UNIVERSITY OF ALBERTA

THE PREDICTIVE VALUE OF THE ASYMMETRICAL TONIC NECK REFLEX IN MOTOR OUTCOME STUDIES OF NEONATAL INTENSIVE CARE SURVIVORS

by

SYLVIA A. WILSON ©

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled **THE PREDICTIVE VALUE OF THE ASYMMETRICAL TONIC NECK REFLEX IN MOTOR OUTCOME STUDIES OF NEONATAL INTENSIVE CARE SURVIVORS** submitted by Sylvia A. Wilson in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE.**

Supervisor

Dated: April 12, 1990.

This Thesis is dedicated to the Department of Occupational Therapy, University of Alberta, the Glenrose Rehabilitation Hospital and to Dr. Charlene Robertson for their support through the years of my work in pediatrics.

ABSTRACT

This post-hoc study utilized the Database from the Neonatal Follow-Up Clinic, Glenrose Rehabilitation Hospital, Edmonton, Alberta. This study of 363 neonatal intensive care survivors examined the prevalence and developmental course of the asymmetrical tonic neck reflex (ATNR) at 3 1/2, 5 1/2 and 8 year assessment intervals and the relationship of a +ATNR at each assessment interval to motor outcome at eight years of age. The results of an analysis of frequency of a +ATNR indicated a high prevalence at the 3 1/2 year assessment interval with decreasing incidence between 3 1/2, 5 1/2 and 8 year assessment intervals. Chi-square analyses (alpha level 0.05) of the relationship of a +ATNR to outcome at 8 years suggest that a residual +ATNR at 8 years of age is highly indicative of dysfunctional motor outcome and that a +ATNR at the 5 1/2 year assessment interval is predictive of dysfunction of balance and equilibrium at age 8 years. Testing for the ATNR at the 5 1/2 year and 8 year assessment intervals is therefore a valuable screening tool. A residual +ATNR at 5 1/2 and 8 years of age would alert the examiner to potential motor dysfunction at age 8 years. Given the high prevalence of a +ATNR at the 3 1/2 year assessment interval a response at 3 1/2 years cannot be considered abnormal. Therefore testing for the ATNR at 3 1/2 years is not a valuable tool for prediction of abnormal motor outcome. The insights provided by this study enhance the collective knowledge of motor development and motor impairment in neonatal intensive care survivors.

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TABLE OF CONTENTS

CHAPTER PAGE

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

THE NEONATAL FOLLOW-UP CLINIC

The Neonatal Follow-Up Clinic, located at the Glenrose Rehabilitation Hospital in Edmonton, was established in 1974 as part of the Northern and Central Alberta Perinatal Program. The Clinic's objective was "the evaluation of neonatal intensive care in this region through documentation of the quality of cognitive, behavioral and motor performance of the survivors" (Robertson, 1980, p. vii). The Clinic provided a unique opportunity to document changes in the abnormal neurological signs observed in neonatal intensive care survivors.

More very low birth weight infants (<1250 grams) born in Alberta now survive, survival increasing from 35.5% in 1975, to 48.5% in 1978, and 57% in 1984 (Robertson & Etches, 1988). Similar changes in survival rates in other geographic regions have been reported by other researchers (Eilers, Desai, Wilson & Cunningham, 1986; Haas, Buchwald-Saal, Leidig & Mentzel, 1986; Steiner, Sanders, Phillips & Maddock, 1980; Stewart, Reynold & Lipscomb, 1981; Vohr & Coll, 1985). Robertson and Etches (1988) reported increased survival along with a decrease in the proportion of neurological impaired infants. However, it was apparent that pre-natal and post-natal complications in these infants continued to be potential threats to their development. The objective of the longitudinal study conducted by Robertson (1980) and team at the Glenrose Rehabilitation Hospital, was the determination of the impact of pre-natal and post-natal complications on the development of these children over the first eight years of their lives.

Two-thirds of the neonatal intensive care survivors followed by the Neonatal Follow-Up Clinic were pre-term infants at < 37 weeks gestation and many were of low birth weight: under 1,500 grams. Other risk factors observed included meningitis, intracranial hemorrhage, convulsions, neonatal encephalopathy associated with birth asphyxia, recurrent apnea requiring or not requiring ventilation, and cyanotic spells (Robertson, 1980).

DEVELOPMENT OF AT-RISK INFANTS

A variety of physical, psychological, behavioral and neurological disorders in children have been associated with prematurity, low birth weight and other characteristics of birth that place a child in an "at-risk" category (Campbell & Wilhelm, 1985; Drillien, 1972; Drillien, Thomson & Burgoyne, 1980; Gesell & Armatruda, 1947; Lee, 1977; Lubchenco, L.O., Horner, F.A., Reed, L.H., Hix, I.E., Metcalf, D., Cohig, R., Elliott, H.C. & Bourg, M., 1963; Parmalee & Schulte, 1970; Vohr & Coll, 1985; Wender, 1971). The abnormalities reported included cerebral palsy, epilepsy, mental deficiency, behavioral and reading disorders. In order to gain an understanding of individual differences in development, one must look at the fundamental processes of development (Laszlo & Bairstow, 1985). The current study focused on one specific aspect of motor development: reflex integration.

Most theorists in the study of human behavior accept that reflex integration is the foundation for movement (Flavel, 1973; Gilfoyle, Grady & Moore, 1981; Luria, 1973; Phillips, 1981). Reflexes present in the normal neonate and infant become integrated into voluntary movement with maturation. The apparent disappearance of primitive reflexes during the normal course of maturity is attributed to the development of higher cortical mechanisms. Presence beyond certain ages is considered a signal of possible neurological dysfunction (Umphred, 1985).

THE ASYMMETRICAL TONIC NECK REFLEX

The asymmetrical tonic neck reflex (ATNR) is considered a useful clinical observation in determining the maturation and integration of the central nervous system (Ayres, 1972; Bobath, 1971; Fiorentino, 1973). It was suggested that this reflex was normal in infancy and was gradually integrated in early childhood (Avery, 1987; Ayres, 1972; Bower, 1974; Coryell & Cardinali, 1979; De Quiros & Schrager, 1978; Fiorentino, 1973). Treatment theories such as Bobath's neurodevelopmental theory and Ayres' sensory-integrative theory, used by occupational therapists and other clinicians, also suggest that at later stages in development the ATNR, along with other primitive reflexes, is incorporated into more complex movement patterns allowing the development of refined motor skills (Zemke, 1980/81). Although the ATNR had been cited as one of the primitive reflexes "which occurs in the normal course of development and is considered important for early diagnosis of neurological abnormalities" (Coryell, Henderson & Liederman, 1982, p. 51), there has been little empirical data to support the premise that there is a relationship between integration of the ATNR and the development of motor skills.

PURPOSE OF THE STUDY

This study was a post-hoc analysis of the longitudinal data collected by the Neonatal Follow-Up Clinic research project on a large sample of neonatal intensive care survivors. Permission to use the Neonatal Follow-Up Clinic Database in this post-hoc study was received from the principle investigator (Appendix A).

The purpose of this study was to analyze the presence or absence of the ATNR in early childhood (independent variable), and to determine its association with normal or dysfunctional motor outcome at 8 years of age (dependent variable). By longitudinally and cross-sectionally studying abnormal neurological signs such as residual primitive reflexes, and looking at their association with dysfunction, the researcher hoped to identify or disqualify this as a predictor of a dysfunctional outcome.

CHAPTER II

RELATED LITERATURE

NEONATAL INTENSIVE CARE SURVIVORS

"The premature birth of a human infant is an experiment of nature that offers us the unique opportunity to study the ontogeny of the organization of the nervous system, and behavior in its earliest form" (Parmalee, 1975, p. 50). Infants born at < 37 weeks gestation are considered pre-term or premature (Prechtel, Fargel, Weinmann & Bakker, 1979).

In 1963 Lubchenco et al. noted a high death rate in pre-term infants many of whom were also of low birth weight. In Lubchenco's study, almost half of the sample of premature infants died at birth or shortly after birth. Of the 94 subjects remaining in the sample, 63 were followed longitudinally to study school performance. Forty-two of the 63 subjects (67%) exhibited some handicap at school age. After looking at the IQ of these subjects it was ascertained that 20 of 35 children with normal IQ had some difficulties in school. This accounted for 31% of the subject pool and included such difficulties as reading and number problems, speech deficits, emotional disturbances and grade repetition. To Lubchenco and associates these statistics indicated that there was a significant correlation between prematurity and birth weight and the presence of handicapping conditions at school age.

Drillien (1972) suggested that "the full extent of less serious impairments associated with low birth weight and other perinatal hazards cannot be assessed before six or seven years of age, when learning difficulties become apparent" (p. 575). Drillien et al. (1980) then went on to study longitudinally the subjects from Drillien's (1972) study. They assessed the development of the 261 subjects at 6 1/2 - 7 years of age. They found that those children with a birth weight under 1500 grams, who had been assessed as neurologically normal in their first year of life, were at some disadvantage in all areas tested compared with control children, although only some differences were statistically significant. Those children who had displayed transient abnormal signs in their first year of life showed more highly significant differences from the control group. The motor scores were significantly different than the control group ($p < .001$). Through their study Drillien et al. suggested that the presence of abnormal neurological signs in the first year of life, exhibited by over 40% of low-birth-weight infants, was predictive of later school difficulties.

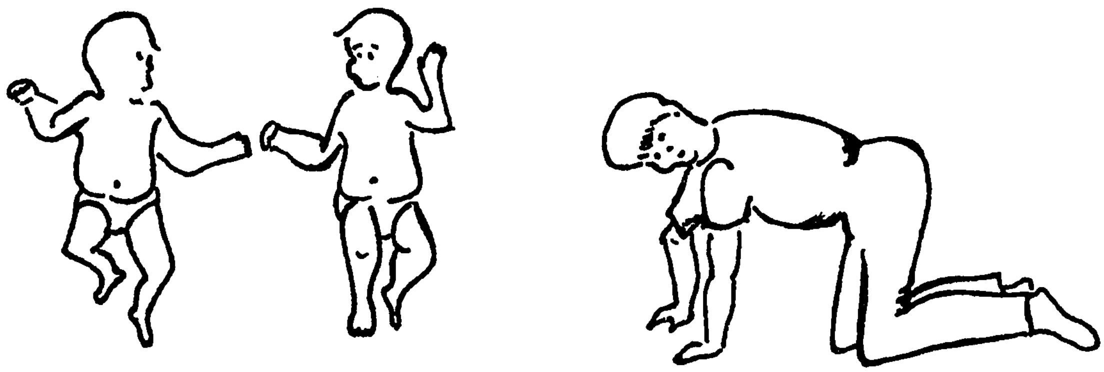
Lee (1977) studied 150 children at 5 and 6 years of age who had been classified according to birth weight. The children of low birth weight scored significantly lower on perceptual and motor skills than the other groups of children with medium and high birth weight ($F = 8.46$, $p < .01$). The mean score of the low birth weight children in tests of body image, balance and locomotor ability was significantly lower than the other two groups ($p < .01$).

Vohr and Coll (1985) indicated that 45% of pre-term children who tested as neurologically normal at one year, displayed poor visual-motor integration at school age. Seventy-five per cent of those children suspect for abnormal neurological status at one year of age also displayed poor visual-motor integration. One hundred per cent of the abnormal group at one year of age later displayed poor visual-motor integration.

In summary, follow-up studies have investigated the impact of an at-risk birth on the development of school related and motor skills (Campbell & Wilheim, 1985; Drillien et al., 1980; Lee, 1977; Lubchenco et al., 1963; Parmalee & Schulte, 1970; Vohr & Coll, 1985; Wender, 1971). Abnormal neurological signs in the first year of life were cited by some researchers as having possible predictive value for later developmental dysfunctions (Drillien et al., 1980; Saint-Anne Dargassies, 1972; Vohr & Coll, 1985). Primitive reflexes were hypothesized to have predictive value by Bigshy (1983) and Drillien et al. (1980). These studies, however, did not isolate individual reflexes to analyze their predictive value. In contrast, Dubowitz, Dubowitz, Palmer, Miller, Fawer and Levene (1984), felt that early neurological signs were not necessarily good predictors of later deficits.

THE SIGNIFICANCE OF THE ATNR AS A PREDICTOR

Primitive reflexes are involuntary, stereotyped, motor responses elicited by an outside stimulus and initially observed in early infancy (Capute, Accardo, Vining, Rubenstein & Harryman, 1978). In normal development, reflexes such as the ATNR (Figure 1) are integrated into higher level reactions facilitating the development of movement. In the observations of primitive reflexes it is "often not the initial severity of the neurological sign that is important to prognosis, but their persistence or speed of resolution" (Dubowitz & Dubowitz, 1981, p. 101).



When the head is rotated to the side, the limbs on
the face side extend, on the skull side flex.

FIGURE-1 The Motor Response of the ATNR

It was suggested that the neonatal assessment of the at-risk infant should include the testing of neurological function in order to be a valid predictor of future outcome (Bierman-van Eendenburg, Jurgens-VanDerZee, Oligna, Huisjes and Touwen, 1981). Saint-Anne Dargassies (1972) pointed out the significance of early neurological signs in diagnosing neurodevelopmental disorders. He noted that the prevalence of primitive reflexes beyond their normal course was indicative of dysfunction. He also noted a significant difference between the ATNR responses of the full-term infant and that of the pre-term infant where the inhibition of the reflex was delayed (Saint-Anne Dargassies, 1977). These findings were later confirmed by Bigsby (1983).

An obligatory, always present, +ATNR is known to be strongly linked with cerebral disturbances such as cerebral palsy (Bobath, 1971; Roberts, 1978; Watt, Robertson & Grace, 1989). An obligatory ATNR significantly interferes with movement as the response does not change with voluntary movement (Avery, 1987; Fiorentino, 1973; Lance & McLeod, 1981; Roberts, 1978). A prolonged, exaggerated, or residual ATNR seen in children beyond infancy was also often cited as neurologically abnormal (Ayres, 1972; De Quiros & Schrager, 1978; Farber, 1982; Finocchiaro, 1974; Morrison, Hinshaw & Carte, 1985; Parmenter, 1975). Although not obligatory, a residual reflex may interfere with normal movement patterns as seen in children with mild motor or sensorimotor dysfunctions. For example, when not suppressed, the ATNR interferes with the learning of such gross motor skills as turning supine to prone, crossing the midline, crawling on hands and knees and using the upper limbs to reach and grasp (Obrzut & Hynd, 1986). These children appear motorically normal, albeit frequently uncoordinated, performing poorly in physical education and in hand functions such as printing (Farber, 1982; Norton, 1972).

As residual or exaggerated primitive reflexes observed beyond infancy are frequently cited as neurologically abnormal, and in that the ATNR is one primitive reflex, it would be useful to determine if the clinical observation of a persistent or residual ATNR can predict motor outcome. Residual ATNR responses are considered to be one marker of poor integration of primitive reflexes into more mature motor patterns (Ayres, 1972; De Quiros & Schrager, 1978; Farber, 1982; Finocchiaro, 1974; Morrison et al., 1985). Residual ATNR responses may not, however, be indicative of later dysfunction as some researchers have noted the presence in individuals who do not exhibit functional problems (Bratzlavsky & Vander Eeken, 1977; Byers, 1938; Hayes & Sullivan, 1976; Hellebrandt, Schade & Carns, 1962; Ikai, 1950; Tokizane, Murao, Ogata & Kondo, 1951; Wells, 1944; Zemke, 1980/81; Zemke & Draper, 1984).

