or hands in contact with the highchair tray (i.e., hands free from support), but was manipulating a toy with one or both hands. The variable of hands free from support was felt to reflect freedom of mobility in the upper extremities which would enable infants to broaden their repertoires of interaction with and exploration of toys (e.g., mouthing or banging a toy while holding it with both hands).

Semistructured interviews with parents were audiotaped and transcribed. All interview transcripts were reviewed while listening to the audiotapes to check accuracy. Analysis of interview data was done using the constant-comparative method as described by Glaser and Strauss (1967) to establish coding categories. Interview data were broken down into text segments which were analyzed and sorted by the investigator. Using this method, the first text segment became the first entry into the first coding category. Subsequent text segments were compared to the one existing category and judged to fit, or to be the first member of a second coding category. This process was repeated until all text segments were sorted into major coding categories. Text segments were then reviewed and assigned subcodes, using the same method as above.

Reliability Procedures

Observation Data

A training videotape was made which included an infant who was not a participant in the study. Prior to scoring videotapes of participants, each rater had a training session with the investigator which lasted until all pairs of raters reliably scored overall agreement of 85% or higher for the three measures including postural alignment, hand to toy contact, and hands/forearms in contact with tray. The point-by-point percent agreement method (i.e., number of agreements divided by total number of agreements plus disagreements multiplied by 100) as described by Kazdin (1982) was used to calculate interrater agreement. Scores for both the alignment (i.e., a 5-point scale) and engagement with toys measures (i.e., 3-point scales) were compared interval-by-interval and needed to be identical to be considered an agreement. At the end of training, raters had achieved a mean of 94% (median = 93%) interrater agreement for postural alignment, 92% (median = 92%) for hand-to-toy contact, and 89% (median = 90%) for hands/forearms in contact with tray.

Interrater reliability sessions between the investigator and each rater were conducted once during Baseline Phase and twice during the Alternating Treatments Phase. The mean, median, and low/high values for point-by-point percent agreement for each participant across measures are shown in Table 2.

TABLE 2. Interrater Reliabilities: Point-by-Point Percent Agreement

	Alignment	No. of Hands on Toy	Hand/Forearm on Tray
Lucas			
mean	.98	.93	.89
median	.98	.93	.90
low/high	.93-1.0	.87-.1.0	.83-.97
David			
mean	.95	.93	.89
median	.94	.93	.88
low/high	.87-1.0	.89-.97	.86-.97
Colin			
mean	.98	.94	.87
median	.97	.94	.87
low/high	.93-1.0	.87-1.0	.83-.90
Shanti			
mean	.98	.93	.87
median	.98	.93	.87
low/high	.93-1.0	.87-.97	.83-.93

Procedural Reliability

To insure that data collection procedures remained consistent across data collection sessions and that factors potentially influencing the validity of the data were controlled, procedural reliability checks were conducted during approximately 25% of the sessions. Parents or an occupational therapist conducted the reliability checks using the Procedural Reliability Checklist (See Appendix F.) The maximum number of procedures not completed in a single data collection session was one, and this occurred on one occasion.

Interview Data

Independent assignment of codes to data segments is recommended as a type of reliability check for interview data (Miles & Huberman, 1984). To insure the trustworthiness of interview data, interrater reliability checks using the percent agreement method (Kazdin, 1982) were done on approximately 90% of the coded data. A colleague was selected to code independently 43 text segments into the five major codes as shown in Appendix G: Coding Scheme for Parent Interviews. Interrater agreement of coding segments using the point-by-point percent agreement method (i.e., number of agreements / total number of agreements plus disagreements x 100) was calculated using the following method. A coding segment was considered an agreement only in cases where both raters assigned a single, identical code. The two cases where the second rater assigned a text segment two separate codes and the first rater assigned a single code were not considered to be in agreement. Interrater agreement using the point-by-point method was 93%.

CHAPTER FOUR

Results

Postural Alignment

Postural alignment was measured by visual analysis of alignment of the upper trunk relative to midline in the coronal plane. Figures 1-4 show the results of postural alignment data for all participants.

Participant 1: Lucas

Baseline data for Lucas initially showed large variability and a marked change in level between sessions 1 and 2 for video 2 (Figure 1). During session 2, Lucas maintained a midline position during 97% of the intervals. He was able to do this by rounding his upper body forward and leaning on the highchair tray, usually with both elbows. However, he was not consistently able to utilize this strategy to support himself, as the declining trend in later baseline sessions demonstrates.

At the onset of the intervention phase, there was a rapid and marked upward shift in level when using the CFS. The trend line for the CFS was fairly stable throughout this phase, with Lucas obtaining a midline position for at least 77% of intervals throughout the eight sessions of this phase. When using the foam liner, the data initially showed marked variability, with a more level trend during the latter half of this phase. Consistent differences in level were maintained throughout the alternating treatments phase, with no overlapping data points across treatments.

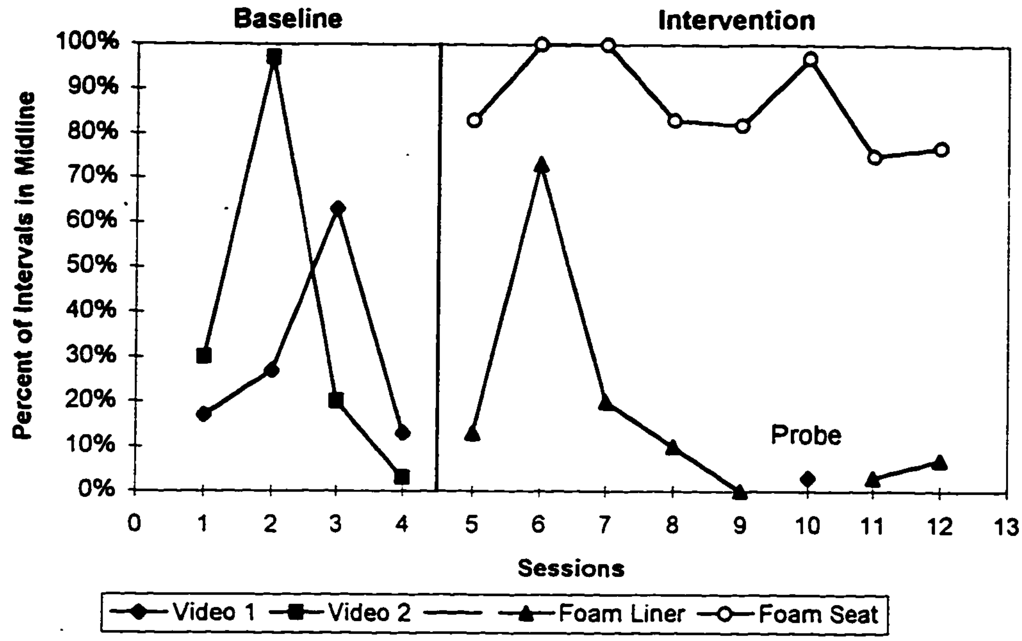

FIGURE 1: Postural Alignment - Lucas

<u>Participant 2: David</u>

As shown in Figure 2, David's baseline data were fairly stable, with no marked variability or trend. The percent of intervals in midline ranged from 26% to 42% during baseline phase. However, due to David's discomfort after quickly slumping to his left side, he required six repositionings by the investigator during session one, and four repositionings during session two. As recorded in both the investigator's log and in ratings of behavioral state, David was noted to be more tolerant and less fussy during most of the first 5-minute videos during both baseline and alternating treatment phases. Physiological changes such as increased sweating were observed at times during the second 5-minute videos in baseline, indicating stress which may have been related to David's congestive heart failure. Despite these observations, David's ability to maintain a midline position was consistently better during video 2 in the baseline condition.

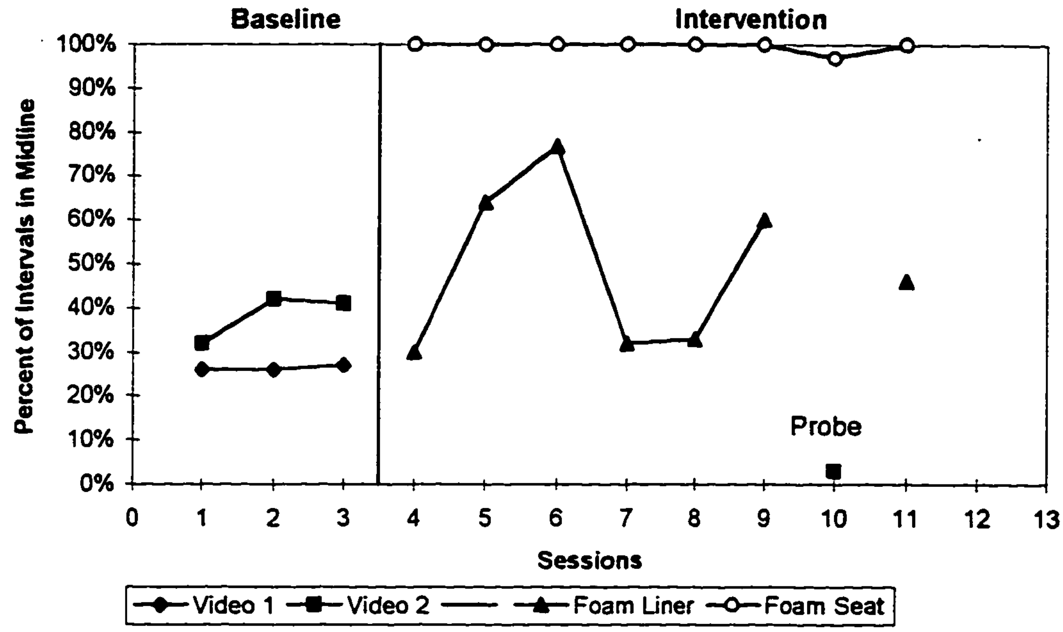

FIGURE 2: Postural Alignment - David

With the introduction of the CFS during session four, there was a rapid and marked change in level, with David maintaining a midline position during 100% percent of intervals on all but one day. These data indicated no trend, regardless of whether the CFS was utilized during video 1 or video 2. Data when using the foam liner were variable, with a higher mean percentage of intervals in midline as compared to baseline (49% versus 28%). Throughout the intervention phase, David did not require any repositionings by the investigator when using the CFS, and required only one repositioning when using the foam liner. The lowest data point occurred during session 10 when the no treatment probe was randomly inserted during video 2, during which David was repositioned once by the investigator.

Participant 3: Colin

Baseline data were unstable, with a sharp decrease in midline positioning during session 2 (Figure 3). Colin's typical pattern was to slump to his left side, with his left arm behind the highchair tray and his head close to the tray. Due to his discomfort in this position as evidenced by fussing and crying, the investigator needed to reposition him twice during session 1, and six times during session 3. Thus the percent of time in midline during these sessions was influenced by the intervention of the investigator repositioning him in midline.