A significant question that arose from a study of the literature, was if some degree of the ATNR persisted beyond infancy into preschool and school age, did this represent some degree of pathology? Could observations of a residual ATNR be interpreted as predictive of present and future dysfunction?

TESTING OF THE ATNR

As noted by Rider (1972), "testing of reflexes is a more objective procedure than many other parts of the neurological examination" (p. 132). Test procedures for the ATNR were clearly defined in medical literature. Interpretation of test observations of the ATNR requires an understanding of the neurophysiology and developmental course of the ATNR.

Early in the century, studies of the tonic neck reflexes were undertaken with decerebrate animals. The ATNR was first described by Magnus and de Klein in 1912 (Schmidt, 1978). They described the postural changes in a decerebrate cat, positioned in quadraped. When the head was rotated sharply about the vertebral axis, both limbs on the jaw side extended, limbs on the skull side flexed. The reflex occurred in pure form when the labyrinths were extirpated. This description of the postural change, seen when the ATNR was elicited, remains to be accepted as the basis of observations of the ATNR.

Byers (1938) noted that in intact animals "active voluntary movements of the head are as potent in calling forth such reflexes as are passive movements imposed on decerebrate animals" (p. 701). Byers also noted that the latent period of the reflex lasted as long as the position of the head was unchanged.

Later in 1982, in their study of the human infant, Coryell, Henderson and Liederman attempted to clearly define the criteria for evaluating the ATNR and the means of eliciting the response. They noted, as did Byers (1938), Peiper (1963), and Paine, Brazelton, Donovan, Drorbaugh, Hubbell and Sears (1964), that the ATNR could be elicited either by passive head turning or by the infant's active head turning. There was some indication that only partial head rotation might be sufficient to elicit the reflex. Although they administered testing by turning the head 90°, they noted that the reflex could be observed following only 30° of head turning. They observed a 46% occurrence when the head was turned partially, with a slightly higher 55% occurrence when the head was turned fully. This finding of a response with either partial or full head rotation was also supported by the studies of Vasella and Karlsson (1962), and Coryell and Cardinali (1979).

Gesell and Ames (1950) suggested that ATNR postures were best seen in the supine infant. The stimuli to the neck propriocepters however did not cease to exist if the infant was placed in an upright or prone orientation. They noted that, in early stages, the prone position inhibited the manifestations of the ATNR, but at later stages of pivoting and creeping, the ATNR became more obvious.

Various researchers observed the ATNR response in a variety of positions in animal and human subjects, supine, sitting, quadraped and standing, with little differentiation of the response in these positions (Ayres, 1972; De Quiros & Schrager, 1978; Ikai, 1950; Roberts, 1978; Short, Watson, Ottenbacher & Rogers, 1983; Sieg & Shuster, 1979; Silver, 1952; Tokizane, Murao, Ogata & Kondo, 1951). Zemke (1980/81) investigated the incidence of the ATNR in supine and quadraped in 40 normal preschool children. Her results indicated that the incidence of the ATNR was lowest in supine and highest in quadraped. There was no sex differentiation. Hellebrandt, Schade and Carns (1962) and Morrison et al. (1985) also described the quadraped position as the most sensitive in testing the ATNR in children and adults. These findings supported the use of the quadraped position in the assessment of preschoolers and school age children.

The position assumed in quadraped prior to testing was critical as effort must be made to isolate ATNR responses from labyrinthe reflexes and righting reactions. Roberts (1978) discussed the "zero position" of the neck prior to eliciting the ATNR (p. 254). In order to test for the presence of the ATNR, the vertebral column must be nearly horizontal, with the face looking down, when the body was positioned in quadraped, hips flexed at 90° (Parmenter, 1983; Roberts, 1978). In this position the weight was equally distributed between the arms and the legs. This position lessened the influence of the labyrinths. If the head was up and tilted, the labyrinth reactions were elicited.

Ayres (1972) recommended that in quadraped, the elbows of the subject should be slightly flexed to avoid locking of the elbows which would inhibit the response. Hands were flat on the floor with fingers extended (Ayres, 1972; Parmenter, 1983).

Both the arms and legs are affected by the ATNR although the effect is more apparent in the upper extremities. The legs are less subject to increased tonicity (Avery, 1987; Capute, Shapiro, Accardo, Wachtel, Ross & Palmer, 1982; Coryell & Cardinali, 1979; Lance & McLeod, 1981; Paine et al., 1964). Because of the differences in observed responses of the arms and legs, Coryell and Cardinali (1979) stated that the arms and legs should be considered separately. If the reflex were to be considered only when seen in the arms and legs simultaneously, much observational evidence would be lost.

To summarize, the ATNR is a normal primitive reflex in infants elicited by either active or passive head turning. The quadraped position is the most sensitive in testing for the ATNR in preschool and school age children. ATNR responses are more apparent in the upper extremities. As the CNS develops, the ATNR is inhibited by higher cortical centers and integrated into normal movement patterns (Bowsher, 1988). Understanding of the developmental course of the ATNR allows the researcher to interpret observations of the ATNR as normal or abnormal.

THE DEVELOPMENTAL COURSE OF THE ATNR

Early behavior forms, such as the primitive reflexes, anticipate the direction of the development towards adulthood (Wade & Whiting, 1986). The reflex is "the primary unit of motor coordination" (Wade & Whiting, 1986, p.67). If the reflex was not normally inhibited post-natally, it would interfere with the development of normal motor schema (Capute et al., 1982; Farber, 1982).

The young fetus is primarily symmetrical with limited head movements. The head is generally maintained in midline (Gesell & Ames, 1950). Minkowski (1921, 1928) and Gesell and Armatruda (1947) observed fetal ATNR posturing as a result of head turning in the third to fifth month of gestation. Age of emergence of an observable ATNR response postnatally was inconsistently reported in the literature, with some researchers observing the ATNR in the first week, others not recording a response until 1-2 months of age (Avery, 1987; Baird & Gordon, 1983; Capute et al., 1982; Coryell & Cardinali, 1979; De Quiros & Schrager, 1978; Gesell & Ames, 1950).

Integration or disappearance of the ATNR was reported by some researchers as occurring somewhere between 2 and 7 months of age (Avery, 1987; Bower, 1974; Cratty, 1970; Silver, 1952). Others report an integration period of up to 16 months of age (Capute et al., 1982; Fiorentino, 1973).

According to Ayres (1972) ATNR responses "never disappear during life but the degree to which a person suppresses or attains mastery over them usually reflects the degree of maturation and integration of postural mechanisms" (p. 80). Influence of the ATNR however should be negligible by 6 years of age.

Other investigators also suggested that the ATNR continues to influence movement of children and normal adults. Parr, Routh, Byrd and McMillan (1974) studied the developmental course of the ATNR of 84 normal children, 3 to 9 years old. They found a consistent response in all children that decreased with age. Similar findings were later supported by Zemke and Draper (1984).

THE ASSOCIATION OF THE ATNR TO MOVEMENT

The ATNR has been considered a pathognomonic of central nervous system disease or brain dysfunction since Magnus and de Klein (1912) described its presence in decerebrate quadrapeds deprived of the labyrinthes and a brain injured child (Capute et al., 1978; Gesell & Ames, 1950; Peiper, 1963; Rider, 1972). Although there was no consensus on the normal developmental course of integration or disappearance of the ATNR response, testing for the ATNR was "frequently used as a clinical tool when evaluating children with maturational lags, sensory integration deficits and behavioral dysfunction" (Parmenter, 1975, p. 463). Evidence does indicate that overall there are more abnormal neurological signs in persons with learning disabilities and/or mild motor dysfunction than in normal subjects (Ayres, 1972; De Quiros & Schrager, 1978; Farber, 1982).

Residual +ATNR responses were considered to be an indicator of poor sensorimotor integration resulting in mild motor dysfunction (Ayres, 1972; Farber, 1982; Finocchiaro, 1974). However, there is little empirical evidence of the relationship of the ATNR to the development of motor skills.

Finocchiaro (1974), tested a control group of 6 subjects and a learning disabled group of 12 subjects. One component of the test battery was a postural reflex test evaluating the presence of three postural reflex responses: the ATNR, tonic labyrinthine reflexes (TLR), symmetrical tonic neck reflex (STNR). The presence of the ATNR in the impaired group was significantly higher than in the control group ($p < .01$). These results led the investigators to suggest further research on the use of reflex testing in the discrimination of perceptual motor dysfunction.

Morrison et al. (1985) administered the Southern California Sensory Integration Test (SCSIT) to 74 children who showed clinical signs of sensory integration dysfunction. The investigators noted that in normal development primitive reflexes such as the ATNR diminish and equilibrium reactions emerge providing the body with the adaptive responses necessary for gross motor activities. They noted the previous findings of Friedlander, Pothier, Morrison and Herman (1982) that established that persistence of primitive reflexes occurred most frequently in neurologically impaired children than in a control group. Nineteen of the learning disabled children screened were included in a study of concurrent validity. The movement patterns of these 19 children were found to be significantly more pathological than the control group in the integration of primitive reflexes, one of which was the ATNR ($r = .85$, $p < .001$). However, subjects showed less pathology of the ATNR than in other areas. The researchers did not find a significant correlation between the domains tested: ATNR, body righting, equilibrium reactions, protective extension and post rotary nystagmus. They suggested in their discussion that a "more systematic research on multiple indices of neurobehavioral functioning will be required to understand the complex interrelationships among these signs" (p. 871).

Decreased integration of primitive reflexes was reported to result in decreased isolation of movement, segmentation of the trunk, rotational component of movement, responsiveness to postural change resulting in postural insecurity and ability to develop anti-gravity muscles (Farber, 1982). Failure to integrate reflexes resulted in inadequate development.

In summary, the testing for the ATNR response was frequently used as a clinical observation in the assessment of perceptual motor development. Positive ATNR responses were considered to be indicators of dysfunction and were shown to be present to a greater extent in impaired groups than in control groups. Decreased integration of the ATNR was cited to have impact on the development of movement patterns. Maturational deficits of motor abilities therefore may be linked neurophysiologically with the ATNR.

SUMMARY

It was clear from the literature that pre-term infants were at higher risk for developmental impairments than full-term infants with an uncomplicated neonatal course (Bigsby, 1983; Drillien, 1972; Drillien et al., 1980; Lee, 1977; Lubchenco et al., 1963; Parmalee & Schulte, 1970; Saint-Anne Dargassies, 1977; Valvano & de Gangi, 1986; Vohr & Coll, 1985). Longitudinal outcome studies of at-risk infants indicated that overall school, perceptual motor and visual motor performance of these infants was lower than a normal control group (Drillien et al., 1980; Lee, 1977; Vohr & Coll, 1985).

The testing for the presence or absence of the ATNR is a routine part of the neurological assessment (Sieg & Shuster, 1979). The reflex can be elicited by passive or active turning of the head resulting in extension of the arm on the face side, flexion of the arm on the skull side. A quadraped position was the most sensitive in testing for the ATNR in preschool and school age children. Most researchers agreed that an obligatory ATNR was abnormal at any age (Avery, 1987; Fiorentino, 1973; Lance & McLeod, 1981; Roberts, 1978). Less certain in the literature was substantiation that a residual ATNR was indicative of future dysfunction (Ayres, 1972; De Quiros & Schrager, 1978; Farber, 1982; Finocchiaro, 1974; Morrison et al., 1985; Obrzut & Hynd, 1986; Zemke, 1980).

Evidence indicated that those subjects with a noted dysfunction or impairment displayed more abnormal neurological signs than a normal control group (Ayres, 1972; De Quiros & Schrager, 1978; Farber, 1982; Friedlander et al., 1982). Residual +ATNR responses were considered to be an indicator of delayed reflex integration which results in mild motor dysfunction (Ayres, 1972; Farber, 1982; Finocchiaro, 1974).

Sensory and motor systems are closely linked neurophysiologically (Farber, 1982). Longitudinal data collected on human motor performance for the purpose of identifying or disqualifying predictors of dysfunction in school age children is valuable. A study of abnormal neurological signs or risk factors such as a prolonged or residual ATNR, its prevalence in preschool and school years and the association with later motor outcome, would add to the understanding of the phenomenon of motor development as it relates to these neonatal intensive care survivors and would assist clinicians in their provision of appropriate therapeutic intervention.

METHODS AND PROCEDURES

Between 1974 and 1979, members of the Neonatal Follow-Up Clinic staff collected data for the prospective, longitudinal study of at-risk neonatal intensive care survivors. A follow-up study of these children was carried out until they were eight years of age. Data for this post-hoc study was obtained from the Database of this Neonatal Follow-Up Clinic research project.

PILOT ANALYSES

A pilot study of the raw data on ATNR observations recorded from infancy to 8 years was completed. It was evident that data collected on the ATNR for the 0-2 year assessment intervals and data at the 3 1/2, 5 1/2 and 8 year assessment intervals were significantly different. It was hypothesized that the difference might be due to the different test positions used in testing for the ATNR: infants were tested in supine; pre-schoolers and school age children were tested in quadraped. The unexplained difference in the data required that this study limit the boundaries to either the 0-2 year assessments or to the 3 1/2, 5 1/2 and 8 years assessments.

In researching the literature it was evident that there was no consensus on the emergence and integration of the ATNR during infancy (Avery, 1987; Baird & Gordon, 1983; Capute et al., 1982; Coryell & Cardinali, 1979; De Quiros & Schrager, 1978; Gesell & Ames, 1950). Emergence of an observable ATNR could not be clearly defined developmentally.

Measurement and interpretation of observations of the ATNR was more reliable at the later ages of 3 1/2, 5 1/2 and 8 years. Presence of an unintegrated, residual ATNR at the 3 1/2, 5 1/2 and 8 year assessment could be interpreted as abnormal.

In the pilot analysis of raw data there was evidence that the presence of the ATNR in the study subjects also decreased with age between 3 1/2 and 8 years of age. This led to an interest in documenting the change of the response between the assessment intervals of 3 1/2, 5 1/2 and 8 years.

The prevailing question of the study, however, was the predictive value of the ATNR of abnormal motor outcome at 8 years of age. There were a number of outcome variables measured in the project at 8 years of age. Test items measured were common items used in clinical evaluations.

RESEARCH QUESTIONS

This investigation was designed to answer the following questions:

1. What proportion of the subjects display the presence of a positive or residual ATNR (+ATNR) or a negative or integrated ATNR (-ATNR) at each assessment interval (3 1/2, 5 1/2 and 8 years)? Prevalence allows an evaluation of the predictive value of the independent variable.
2. And, what percentage of these subjects display a loss or a gain of a +ATNR over time between 3 1/2 years, 5 1/2 years and 8 years? This allows a tracing of the developmental course of the ATNR in these subjects over this period of time.

3. If there is a +ATNR at any of these ages, how likely is the subject to have an abnormal motor outcome and is this relationship significant? This fundamental question tests the hypothesis that a persistent or residual ATNR at any of the specified ages is a risk factor for dysfunctional motor performance at 8 years of age.
4. Do the observations of a +ATNR have predictive value?

In planning the study, it was considered that, if the premise of a predictive value of a +ATNR was supported, the knowledge may assist in the diagnostic process. It was also apparent that if the premise was not supported, the efficacy of the use of a test for the ATNR in an occupational therapy assessment would be questionable.

SUBJECT SELECTION

To be included in this study, all subjects required complete ATNR data over the three assessment periods and complete motor outcome data at the 8 year assessment interval. If data was incomplete, subjects were not included in the study sample. Excluded from the primary study were infants diagnosed with congenital malformations and chromosomal abnormalities as their neonatal problems and outcomes could be defined at birth. This exclusion ensured that the sample was representative of neonatal intensive care survivors with unknown prognosis. For the purpose of this study, subjects with cerebral palsy, as determined on outcome at 8 years of age, were excluded prior to analysis of data. This ensured that subjects misdiagnosed early as cerebral palsy were not excluded from the outcome study.

A sample of 433 children, age range from 35 months to 116 months, with complete data was initially drawn from the subject pool. This initial sample was used to determine if there were significant differences in performance between Caucasian and non-Caucasian subjects. There were 89.6% Caucasian subjects and 10.4% non-Caucasian subjects. Comparisons between Caucasians and non-Caucasians were made across 20 variables (ATNR and outcome variables). A significant difference was found on two of the twenty comparisons. These were hopping (right) and hopping (left). Overall the null hypothesis of no difference was not rejected on the basis of the significance testing therefore the decision was to include both groups in the study sample (summary of data in Appendix D).

Further analysis of this initial sample of 433 subjects determined that there was no significant difference overall between the outcome results of subjects with English as a mother tongue and those who did not have English as their mother tongue (Appendix D). The one exception was tandem walking. This ensured that overall the understanding of verbal instructions was not affected by a difficulty comprehending the English language.

The initial sample of 433 subjects was further delineated by age categories. The 3 1/2 year assessment subjects were defined as those subjects between 36 months and 48 months. The 5 1/2 year assessment subjects were defined as those subjects between 60 months and 72 months. The 8 year assessment subjects were defined as those subjects between 84 months and 108 months.

Subjects outside of these age categories were excluded. This resulted in a sample size of 363 subjects each with complete data across assessment intervals as well as complete outcome data.

SAMPLE

The range and mean age of the 363 subjects is illustrated in Table 1. The mean gestation for the sample was 35.01 weeks ranging from 26 weeks to 43 weeks. The mean birth weight was 2186.19 grams ranging from 630 grams to 4725 grams.

TABLE 1 Age range and mean age of subjects.

ASSESSMENT INTERVAL	AGE RANGE	MEAN AGE
3 1/2 Year Assessment	36- 48 months	42.82 months
5 1/2 Year Assessment	60- 72 months	66.41 months
8 Year Assessment	84-108 months	95.58 months

These at-risk, neonatal intensive care survivors were cared for at the Royal Alexandra Hospital and University of Alberta Hospital neonatal intensive care units. In addition to the infants born at these centers (n = 210), infants at risk were transferred from other hospitals in Edmonton and Northern and Central Alberta, Yukon Territory, Northwest Territories and part of Northeastern British Columbia Hospitals to these specialized units (n = 153).

As this sample was drawn from the infants cared for by these two tertiary care intensive care units it is considered to be representative of this region. The information may be generalized to other regions with caution as there may be unappreciated factors in neonatal intensive care which would result in a mismatch of samples. Clinical judgment then must be exercised in conjunction with statistical analysis to generalize from the findings (Riegelman, 1981).

For the Neonatal Follow-Up Clinic research project the children were categorized on the basis of diagnosis at the time of referral to the Clinic (Appendix B). With parental consent all infants in the categories were included in the project and were followed periodically for 8 years. Consent forms were signed by parents on program admission and updated twice by discharge at 8 years. An information letter was given to parents prior to their visit to the Clinic (excerpts in Appendix C).

The sample consisted of 200 males and 163 female subjects. In planning this study it was not intended that a hypothesis of difference between sexes be made. In reviewing the literature on the ATNR there was no evidence of a difference between males and females in regard to the presence or absence of the ATNR throughout development. As well investigators have extensively examined the differences of motor performance of males and females: some investigators noted differences, others felt these differences might be related to other factors such as size, strength and social experience (Thomson & French, 1985). The analysis of differences of performance between the sexes has no clinical significance to the questions in this study and therefore will not be included.

The relationship of the socioeconomic status of the subjects was also not a primary question of this study, although it is acknowledged that socioeconomic status may be associated with movement experience and subsequently motor outcome. The effect of socioeconomic status on motor outcome would require an additional study.

IQ scores were recorded by certified psychologists. Children for this study were identified as having an IQ of greater than 56. A comparison of motor outcome in relationship to IQ was not undertaken for this study.

SUBJECT COMPLIANCE

Systematic procedures were put in place at the onset of the primary project to decrease non-response errors. Clinic conditions and communications were designed to facilitate ongoing participation by the children and their parents in the project. A description of the purpose of the study was given to the parents prior to the discharge of the infants from the neonatal intensive care units. At appropriate ages, appointment cards were sent out followed by confirmation telephone calls. Similar information was distributed to parents at 3 1/2 year, 5 1/2 year and 8 year assessment intervals. Excerpts of the contents of these information hand-outs are outlined in Appendix C. After each visit, a conference summary was sent to the parents giving them an overview of assessment findings. These summaries were a reaffirmation of information shared with them by individual testers on the assessment day. Overall, clinic conditions were conducive to the needs of the parents and children. All of these efforts resulted in a follow-up rate of 80% at age 8 years.

DESIGN

This study was a post-hoc analysis of data collected for the prospective and longitudinal project of the Neonatal Follow-Up Clinic on high-risk neonatal intensive care survivors.

Figure 2 illustrates the study design. The independent variables were ATNR responses observed individually within the same subjects at 3 1/2, 5 1/2 and 8 year assessment intervals. The dependent variables were motor outcome measures of the following motor components: standing balance (eyes open), hopping, tandem walking, running, stair climbing, equilibrium, finger-nose touching and alternating finger movements (Figure 3).

Both the independent and dependent variables were treated as nominal data as they were defined categorically. The categorization of the observations of the ATNR were +ATNR (response) which was a negative observation; and -ATNR (no response) which was a positive observation. Motor outcome was categorized as abnormal or normal.

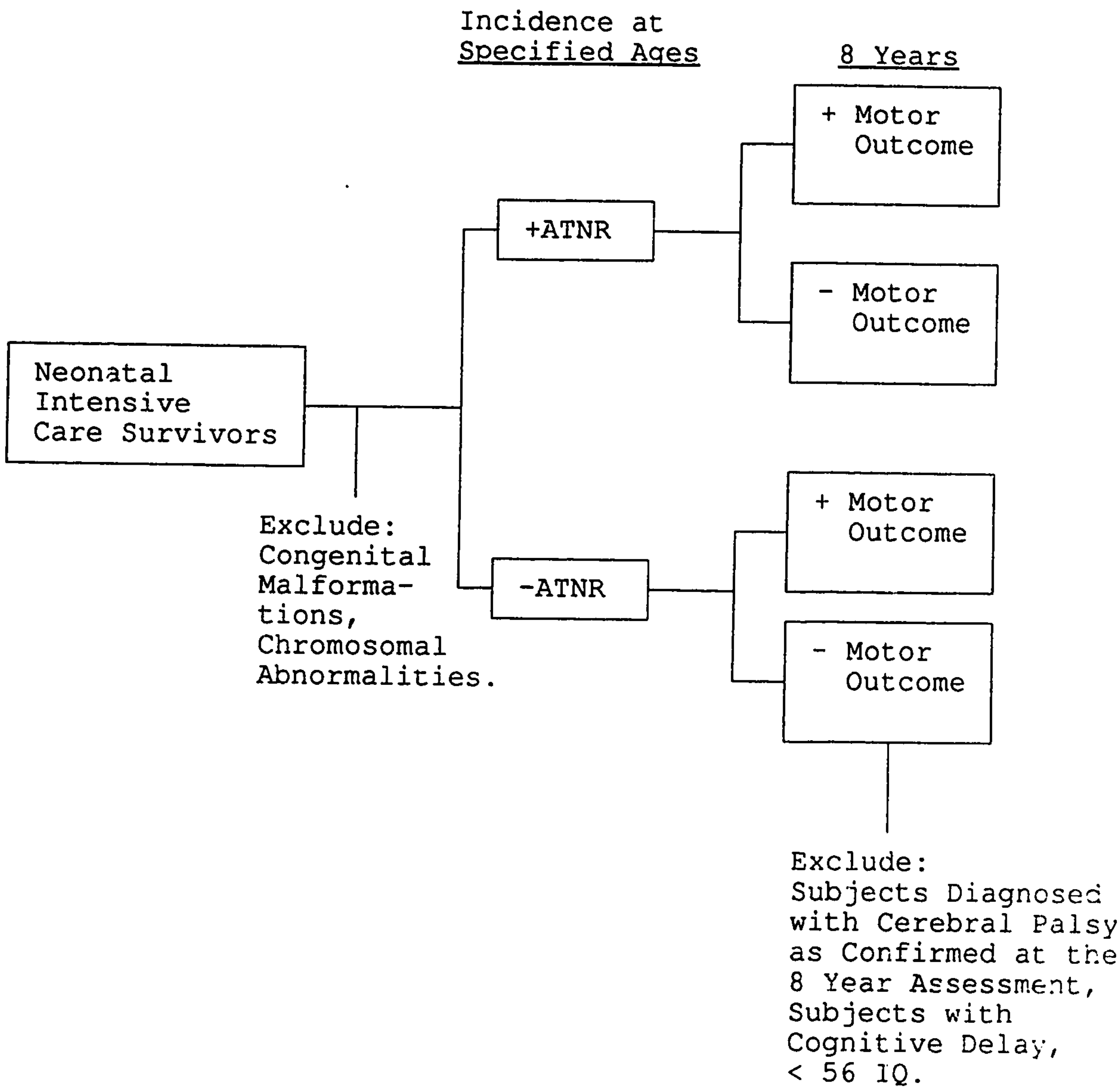


FIGURE-2 Follow-Up Study Design
(adapted from Gehlbach, 1988, p.47)

INDEPENDENT VARIABLE	DEPENDENT VARIABLE
ATNR at 3 1/2 years ATNR at 5 1/2 years ATNR at 8 years	At 8 years: standing balance hopping tandem walking running stair climbing finger-nose touching alternating finger movements

FIGURE-3 Independent and Dependent Variables

STUDY OBJECTIVES

The objectives of this study were:

1. To document the prevalence of a residual ATNR at the approximate assessment ages of 3 1/2 years, 5 1/2 years and 8 years of age;
2. To determine the percentage of loss and gain of an observed residual ATNR between assessments at 3 1/2, 5 1/2 and 8 years of age;
3. To test the hypothesis that a persistent ATNR at any of the specified ages, 3 1/2, 5 1/2 or 8 years, was a risk factor for dysfunctional motor performance at 8 years of age. The relationship of a residual ATNR to motor outcome at age 8 years was examined at individually at each age: 3 1/2 years to motor outcome at 8 years; 5 1/2 years to motor outcome at 8 years; 8 years to motor outcome at 8 years.

DATA COLLECTION

For the Neonatal Follow-Up Clinic research project, an interdisciplinary approach to evaluation was taken resulting in a wealth of data. Testers were a team of specialists: an audiologist, a nurse, an occupational therapist, an opthamologist, a pediatrician with special interest in development and child neurology, a physical therapist, a psychologist, a social worker, a speech and language pathologist, and an educator. Evaluation consisted of regular assessments of growth, motor and sensory development and psychomotor, cognitive and educational performance (Robertson, 1980).

The primary investigator for the research compiled a data collection and coding manual which contained a copy of all data collection forms used by all the disciplines involved in data collection (Robertson, 1980). Assessment and data collection manuals were developed for the 3 1/2 year and 5 1/2 year assessments. Data collection forms were developed for the 8 year assessment. The manuals were designed to ensure accurate and objective data collection and to limit measurement error. Manuals were based on referenced norms and were designed to provide criterion based administration and scoring. The forms included scoring criterion for test items. Excerpts are shown in Appendix E.

Data collected for the Neonatal Follow-Up Clinic research project was computerized. This database was used for the statistical analyses within this study. Instrumentation was therefore predetermined for this study.

Testing for the ATNR:

Testing for the ATNR, the independent variable, was an objective procedure. In general, the testing of reflexes is more objective than many aspects of the neurological examination as methods of eliciting reflexes, observation and recording of responses are well defined (Rider, 1972).

Various studies of the ATNR in human subjects used a number of methods: observational (Ayres, 1972; Capute, et al., 1982; Coryell & Cardinali, 1979; De Quiros & Schrager, 1978; Roberts, 1978); electromyographic (Bratzlavsky & Vander Eeken, 1977; Ikai, 1950; Tokizane et al., 1951; Zemke, 1980/81; Zemke & Draper, 1984); and goniometric (Dunn, 1981; Heilebrandt et al., 1962; Parmenter, 1975; Parr et al., 1974). Observational studies are the most practical in the clinical setting although not as precise as goniometric or electromyographic measurements. Goniometer recording is only practical with older children who can hold a position on request so as to complete measurement. Electromyographic studies, although the most sensitive, are the most intrusive for infants and children.

Observational data was collected by occupational therapists and the Clinic physician for the Neonatal Follow-Up Clinic research project. Test administration, scoring of the response and its developmental course and the terminology to be used in documentation was compiled in referenced assessment manuals designed for the study (excerpts in Appendix E). A decision was made from the onset of the project to dichotomize the results into two categories, response and no response, as scoring was descriptive rather than interval in nature (Appendix F).

At the 3 1/2 year assessment, testing for the ATNR was administered in the quadraped position. The child's head was turned passively to each side by the examiner. As recommended by Ayres (1972) the child's elbows were positioned in slight flexion to prevent a locked elbow. A locked elbow would inhibit the elbow flexion on the skull side expected when a +ATNR is elicited.

The documentation of responses included the choice of three descriptive observations. In recording the findings, the examiner could make only one choice. The choices were:

1. no flexion response (no observable change in position and tone);
2. slight flexion response (minimal to slight change in tone or position observed);
3. definite flexion response (significant change observed in joint position or tone).

At the 5 1/2 year assessment the quadraped position was more specifically defined. The hips were to be at 90°, hands flat on the floor with shoulders at 90° and the fingers pointed forward and slightly inward to position the arms to prevent locking of the arms. The head was in a neutral position before the examiner manually turned it to either side. The head was held at each side for 3-5 seconds to allow for adequate observation.

The documentation of responses at the 5 1/2 year assessment included the choice of four descriptive observations. In recording the findings, the examiner could make only one choice. The choices were:

1. no flexion response;
2. slight flexion response;

3. definite flexion response;

4. untestable.

At the 8 year assessment interval, the ATNR was assessed in the same manner as outlined at the 5 1/2 year assessment. Six categories were used to define observations. In recording the findings, the examiner could make only one choice. The choices were:

1. absent;

2. slightly present;

3. definite;

4. obligatory (interfering with activity);

5. not applicable because of severity of handicap;

6. not tested because of normal development.

Those subjects with responses of 5 and 6 were excluded from the sample. At each age interval, data was recorded for both the right side and left side responses.

Testing Motor Outcome Variables:

The dependent variables in this study were specific motor performance variables recorded at the 8 year assessment interval. As scoring for the variables was primarily descriptive rather than interval, scoring was dichotomized as normal or abnormal (Appendix F).