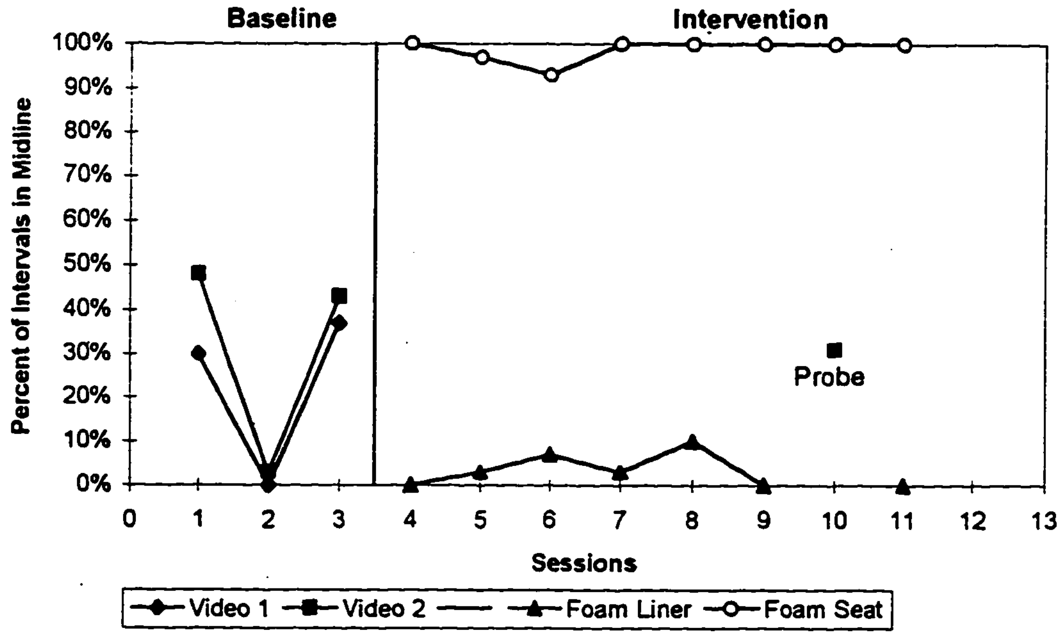

FIGURE 3: Postural Alignment - Colin

Colin demonstrated a marked improvement in his ability to maintain a midline position with the introduction of the CFS, with percent of intervals in midline ranging from 93% to 100%. Data for the foam liner were generally lower than baseline, and revealed no trend. When the no treatment probe was inserted during session 10, there was a noticeable change in level, with sitting posture in midline improved, but still significantly below that of the CFS. However, during this session Colin was noted to be very fussy as he pushed back into trunk extension and shoulder retraction, and required three positionings by the investigator after slumping to his left side.

Participant 4: Shanti

As shown in Figure 4, baseline data were fairly stable with Shanti having the lowest percent of intervals (ranging from 0% to 17%) in midline as compared to the other infants. Her typical pattern was to quickly slump to her left (i.e., less involved) side after positioning in midline by the investigator. During session 3, video 1, Shanti required three repositionings by the investigator after slumping to her left so that her head was nearly on the highchair tray.

There was a marked change in level with introduction of the CFS during session 4 which was maintained throughout data collection. Shanti maintained a midline position during 100% of the intervals on every day except during session 10. Data when using the foam liner were fairly stable with the exception of a noticeable improvement in midline positioning during session 7, when Shanti required one repositioning due to discomfort from malalignment.

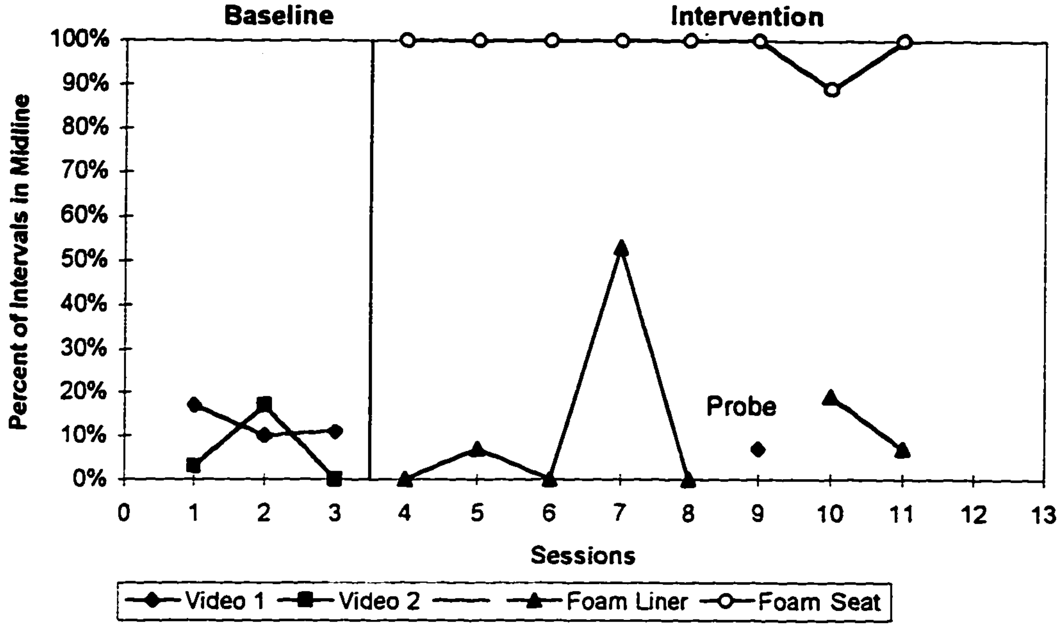

FIGURE 4: Postural Alignment - Shanti

Engagement with Toys

Data showing the percent of intervals during which infants demonstrated bimanual play with toys and no hand or forearm support on the tray while engaged with toys are shown in Figures 5-12. Data points above each session in these figures are staggered, with the data point furthest to the left for any given session indicating video 1.

Participant 1: Lucas

No significant effects of either the foam liner or the CFS on bimanual toy use were seen on visual inspection (Figure 5). The baseline phase was characterized by marked variability and no consistent trends. With the introduction of the alternating treatments there were immediate shifts in levels, with bimanual toy use increasing with use of the

CFS, and declining with the use of the foam liner. However, this shift was immediately followed by shifts in opposite directions for both treatments. Data throughout this phase continued to be variable with slight downward trends for both treatments.

During baseline phase, Lucas used one or both arms on the tray for support during most intervals (Figure 6). His percent of intervals with both arms free from support ranged from 0% to 13% during baseline, with a mean of 4% and a median of 3%. When the foam liner was used, the trend was similar to that during baseline (i.e., no trend). The percent of intervals with arms free from support while using the foam liner ranged from 0% to 17%, with a mean of 4% and a median of 0%. With the use of the CFS, there was a slight upward trend in the data near the end of the phase. The percent of intervals with arms free from support while using the CFS ranged from 0% to 30%, with a mean of 9% and a median of 7%.

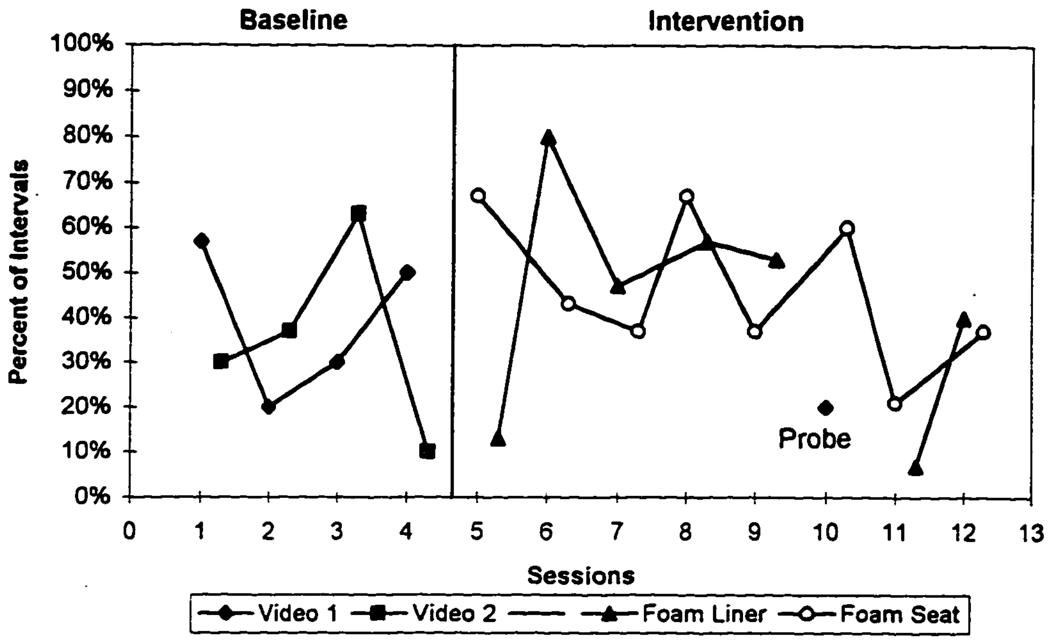

FIGURE 5: Two Hands on Toy - Lucas

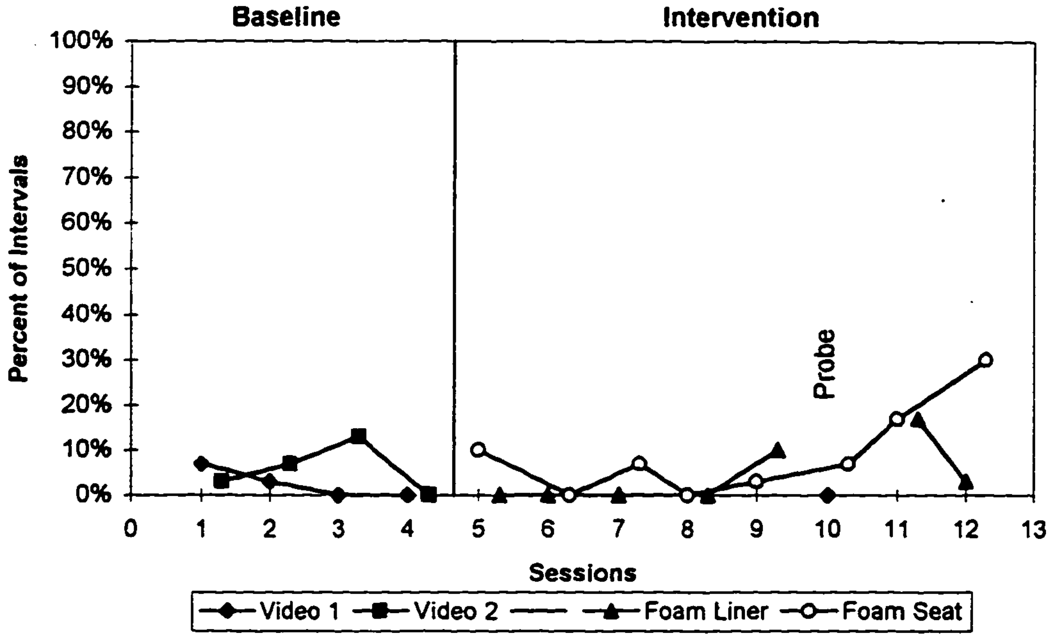

FIGURE 6: No Hands on Tray and One or Two Hands on Toy - Lucas

Participant 2: David

As shown in Figure 7, David's ability to use both hands for play was extremely limited during both baseline and alternating treatments phases. During the 22 5-minute videotape sessions, the percent of intervals of David's bimanual toy use ranged from 0% to 3%, with a mean of .4% and a median of 0%. David frequently supported himself by propping on an extended arm with his hand placed down on the highchair seat, while manipulating a toy with his other hand. He also tended to hold both arms up off the highchair tray in shoulder retraction.

Data showing David's percent of intervals with arms free from support while engaged with toys are presented in Figure 8. Baseline data show no trend. During most of the alternating treatments phase, there was a slight upward trend suggesting increased ability to have arms free from support while engaged with toys when using the foam liner. Data for use of the CFS were fairly level except for an increase during the last session. Due to David's observed pattern of fatigue during the second half of data collection sessions, data were visually analyzed by order of treatment during the intervention phase. Visual analysis revealed that during the majority of sessions (i.e., 6 of 8), engagement with toys without arm support was increased during video 1, regardless of the seating intervention. Across all video 1 sessions during the intervention phase, the percent of intervals with arms free from support ranged from 7% to 53%, with a mean of 26% and a median of 24%. This was higher than during video 2 sessions, where percent of intervals ranged from 3% to 43%, with a mean of 15% and a median of 10%.