The dependent outcome variables used to measure normal or abnormal motor outcome were the motor components: standing balance (eyes open), hopping, tandem walking, running, stair climbing, equilibrium, finger-nose touching and alternating finger movements. These neurodevelopmental test items were commonly included in the clinical observations of a child's motor performance along with other items.

Standing balance (eyes open) was timed in seconds to one decimal using a stopwatch. If the task could not be done it was recorded as zero. Timing began when the child lifted the foot and stopped when:

(a) the child touched the foot to the floor; or,

(b) the child's hand was extended to give balance; or,

(c) if the foot used for standing was displaced by hopping or movement (slight foot muscle movement without displacement was accepted).

Standing balance was timed both for the right and left foot.

Hopping was measured for both the right and left feet. Hopping was measured in the number of hops. The child was asked to demonstrate continuous hops on the spot. The free foot was not to touch the ground. An occasional momentary loss of balance was allowed.

Tandem walking was done on a one inch line (dark green tape on light colored tile). The child was instructed to walk placing the heel of the forward foot directly in front of the toe of the back foot, stepping forward in the same manner along the line.

Tandem walking was scored by choosing a predetermined category. Eight choices were available. Only one could be chosen by the examiner:

1. completes the distance without stepping off the line or using the hands and arms to balance;
2. completes the distance but uses the arms to balance or curls hands;
3. completes the distance but leans to the left or right;
4. completes the distance but steps off the line (deviates from the line) once;
5. completes the distance but has two to four deviations;
6. completes the distance but has five to six deviations;
7. child cannot walk three steps successively without deviating from the line;
8. cannot do the task.

Equilibrium reactions were also recorded qualitatively from observations made by the examiner. Equilibrium was tested in sitting and standing. With the child in floor sitting, legs crossed, the examiner gave a slight push to displace the child's weight forward, lateral and backward. In standing (Romberg position) the child's weight was also displaced in the same manner. Instructions given were: "Don't let me push you over". Two trials were allowed.

Equilibrium responses were recorded using predetermined descriptive categories. Responses were scored for sitting and standing using the following choices:

1. normal;
2. deficit posterior;
3. deficit lateral - right and posterior;
4. deficit lateral - left and posterior;
5. deficit lateral - both and posterior;
6. deficit all directions;
7. cannot be tested.

Finger-nose touching was also a qualitative measure. The child extended his/her arm to touch the examiner's finger, then brought his/her finger to his/her nose and repeated the movement. Both the right and left arms were tested.

Finger-nose touching responses were recorded using the following observational choices:

1. normal;
2. slight unsteadiness;
3. ataxia;
4. cannot do.

Alternating finger movement consisted of the subject touching the thumb to each of the fingers moving from the index finger to the little finger and then from the little finger to the index finger. Each hand was tested. Two trials were given.

Responses for alternating finger movement were recorded as one of the following:

1. normal, smooth;
2. movement normal but apparent difficulty with understanding;
3. abnormal because of apparent lack of awareness;
4. slow deliberate movement but complete;
5. incomplete - partial;
6. overflow movement to opposite hand;
7. overflow movement beyond hands;
8. cannot do.

Running was administered in the following way. The child was asked to run. Posture, balance and gait were observed with awareness of whether the child moved with steady, coordinated movements.

Recording of running responses used the following descriptive categories:

1. normal;
2. poor quality but to age level;
3. mild delay up to six months;
4. moderate delay greater than six months;
5. severe delay greater than two years;
6. cannot do task.

Poor quality responses were those responses in which performance was poorer than expected.

Both stairs-up and stairs-down were measured in the same way. The child ascended or descended one flight of stairs. Stairs used were free-standing without side rails. At age eight, the child was expected to ascend or descend stairs without support in a coordinated manner, alternating feet. More than one chance could be given.

Scoring for stairs-up and stairs-down was the same as for the 5 1/2 year assessment interval therefore the descriptive labels of mild, moderate and severe are not applicable at age 8 years. At 8 years a recorded delay scored as 3, 4, 5 were all considered abnormal. Poor quality describes a performance which was poorer than expected. The following descriptive categories were used:

1. normal;
2. poor quality but to age level;
3. mild delay up to six months;
4. moderate delay greater than six months;
5. severe delay greater than two years;
6. cannot do the task.

DATA COMPUTERIZATION PROCESSES

Forms were used in the collection of data. Figure 4 illustrates a sample of the form design used. Appendix E contains excerpts of the forms used for recording data for this study. Data was verified and keypunching was accomplished directly from these forms.

3 1/2 Year Assessment

ATNR (quadraped position): right __/__
left __/__

1. no flexion response
2. slight flexion response
3. definite flexion response

5 1/2 Year Assessment

ATNR (quadraped position): right __/__
left __/__

1. no flexion response
2. slight flexion response
3. definite flexion response
4. untestable

8 Year Assessment

ATNR (quadraped) - face to right __/__
ATNR (quadraped) - face to left __/__

1. Absent
2. Slightly Present
3. Definite
4. Obligatory, interfering with activity
5. N/A because of severity of handicap
6. N/T because of normal development

FIGURE-4 Descriptive Categories Used in Data Collection of ATNR Responses at the 3 1/2, 5 1/2 and 8 Year Assessments

For the design of this study, a dichotomization of ATNR observations into present (response) and absent (no response) was required for clarity of interpretation. This required an interpretation of the scoring criterion as present or absent. A full summary of the process of data dichotomization is outlined in

Appendix F. An example of the process is illustrated in Figure 5.

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1. no flexion response
2. slight flexion response
3. definite flexion response

If 1, code as 0 (absent)
If 2 or 3, code as 1 (present)

FIGURE-5 Data Dichotomization ATNR - 3 1/2 Year Assessment

The dependent variables of motor outcome were measured in a variety of ways. Although some measures were quantitative, others qualitative, the choice was made to dichotomize all the findings into abnormal and normal to address the primary research question: is the presence of a ATNR predictive of an abnormal motor outcome. A definition of the normal and abnormal motor outcome is given in Appendix F. Dichotomization of the quantitative measures of standing balance and hopping into abnormal and normal was determined using Test of Motor Impairment (TMI) and the Learning Staircase Assessment Inventory System respectively (Appendix F). Qualitative measures were dichotomized by clinical interpretation of abnormal and normal (Appendix F). An example of the process is illustrated in Figure 6.

1. Normal
2. Slight unsteadiness
3. Ataxia
4. Cannot do

If 1, code as 0 (normal)
It 2, 3 or 4, code as 1 (abnormal)

FIGURE-6 Data Dichotomization Finger-Nose Touching - 8 Year Assessment

RELIABILITY AND VALIDITY

For the 3 1/2 year and 5 1/2 year test intervals, testers were trained and testing guidelines were followed consistently and precisely. Training consisted of a one month period of co-assessment with a trained examiner completing a minimum of 24 assessments on individual subjects. Six testers were trained to complete these assessments. Assessment standards were developed and outlined in referenced, criterion based manuals which support construct validity. Both the establishment of standards and the use of trained testers limited the possibility of measurement error. No interrater reliability or intrarater reliability measurements were completed prior to data collection.

The use of one observer in the collection of ATNR and motor outcome data at the 8 year assessment interval and the predetermined criteria for data collection strengthens the reliability of the resultc and guards against the threat of different interpretations over time. The motor outcome variables were readily interpreted from developmental norms which strengthens content validity (Coughran & Goff, 1976; De Quiros & Schrager, 1978; Dunn, 1981; Henderson & Hall, 1982; Stott, Moyes & Henderson, 1984). No intrarater reliability measures were completed prior to data collection.

DATA ANALYSIS

This study answered the following questions:

1. What proportion of the subjects displayed the presence of a positive or residual ATNR (+ATNR) or a negative or integrated ATNR (-ATNR), at each assessment interval (3 1/2, 5 1/2 and 8 years)? What percentage of these subjects displayed a loss or gain of a +ATNR over time between 3 1/2 years, 5 1/2 years and 8 years?
   (a) The prevalence rate of a +ATNR or a -ATNR at a single point in time was calculated in cases identified per total number of subjects assessed and percentages of the total displaying a +ATNR and a -ATNR.
   (b) To determine the percentages of loss or gain of a +ATNR over time, frequency data was tabulated on contingency tables.
2. If there was a +ATNR how likely was the subject to have an abnormal motor outcome?

   The directional research hypothesis was that there would be significantly decreased motor performance in children displaying a +ATNR than children displaying a -ATNR.

(a) A Chi Square 2 X 2 table with Yates Correction was calculated to determine the relative risk for each of the outcome variables. The relationship of the ATNR response at the 3 1/2 year, 5 1/2 year and 8 year assessment intervals to the motor outcome variables was calculated.

(b) A test for the statistical significance of the relative risk was calculated at an alpha level of .05 to determine if the association was significant.

LIMITATIONS OF THE STUDY

In this study it was not assumed that the ATNR was the only possible marker of abnormal motor outcome at 8 years of age. It was intended that the study would add further to the body of knowledge on motor outcome of neonatal intensive care survivors.

Being a post-hoc study within a larger research project, the data and its method of collection were predetermined. Data collection was systematically and specifically completed and therefore does not threaten the validity of this study.

This study did not examine the effect of socioeconomic status or intelligence on the motor outcome. Although these factors may have an effect on outcome. it would require additional studies to examine these dimensions.

RESULTS

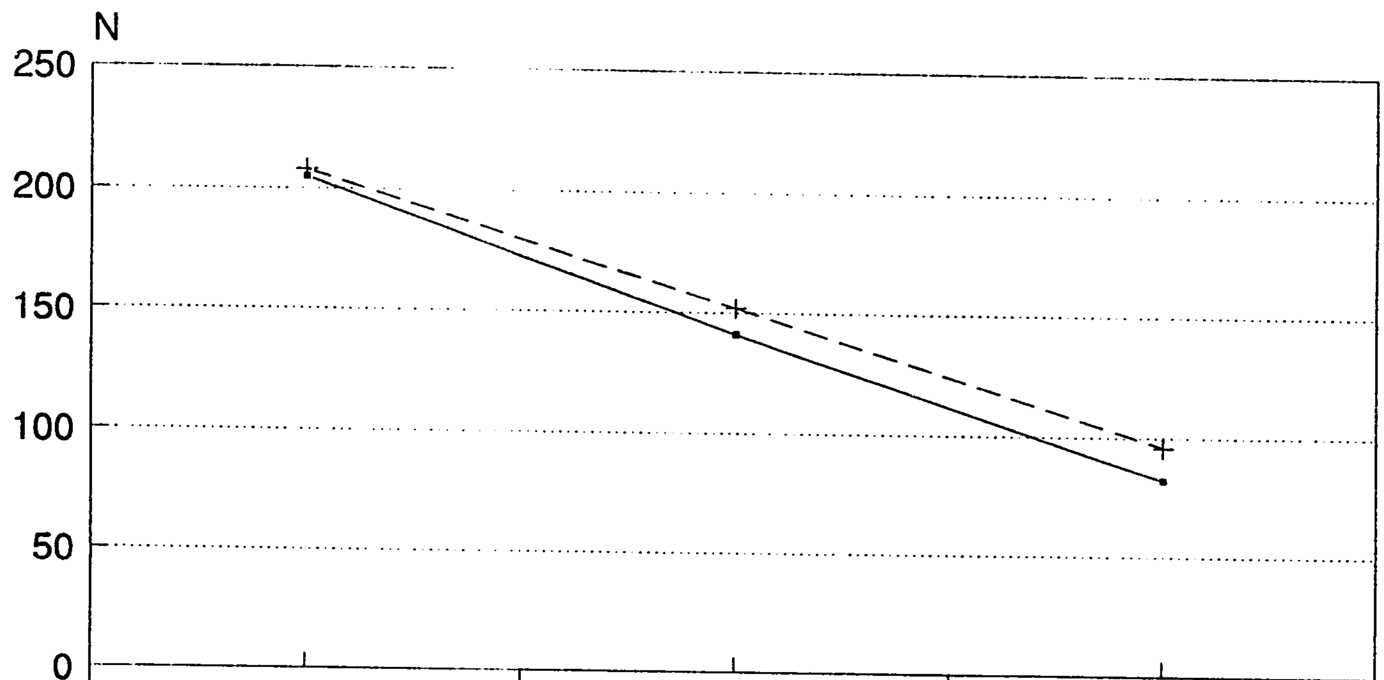
SUMMARY OF THE PREVALENCE OF THE ATNR

Before analyzing the predictive value of the ATNR on motor outcome, the prevalence or probability of a +ATNR must be measured (Riegelman, 1981). Prevalence represents the fraction or proportion of a group possessing a clinical condition at a given point in time (Fletcher, Fletcher & Wagner, 1988). Table 2 provides cross-sectional information on the prevalence of the ATNR at the 3 1/2, 5 1/2 and 8 year assessment intervals. Figure 7 illustrates the prevalence graphically.

The presence of a +ATNR to the right and left decreases with age as illustrated in Table 3. Between the 3 1/2 year assessment and 5 1/2 year assessment the prevalence decreased by 17.7% (right) and 15.7% (left). Between the 5 1/2 year assessment and the 8 year assessment the prevalence decreased again by 16.2% (right) and 15.2% (left). This represents a 33.9% (right) and 30.9% (left) decrease between 3 1/2 years and 8 years.

TABLE 2 ATNR frequency at 3 1/2 years, 5 1/2 years and 8 years. N = 363

ASSESSMENT INTERVAL	VARIABLE	FREQUENCY	PERCENT
3 1/2 YEAR ASSESSMENT	-ATNR (R)	158	43.5
	-ATNR(L)	155	42.7
	+ATNR (R)	205	56.5
	+ ATNR(L)	208	57.3
5 1/2 YEAR ASSESSMENT	-ATNR(R)	222	61.2
	-ATNR(L)	212	58.4
	+ATNR(R)	141	38.8
	+ATNR(L)	151	41.6
8 YEAR ASSESSMENT	-ATNR(R)	281	77.4
	-ATNR(L)	267	73.6
	+ATNR(R)	82	22.6
	+ATNR(L)	96	26.4



	3.5 Years	5.5 Years	8 Years
ATNR(R)	205	141	82
ATNR(L)	208	152	96

FIGURE 7 - Prevalence of the ATNR

TABLE 3 Decreasing prevalence of a +ATNR

	3 1/2 YEARS	5 1/2 YEARS	8 YEARS
+ATNR(R)	56.5%	38.8%	22.6%
+ATNR(L)	57.3%	41.6%	26.4%

SUMMARY OF THE RELATIONSHIP OF THE ATNR TO MOTOR OUTCOME

The directional research hypothesis of this study was that there would be significantly decreased motor performance in children displaying a +ATNR when compared to children displaying a -ATNR. The ATNR responses at each assessment interval in relationship to motor outcome were calculated individually. A Chi-square 2 X 2 table with Yates Correction was calculated analyzing the extent that the observed frequencies in each cell in the table differed from the expected frequencies. A test for the statistical significance of the relative risk of an abnormal outcome was calculated for each variable (alpha level .05). The critical value of Chi-square equalled 3.84 (df = 1) at an alpha level of .05.

Relationship of ATNR Responses (3 1/2 years) to Motor Outcome

Table 4 provides Chi-square values and significance levels calculated to determine if there was a significant relationship between a +ATNR at the 3 1/2 year assessment interval and each of the individual motor outcome measures at the 8 year assessment interval. ATNR:right and ATNR:left were crosstabulated with motor outcomes separately. The Chi-square values measured at the 3 1/2 year assessment interval did not exceed 3.84 on any of the measures and therefore were not significant thus the presence of a +ATNR at 3 1/2 years was not considered predictive of abnormal motor outcomes at the 8 year assessment interval.

TABLE 4 ATNR (3 1/2 year assessment) crosstabulated with motor outcome

ATNR (RIGHT) 3 1/2 YEAR ASSESSMENT CROSSTABULATED WITH:	CHI-SQUARE	SIGNIFICANCE LEVEL
Standing Balance (right): eyes open	0.073	0.7865
Standing Balance (left): eyes open	2.964	0.0851
Hopping (right)	0.027	0.8698
Hopping (left)	0.313	0.5760
Tandem walking: forward	3.555	0.0594
Equilibrium reaction: sitting	0.000	0.9960
Equilibrium reaction: standing	0.072	0.7880
Finger nose (right)	3.033	0.0816
Finger nose (left)	0.177	0.6735
Alternating finger (right)	0.714	0.3981
Alternating finger (left)	1.524	0.2171
Running	0.000	1.0000
Stairs-up	0.000	0.9877
Stairs-down	0.074	0.7851
ATNR (LEFT) 3 1/2 YEAR ASSESSMENT CROSSTABULATED WITH:	**CHI-SQUARE**	**SIGNIFICANCE LEVEL**
Standing Balance (right): eyes open	0.675	0.4112
Standing Balance (left): eyes open	1.112	0.2916
Hopping (right)	0.137	0.7111
Hopping (left)	1.998	0.1574
Tandem walking: forward	3.056	0.0804
Equilibrium reaction: sitting	0.289	0.5910
Equilibrium reaction: standing	0.852	0.3561
Finger nose (right)	0.546	0.4600
Finger nose (left)	0.033	0.8555
Alternating finger (right)	0.478	0.8270
Alternating finger (left)	0.358	0.5499
Running	0.145	1.7031
Stairs-up	1.031	0.3098
Stairs-down	3.140	0.0764

p = .05

Relationship of ATNR Responses (5 1/2 years) to Motor Outcome

Table 5 provides Chi-square values and significance levels calculated to determine if there was a significant relationship between a +ATNR at the 5 1/2 year assessment interval and each of the individual motor outcome measures at the 8 year assessment interval. ATNR:right and ATNR:left were crosstabulated with motor outcomes separately. Chi-square values exceeding the critical value of 3.84 were found and confirmed a significant relationship between a +ATNR to the right and the abnormal motor outcomes of standing balance:right ($p \leq .01$), equilibrium reaction:sitting ($p \leq .01$) and equilibrium:standing ($p \leq .01$). A significant relationship was also confirmed between a +ATNR to the left and the abnormal motor outcomes of standing balance:right ($p \leq .01$), standing balance:left ($p \leq .05$), hopping:left ($p \leq .05$) and equilibrium:sitting ($p \leq .05$). Chi-square values for other motor outcome comparisons at 5 1/2 years do not provide predictive evidence.

TABLE 5 ATNR (5 1/2 year assessment) crosstabulated with motor outcome

5 1/2 YEAR ASSESSMENT: ATNR (RIGHT) CROSSTABULATED WITH:	CHI-SQUARE	SIGNIFICANCE LEVEL
Standing Balance (right): eyes open	7.679	0.0056**
Standing Balance (left): eyes open	2.405	0.1210
Hopping (right)	0.255	0.6134
Hopping (left)	3.101	0.0782
Tandem walking: forward	0.405	0.5247
Equilibrium reaction: sitting	9.321	0.0023**
Equilibrium reaction: standing	8.298	0.0040**
Finger nose (right)	0.197	0.6574
Finger nose (left)	1.617	0.2034
Alternating finger (right)	1.950	0.1626
Alternating finger (left)	0.000	1.0000
Running	0.209	0.6476
Stairs-up	0.8209	0.3652
Stairs-down	1.122	0.2896
5 1/2 YEAR ASSESSMENT: ATNR (LEFT) CROSSTABULATED WITH:	**CHI-SQUARE**	**SIGNIFICANCE LEVEL**
Standing Balance (right): eyes open	6.842	0.0089**
Standing Balance (left): eyes open	4.179	0.0409*
Hopping (right)	0.807	0.3690
Hopping (left)	5.845	0.0156*
Tandem walking: forward	3.517	0.0608
Equilibrium reaction: sitting	4.623	0.0315*
Equilibrium reaction: standing	3.385	0.0658
Finger nose (right)	0.997	0.3179
Finger nose (left)	2.845	0.3179
Alternating finger (right)	1.466	0.0916
Alternating finger (left)	0.000	1.0000
Running	0.000	1.0000
Stairs-up	0.866	0.3520
Stairs-down	0.000	1.0000

* p = .05
** p = .01

<u>Relationship of ATNR Responses (8 years) to Motor Outcomes</u>

Table 6 provides Chi-square values and significance levels calculated to determine if there was a significant relationship between a +ATNR at the 8 year assessment interval and each of the individual motor outcome measures at the 8 year assessment interval. Chi-square values for all but one of the calculations exceeded the critical value of 3.84. The relationship of the left ATNR to right side hopping was not significant. The relationship between the ATNR responses at the 8 year assessment interval and all other outcome variables provided conclusive evidence that a +ATNR was a significant indicator for abnormal motor outcome at 8 years.

The ATNR:right was significantly related at $p \leq .001$ to abnormal motor outcomes of: standing balance (right), standing balance (left), hopping (left), tandem walking, equilibrium reaction:sitting, equilibrium reaction:standing, finger nose (left), alternating finger (right), alternating finger (left), and stairs-down. The ATNR:right was also significantly related at $p \leq .01$ to finger nose (right), running and stairs-up and right was significantly related at $p \leq .05$ to hopping (right).

The ATNR:left was significantly related at $p \leq .001$ to the abnormal motor outcomes of: standing balance (right), hopping (left), tandem walking, equilibrium reaction:sitting, finger nose (right), finger nose (left), alternating finger (right), alternating finger (left), running, stairs-up and stairs-down. The ATNR:left was significantly related at $p \leq .01$ to the motor outcome standing balance (left).

TABLE 6 ATNR (8 year assessment) crosstabulated with motor outcome

ATNR (Right) Crosstabulated with:	CHI-SQUARE	SIGNIFICANCE LEVEL
Standing Balance (right): eyes open	18.728	.0000 ***
Standing Balance (left): eyes open	15.702	.0001 ***
Hopping (right)	3.834	.0502 *
Hopping (left)	14.752	.0001 ***
Tandem walking: forward	13.682	.0002 ***
Equilibrium reaction: sitting	31.409	.0000 ***
Equilibrium reaction: standing	23.838	.0000 ***
Finger nose (right)	9.020	.0027 **
Finger nose (left)	15.781	.0001 ***
Alternating finger (right)	20.656	.0000 ***
Alternating finger (left)	15.783	.0001 ***
Running	7.663	.0056 **
Stairs-up	6.723	.0095 **
Stairs-down	14.790	.0001 ***
ATNR (Left) Crosstabulated With:	**CHI-SQUARE**	**SIGNIFICANCE LEVEL**
Standing Balance (right): eyes open	15.707	.0001 ***
Standing Balance (left): eyes open	7.336	.0068 **
Hopping (right)	2.398	.1215
Hopping (left)	10.493	.0012 ***
Tandem walking: forward	11.604	.0007 ***
Equilibrium reaction: sitting	12.377	.0004 ***
Equilibrium reaction: standing	8.419	.0037 **
Finger nose (right)	11.937	.0006 ***
Finger nose (left)	18.848	.0000 ***
Alternating finger (right)	20.115	.0000 ***
Alternating finger (left)	19.165	.0000 ***
Running	15.564	.0001 ***
Stairs-up	7.346	.0067 ***
Stairs-down	16.457	.0000 ***

* p = .05
** p = .01
*** p = .001

SUBSIDIARY ANALYSES

Additional Analysis of ATNR Responses

Cell frequencies in crosstabulations of ATNR:right and ATNR:left responses provided additional information about frequencies and distribution of these responses. Table 7 summarizes the information.

TABLE 7 ATNR left/right differences.

DISTRIBUTION	3 1/2 YEAR ASSESSMENT		5 1/2 YEAR ASSESSMENT		8 YEAR ASSESSMENT	
	n	%	n	%	n	%
+ATNR R & L	180	49.59	109	30.03	60	16.53
-ATNR R & L	130	35.81	180	49.59	245	67.49
+ATNR R ONLY	25	6.89	32	8.82	22	6.06
+ATNR L ONLY	28	7.71	42	11.57	36	9.92

At the 3 1/2 year assessment interval the majority of the subjects displaying a +ATNR, displayed a bilateral +ATNR (49.59%). The percentage of subjects with a bilateral +ATNR decreased at the 5 1/2 year assessment (30.03%) and further at the 8 year assessment (16.53%).

The proportion of subjects that displayed a unilateral +ATNR was less across intervals than subjects with a bilateral +ATNR. A +ATNR:right only was recorded at 6.89% at the 3 1/2 year assessment interval, increasing to 8.82% at 5 1/2 years and decreasing to 6.06% at 8 years. A +ATNR:left only was recorded at 7.71% at the 3 1/2 year assessment interval, also increasing at 5 1/2 years to 11.57% and decreasing at 8 years to 9.92%.

CHAPTER V

DISCUSSION AND CONCLUSIONS

The results of this investigation suggested that a residual +ATNR at 8 years of age was highly indicative of dysfunctional motor development at age 8 years and that a residual +ATNR at 5 1/2 years of age was predictive of dysfunction of balance and equilibrium at age 8 years. Testing for the ATNR therefore would be a valuable screening tool. A residual +ATNR at 5 1/2 or 8 years of age would alert the examiner to potential motor dysfunction at age 8 years.

The prevalence of a +ATNR response decreased over time by 33.9% (right) and 30.9% (left) between the 3 1/2 years and 8 year assessment intervals. The prevalence of the ATNR in these neonatal intensive care survivors parallels that reported for normal children.

The recorded results of the prevalence of the +ATNR in this study were supported by the results reported by Parr et al. (1974). These researchers, in measuring the degree of elbow flexion elicited by a +ATNR response in 84 normal subjects, three to nine years of age, noted a decrease of flexion as the subject aged, the change levelling off at age six to seven years ($F = 0.77$). Zemke and Draper (1984) studied the magnitude of ATNR responses in normal three year old and five year old subjects ($N = 40$). The change in magnitude of elbow flexion was measured using electrogoniometers. The magnitude of the ATNR decreased significantly with age from 20° at three years of age to 14° at five years of age ($F = 5.50$, $p = .02$). A decrease of a +ATNR over time as measured by this study of

363 subjects, by the studies of Parr et al. (1974) and Zemke and Draper (1984), supports Ayres' (1972) premise that ATNR responses are present in young children but decrease with maturation.

In comparing the outcomes of Parr et al. (1974), Zemke and Draper (1984) and this study, there was strong evidence that in both normal and neonatal intensive care survivors +ATNR responses decreased with age. This suggested that the developmental course of the ATNR for normal and neonatal intensive care survivors was similar.

Subsidiary analysis of ATNR responses provided further information of clinical interest. In the analysis of a +ATNR:right only and a +ATNR:left only, a decrease in the response was not noted over time. In contrast, there was an increase in the prevalence of both the +ATNR:right and +ATNR:left at the 5 1/2 year assessment interval, followed by a decrease at the 8 year assessment interval. These results support the findings of Byers (1938) who suggested that primitive reflexes may reappear at various points in time because of a lack of more mature postural mechanisms. Further analysis of the motor characteristics of subjects with a unilateral +ATNR would be of future interest.

Further analysis of the significance of the difference between the developmental course of bilateral +ATNR responses and that of +ATNR:right only and +ATNR:left only would be of clinical interest. Appendix D contains preliminary analyses of dominance factors. Although dominance was not significantly related to an overall +ATNR it would be interesting to study subjects from the same sample who displayed either a +ATNR:right only or a +ATNR:left only to examine the relationship of the responses to the dominance of the subjects and to motor outcomes measuring right/left differences. The hypothesis would be that a relationship exists between a unilateral ATNR and the establishment of dominance and lateralization.

Investigations into the relationship of a +ATNR to abnormal motor outcomes were undertaken. There was a high prevalence of a +ATNR in subjects at the 3 1/2 year assessment interval: 56.5% right and 57.3% left. This high prevalence of a +ATNR coincides with the findings reported by Zemke (1980/81). Zemke stated that such a high incidence precludes a +ATNR from being considered abnormal at three years of age. It is probable that children do not integrate the ATNR until a later age. Given this high prevalence of a +ATNR at the 3 1/2 year assessment interval, it was not surprising that there was no significant relationship between a +ATNR and abnormal motor outcomes at eight years of age. Therefore a +ATNR at 3 1/2 years could not be considered to have predictive value as a marker of future motor dysfunction. A +ATNR at 3 1/2 years cannot be considered abnormal and therefore would not be a valuable predictive tool at this age.

It may be suggested from analysis completed in this study, that a +ATNR at 5 1/2 years has predictive value for abnormal development of equilibrium and balance activities. There were significant relationships between a +ATNR response at the 5 1/2 year assessment interval and the specific motor outcome variables of standing balance, equilibrium and hopping ($p \leq .05$).

ATNR responses were noted by Ayres (1972) and Morrison et al. (1985) to be associated with the development of equilibrium and balance. Ayres (1972) observed that the lack of integration of primitive reflexes in general interfered with the maturation of postural and equilibrium reactions. These early observations were supported by Morrison et al. (1985) who noted that in normal development, primitive reflexes such as the ATNR diminish, and equilibrium reactions emerge, from which gross motor skills develop.

A lack of integration in a five to six year old child would alert the examiner to possible future difficulties with equilibrium and balance. Taking this one step further, these findings suggested that continued follow-up at seven to nine years of age of a child displaying a +ATNR at 5 1/2 years was warranted.

A highly significant relationship was demonstrated between a +ATNR at the 8 year assessment interval and motor outcome at eight years. These findings supported the hypothesis that a persistent ATNR was a risk factor for dysfunctional performance at 8 years of age ($p \leq .05$ - .000). The decrease in the prevalence of a +ATNR by eight years of age suggested that maturation and integration of this reflex had occurred in the majority of the subjects suggesting that in most neonatal intensive care survivors the ATNR gives way to the development of more mature motor abilities as was suggested by Ayres (1972). Those children continuing to display a +ATNR also demonstrated deficits in many aspects of motor development. Decreased integration of primitive reflexes has been reported to result in decreased isolation of movement, segmentation of the trunk, rotation and responsiveness to postural change (Farber, 1982). These deficits in turn would have a negative impact upon the development of motor skills such as identified in this study.

The results obtained from this investigation provided evidence that maturational deficits of motor abilities were linked with the persistence of a residual +ATNR at eight years of age. The significant results suggested that evidence of a +ATNR at the 8 year assessment interval was highly indicative of motor dysfunction and could be used effectively as a screening tool. The observations of a +ATNR would alert an examiner to the possibility of associated motor impairment in the seven to nine year old child.