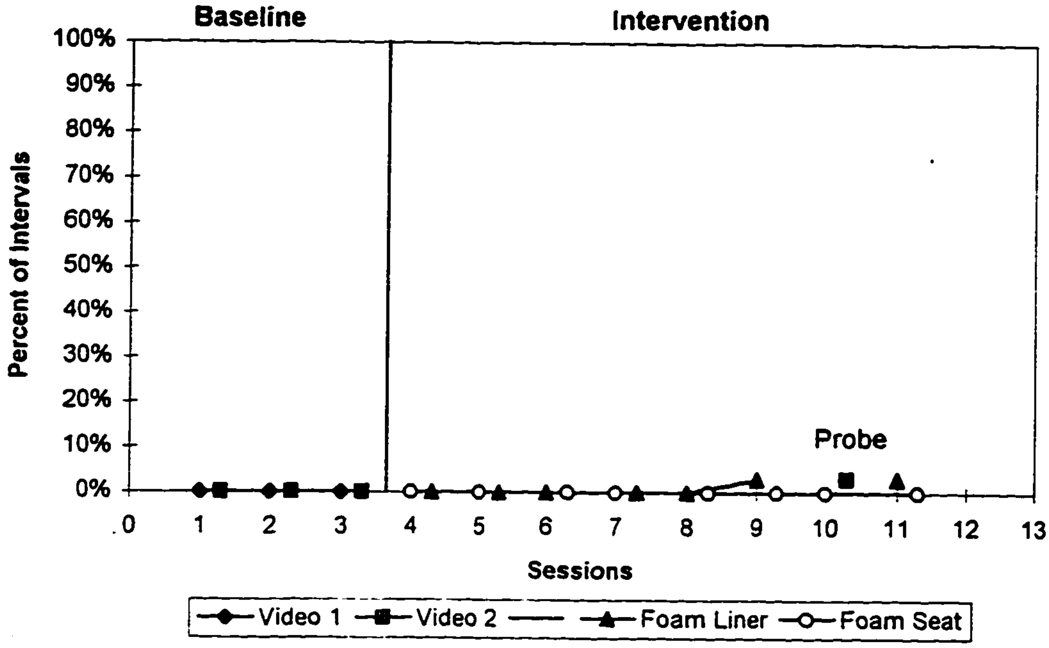

FIGURE 7: Two Hands on Toy - David

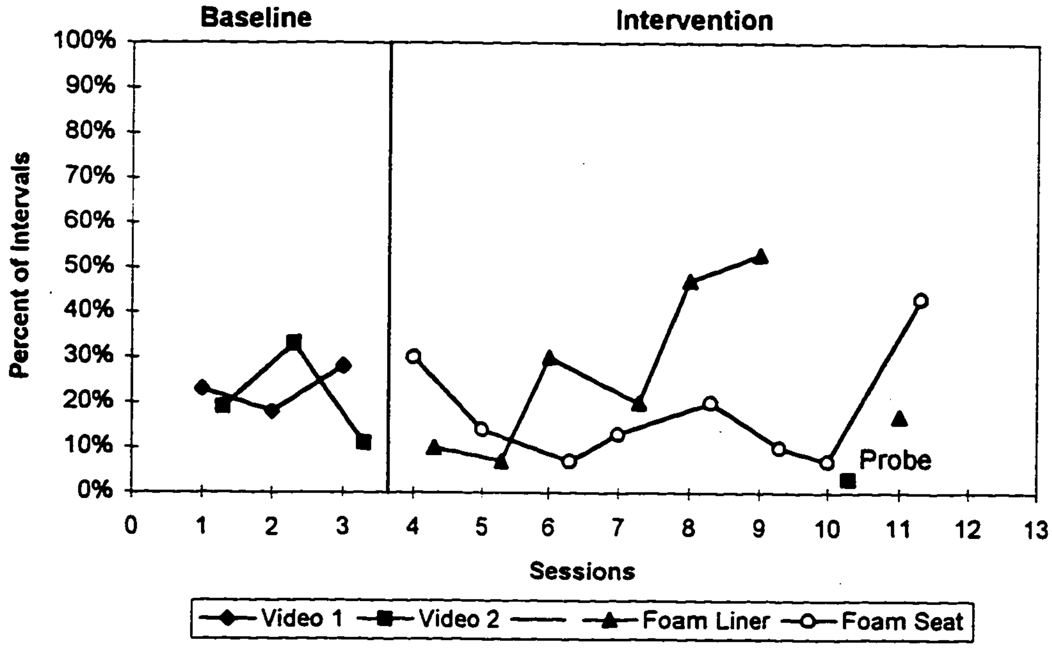

FIGURE 8: No Hands on Tray and One or Two Hands on Toy - David

Participant 3: Colin

Despite requiring several repositionings by the investigator for malalignment during baseline, Colin demonstrated fair ability to bimanually play with toys. As shown in Figure 9, the percent of intervals of bimanual toy use during baseline ranged from 47% to 73%, with a mean of 59% and a median of 60%. The data showed more variability for both treatments in the intervention phase, with no apparent trends. Bimanual toy use when using the foam liner showed a lower mean percent of 38% (median was 40%) when compared to baseline, and ranged from 20% to 57%. While more variable, the data when Colin used the CFS indicated a mean percent of bimanual toy use of 60% (median was 65%), which was very similar to baseline.

Data showing Colin's percent of intervals with arms free from support while engaged with toys are presented in Figure 10. Baseline data showed a downward trend during session 2, with increased frequency of playing with toys with arms free from support during session 3. Because of discomfort caused by marked leaning over the lateral edge of the highchair tray, Colin was repositioned once by the investigator during session 1, and six times during session 3. The percent of intervals with arms free from support ranged from 0% to 37% during baseline, with a mean and median of 18%.

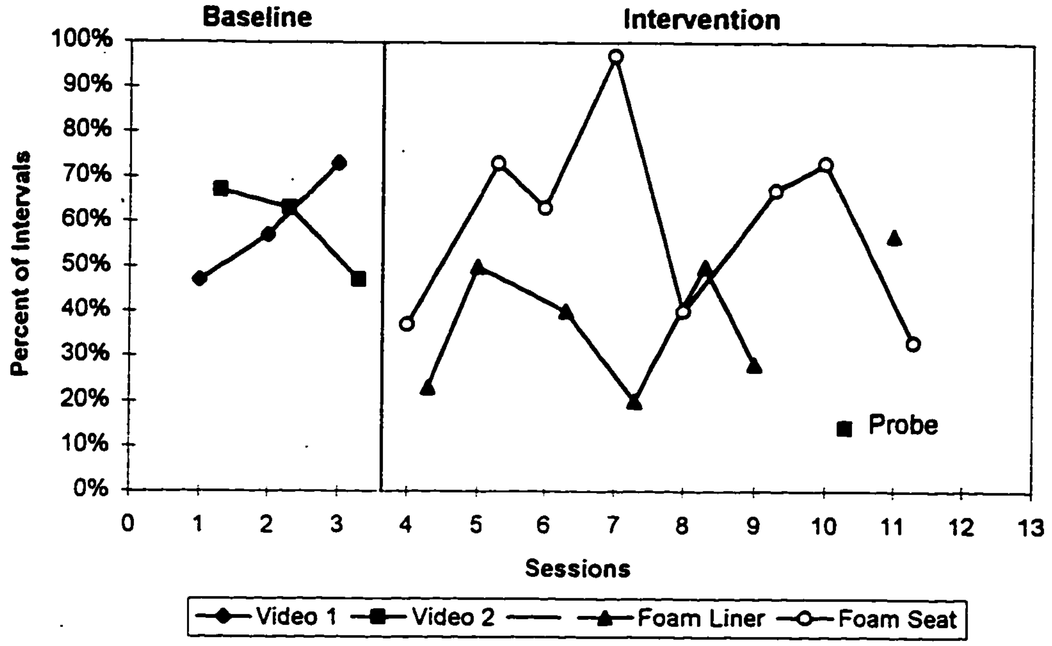

FIGURE 9: Two Hands on Toy - Colin

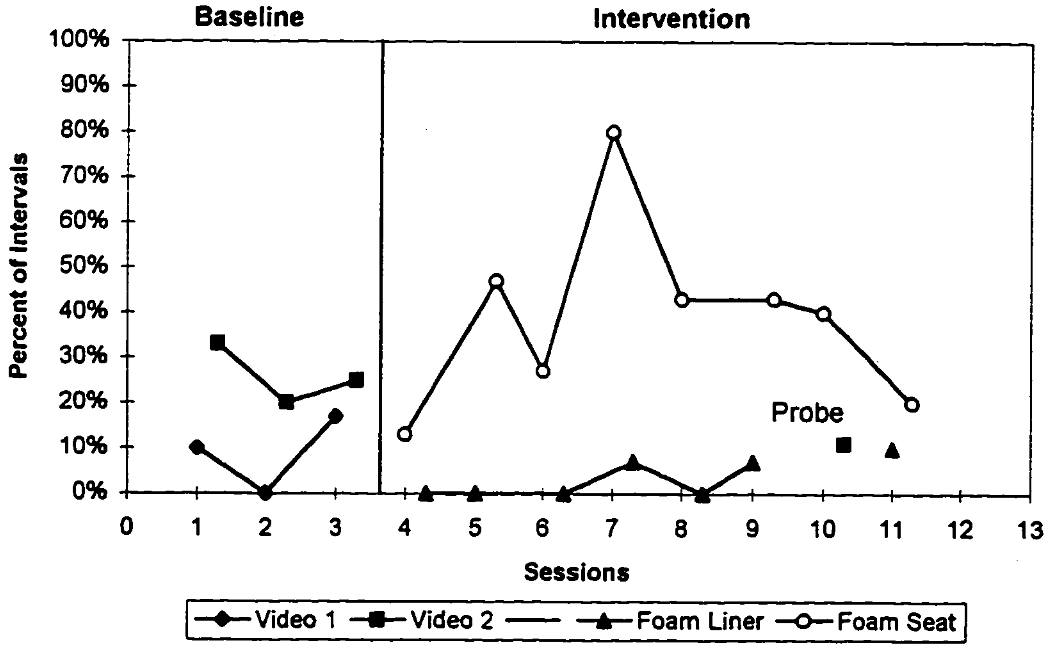

FIGURE 10: No Hands on Tray and One or Two Hands on Toy - Colin

During the first half of the intervention phase, there was an upward trend in the data while using the CFS, with a downward trend in the latter half of this phase, returning to approximately baseline levels. While using the CFS, the mean percent of intervals with arms free from support while engaged with toys was 39% (median was 42%), and ranged from 13% to 80%. Data while using the foam liner were stable, but much lower, with a slight upward trend toward the end of the phase. The mean percent of intervals with arms free from support while using the foam liner was 3% (median was 0%), and ranged from 0% to 19%. There were no overlapping data points between treatments during the intervention phase.

Participant 4: Shanti

Baseline data for bimanual play with toys were fairly stable at a low level (Figure 11). The percent of intervals using two hands for play with toys ranged from 0% to 10% during this phase, with a mean of 3% and a median of 0%. When the intervention phase began, there was a slight change in level for both treatments, with a greater increase in bimanual play when using the foam liner. Data during the intervention phase were more variable than during baseline, with no trend noted for either the foam liner or the CFS. The highest percent of intervals of bimanual play (i.e., 40%) was during session 9, when the baseline probe of no intervention was in effect. The mean percent of intervals for bimanual play was greater when Shanti was using the foam liner (16%, range 10% to 27%) than when using the CFS (11%, range 0% to 27%).

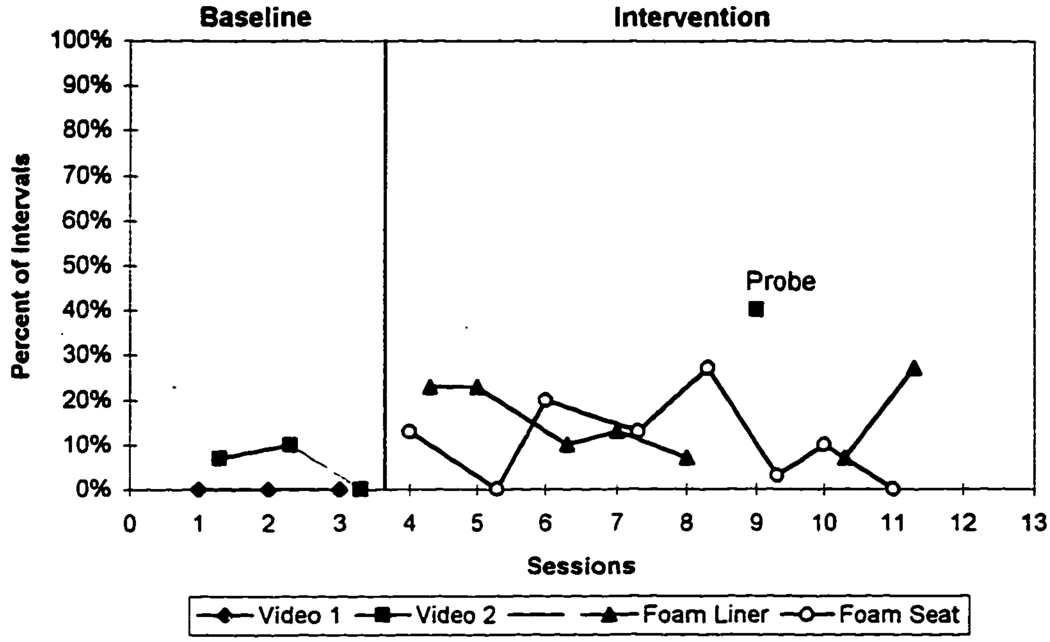

FIGURE 11: Two Hands on Toy - Shanti

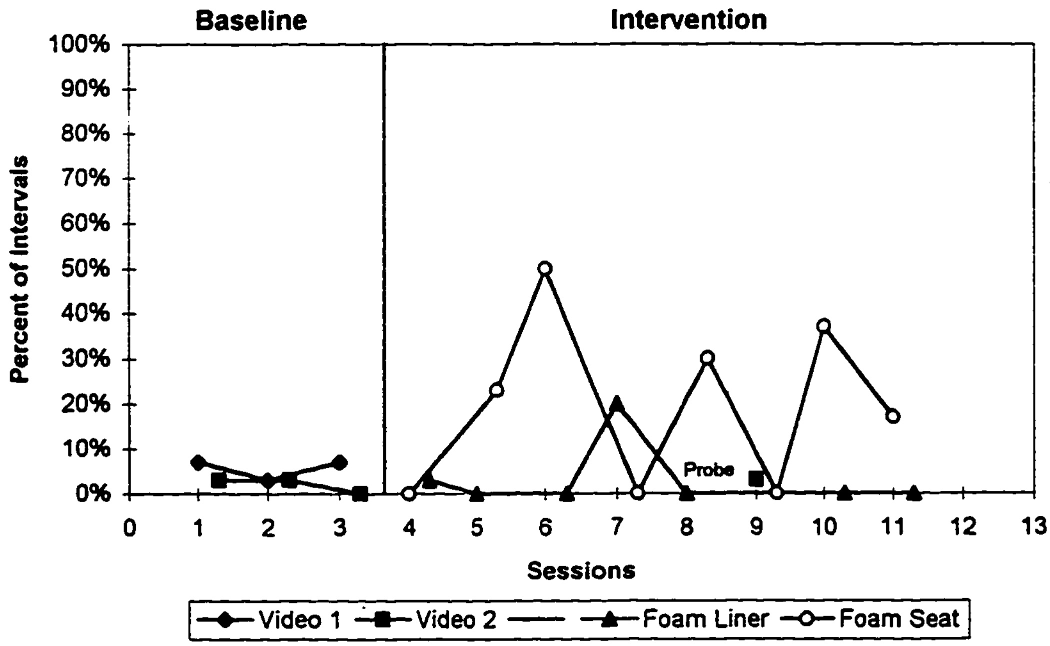

FIGURE 12: No Hands on Tray and One or Two Hands on Toy - Shanti

Data for Shanti's engagement with toys with both arms free from support are presented in Figure 12. Data during baseline were stable at a low level, with a mean percent of intervals of 4% (median was 3%), and ranged from 0% to 7%. Data remained at a low level throughout the intervention phase when Shanti was using the foam liner. During this condition, the mean percent of intervals with both arms free from support while engaged with toys was 3% (median was 0%), and ranged from 0% to 20%. Data when using the CFS were quite variable, with some significant shifts in level as compared to baseline, but with little stability. The mean and median percent of intervals with both hands free from support while engaged with toys was 20% when Shanti was using the CFS, and ranged from 0% to 50%.

Parental Perceptions

After coding of semi-structured interviews, two major themes were identified. These themes are described below, using quotations from respondents to illustrate the data sources.

Theme 1. Acceptability: "I Wouldn't Leave Home Without It"

As described by Schwartz and Baer (1991), the purpose of including a measure of social validity is to evaluate the acceptability or viability of an intervention for consumers, in this case, parents. All four mothers in this study reported that they used the CFS as an insert in their infants' highchairs consistently. In addition to feeding their infants in the CFS, some mothers also used the CFS in alternate ways, such as placing it on the floor where their infants could play. Mothers expressed their satisfaction with the CFS as opposed to previous positioning strategies as follows:

> "It (i.e., the foam seat) definitely helped give him the support like nothing else really would because it's customized and it just hugs him very nicely...there's nothing else that we have that makes it so that he can't scoot forward by sliding his butt forward...there are other things called Tidy Saddles but they don't give him the support that he needs right now..." (David's mother)

> "It (i.e., the foam seat) just makes things a lot easier. I think it works. And it's such a simple thing to do, really. So I think it's a great thing...I wouldn't leave home without it!" (David's mother)

> "Positively, absolutely clear, for children with lower muscle tone it was the best thing that he needed at that time because the alternative was feeding with things (i.e., towels) on the sides...It was just a lot more convenient and it was more complete support for him." (Colin's mother)

Overall, parental attitudes toward the CFS were very positive. Mothers found the CFS easy to use and used it consistently in the highchairs. When probed regarding any potential negative aspects associated with the CFS, two mothers mentioned that the CFS could not be transferred into their infants' strollers:

> "The only negative aspect actually would be that they don't have them in strollers. I think it would be something that should be encouraged in more widely developed areas." (Lucas' mother)

> "It doesn't fit in my stroller. That's not a big deal actually. We don't use the stroller that much." (David's mother)

Parents were specifically asked to discuss any negative aspects of using the CFS for themselves or their infants. No negative aspects for infants were reported. One mother described some difficulty in terms of physical effort when removing her child from the CFS as follows:

> "When I would pull him out of the highchair, one arm is holding him and the other arm is getting the tray...and with this (i.e., the foam seat) it added another element of having to get it off his bum because it would stick to him...It was just difficult using it. But it was a definite plus." (Colin's mother)

Some parents expressed a desire for the CFS to become more widely available and suggested that even typically developing children may benefit from it. Their comments included the following:

> "I think it's (i.e., the foam seat) very positive for not just children with developmental needs but also probably for just normal children in helping strengthen their trunk...or just in encouraging them to sit up properly." (Lucas' mother)

> "It's a real nice device that works well for us. I'm very glad it was there, and I guess I'd like to see it more in use, and I guess I'd like most people who could be served well by it to know about it." (David's mother)

<u>Theme 2. Greater Independence for Mothers and Infants: "Letting Him Explore His Little World"</u>

All respondents reported positive effects of using the CFS for themselves and their infants. Mothers indicated that the CFS provided them with increased independence when performing caregiving responsibilities and household tasks. Mothers described this increased freedom as follows:

> "...in terms of feeding it was a lot easier because I wasn't having to deal with towels and everything, and he was just sitting right up." (Colin's mother)

> "...it's (i.e., the foam seat) been a huge relief, and just time-wise it's allowed me to do things while he's doing things. I mean he's doing his work, his play, while I'm getting things done and we're both happier actually. Less anxiety and he's just real happy. So it's made things a lot easier for both my husband and myself." (David's mother)

> "When she's in the highchair I can do the housework and see her, and when I am in the bathroom and doing work in the kitchen I can see her." (Shanti's mother)

In addition to positive effects of the CFS related to their caregiving responsibilities, mothers perceived multiple benefits of the CFS for their infants. All respondents reported greater independence for their infants in several functional areas (e.g., play, hand use, social interaction). Some mothers indicated that their infants were better able to use their hands for play as described below:

> "It (i.e., the foam seat) makes it easier for him. Where before he would have to use his hands to keep himself up...now it's more that he can just play...he doesn't have to worry about that really. He's been able to use his hands to push his pop-up toys back down, and he's mobile basically with his hands. He's not having to support himself in sitting up or anything so he can play real easily." (Lucas' mother)

> "I guess this is kind of an assumption, but it's pretty coincidental with putting him in the foam seat that he did start transferring toys and pulling things over his head with two hands...he just has a lot of opportunity without trying to concentrate on using one hand to hold himself up." (David's mother)

Two of four mothers had been feeding their infants in a highchair or walker prior to receiving the CFS. These mothers perceived that their infants' postural alignment was improved when they used the CFS as described below:

> "When I had him in the highchair before the study, I would roll towels and stuff them in the sides and behind him or beneath him

> or whatever to try to get him to stay up because he was completely flexible...but with the foam seat, he was able to sit up and there was no problem." (Colin's mother)

> "The foam seat is OK for her. She doesn't fall to the side. She keeps up straight in that." (Shanti's mother)

Another perceived benefit of the CFS reported by some mothers was improved social interaction for their infants. Respondents described new opportunities for their infants to engage with other family members as follows:

> "He clearly likes dinner time when we're all home...he's looking at us and we give him crackers to play around with...he loves being at the table with all of us." (David's mother)

> "It (i.e., the foam seat) enables me to face him instead of being behind him...I can face him and play with him and that's a nice thing too because then we can be face to face, and he can learn facial expressions...actually that's very valuable." (David's mother)

> "Using the foam seat he can still be, if like there's a group of us sitting at the table, he doesn't feel like he's out of what's going on because he's sitting right up there." (Lucas' mother)

In addition to improved performance of specific skills such as hand use, some mothers reported that their infants had greater independence in the following ways:

> "It's (i.e., the foam seat) helping David do things by himself, and just exploring his little world. And he clearly enjoys being able to do that." (David's mother)

> "I think it (i.e., the foam seat) freed him up to not have to concentrate so much on sitting up and be able to put his energy into playing or eating or grasping...or anything than just having to concentrate on keeping his head above the tray basically." (Colin's mother)

Summary

Results of this study indicated a clear, positive effect of the CFS on promoting postural alignment in midline for all participants. The effect of the CFS on postural alignment was sustained throughout the intervention phase. Findings for the effect of the CFS on facilitating engagement with toys were mixed. The data did not support the effect of the CFS on increasing bimanual play with toys for any of the participants. For two participants, increased ability to play with toys while both arms were free from the support of the highchair tray was observed when using the CFS. Following use of the seat at home, feedback from mothers was positive. All four mothers indicated that they liked using the CFS, and that they believed the CFS had beneficial effects for themselves and their infants.