Outcome measures in this study consisted of a cross-section of motor variables. A +ATNR was related to each individual motor variables. This provided valuable insight into the influence of a +ATNR to certain variables. Subsidiary analysis of these motor outcome variables calculated the frequency of abnormal scores (range 0 - 14) of the motor outcomes over subjects. Frequency results as illustrated in Appendix D provided an initial perception of the number of abnormal variables recorded across subjects. The most frequent value (mode) in the distribution was 0 indicating that these children had normal scores across the motor variables. Fifty percent of children had a score of 2 or less indicating that these children had deficits in up to two of these motor tasks. The average deficit score was 3.069. Further attempts to study possible clusters of motor outcomes and their relationship to a +ATNR would be warranted and would provide valuable diagnostic information.

In summary, the objective of this study to document the prevalence of a residual ATNR at 3 1/2, 5 1/2 and 8 year assessment intervals was achieved. Results demonstrated a decreasing response over time and supported the reported findings of other studies. Additional questions of clinical interest arose from the contrasting prevalence of unilateral +ATNR responses.

The hypothesis of a relationship between a +ATNR and abnormal motor outcome was supported at the 5 1/2 and 8 year assessment intervals. A +ATNR at the 5 1/2 year assessment interval would alert an examiner to the possibility of future balance and equilibrium difficulties at the 8 year assessment interval. Further to these study findings, it would be valuable to study the relationship of a +ATNR at the 5 1/2 year assessment interval with motor performance recorded at 5 1/2 years to gain further insights into the relationship of the ATNR to motor development.

The observation of a +ATNR at the 8 year assessment interval would be effective in the screening of motor dysfunction at 8 years. A study of possible clusters of the motor outcomes at 8 years would add further to the understanding of the relationship of the ATNR to motor development.

In contrast, an observation of a +ATNR at the 3 1/2 year assessment interval cannot be interpreted as predictive. The efficacy of the use of ATNR testing for the purpose of prognostication of motor outcome at 3 1/2 years can be questioned.

Since assessments were completed on a sample of neonatal intensive care survivors, caution must be exercised in generalizing the results to other groups of children. Future investigations into the prevalence of ATNR responses and subsequent motor outcome of subjects from other defined groups are warranted.

It cannot be assumed that the ATNR is the only possible marker of motor outcome at eight years of age. A study of additional possible markers such as other primitive reflexes in the same sample of children would provide further insight into the relationship of primitive reflexes to motor development.

The evidence resulting from this study provided one piece to a complex puzzle. Further scientific studies are necessary to confirm the role of the ATNR, among other primitive reflexes, as a predictor of motor outcome in at-risk neonatal intensive care survivors.

REFERENCES

Avery, G.B. (1987). Neonatology: Pathophysiology and Management of the Newborn (3rd ed.). Philadelphia: J.B. Lippincott Company.

Ayres, A.J. (1968). Sensory integrative processes and neuropsychological learning disabilities. Learning Disorders, 3, 41-58. Seattle, Washington: Special Child Publications.

Ayres, A.J. (1972). Sensory Integration and Learning Disorders. Los Angeles: Western Psychological Services.

Ayres, A.J. (1975). Sensorimotor foundations of academic learning in perceptual and learning disabilities in children. In. W.M. Cruickshank & D.P. Halahan, Research and Theory (pp. 301-358). New York: Syracruse University Press.

Baird, H.S. & Gordon, E.C. (1983). Neurological Evaluation of Infants and Children. Philadelphia: Lippincott, Co.

Bierman-van Eedenburg, M.E.C., Jurgens-VanDerZee, A.D., Oligna, A.A., Huisjes, H.H. & Touwen, B.C.L. (1981). Predictive value of neonatal neurological examination: A follow-up study at 18 months, Developmental Medicine Child Neurology, 23, 296-305.

Bigsby, R. (1983). Reaching and asymmetrical tonic neck reflex in pre-term and full term infants. Physical and Occupational Therapy in Pediatrics, 3, 25-42.

Bobath, B. (1971). Abnormal Postural Reflex Activity Caused By Brain Lesions (2nd ed.). London: William Heinemann Medical Books.

Bower, T.G.R. (1974). Development in Infancy. San Francisco: W.H. Freeman & Company.

Bowsher, D. (1988). Introduction to the Anatomy and Physiology of the Nervous System (5th ed.). Oxford: Blackwell Scientific Publications.

Bratzlavsky, M. & Vander Eecken, H. (1977). Postural reflexes in cranial muscles in man. Acta Neurol. Belgium, 77, 5-11.

Byers, R.K. (1938). Tonic neck reflexes in children. American Journal of Diseases in Children, 55, 696-742.

Campbell, S.K. & Wilhelm, I.J. (1985). Development from birth to 3 years of age of 15 children at high risk for central nervous system dysfunction. Physical Therapy, 65(4), 463-469.

Capute, A.J., Accardo, P.J., Vining, E., Rubenstein, J. & Harryman, S. (1978). Primitive Reflex Profile. Baltimore: University Park Press.

Capute, A.J., Shapiro, B., Accardo, P.J., Wachtel, R.C., Ross, A. & Palmer, T.B. (1982). Motor functions: Associated primitive reflex profile. Developmental Medicine Child Neurology, 24, 662-669.

Coryell, J. & Cardinali, N. (1979). The asymmetrical tonic neck reflex in normal full-term infants. Physical Therapy, 59(6), 747-753.

Coryell, J., Henderson, A. & Liederman, J. (1982). Factors influencing the asymmetrical tonic neck reflex in normal infants. Physical and Occupational Therapy in Pediatrics, 2(2/3), 51-65.

Coughran, L. & Goff, M. (1976). Learning Staircase: Teacher's Guide. Austin, Texas: Learning Concepts.

Cratty, B. (1970). Perceptual and Motor Development in Infants and Children. New York: MacMillan Publishing Co. Inc.

De Quiros, J. & Schrager, O. (1978). Neuropsychological Fundamentals in Learning Disabilities. San Rafael, California: Academic Therapy Publications.

Drillien, C.M. (1972). Abnormal neurologic signs in the first year of life in low-birthweight infants: Possible prognostic significance. Developmental Medicine Child Neurology, 14, 575-584.

Drillien, C.M., Thomson, A.J.M. & Burgoyne, K. (1980). Low-birthweight children at early school-age: A longitudinal study. Developmental Medicine Child Neurology, 22, 26-47.

Dubowitz, L. & Dubowitz, V. (1981). The Neurological Assessment of the Pre-term and Full-term Newborn Infant. London: Wm. Heinemann Medical Books Ltd.

Dubowitz, L.M.S., Dubowitz, V., Palmer, P.G., Miller, G., Fawer, C.L., Levene, M.I. 1984). Correlation of neurologic assessment in the preterm infant with outcome at 1 year. The Journal of Pediatrics, 105(3), 452-456.

Dunn, W. (1981). A Guide to Testing Clinical Observations in Kindergartners. American Occupational Therapy Association, Inc.

Eilers, B.L., Desai, N.S., Wilson, M.A. & Cunningham, M.D. (1986). Classroom performance and social factors of children with birthweight of 1,250 grams or less: Follow-up at 5-8 years of age. Pediatrics, 7(2), 203-217.

Farber, S.D. (1982). Neurorehabilitation: A Multisensory Approach. Toronto: W.B. Saunders, Co.

Finocchiaro, A.C. (1974). Learning disabled children with postural reflex dysfunction. American Journal of Occupational Therapy, 28(1), 30-34.

Fiorentino, M. (1973). Reflex Testing Methods for Evaluating CNS Development (2nd ed.). Springfield, Illinois: Charles C. Thomas Publisher.

Flavel, J. (1963). The Developmental Psychology of Jean Piaget. New York: Van Nostrand Co.

Fletcher, R.H., Fletcher, S.W. & Wagner, E.H. (1988). Clinical Epidemiology: the Essentials. Baltimore: Williams & Wilkins.

Friedlander, S., Pothier, P., Morrison, D. & Herman, L. (1982). The role of neurological-developmental delay in childhood psychopathology. American Journal Orthopsychiatric, 52(1), 102-108.

Gelbach, S. (1988). Interpreting the Medical Literature: Practical Epidemiology for Clinicians (2nd ed.). New York: MacMillan.

Gesell, A. & Ames, L.B. (1950). Tonic-neck-reflexes and symmetro-tonic behavior. Journal of Pediatrics, 36, 165-176.

Gesell, A. & Armatruda, C.S. (1947). Developmental Diagnosis: Normal and Abnormal Child Development (2nd ed.). New York: Paul B. Hoeber Inc.

Gilfoyle, E.M., Grady, A. & Moore, J. (1981). Children Adapt. New Jersey: Charles B. Slack, Inc.

Glantz, S.A. (1987). Primer in Biostatistics (2nd ed.). New York: McGraw-Hill Company.

Haas, G., Buchwald-Saal, M., Leidig, E. & Mentzel, H. (1986). Improved outcome in very low birth weight infants from 1977-1983. European Journal of Pediatrics, 145, 337-340.

Hayes, K.C. & Sullivan, J. (1976). Tonic neck reflex influence on tendon and Hoffman reflexes in man. Electromyography in Clinical Neurophysiology, 16, 251-261.

Hellebrandt, F.A., Schade, M. & Carns, M.L. (1962). Methods of evoking the tonic neck reflexes in normal human subjects. American Journal of Physical Medicine, 41, 91-139.

Henderson, S.E. & Hall, D. (1982). Concomitants of clumsiness in young school children. Developmental Medicine and Child Neurology, 24, 444-459.

Ikai, M. (1950). Tonic neck reflex in normal persons. Japanese Journal of Physiology, 1, 118-124.

Komich, M.P., Lansford, A., Lord, L. & Tearney, A. (1974). The sequential development of infants of low birth weight. American Journal of Occupational Therapy, 27(7), 396-402.

Lance, J.W. & McLeod, J.G. (1981). A Physiological approach to Clinical Neurology (3rd ed.). London: Butterworths.

Laszlo, J.I. & Bairstow, P.J. (1985). Perceptual-Motor Behavior: Developmental Assessment and Therapy. Praeger Special Studies. New York: Praeger Scientific.

Lee, A.M. (1977). Relationship between birthweight and perceptual motor performance in children. Perceptual and Motor Skills, 45, 119-122.

Lubchenco, L.O., Horner, F.A., Reed, L.H., Hix, I.E., Metcalf, D., Cohig, R., Elliott, H.C., & Bourg, M. (1963). Sequelae of premature birth. American Journal of Diseases of Children, 106, 101-115.

Luria, A.R. (1973). The Working Brain: An Introduction in Neuropsychology. New York: Basic Books, Inc.

Minkowski, M. (1921). Sur les mouvements, les reflexes et les reactions musculaires du foetus humain de 2 a 5 mois et leur relations avec le systeme nerveux foetal. Rev. Neurologic, 37, 1105.

Minkowski, M. (1928). Neurobiologische studien am menschlichen foetus. Lief, 253S, 511-618.

Morrison, D.C, Hinshaw, S.P. & Carte, E.T. (1985). Signs of neurobehavioral dysfunction in a sample of learning disabled children: Stability and concurrent validity. Perceptual and Motor Skills, 61, 863-872.

Norton, Y. (1972). Minimal cerebral dysfunction. The American Journal of Occupational Therapy, 26(4), 186-199.

Obrzut, J.E. & Hynd, G.W. (1986). Child Neuropsychology: Theory and Research, Vol. 1. Orlando: Academic Press Inc.

Paine, R.S., Brazelton, T.B., Donovan, D., Drorbaugh, J.E., Hubbell, J.P. & Sears, E.M. (1964). Evolution of postural reflexes in normal infants and in the presence of chronic brain syndrome. Neurology, 14, 1036-1048.

Parmalee, A.H. (1975). Neurophysiological and behavioral organization of premature infants in the first months of life. Biological Psychiatry, 10(5), 501-512.

Parmalee, A.H. & Schulte, F.J. (1970). Developmental testing of the pre-term and small-for-date infants. Journal of Pediatrics, 45(1), 21-28.

Parmenter, C.L. (1975). The asymmetrical tonic neck reflex in normal first and third grade children. American Journal of Occupational Therapy, 29(8), 463-468.

Parmenter, C.L. (1983). An asymmetrical tonic neck reflex rating scale. American Journal of Occupational Therapy, 37(7), 462-465.

Parr, C., Routh, D., Byrd, M. & McMillan, J. (1974). A developmental study of the asymmetrical tonic neck reflex. Developmental Medicine Child Neurology, 16, 329-335.

Consultants Bureau.

Phillips, J.L. (1981). Piaget's Theory: A Primer. San Francisco: W.H. Freeman & Company.

Prechtl, H.F.R., Fargel, J.W., Weinmann, H.M. & Bakker, H.H. (1979). Postures, mobility and respiration of low-risk pre-term infants. Developmental Medicine Child Neurology, 21, 3-27.

Rider, B.A. (1972). Tonic neck reflexes. The American Journal of Occupational Therapy, 26(3), 132-134.

Riegelman, R.K. (1981). Studying a Study and Testing a Test. Boston: Little, Brown and Company.

Roberts, T. (1978). Neurophysiology of Postural Mechanisms (2nd ed.). Toronto: Butterworths.

Robertson, C.M.T. (1980). Neonatal Follow-up Study: Data Collection and Coding Manual (unpublished). Neonatal Follow-Up Clinic, Glenrose Hospital, Edmonton, Alberta, Canada.

disability among neonates at high risk born between 1975 and 1984 in Alberta. Canadian Medical Association Journal, 139(3), 225-229.

Ryan, E.D. (1963). Relative academic achievement and stabilometer performance. Research Quarterly, 34, 185-190.

Saint-Anne Dargass[illegible] (1972). Neurodevelopmental symptoms during the first year of life. Developmental Medicine Child Neurology, 14, 235-246.

Saint-Anne Dargassies, S. (1977). Long-term neurological follow-up study of 286 truly premature infants: neurological sequelae. Developmental Medicine Child Neurology, 19, 462-478.

Schmidt, R.A. (1988). Motor Control and Learning (2nd ed.). Champaign, Illinois: Human Kinetics Publishers, Inc.

Schmidt, R.F. ed. (1978). Fundamentals of Neurophysiology (2nd ed.). New York: Springer-Verlag.

Short, M.A., Watson, P.J., Ottenbacher, K., Rogers, C. (1983). Vestibular - proprioceptive functions in 4 year olds: normative and regression analysis. American Journal of Occupational Therapy, 37(2), 102-109.

asymmetrical tonic neck reflex. American Journal of Occupational Therapy, 33(5), 311-316.

Silver, A.A. (1952). Postural and righting responses in children. The Journal of Pediatrics, 41, 493-498.

Singer, R.N. (1980). Motor Learning and Human Performance: An Application to Motor Skills and Movement Behaviors (3rd ed.). New York: MacMillan Publishing Co. Ltd.

Start, K.B. (1964). Intelligence and improvement of gross motor skill after mental practise. British Journal of Educational Psychology, 34, 85-90.

Steiner, E.S., Sanders, E.M., Phillips, E.C. & Maddock, C.R. (1980). Very low birthweight children at school age: neonatal management methods. British Medical Journal, 281, 1237-1248.