CHAPTER FIVE

Discussion

The purpose of this study was to examine the effects of a contoured foam seat on postural alignment and a functional upper extremity activity of engagement with toys for infants with neuromotor impairments. Parental perceptions of the CFS following home use were also assessed via a semi-structured interview. In this chapter, theoretical and practical implications of the findings for each dependent variable are discussed. Limitations of this research are described, as well as suggestions for future research.

Dependent Variable 1: Postural Alignment

Adapted from a definition by Shumway-Cook and Woollacott (1995), postural alignment in this study was defined as "the arrangement of upper body segments over the pelvis to allow midline positioning while sitting." Results of this study offer strong support demonstrating the benefit of a CFS in improving postural alignment in the coronal plane for infants when used as an insert in a highchair. All four participants showed a marked improvement in their ability to maintain a midline seating orientation when seated in a CFS, and this improvement was consistent throughout the intervention phase (Figs. 1-4). In addition to improved postural alignment recorded during the relatively brief (i.e., 5-minute) data collection sessions, mothers also reported that their infants were able to sit up straight when using the CFS for longer periods at home.

It appears that the CFS was effective in facilitating improved alignment of the upper body segments (i.e., trunk, shoulders, and head) over the pelvis to allow midline positioning in the coronal plane. This supports the recommendations in the seating literature that the position of the pelvis dictates posture in the rest of the body (Cook & Hussey, 1993; Reid, 1995), and should be addressed first when adapting a seating position (Trefler & Taylor, 1991). There may be several factors contributing to the effectiveness of the CFS in facilitating postural alignment. First, it is hypothesized that the primary reason the CFS is effective in promoting postural alignment is related to its function of keeping the pelvis in a neutral or slightly anterior position, as opposed to positions of posterior tilt, pelvic obliquity, and/or pelvic rotation. In addition to the depression for the pelvis being shaped in a neutral or slightly anterior tilt depending upon the infant's typical sitting posture, a foam abduction pommel was also in place to help stabilize the pelvis. Musculoskeletal compensations associated with a posterior pelvic tilt, such as kyphosis and head hyperextension, have frequently been described in the literature (Scherzer & Tscharnuter, 1990; Shumway-Cook & Woollacott, 1995). With the pelvis held in a neutral or slightly anterior position, it is suggested that these compensations are not necessary to maintain an upright position against gravity.

The hypothesis of pelvic positioning as a determinant of postural alignment also has been supported by several studies (Dilger & Ling, 1986; Miedaner, 1990; Myhr & von Wendt, 1991). As described in the literature review, these authors found that seating devices that placed the pelvis in a neutral or slightly anterior tilt promoted thoracic extension and improved alignment of upper body segments for children with a variety of neuromotor impairments. The importance of pelvic positioning and mobility in the development of independent sitting also has been described for typically developing infants. An interesting observational longitudinal study by Green, Mulcahy, and Pountney (1995) documented the levels of prone and supine lying abilities of typically developing infants, and examined the relationship of these abilities to sitting abilities. Infants were videotaped while lying both on the floor and on an acrylic-topped table, which clearly showed areas of body contact and load-bearing areas. In both prone and supine lying, pelvic positioning moved through a sequence of posterior tilt, to neutral, and then anterior tilt as the infants matured. In order to maintain a sitting position while propping on hands, infants had to first progress through levels of lying ability during which the pelvis was anteriorly tipped and the shoulder girdle protracted. In a second phase of the same study, 34 children with cerebral palsy were observed in prone, supine, and sitting. Similar to the typically developing infants, children who had not reached the above positions of the pelvis and shoulder girdle while lying were not able to maintain a sitting position when placed. Although a relationship between lying abilities and sitting abilities was noted, the relationship cannot be presumed to be causal. The authors stressed that emerging motor behaviors were the result of a complex interaction of the organism, the environment, and the motor task.

A second possible reason for the efficacy of the CFS may be the increased contact it provided with surface areas of the infants' bodies. In contrast to the contoured surface of the CFS, the highchair seat surface was a planar or flat surface that provided relatively limited body contact. Each CFS was custom-fitted using tracings around the infant's pelvis as cutting lines to insure a snug fit. The CFS nested the entire pelvis as well as the posterior and lateral aspects of the infants' thighs, and provided a significantly broader base of support than the infant's pelvis resting on the highchair seat. Each CFS also provided additional body contact at the lower trunk via the lateral foam blocks. Contoured seats, as described by Cook and Hussey (1995), provide increased body contact with the seating surface, which in turn provide increased support and control.

Additional postural support may also have been provided by the non-slip foam surface of the CFS. The alternating treatments design used in this study allowed comparison of each participant's postural alignment on three seating surfaces-a vinyl highchair seat, a thin foam liner, and a CFS. As shown in Figure 2, one participant in this study demonstrated improved ability to maintain midline positioning while seated on the thin foam liner versus the vinyl highchair seat. The vinyl surface of the highchair seat may have allowed pelvic movement in a sideways direction, leading to pelvic obliquity and asymmetrical weight bearing. Similarly, slipping forwards on the vinyl surface may have allowed the pelvis to move into a posterior position, with resulting compensations in upper body segments which prevented the maintenance of a midline position. While not as dramatic or stable as the changes noted while sitting in the CFS, David's ability to maintain a midline position was improved when seated on a thin foam liner. These findings suggest that, for some infants, particularly those with minimal neuromotor impairments, altering the texture of the seating surface to a non-slip surface may facilitate improved postural alignment.

It is also feasible that the relatively compliant texture of the CFS versus the harder surface of the highchair seat was related to improved postural alignment. The more compliant texture of the CFS provided the infants with a different type of somatosensory input than the firmer highchair seat. Green et al. (1995) observed that children with cerebral palsy performed at higher ability levels when lying on the floor versus on the harder surface of the acrylic tabletop. The authors speculated that the children "sunk into" the more compliant floor surface, which in turn provided greater load-bearing and a reduction in degrees of freedom. These observations warrant further investigation of seating surfaces on emergent motor skills in children with neuromotor impairments.

A variety of possible mechanisms, including biomechanical, musculoskeletal, and somatosensory, have been offered as reasons for the effectiveness of the CFS in promoting postural alignment. At this time they are speculative, and will require further investigation. However, regardless of the mechanism, this study demonstrated that the CFS improved postural alignment for all participants. Despite some variability in the data, particularly during baseline for Participant 1, there are no overlapping data points during the intervention phase for the CFS and the other treatment at any time, for any participant. These data strongly support a causal relationship between the CFS and improved postural alignment in midline for infants with neuromotor impairments.

The importance of improved postural alignment and the implications of these findings for infants and their caregivers must be interpreted cautiously. Prevention of deformities as a result of improved postural alignment is often purported to be a benefit of adaptive seating devices in the seating literature (Bergen, Presperin & Tallman, 1990; Trefler, 1984; Ward, 1984). However, in view of limited empirical data, a causal relationship cannot be assumed. Many of the long-term benefits of recommended positioning techniques for children with neuromotor impairments are at the present time speculative, and will require controlled, longitudinal studies.

According to the systems theory, experience and learning are essential elements in the development of motor skills. Experience in antigravity positions as a factor in developing postural control is an important variable in need of further research. It has been hypothesized that as children gain experience in antigravity positions, sensory-motor maps develop (Shumway-Cook & Woollacott, 1995). These sensory-motor maps are used to develop appropriate internal representations that are matched to input from other systems such as vision, somatosensory, and vestibular. Positioning in adaptive seating devices that allows experience in antigravity positions may contribute to the development of sensory-motor maps, and in turn to the development of postural control. It is also feasible that improper selection and use of adaptive seating devices may result in restriction of movement in antigravity positions, instead of affordance of movement opportunities. Sound clinical decision making should incorporate ongoing re-evaluation of the necessity for the external support that adaptive seating devices provide, with frequent opportunities to observe children with less support while engaged in functional activities. Similarly, in clinical research activities the insertion of a no-treatment probe during the intervention phase in an alternating treatments design provides an opportunity to check if maturation or carryover effects of an adaptive seating device are factors.

In addition to theoretical implications, there are several practical implications for the finding of improved postural alignment. First, the CFS was effective in providing an upright sitting position for some infants who were previously not able to maintain the position. The CFS was a very low-cost intervention that could easily be fitted to a variety of commercial highchairs, thus eliminating the need to purchase expensive adaptive equipment. Since the device was so cost effective, more than one CFS could be fabricated for a given infant, so that parents would be able to use it as a floor sitter or as an insert in a stroller. The CFS could easily be modified or replaced to accommodate growth or changing postural support needs. Finally, some parents reported that the CFS was cost effective in terms of their time in that they did not have to continually rearrange rolled towels to help their infants sit straight in highchairs.

Dependent Variable 2: Engagement with Toys

As recommended by Campbell (1990), research studies of children with neuromotor impairments need to focus not only on traditional outcomes such as improved posture, but should also include changes in related functional performance. Similarly, Reid (1996) cautions against stabilizing children to "look perfect" when the positioning system may cause a loss in function. The second dependent variable in this study, engagement with toys, was selected as representative of a functional upper extremity activity developmentally appropriate for infants 9 to 24 months of age. For purposes of this study, engagement with toys was defined as "manipulation of a toy with one or both hands." Two types of data were recorded as measures of engagement with toys: 1) the number of hands in contact with the toy, and 2) the number of hands or forearms in contact with the highchair tray. Bimanual play (i.e., intervals when two hands were in contact with the toy) and intervals when the infant had no hands or forearms in contact with the tray while simultaneously contacting a toy with one or both hands were felt to reflect increased function and freedom of movement in the upper extremities, and were graphed and analyzed.

As seen in Figures 5-12, results were variable, with no clear effect of the CFS on bimanual play with toys for any participant, and some effect of the CFS in facilitating no hand/forearm support for two participants, Colin and Shanti. These findings will first be interpreted in relation to the developmental theory that midline orientation and proximal stability facilitate movement and function of the upper extremities (Boehme, 1988). Based on feedback from clinicians, it was hypothesized that infants may be able to engage in bimanual play with toys more frequently if they are not using one hand to grasp the lip of the highchair tray, or propping on one hand to provide distal stabilization. Thus, if the infants do not have to concentrate as hard on remaining upright, they may be able to explore the toys in a greater variety of ways.

The data for bimanual play with toys indicate that infants' hand-to-toy contact was similar regardless of their postural alignment. There are several possible reasons for these findings. First, the data for hands/forearms free from support (Figures 6, 8, 10, and 12) indicate that the infants generally kept at least one upper extremity in contact with the highchair tray during most intervals, which may have limited the ability to have that upper extremity in contact with a toy. Second, the toys were selected to offer opportunities for bimanual play, but they did not require two hands to lift or explore. Thus, motivation to use both hands could not be controlled, and may have been a factor. Finally, the measurement system may be a factor which influenced results. Instead of momentary time sampling, perhaps the duration of time engaged in bimanual play would have been a significant variable.