Stewart, A.L., Reynolds, E.O.R. & Lipscomb, A.P. (1981). Outcome of infants with very low birthweight: Survey of world literature. Lancet, 1, 1038-1041.

Stott, D.H., Moyes, F.A. & Henderson, S.E. (1984). Test of Motor Impairment, (Henderson Revision). Guelph, Ontario: Brook Educational Publishing Ltd.

correlation between perceptual - motor and intellectual abilities for the pre-school and early elementary age children. Journal of Motor Behavior, 4, 23-29.

Thomas, J.R. & French, K.E. (1985). Gender differences across age in motor performance: A meta-analysis. Psychological Bulletin, 98, 260-282.

Tokizane, T., Murao, M., Ogata, T. & Kondo, T. (1951). Electromyographic studies on tonic neck, lumbar and labyrinthe reflexes in normal persons. Japanese Journal of Physiology, 2, 130-146.

Umphred, D.A. ed. (1985). Neurological Rehabilitation. Toronto: C.V. Mosby, Company.

Valvano, J. & Degangi, G. (1986). Atypical posture and movement findings in high-risk, pre-term infants. Physical and Occupational Therapy in Pediatrics, 6(2), 71-81.

Vasella, F. & Karlsson, B. (1962). Asymmetrical tonic neck reflex: a review of the literature and a study of its presence in the neonatal period. Developmental Medicine Child Neurology, 4, 368-369.

Neurodevelopmental and school performance of very low birthweight infants: a seven year longitudinal study. Pediatrics, 76(3), 345-350.

Wade, M.G. & Whiting, H.T.A. (1986). Motor Development in Children: Aspects of Coordination and Control. Boston: Martinus Nijhoff Publishers.

Watt, J., Robertson, C.M.T. & Grace, M.G.A. (1989). Early prognosis for ambulation of NICU survivors with cerebral palsy. Developmental Medicine and Child Neurology, 31, 766-773.

Wells, H.S. (1944). The demonstration of tonic neck and labyrinthe reflexes and positive heliotropic responses in normal human subjects. Science, 99(2559), 36-37.

Wender, P.H. (1971). Minimal Brain Dysfunction in Children. New York: Wiley-Interscience.

Zemke, R. (1980/81). Incidence of ATNR response in normal pre-school children. Physical and Occupational Therapy in Pediatrics, 1(2), 31-37.

Zemke, R. & Draper, D.C. (1984). Notes on measurement of the magnitude of the asymmetrical tonic neck reflex response in normal preschool children. Journal of Motor Behavior, 16(3), 336-343.

APPENDIX A

PERMISSION TO USE DATA FROM THE NEONATAL FOLLOW-UP PROJECT

Rehabilitation
Hospital

EDMONTON
ALBERTA T5G 0B7
(403) 471 2262
FAX (403) 471 7976

22 January 90

Mrs. Sylvia Wilson
Graduate Student
University of Alberta and,
Director, Occupational Therapy
Pediatric Rehabilitation Unit
Glenrose Rehabilitation Hospital
10230 - 111 Avenue
Edmonton, Alberta T6G 0B7

Dear Mrs. Wilson:

It has been a pleasure to be a part of your supervisory committee for your graduate studies toward a Master of Science - Occupational Therapy. Your research topic, "The predictive value of the ATNR in studies of neonatal intensive care survivors" it is of great to me. Your thesis proposal is well done.

ve requested, in writing, data from the Neonatal Follow-up Clinic base. Because of your previous involvement with the Follow-up Clinic, I know that you have an appreciation for the Database and I am pleased to insure that the material will be forwarded to you.

As you indicated in your letter, it will be necessary for your to acknowledge the Northern and Central Alberta Perinatal Program and the Glenrose Rehabilitation Hospital as providing support for the study indirectly through the Database. This Database was financially supported from money from the Department of Hospitals through the Northern and Central Alberta Perinatal Program to the Glenrose Rehabilitation Hospital. The Follow-up Clinic was initially established to provide service for neonatal intensive care graduates and to provide a pilot study for the long term outcome of those children. Details of the data collected in the Database and the consultants used is outlined in our Data Collection Manual. In 1974, I was invited to direct this project by Dr. G. Eddy, then Clinical Director of Glenrose School Hospital. Essentially, consultants from all of the Departments in the Glenrose School Hospital contributed to the ideas for the evaluation of the children at the various ages. The Alberta Hospital Act allows for the establishment of databases in hospital settings.

In my position as previous and current director of the Neonatal Follow-up Clinic and with the advice of Dr. C. Banner, previous head of the Department of Psychology in the Glenrose School Hospital and then Chairman of the Research and Ethics Committee of the Glenrose

Rehabilitation Hospital and Mr. Tom Acheson, Director of Computer Services at Glenrose Hospital, a method was established for the distribution of this data. This method requires a letter from you with your research plan and this is now complete in your research proposal. It also requires that you complete the SPSS File Generation Forms indicating precisely the data you require. These have been received.

As I have mentioned to you before, it was documented many years ago in the minutes of the Northern and Central Alberta Perinatal Program-Advisory Committee, that it is necessary for me to be an author on all papers to insure that the data is correctly represented. We have discussed this point and, I am pleased that you plan to publish the fruit of your work for your Master's Thesis and I believe that there will be at least two potential papers following the completion of the data analysis.

Janis Kyle, Consultant for the Neonatal Follow-up Clinic, Glenrose Hospital for Research Design and Data Analysis, and I have reviewed your request and the data and we feel that the data is clean, verified, and can answer the questions you have posed.

It is my understanding that you would like to have the data transferred to you as SPSS-X variables for your use on a IBM compatible home computer format.

I anticipate continued involvement with your project, both now as you complete your Master's thesis and subsequently as we work toward publishing this most interesting data.

Yours sincerely,

Charlene M.T. Robertson, M.D., F.R.C.P.(C)
Associate Professor, Department of Pediatrics; and
Director, Neonatal Follow-up Clinic
Glenrose Rehabilitation Hospital

CMTR*jr

cc: Dr. H. Madill
Chairman of the Supervisory Committee,
Professor, Department of Occupational Therapy
School of Rehabilitation Medicine
University of Alberta; Edmonton, Alberta

Mrs. J. Kyle
Consultant, Glenrose Rehabilitation Hospital

Dr. J. Watt, Acting Clinical Director

Dict: 19 Jan 90/Typed: 22 January 90/L: .754

APPENDIX B

EXCERPTS FROM NEONATAL FOLLOW-UP STUDY:

DATA COLLECTION AND CODING MANUAL

(ROBERTSON, 1980)

NEONATAL FOLLOW-UP CLINIC CLASSIFICATION CODES

The following is a description of the various classification codes employed to categorize children in the Neonatal Follow-Up Study. On the basis of diagnosis at the time of referral to the Follow-Up Clinic, a classification code is assigned to each infant. This coding system, then, pertains to all of the following groups of children:

(a) survivors who are seen at the Follow-Up Clinic (patient numbers in the 0000 and 7999 range)

(b) survivors who are not seen at the Follow-Up Clinic, for reasons such as death after discharge, parental refusal, inability to locate or Follow-By-Mail (patient numbers in the 8000 to 8999 range)

(c) infants who died while in hospital (patient numbers in the 9000 to 9999 range)

Code 1 All infants weighing 1500 grams or less at birth and cared for in either the Royal Alexandra Hospital or the University of Alberta Hospital, Neonatal Intensive Care Units.

Code 2* All infants cared for in either the Royal Alexandra Hospital or the University of Alberta Hospital, Neonatal Intensive Care Units, weighing more than 1500 grams at birth, with central nervous system conditions complicating their course. These central nervous system conditions include:

- meningitis
- suspected or known intracranial hemorrhage
- convulsions
- anoxic encephalopathy (three stages - mild to severe)
- birth trauma or birth asphyxia sufficient to require admission to the Neonatal Intensive Care Unit for treatment (not just observation unit)
- recurrent apnea requiring ventilation
- recurrent apenic or cyanotic spells thought to be on central nervous system bases

Note: this excludes all children with central nervous system disorders known to be associated with handicap, and who are followed elsewhere, e.g. children with Down's syndrome. Meningomyelocele, Trisomy E., etc.

* Originally, infants fitting these diagnostic criteria were randomly assigned either classification code '2' (to be followed) or '5' (not to be followed). However, after the first year of the clinic, it was considered necessary to follow all such infants. As a result, both code '2' and code '5' may exist in the data and are to be

considered identical groups.

Code 3 Fifty percent of all infants cared for in either the Royal Alexandra Hospital or the University of Alberta Hospital, Neonatal Intensive Care Units, weighing more than 1500 grams at birth, and requiring ventilation, but not falling into category '2'. These are determined by the flip of a coin, with 'heads' being chosen.

For infants born between August 1, 1974 and August 1, 1977, this code pertains to all such infants requiring ventilatory aids and assistance, and ventilation.

For infants born from September 1, 1977, this code pertains only to infants receiving total ventilation.

Code 4 A ten percent random sample of all infants discharged from either the Royal Alexandra Hospital or the University of Alberta Hospital, Neonatal Intensive Care Units, weighing more than 1500 grams at birth, and not falling into category '1', '2' or '3'. This code was used for infants born between August 1, 1974 and August 1, 1977, and was then discontinued.

Code 6 Infants cared for in either the Royal Alexandra Hospital or the University of Alberta Hospital, Neonatal Intensive Care Units, weighing more than 1500 grams at birth, and requiring ventilation. These infants did not fall into the statistical group for category '3', because on the flip of a coin they were 'tails'. Due to special referral from a physician, some of these infants are being followed.

Code 7 Infants cared for in either the Royal Alexandra Hospital or the University of Alberta Hospital, Neonatal Intensive Care Units, weighing more than 1500 grams at birth with specific problems of concern to the Neonatalogist, but not fitting the diagnostic criteria for code '1', '2', '3' or '6'.

Code 8 Infants cared for in either the Royal Alexandra Hospital or the University of Alberta Hospital, Neonatal Intensive Care Units, who were initially not selected for follow-up but were later referred to the Neonatal Follow-Up Clinic by a physician.

Code 9 Infants who were not cared for in either the Royal Alexandra Hospital or the University of Alberta Hospital, Neonatal Intensive Care Units, but were primarily (from another Neonatal Intensive Care Unit), or secondarily referred by a physician. Data on these infants will not be entered into the computer as a part of the major study, but may be used by individual Glenrose departments for their research.

Code 0 Infants cared for in either the Royal Alexandra Hospital or the University of Alberta Hospital, Neonatal Intensive Care Units, but not fitting any of the above diagnostic criteria. These infants may have no specific diagnosis or may have a congenital malformation which should exclude them from the Follow-Up Study (e.g. central nervous system malformation, chromosomal abnormality, or intrauterine infectious malformation). Normally, no data would be retained on this group of infants except on special request by the Neonatologists for the purpose of their own research.

APPENDIX C

PARENTAL INFORMATION AND GLENROSE REHABILITATION HOSPITAL CONSENT FORM

Excerpts of parental information distributed by the Neonatal Follow-Up Clinic are included. These were distriubted in personal letter format.

PARENTAL INFORMATION

Title: Neonatal Follow-Up Clinic

Investigator: Dr. Charlene Robertson

This is a follow-up clinic for children who were cared for in the intensive care unit shortly after birth. Specialized care for small or ill newborns is improving each year and these babies are developing much better than they have in the past. The purpose of the Neonatal Follow-Up Clinic is to examine the babies carefully for normal development, including muscle tone and movement, hearing, vision, and speech. If any problems are found then early therapy can be recommended. By examining most of the babies who required intensive care in the newborn period we will be able to determine what areas of newborn care require improvement so that all these babies are as healthy as possible.

______________ will be reviewed by a team of specialists from the departments of physiotherapy, occupational therapy, and nursing. A paediatrician will also evaluate their recent progress.

PARENTAL INFORMATION

(3 1/2 YEAR ASSESSMENT)

Title: Neonatal Follow-Up Clinic

Investigator: Dr. Charlene Robertson

Thank you so very much for your continued cooperation with the Neonatal Follow-Up Clinic.

The Neonatal Follow-Up Clinic is designed to follow babies receiving specialized care in the newborn period. Through our knowledge of how these babies are doing in their development we assist in making changes in care in the nurseries and help to improve care for future babies. The majority of babies receiving Intensive Care do very well in all aspects of their development, but it is only by seeing the children or having knowledge of how they are doing that we can discover areas where obstetrical and neonatal care in Northern and Central Alberta can be improved.

As the children grow older the assessment and therapists change and include other areas of development; such as speech and school-related tasks.

PARENTAL INFORMATION

(5 1/2 YEAR ASSESSMENT)

Title: Neonatal Follow-Up Clinic

Investigator: Dr. Charlene Robertson

The Neonatal Follow-Up Clinic, established in 1974, provides follow-up for selected newborns who have received tertiary neonatal intensive care at either the University Hospital or the Royal Alexandra Hospital in Edmonton, Alberta. The Follow-Up Clinic is part of the Northern and Central Alberta Perinatal Program. The majority of children seen in the clinic are doing well. The cooperation of the parents and physicians of these children is greatly appreciated as "follow-up" provides us with the opportunity of evaluating Neonatal Intensive Care and improving the care for future children. The children seen at age 5 1/2 years have attended the clinic regularly since infancy and are part of a longitudinal study which will give us the outcome in terms of the school performance of these children at age eight years.

The interdisciplinary assessment team at age 5 1/2 years includes Psychology, Nursing, Speech Pathology, Audiology for some children and Education. In addition, a paediatric examination is completed by Dr. C. Robertson.

Assessments include the Stanford-Binet Intelligence Scale (L-M); the Developmental Test of Visual Motor Integration (Beery); a speech and language evaluation coded according to the Communication Behavior Rating; the Peabody Picture Vocabulary Test; as well as an educational review of school readiness skills. An attempt is made to complete the Snellen Vision Test and the Titmus Stereoscopic Vision Test.

LETTER TO PARENTS PRIOR TO 8 YEAR ASSESSMENT

You have been so very helpful in assisting us with our Neonatal Follow-Up Program in the past. I wish to take this opportunity to thank you and also to ask you to come one more time for the last visit to the Clinic.

When you first brought (CHILD'S FIRST NAME ONLY--USE CORRECT FIRST NAME) to the Clinic, we told you of the long-term longitudinal nature of this follow-up program and our desires to see the children until school age. Some changes have taken place in the Neonatal Intensive Care Units because of the follow-up program and your cooperation. One of the greatest areas of value has been in determining which of the ill neonates are the ones "at-risk" for later developmental problems. At the beginning of our program, all infants cared for in Neonatal Intensive Care Units were considered to be "at-risk". From participation of all the parents we know the number of infants with handicaps interfering with walking or seeing or hearing is less than 15% of all of the children seen and we know which are the complicating factors in the newborn period likely to produce these handicaps. It is now possible to work to avoid those complicating factors likely to be associated with handicaps. Very specific neonatal research is going on at this time in our hospitals in the areas of asphyxia, blood pressure and nutrition, particularly for the very small pre-term newborn. By coming to the Clinic you have helped make these advances possible.

Equally as important as knowing the problem areas is to know which children do well. It is important to be able to tell the parents of a very ill newborn that the baby will do well with very little chance of a developmental handicap. We now can be much more accurate about the outcome of an ill newborn than we could in 1974 when the Clinic started. You have helped us in this.