Results of the effect of the CFS on hand/forearm contact with the tray varied across participants. Lucas demonstrated some increased time with no hand/forearm support toward the end of the intervention phase (Figure 6), suggesting a possible learning effect in his ability use his arms more freely. David's ability to free his arms from support appeared more related to his level of fatigue than to either type of seating intervention (Figure 8). A clear effect of the CFS in promoting increased time with arms free from support was evident for Colin (Figure 10). In addition, during viewing of the videotapes by the investigator, Colin was anecdotally noted to have increased variety of his hand movements and more individualized finger movements while seated in the CFS. Colin was the participant who was rated as having the highest level of postural support on the Level of Sitting Scale (Roxborough et al., 1994) at enrollment into the study. This higher level of initial postural control may have been a factor in Colin's improved freedom of movement in the upper extremities relative to the other participants. For Shanti, percent of time with hands/arms free from support (Figure 12) was increased when using the CFS (i.e., 20% versus 4% during baseline). Although Shanti did not lean on her left forearm as frequently when seated in the CFS as she did during baseline, she still did not demonstrate increased bimanual play during the intervention phase. This was most likely due to the degree of spasticity and sensory impairment of her right upper extremity.

A possible factor contributing to the inconsistent effects of the CFS on ability to free the arms from support relates to the measurement system. In this study, there was no effort made to qualify the variable of hands/forearms in contact with the tray. While viewing videotapes, raters were simply instructed to record the number of hands or forearms in contact with the highchair tray. Thus, there was no means for raters to distinguish between weight bearing in the upper extremities for support (i.e., leaning) versus light contact (i.e., resting) of the upper extremities on the highchair tray for convenience. The infants could obviously not respond to verbal cues such as, "Raise both arms over your head." Over time, there are likely to be differences in functional upper extremity use if postural instability requires an individual to keep one hand positioned for support versus the serendipitous placement of a hand or forearm on a convenient surface. However, these variables were not able to be evaluated in this study.

A second possible factor that may have influenced potential effects of the CFS on freedom of mobility in the upper extremities relates to the design of the CFSs. In a clinical setting, additional lateral trunk support can be provided by increasing the height of foam supports along the child's trunk. The height of lateral supports is thus individualized and determined by the child's postural support needs. However, in this study the foam side supports needed to be below the level of the highchair tray so that they were hidden from the raters' view. It is possible that for some participants additional postural support as provided by lateral trunk supports may have facilitated upper extremity function.

As described in Chapter Two, results of studies examining the effects of various adaptive seating devices on upper extremity function are conflicting. Improvements in upper extremity performance of children with cerebral palsy have been associated with seating systems that provided an upright (Nwaobi, 1987) or slightly forward-tipped (Myhr & von Wendt, 1991) seating systems. The finding in this study that upper extremity function varied both within and across participants has practical implications for researchers. One of the most challenging issues facing researchers of children with neuromotor impairments is the within-subject and between-subject variability of this population. Children with neuromotor impairments, even those of similar diagnostic categories, are notoriously heterogeneous. In addition to between-subject variability related to neuromotor characteristics, variability of mood and state regulation can influence the performance of individual infants. Group studies in which data are pooled and analyzed on the basis of two measurements (i.e., pre- and post-test) typically do not allow the investigator to identify sources of variability and make design alterations. The alternating treatments design with repeated measures over time enables the investigator to control for more threats to internal validity, and can demonstrate causal relationships between given treatments and infants' performances.

If it can be assumed that the CFS provided stability for the infants as demonstrated by their ability to maintain upright sitting, the theory of proximal stability facilitating upper extremity function and mobility was not supported for all participants in this study. However, it is suggested that findings from this study are not inconsistent with the theory for the following reasons. It has been proposed that there are multiple systems contributing to postural control (Shumway-Cook & Woollacott, 1995). These include musculo-skeletal components, sensory systems and strategies, neuromuscular synergies, anticipatory and adaptive mechanisms, and internal representations. The manner in which these systems are organized is dependent upon the functional task and environmental constraints. It is suggested that the CFS may have a role in modifying some of the systems (e.g., musculoskeletal components, sensory systems), but that the interaction of multiple systems is required for functional movement to emerge. Thus, the postural support that the CFS provided may be a necessary but not sufficient component for functional movement. This parallels the findings of Case-Smith et al. (1989) who suggested that while there may be a relationship between proximal and distal motor control in typically developing infants, it is not a cause and effect relationship.

It is further suggested that the demands of the motor task are a critical component in the emergence of postural control and motor skill. An example of the relationship between task demands and motor skill was observed coincidentally during this study while videotaping David after a data collection session in his home. Over a 5-minute period as his mother placed several hats in succession on his head, David (while sitting in the CFS) was repeatedly able to lift both arms overhead to remove each hat. Although data from this study (Figure 8) do not demonstrate this ability, David was clearly able to free both arms from the support of the highchair tray when motivated to do so. Thus, other dependent measures (i.e., tasks) may be more reflective of functional upper extremity activity for young children. Some of these may include qualitative measures of hand function, duration of independent play, and self-feeding ability.

Dependent Variable 3: Parental Perceptions

While not intended to be a primary dependent measure, the assessment of parental perceptions of the seating intervention was included for several reasons. First, federal legislation recognizes the family as a client in early intervention services, and feedback from family members is an essential component of family-centered research (McGonigel, 1988). Second, the inclusion of social validity measures is a recommended practice in the evaluation of early intervention services (Schwartz & Baer, 1991), since it doesn't matter if an intervention is effective if parents will not use it. Finally, it is a logical assumption that the evaluation of functional outcomes for children with disabilities should include naturalistic settings such as the home where a variety of functional skills can be observed over extended periods of time.

The mothers of participants in this study were specifically asked about their perceptions of the effects of the CFS on postural alignment and upper extremity function. All mothers corroborated the observational measures that demonstrated the effectiveness of the CFS in promoting improved postural alignment. They indicated that their infants sat straighter in the CFS, some mothers reported that they no longer had to use rolled towels when feeding their infants, and one mother reported that she no longer had to kneel on the floor as she fed her infant in her walker. While the observational measures did not demonstrate significant effects of the CFS on engagement with toys for all participants, all mothers described instances when their infants had demonstrated improved manipulation (e.g., transferring hand to hand) of toys when seated in the CFS.

All mothers reported that the CFS was easy to use, and that they used it consistently. In contrast to the 5-minute observation periods during data collection, mothers were able to observe their infants in the CFS several times daily for extended periods of time. Used as part of their daily routines, mothers were able to identify several perceived benefits of the CFS not examined in this study. These benefits were described as positive outcomes both for themselves and their infants. An unexpected finding was that of the reported increase in social interaction for infants as a result of sitting in the CFS. Three of four mothers described the new opportunities their infants had to engage with others, how the infants enjoyed being a part of the group at the dinner table, and how the face-to-face position was beneficial for imitating facial expressions.

All mothers also described perceived benefits for themselves as a result of using the CFS. They indicated that they had more time for household tasks because the CFS provided their infants with a comfortable position for play where they were contented. One mother, in describing positioning strategies she had used prior to the CFS, responded in part:

> "I would try to pillow him in sometimes with three pillows, but they would always disassemble...and then we would have him in the playpen on his stomach or his back...or sitting in between my legs, which I could waste away a good part of the afternoon doing that but there are times when I just can't do that all day... so it's nice to have something hug him so tightly around his back and give him support without it always being us." (David's mother)

Two mothers stated that they had feelings of peace of mind and lessened anxiety because they knew the CFS was a safe, comfortable, positioning device that enabled their infants to perform skills (e.g. self-feeding, play) that they previously could not do independently. This feedback from mothers provides practical suggestions for researchers. These parents speak to the value of family resources such as time and energy, variables that have been typically overlooked as outcome measures for studies examining adaptive equipment.

The mothers in this study provided a more holistic view of their infants' lives within the context of the family, and also provided insights into potential outcome measures that are functional for infants and meaningful to parents. As recommended by Palisano, Campbell, and Harris (1994), a primary concern of physical therapists should be secondary prevention to limit impairment (e.g., muscle shortening, sensory deficits) and thus minimize functional limitations. Physical therapists and occupational therapists involved in this study were concerned about the potential musculoskeletal and orthopedic benefits (e.g., improved postural alignment, prevention of deformities) of adaptive seating devices, as well as with potential effects on upper extremity function. Mothers considered the opportunities for greater independence in play and social interactions that the CFS allowed them and their infants to be of major importance. These differing perspectives parallel different levels of the disabling process as conceived by the National Center for Medical Rehabilitation Research (NCMRR), with therapists more focused at the impairment and functional limitation levels, and parents more concerned at the disability level with their infants' abilities to perform tasks such as self-feeding, play, and engagement with family members. These insights from participants' mothers relating to the social and contextual repercussions of neuromotor impairments are valuable information for the planning of future studies.

Based on feedback from the mothers, it appears that the CFS was effective in facilitating opportunities for their infants that resulted in improved performance in a variety of areas. This improvement may be related to the development of adaptive and anticipatory mechanisms as a result of the infants' new experiences in a vertical environment (Shumway-Cook & Woollacott, 1993). As suggested in systems theory of postural control, with increasing experience the infant learns to predict the postural requirements associated with various tasks and environments. Further research is necessary to examine the effects of experience on acquisition of functional motor skills in infants with neuromotor impairments.

Limitations

Several steps were taken in designing this study to make it clinically relevant, and to minimize threats to internal and external validity. Despite design considerations, this study had several limitations. The first of these related to the fabrication phase of the CFS. The clinician who fabricated the CFSs for this study had six years experience in the fabrication and use of CFSs. She also taught workshops for therapists in the design and fabrication of CFSs. Her level of experience and expertise with CFSs was not similar to the typical clinician. Thus, it is not known whether other therapists would be able to employ the same degree of problem solving in designing CFSs, or would demonstrate similar manual skills in the fabrication stage. This raises concerns related to an aspect of procedural validity which White (1984) described as "the degree to which a program, as implemented during the course of an evaluation, can be replicated or functionally approximated outside of the conditions of the evaluation" (p. 107).

A second limitation was the measurement system and its relationship to the confounding variable of the infants' motivation. It seemed appropriate to consider engagement with toys as a functional upper extremity activity for infants. Toys were selected that were felt to be visually appealing and more interesting for the infants to manipulate with two hands. Indeed, the infants appeared highly motivated to engage with the toys throughout the entire study, regardless of the seating intervention. However, the two types of data collected (i.e., number of hands in contact with a toy and number of hands or forearms in contact with the tray) did not necessarily measure the infants' upper extremity function because the infants were able to explore the toys in a variety of ways without demonstrating skills considered to be the most optimal (i.e., bimanual play with toys and play with toys with hands or forearms free from support). In other words, the task (i.e., engage with toys) the infants were presented with did not require them to demonstrate the dependent measures to be successful, and they could not be coaxed to demonstrate their "best performance." Other dependent measures may be more reflective of functional upper extremity performance for infants, particularly infants with more limitations in reaching and manipulation skills than the participants in this study. A more sophisticated technology (e.g., three-dimensional motion analysis system) for data recording would provide the researcher with both quantitative and qualitative data that may be more reflective of the functional upper extremity skills of infants.

The small sample size is the most significant factor limiting generalizability of findings. Findings obviously cannot be generalized to children of different ages, or with different diagnoses, and replication will be necessary to provide external validity. The process of replicating studies to allow generalization has been described by Kazdin (1972). First, direct replication is conducted in which the study is replicated on a number of children, allowing generalizability across participants. Then systematic replication can be done which explores the effects of the intervention in different settings and with therapists having varying levels of expertise.

Suggestions for Future Research

It is hoped that this study will provide an impetus for further studies examining the effects of adaptive seating devices for young children with neuromotor impairments. Given the current state of limited fiscal and human resources, it is imperative that physical and occupational therapists participate in outcomes-based research that documents the efficacy and acceptability of their interventions. Reliance on theoretical constructs as the basis for interventions will not be acceptable for the continued support of third-party payers. Accountability and documentation of scientifically based practice are essential.

The following recommendations may contribute to the design and conduct of seating studies for young children with neuromotor impairments. First, the use of single-subject designs has potential for conducting well controlled clinical research studies with this population. A major threat to internal validity of group designs is the potential masking of treatment effects due to the marked heterogeneity of children with neuromotor impairments. In contrast, some of the single-subject designs such as the alternating treatments design have the ability to demonstrate causal relationships between given treatments and subject performance while controlling for potential threats to internal validity (Ottenbacher, 1986). These designs are typically more cost-effective to implement than group designs in terms of time and manpower.

A major concern in research relates to the sensitivity, reliability, and validity of the measurement tools. This study employed observational techniques to assess outcome measures. In addition to observational measures, valid and reliable assessment tools are necessary to document functional changes for young children as a result of using adaptive seating devices. Currently there are new assessment tools such as the Seated Postural Control Measure (Roxborough et al., 1994), the Sitting Assessment Scale (Myhr et al., 1993), and the Sitting Assessment for Children with Neuromotor Dysfunction (Reid, 1995) which are undergoing reliability and validity studies as part of ongoing test development. These measures should assist clinicians in the continued testing of theory which informs clinical practice.

A strength of this study was the fact that data were collected in the infants' homes. Clients' functional skills are often best demonstrated in naturalistic settings such as home and school versus the therapeutic setting. The inclusion of these settings in research efforts will not only give researchers insight into skills necessary for children to function in their daily lives, but also will strengthen the validity and generalizability of findings.

Additional studies examining the effects of the CFS for children representing a variety of age and diagnostic groups would support external validity. Dependent measures that reflect functional skills in the child's typical environment (e.g., self-feeding) versus the clinical setting need to be included. This study demonstrated a reliable, low-cost measurement system that clinicians can use to evaluate effects of seating interventions on postural alignment for young children. Videocameras are now standard equipment in homes, schools, hospitals, and developmental centers. Thus, it seems feasible that this study could be replicated fairly easily by clinicians.

It is critical that clinicians become aware of the limitations of their interventions, and avoid the indiscriminate use of interventions for which there is no documented efficacy. Further research, including publication of studies demonstrating negative effects, is necessary to identify those features of adaptive seating devices that are most efficacious for children. Only through the systematic documentation of treatment efficacy across a variety of subjects and settings will theory be validated and sound intervention decisions be made.

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APPENDIX A: Level of Sitting Scale (LSS)
by Roxborough, Fife, Story, and Armstrong (1994)

The eight levels of the LSS are based on the amount of support required to maintain the sitting position and, for those children who can sit independently without support, the stability of the child while sitting.

LSS Administration

The child is in a sitting position on a high mat or bench with the thighs supported to the back of the knees and feet unsupported. The "sitting position" is defined as follows:

> The child's hips and trunk can be flexed sufficiently so that the trunk (defined by a line joining the first thoracic vertebra and the sacrum) is inclined at least 60 degrees, and; the child's head position is either neutral with respect to the trunk or flexed, and; the position can be maintained for a minimum of 30 seconds, with due regard for the comfort and safety of the child.

Note: Maintenance of sitting for 30 seconds is required to pass Levels 2 to 5. If the child has passed Level 5, it is not necessary to again maintain the position to pass Levels 6 to 8.

To assess the level of sitting, the child is first asked or assisted to assume the sitting position. If the sitting position is independently maintained for 30 seconds, the child is then requested to shift his trunk and re-erect or is encouraged to do so by being offered a toy to reach.

Level	Descriptor	Definition
1	Unplaceable	Child cannot be placed or held by one person in sitting position
2	Supported from head downward	Child requires support of head, trunk and pelvis to maintain sitting position
3	Supported from shoulders or trunk downward	Child requires support of trunk and pelvis to maintain sitting
4	Supported at pelvis	Child requires support only at the pelvis to maintain sitting
5	Maintains position, does not move	Child maintains the sitting position independently if he/she does not move limbs or trunk
6	Shifts trunk forward, re-erects	Child, without using hands for support, can incline the trunk at least 20 degrees anterior to the vertical plane and return to
7	Shifts trunk laterally, re-erects	Child, without using hands for support, can incline the trunk at least 20 degrees to one or both sides of midline and return to the neutral position
8	Shifts trunk backward, re-erects	Child, without using hands for support, can incline the trunk at least 20 degrees posterior to the vertical plane and return to the neutral position

APPENDIX B: Parent Interview Guide

(Before beginning, thank parent for participation, explain purpose of interview, ask if they have any questions, explain reason for tape recording.)

1) Tell me how you used the foam seat.

   Probes:

   - How frequently did you use the foam seat with your child? (e.g. at every meal, once daily, 2-3 times per week, never).

   - When (i.e. during what activities) and where (at home, grandparents' home, etc.) did you use it?

2) Before the foam seat was given to you three weeks ago, what positions was your child in for eating? For play?

3) Since the foam seat was given to you three weeks ago, what positions has your child been in for eating? For play?

4) How did using the foam seat affect your child's ability to sit upright?

   - Probe for potential negative and positive effects

5) How did using the foam seat affect your child's ability to grasp and play with toys?

   - Probe for potential negative and positive effects

6) Are there any other changes in your child's behavior that you notice when he/she is sitting in the foam seat? (If Yes, please describe.)

7) What has the impact of the foam seat been on your caregiving responsibilities (e.g., feeding your child, playing with your child, taking your child to others' homes, etc.)?

8) What is your overall attitude about the foam seat?

APPENDIX C: Rater's Scoring Sheets

Participant #________ Date ______ Session # ____ Rater __________

Interval	Video 1: Alignment				
1	R2	R1	O	L1	L2
2	R2	R1	O	L1	L2
3	R2	R1	O	L1	L2
4	R2	R1	O	L1	L2
5	R2	R1	O	L1	L2
6	R2	R1	O	L1	L2
7	R2	R1	O	L1	L2
8	R2	R1	O	L1	L2
9	R2	R1	O	L1	L2
10	R2	R1	O	L1	L2
11	R2	R1	O	L1	L2
12	R2	R1	O	L1	L2
13	R2	R1	O	L1	L2
14	R2	R1	O	L1	L2
15	R2	R1	O	L1	L2
16	R2	R1	O	L1	L2
17	R2	R1	O	L1	L2
18	R2	R1	O	L1	L2
19	R2	R1	O	L1	L2
20	R2	R1	O	L1	L2
21	R2	R1	O	L1	L2
22	R2	R1	O	L1	L2
23	R2	R1	O	L1	L2
24	R2	R1	O	L1	L2
25	R2	R1	O	L1	L2
26	R2	R1	O	L1	L2
27	R2	R1	O	L1	L2
28	R2	R1	O	L1	L2
29	R2	R1	O	L1	L2
30	R2	R1	O	L1	L2

No. of times child requires repositioning____________

Rating of child's predominant state:

1. **Happy, e.g. smiling**
2. **Neutral**
3. **Periodic fussing, whining**

Comments:

Interval	Video 2: Alignment				
1	R2	R1	O	L1	L2
2	R2	R1	O	L1	L2
3	R2	R1	O	L1	L2
4	R2	R1	O	L1	L2
5	R2	R1	O	L1	L2
6	R2	R1	O	L1	L2
7	R2	R1	O	L1	L2
8	R2	R1	O	L1	L2
9	R2	R1	O	L1	L2
10	R2	R1	O	L1	L2
11	R2	R1	O	L1	L2
12	R2	R1	O	L1	L2
13	R2	R1	O	L1	L2
14	R2	R1	O	L1	L2
15	R2	R1	O	L1	L2
16	R2	R1	O	L1	L2
17	R2	R1	O	L1	L2
18	R2	R1	O	L1	L2
19	R2	R1	O	L1	L2
20	R2	R1	O	L1	L2
21	R2	R1	O	L1	L2
22	R2	R1	O	L1	L2
23	R2	R1	O	L1	L2
24	R2	R1	O	L1	L2
25	R2	R1	O	L1	L2
26	R2	R1	O	L1	L2
27	R2	R1	O	L1	L2
28	R2	R1	O	L1	L2
29	R2	R1	O	L1	L2
30	R2	R1	O	L1	L2

No. of times child requires repositioning____________

Rating of child's predominant state:

1. **Happy, e.g. smiling**
2. **Neutral**
3. **Periodic fussing, whining**

Comments:

Participant # ________ Date _______ Session # ____ Rater ____________

Interval	Video 1: No. of Hands Engaged with Toy			Interval	Video 1: No. of Hands/Forearms on Tray		
1	0	1	2	1	0	1	2
2	0	1	2	2	0	1	2
3	0	1	2	3	0	1	2
4	0	1	2	4	0	1	2
5	0	1	2	5	0	1	2
6	0	1	2	6	0	1	2
7	0	1	2	7	0	1	2
8	0	1	2	8	0	1	2
9	0	1	2	9	0	1	2
10	0	1	2	10	0	1	2
11	0	1	2	11	0	1	2
12	0	1	2	12	0	1	2
13	0	1	2	13	0	1	2
14	0	1	2	14	0	1	2
15	0	1	2	15	0	1	2
16	0	1	2	16	0	1	2
17	0	1	2	17	0	1	2
18	0	1	2	18	0	1	2
19	0	1	2	19	0	1	2
20	0	1	2	20	0	1	2
21	0	1	2	21	0	1	2
22	0	1	2	22	0	1	2
23	0	1	2	23	0	1	2
24	0	1	2	24	0	1	2
25	0	1	2	25	0	1	2
26	0	1	2	26	0	1	2
27	0	1	2	27	0	1	2
28	0	1	2	28	0	1	2
29	0	1	2	29	0	1	2
30	0	1	2	30	0	1	2

Comments:

Interval	Video 2: No. of Hands Engaged with Toy			Interval	Video 2: No. of Hands/Forearms on Tray		
1	0	1	2	1	0	1	2
2	0	1	2	2	0	1	2
3	0	1	2	3	0	1	2
4	0	1	2	4	0	1	2
5	0	1	2	5	0	1	2
6	0	1	2	6	0	1	2
7	0	1	2	7	0	1	2
8	0	1	2	8	0	1	2
9	0	1	2	9	0	1	2
10	0	1	2	10	0	1	2
11	0	1	2	11	0	1	2
12	0	1	2	12	0	1	2
13	0	1	2	13	0	1	2
14	0	1	2	14	0	1	2
15	0	1	2	15	0	1	2
16	0	1	2	16	0	1	2
17	0	1	2	17	0	1	2
18	0	1	2	18	0	1	2
19	0	1	2	19	0	1	2
20	0	1	2	20	0	1	2
21	0	1	2	21	0	1	2
22	0	1	2	22	0	1	2
23	0	1	2	23	0	1	2
24	0	1	2	24	0	1	2
25	0	1	2	25	0	1	2
26	0	1	2	26	0	1	2
27	0	1	2	27	0	1	2
28	0	1	2	28	0	1	2
29	0	1	2	29	0	1	2
30	0	1	2	30	0	1	2

Comments:

APPENDIX D: Percent of Intervals in Midline

TABLE 3: Percent of Intervals in Midline - Lucas

Session	Video 1	Video 2	Foam Liner	Foam Seat
1	17%	30%		
2	27%	97%		
3	63%	20%		
4	13%	3%		
5			13%	83%
6			73%	100%
7			20%	100%
8			10%	83%
9			0%	82%
10	3%			97%
11			3%	75%
12			7%	77%
4.5	0%			
4.5	100%			

TABLE 4: Percent of Intervals in Midline - David

Session	Video 1	Video 2	Foam Liner	Foam Seat
1	26%	32%		
2	26%	42%		
3	27%	41%		
4			30%	100%
5			64%	100%
6			77%	100%
7			32%	100%
8			33%	100%
9			60%	100%
10		3%		97%
11			46%	100%
12				
3.5	0%			
3.5	100%			

TABLE 5: Percent of Intervals in Midline - Colin

Session	Video 1	Video 2	Foam Liner	Foam Seat
1	30%	48%		
2	0%	3%		
3	37%	43%		
4			0%	100%
5			3%	97%
6			7%	93%
7			3%	100%
8			10%	100%
9			0%	100%
10		31%		100%
11			0%	100%
12				
3.5	0%			
3.5	100%			

TABLE 6: Percent of Intervals in Midline - Shanti

Session	Video 1	Video 2	Foam Liner	Foam Seat
1	17%	3%		
2	10%	17%		
3	11%	0%		
4			0%	100%
5			7%	100%
6			0%	100%
7			53%	100%
8			0%	100%
9	7%			100%
10			19%	89%
11			7%	100%
12				
3.5	0%			
3.5	100%			

APPENDIX E: Percent of Intervals Hands On Tray and Toy

TABLE 7: Percent of Intervals Hands on Tray and Toy - Lucas

Session	Video #	Condition	Session	2 Hands on Toy	No Hands On Tray; 1 or 2 Hands on Toy
1	1	Baseline	1	57%	7%
2	1	Baseline	2	20%	3%
3	1	Baseline	3	30%	0%
4	1	Baseline	4	50%	0%
10	1	Baseline	10	20%	0%
1	2	Baseline	1.3	30%	3%
2	2	Baseline	2.3	37%	7%
3	2	Baseline	3.3	63%	13%
4	2	Baseline	4.3	10%	0%
5	2	Foam Liner	5.3	13%	0%
6	1	Foam Liner	6	80%	0%
7	1	Foam Liner	7	47%	0%
8	2	Foam Liner	8.3	57%	0%
9	2	Foam Liner	9.3	53%	10%
11	2	Foam Liner	11.3	7%	17%
12	1	Foam Liner	12	40%	3%
5	1	Foam Seat	5	67%	10%
6	2	Foam Seat	6.3	43%	0%
7	2	Foam Seat	7.3	37%	7%
8	1	Foam Seat	8	67%	0%
9	1	Foam Seat	9	37%	3%
10	2	Foam Seat	10.3	60%	7%
11	1	Foam Seat	11	21%	17%
12	2	Foam Seat	12.3	37%	30%

TABLE 8: Percent of Intervals Hands on Tray and Toy - David

Session	Video #	Condition	Session	2 Hands on Toy	No Hands On Tray; 1 or 2 Hands on Toy
1	1	Baseline	1	0%	23%
2	1	Baseline	2	0%	18%
3	1	Baseline	3	0%	28%
1	2	Baseline	1.3	0%	19%
2	2	Baseline	2.3	0%	33%
3	2	Baseline	3.3	0%	11%
10	2	Baseline	10.3	3%	3%
4	2	Foam Liner	4.3	0%	10%
5	2	Foam Liner	5.3	0%	7%
6	1	Foam Liner	6	0%	30%
7	2	Foam Liner	7.3	0%	20%
8	1	Foam Liner	8	0%	47%
9	1	Foam Liner	9	3%	53%
11	1	Foam Liner	11	3%	17%
4	1	Foam Seat	4	0%	30%
5	1	Foam Seat	5	0%	14%
6	2	Foam Seat	6.3	0%	7%
7	1	Foam Seat	7	0%	13%
8	2	Foam Seat	8.3	0%	20%
9	2	Foam Seat	9.3	0%	10%
10	1	Foam Seat	10	0%	7%
11	2	Foam Seat	11.3	0%	43%

TABLE 9: Percent of Intervals Hands on Tray and Toy - Colin

Session	Video #	Condition	Session	2 Hands on Toy	No Hands On Tray; 1 or 2 Hands on Toy
1	1	Baseline	1	47%	10%
2	1	Baseline	2	57%	0%
3	1	Baseline	3	73%	17%
1	2	Baseline	1.3	67%	33%
2	2	Baseline	2.3	63%	20%
3	2	Baseline	3.3	47%	25%
10	2	Baseline	10.3	14%	11%
4	2	Foam Liner	4.3	23%	0%
5	1	Foam Liner	5	50%	0%
6	2	Foam Liner	6.3	40%	0%
7	2	Foam Liner	7.3	20%	7%
8	2	Foam Liner	8.3	50%	0%
9	1	Foam Liner	9	28%	7%
11	1	Foam Liner	11	57%	10%
4	1	Foam Seat	4	37%	13%
5	2	Foam Seat	5.3	73%	47%
6	1	Foam Seat	6	63%	27%
7	1	Foam Seat	7	97%	80%
8	1	Foam Seat	8	40%	43%
9	2	Foam Seat	9.3	67%	43%
10	1	Foam Seat	10	73%	40%
11	2	Foam Seat	11.3	33%	20%

TABLE 10: Percent of Intervals Hands on Tray and Toy - Shanti

Session	Video #	Condition	Session	2 Hands on Toy	No Hands On Tray; 1 or 2 Hands on Toy
1	1	Baseline	1	0%	7%
2	1	Baseline	2	0%	3%
3	1	Baseline	3	0%	7%
9	1	Baseline	9	40%	3%
1	2	Baseline	1.3	7%	3%
2	2	Baseline	2.3	10%	3%
3	2	Baseline	3.3	0%	0%
4	2	Foam Liner	4.3	23%	3%
5	1	Foam Liner	5	23%	0%
6	2	Foam Liner	6.3	10%	0%
7	1	Foam Liner	7	13%	20%
8	1	Foam Liner	8	7%	0%
10	2	Foam Liner	10.3	7%	0%
11	2	Foam Liner	11.3	27%	0%
4	1	Foam Seat	4	13%	0%
5	2	Foam Seat	5.3	0%	23%
6	1	Foam Seat	6	20%	50%
7	2	Foam Seat	7.3	13%	0%
8	2	Foam Seat	8.3	27%	30%
9	2	Foam Seat	9.3	3%	0%
10	1	Foam Seat	10	10%	37%
11	1	Foam Seat	11	0%	17%

APPENDIX F: Procedural Reliability Checklist

Participant No. _____ Session No. ____ Video No. ____ Date_________ Rater _____

Procedure Completed

Yes	No	NA		
___	___	___	1.	During alternating treatments phase, randomly selects order of treatments by flipping coin.
___	___	___	2.	Palpates and marks both acromions on child.
___	___	___	3.	Checks that fabric drape is in place.
___	___	___	4.	Includes data collection info. (i.e. participant no., date, session and video no.) on placard and records in subject's file and on videotape.
___	___	___	5.	Secures seatbelt unless child is seated in insert.
___	___	___	6.	Times 2-minute free play period with stopwatch.
___	___	___	7.	Positions child so that nose is in alignment with vertical dowel.
___	___	___	8.	Presents toy at midline of tray to signal beginning of first 5-minute observation.
___	___	___	9.	If child does not visually attend to toy or touch toy within 20 secs., removes toy and presents new toy.
___	___	___	10.	Times first 5-minute seating condition with timer in camera.
___	___	___	11.	If child becomes uncomfortable (e.g. cries for > 10 sec.), repositions child in midline.
___	___	___	12.	Removes child from seat for break and times 2-minute break.
___	___	___	13.	Secures seatbelt unless child is seated in insert.
___	___	___	14.	Times 2-minute free play period with stopwatch.
___	___	___	15.	Positions child so that nose is in alignment with vertical dowel.
___	___	___	16.	Presents toy at midline of tray to signal beginning of second 5-minute observation.
___	___	___	17.	If child does not visually attend to toy or touch toy within 20 secs., removes toy and presents new toy.
___	___	___	18.	Times second 5-minute seating condition with timer in camera.
___	___	___	19.	If child becomes uncomfortable (e.g. cries for > 10 sec.), repositions child in midline.
___	___	___	20.	If child has a change in attending due to environmental distraction (e.g. sibling interferes), stops taping until distraction is eliminated.
___	___	___	21.	If parent requests, investigator terminates session.

APPENDIX G: Coding Scheme for Parent Interviews

Major Code I: Positioning Before Seat (PBS)
Subcodes: 1) LAP-parent's lap
2) FLR-floor
3) EQP-other equipment

Major Code II: Foam Seat Use (USE)
Subcodes: 1) FRQ-frequency
2) LOC-location
3) ACT-activity (e.g., feeding, play, etc.)

Major Code III: Parental Attitudes re: Seat (ATT)
Subcodes: 1) POS-positive
2) NEG-negative

Major Code IV: Perceived Function for Child (CLD)
Subcodes: 1) SOC-social/communication
2) PLY-play
3) HND-hand use
4) SUP-postural support
5) FED-self-feeding
6) CON-contented/comfortable
7) IND-independence

Major Code V: Function for Parent (PAR)
Subcodes: 1) TIM-time
2) ENG-engagement with infant
3) EAS-ease of caregiving
4) POM-peace of mind

VITA
KATHLEEN WASHINGTON

EDUCATION

1996 Ph.D in Education, University of Washington, Seattle, WA.
1979 M.S in Exceptional Education, University of Wisconsin-Milwaukee, Milwaukee, WI.
1970 B.S. in Physical Therapy, Marquette University, Milwaukee, WI.

CURRENT POSITION

Head, Physical Therapy, Center on Human Development and Disability, University Washington, Seattle, WA.
Clinical Instructor, Department of Rehabilitation Medicine, University of Washington, Seattle, WA.

PUBLICATIONS

Washington, K., & Schwartz, I. S. (1996). Parental perceptions of the effects of physical and occupational therapy services on caregiving competency. Physical and Occupational Therapy in Pediatrics, 16, 33-53.

Washington, K., & Deitz, J. C. (1995). Performance of full-term 6-month-old infants on the Movement Assessment of Infants. Pediatric Physical Therapy, 7, 65-74.

Washington, K., Schwartz, I. S., & Swinth, Y. (1994). Physical and occupational therapists in naturalistic early childhood settings: Challenges and strategies for training. Topics in Early Childhood Special Education, 14, 333-349.

Washington, K., & Harris, S. R. (1989). Mental and motor performance of low-birthweight infants with normal developmental outcome. Pediatric Physical Therapy, 1, 159-165.

Washington, K. (1987). Neurodevelopmental outcome of low-birthweight infants with intraventricular hemorrhage: Annotated bibliography. Physical and Occupational Therapy in Pediatrics, 7, 91-101.

Tada, W., Crowe, T. K., & Washington, K. (1984). Physical therapy documentation: A model for the word processor. Physical Therapy, 65, 1394-1394.

HONORS/AWARDS

June 1996	Gatzert Child Welfare Fellowship ($4000)
February 1996	Doi Doctoral Research Award ($750)
Winter 1990	Distinguished Alumna Award, Marquette University Physical Therapy Alumni Association