In planning the evaluation of the children until age eight years of age, it was hoped that we could compare the school performance of the children to the newborn illnesses. If a pattern of newborn problems appears which is related to school difficulties, for example problems in reading or arithmetic, then we can tackle these neonatal illnesses as well have those mentioned in paragraph two above.

We know that many of the children have never had any problem on their visits to the Neonatal Follow-Up Clinic and are doing very well in school. We hope to be able to see all these children at age eight years as well. Their neonatal pattern is important as it reinforces that certain neonatal illness can be well treated without side-effects. You may think that it is the child that, for example, requires a respirator for several weeks that will have difficulties - but that is not the case. Many very ill children do well. The underlying plan of this follow-up program has always been the prevention of handicaps.

The eight year-old assessment will be in approximately six months and we invite you to participate. Clinics for 1985 will be held Wednesdays and Fridays except during summer (July and August) and Christmas vacations. The assessment of your child will be the approximate length of a school day and the emphasis will be school-related tasks. The detailed assessments of gross-motor, balance, equilibrium and fine-motor tasks will have less emphasis than in past assessments. All tests will be described and discussed with you and your child before testing.

You are invited to have a complete eye examination for your child at the Orthoptic Clinic, Clinical Sciences Building, at the University of Alberta to take place on a day arranged by yourself with the Orthoptic Clinic. If you wish this examination, please let my secretary know and a referral will be made. You will get a copy of the referral letter.

Hearing has been checked at previous assessments and this will not routinely be done at age eight years.

Parents will be welcome to observe their child's assessment for part of the time and the therapists and educators would like the opportunity to interview you and may ask you to complete check-lists as they have done in the past. As this will not take all of your time, you may wish to bring reading material or handiwork. Literature of the outcome of the children seen in the Clinic until age two years will be available to read if you wish.

We will be very grateful to you if you can come to see us once more.

Thank you for your participation.

PARENTAL INFORMATION

Title: Neonatal Follow-Up Clinic

Investigator: Dr. Charlene Robertson

The Neonatal Follow-Up Clinic is designed to follow Neonatal Intensive Care graduates until 8 years of age. Through documentation of the quality of the cognitive, behavioral, and motor abilities and the long-term school performance of these children, we assist in the evaluation of Neonatal Intensive Care in this region.

This 8 year old assessment is primarily educational with evaluations of spatial, language, and cognitive development as well as school related skills. All the children are seen by nursing, psychology and education. If there has been a previous hearing loss they are seen by audiology. Consultation is available with speech pathology and ophthalmology. The children are not regularly seen by speech pathology as they have previously been seen and referred to community speech therapists if there has been any concern. Most children are seen by Dr. C. Robertson, Paediatrician.

The following report will be supplemented by a letter to the parents with any major educational recommendations. Detailed individual department reports are available on request.

Following the 8 year old assessment, the children are discharged from the Neonatal Follow-Up Clinic and the files are closed. If there are individual concerns, these children may be re-referred to the Glenrose School Hospital by the attending physician to be assessed by a specific department. A few files will remain open under the regular Physically Handicapped Children's Unit of the

Glenrose School Hospital.

We are indeed grateful to all of the children and their parents and physicians that have cooperated so completely to help make this longitudinal follow-up possible. We sincerely express our appreciation and gratitude to them.

Consent form

APPENDIX D

SUBSIDIARY ANALYSES

RACE CROSSTABULATED WITH ATNR AND OUTCOME VARIABLES

RACE CROSSTABULATED WITH:	CHI-SQUARE	SIGNIFICANCE LEVEL
ATNR (right): 3 1/2 Year Assessment	0.277	0.5987
ATNR (left): 3 1/2 Year Assessment	2.771	0.0960
ATNR (right): 5 1/2 Year Assessment	0.096	0.7565
ATNR (left): 5 1/2 Year Assessment	0.082	0.7742
ATNR (right): 8 Year Assessment	0.001	0.9803
ATNR (left): 8 Year Assessment	0.094	0.7597
Standing Balance (right): eyes open	0.502	0.4787
Standing Balance (left): eyes open	2.098	0.1475
Hopping (right)	5.610	0.0179*
Hopping (left)	7.601	0.0058**
Tandem walking: forward	1.629	0.2019
Equilibrium reaction: sitting	0.000	1.0000
Equilibrium reaction: standing	0.102	0.7499
Finger nose (right)	0.000	1.0000
Finger nose (left)	0.000	1.0000
Alternating finger (right)	1.039	0.3090
Alternating finger (left)	0.680	0.4097
Running	0.280	0.5969
Stairs-up	0.004	0.9472
Stairs-down	3.305	0.0691

* p = .05
** p = .01

MOTHER TONGUE CROSSTABULATED WITH OUTCOME VARIABLES

MOTHER TONGUE CROSSTABULATED WITH:	CHI-SQUARE	SIGNIFICANCE LEVEL
Standing Balance (right): eyes open	0.400	0.5269
Standing Balance (left): eyes open	0.000	1.0000
Hopping (right)	0.000	1.0000
Hopping (left)	0.000	1.0000
Tandem walking: forward	5.078	0.0242*
Equilibrium reaction: sitting	2.588	0.1077
Equilibrium reaction: standing	2.649	0.1036
Finger nose (right)	0.000	1.0000
Finger nose (left)	0.018	0.8922
Alternating finger (right)	0.000	1.0000
Alternating finger (left)	0.299	0.5845
Running	0.793	0.3732
Stairs-up	2.222	0.1361
Stairs-down	0.244	0.6214

* $p = .05$

DOMINANCE: FREQUENCY AND CROSSTABLUATION WITH ATNR

Dominance of Subjects

DOMINANCE: HAND	FREQUENCY	PERCENT
Right	312	86.0
Left	48	13.2
Mixed	3	.8

Frequency of ATNR responses according to dominance

	DOMINANCE	+ATNR:RIGHT		+ATNR:LEFT	
3 1/2 YEAR ASSESSMENT	Right	180	57.69%	183	58.65%
	Left	23	47.92%	22	45.83%
	Mixed	2	66.67%	3	100%
5 1/2 YEAR ASSESSMENT	Right	121	38.78%	128	41.02%
	Left	19	39.58%	22	45.83%
	Mixed	1	33.33%	1	33.33%
8 YEAR ASSESSMENT	Right	69	22.12%	83	26.60%
	Left	13	27.08%	13	27.08%
	Mixed	0	0%	0	0.00%

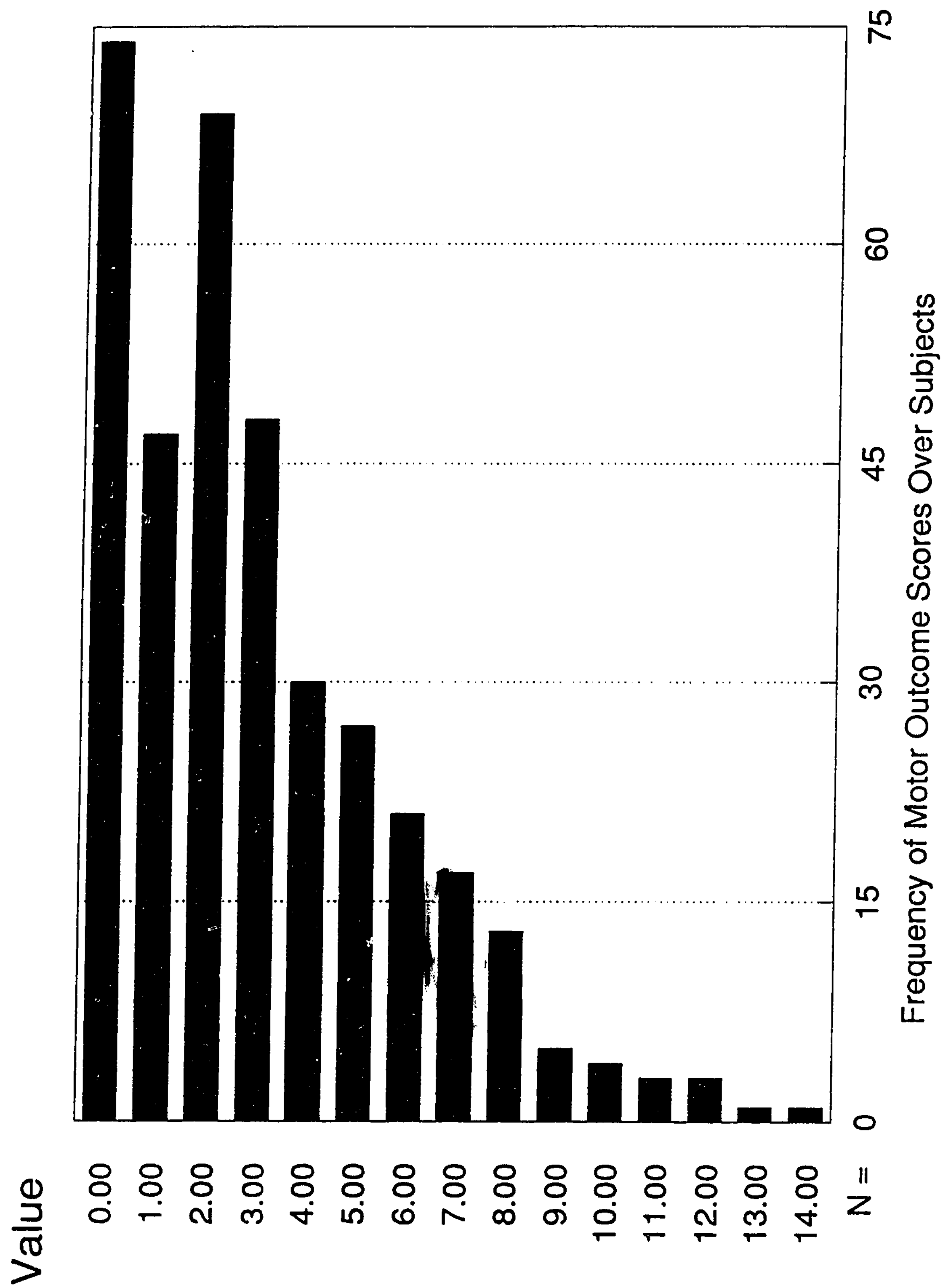
Hand dominance crosstabulated with ATNR responses

HAND DOMINANCE CROSSTABULATED WITH	CHI-SQUARE	SIGNIFICANCE LEVEL
ATNR (right): 3 1/2 Years	0.267	.8749
ATNR (left): 3 1/2 Years	1.905	.3857
ATNR (right): 5 1/2 Years	0.370	.8310
ATNR (left): 5 1/2 Years	0.757	.6849
ATNR (right): 8 Years	3.291	.1929
ATNR (left): 8 Years	1.642	.4400

FREQUENCY OF MOTOR OUTCOME SCORES OVER SUBJECTS

VALUE	FREQUENCY	PERCENT
0	74	20.4
1	47	12.9
2	69	19.0
3	48	13.2
4	30	8.3
5	27	7.4
6	21	5.8
7	17	4.7
8	13	3.6
9	5	1.4
10	4	1.1
11	3	0.8
12	3	0.8
13	1	0.3
14	1	0.3

Mean = 3.069
Median = 2.000
Mode = 0.000


Value
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
13.00
14.00
N =
0
15
30
45
60
75
Frequency of Motor Outcome Scores Over Subjects

APPENDIX E

EXCERPTS FROM ASSESSMENT MANUALS AND FORMS USED IN DATA COLLECTION

Data was specifically requested identifying:

1. form number
2. assessment number
3. card number
4. card column
5. description

The excerpts reflect the data required for this study. Additional supplementary data was requested from the data base of which a few provided data for subsidiary analyses:

. hospital of birth

. gravida

. multiple births

. resuscitation method

. week of gestation by examination (Dubowitz)

. weight category

. birth weight (grams)

. no ventilation of any kind (as opposed to ventilation)

. convulsions (present or absent)

. neurological and developmental exam on discharge from intensive care

. chronological age at time of assessments

. dominance

EXCERPT FROM 2 - 4 ASSESSMENT MANUAL UTILIZED FOR ASSESSMENT AT THE 3 1/2 YEAR INTERVAL

ASYMMETRICAL TONIC NECK REFLEX

Administration:

Quadruped - child in the quadruped position, his head is turned to each side passively by the examiner. The child's eyes can be closed. The elbows should be slightly flexed before the head is turned, for a locked elbow will prevent the observation of the slight movements which indicate a change in tone.[1]

Response: Extensor tone in the muscles of the arm toward which the head is turning and a relative increase in flexor tone or decrease in extensor tone of the opposite arm.[1,2] The legs may also show a response of flexion on the occiput side and extension on the jaw side.[1,3] Resistance to passive turning of the head is believed to be a function of the child's attempt to avoid the disorganizing influence of the Tonic Neck Reflex.[1] Trunk rotation and/or loss of balance are also noted.

Developmental Course: The response may be absent or present in the newborn.[3] Attitudes may be more definite toward the 4 - 5 weeks when the infant has developed more extensor tone.[4] A positive response is normal up to 4 - 6 months.[5]

Documentation: ATNR

1. No flexion response - no observable change in position or tone.

2. Slight flexion response - minimal to slight change in tone or position observed.
3. Definite flexion response - significant change observed in joint position or tone.

EXCERPT FROM OCCUPATIONAL THERAPY (3 1/2 YEAR) - FORM #7

This form is applicable to the 3 1/2 year assessment only. For assessment guidelines and specific documentation criteria, please consult the Occupational Therapy Assessment Manual for 3 1/2 Year Olds (in the Rehabilitation Department, Glenrose School Hospital).

All missing data is left blank.

NEONATAL FOLLOW UP CLINIC - OCCUPATIONAL THERAPY (3 1/2 YEARS)

Classification code	Col. 1 / /
Glenrose patient number	2 / / / / /
Form number	6 / 0/ 7/
Assessment number	8 / / /
Card number	10 / 1/

Chronological age (in months)	11 / / / /

Reflex Integration:

Coding for columns 44 to 47 inclusive:

1. no flexion response
2. slight flexion response
3. definite flexion response

ATNR (quadruped position): right	46 / /
left	47 / /

EXCERPT FROM 5 1/2 YEAR ASSESSMENT MANUAL:

ASYMMETRICAL TONIC NECK REFLEX

Detection of the degree of residual or poorly integrated tonic neck and tonic labyrinthine reflexes are important in the evaluation of postural mechanisms with regard to learning disabled children. Abnormal presence of these reflexes has been suggested as an indication of poor sensory integration. The ATNR is elicited by stimulation of receptors in joint capsules of the neck; its degree of integration and its influence upon equilibrium are reflected both in the Schilder's Arm Extension Text and in the quadruped position.

Developmental Course: The response may be absent or present in the newborn. Attitudes may be more definite toward 4 - 5 weeks of age when the infant has developed more extensor tone. A positive response is normal up to 4 - 6 months. Integration into the CNS is felt to be largely due to inhibition as higher cortical centers of the brain mature. The reflexes do not disappear during life but the degree of suppression or attaining mastery over them is felt to reflect the degree of maturation and integration of postural mechanisms.

Administration: Child assumes the "all fours"/quadruped position. Be sure that: knees are far enough back to prevent sitting on the legs (about 90° of hip flexion), hands are flat on the floor with shoulders flexed to 90° and that fingers point forward and slightly inward on the floor (not outward), as this position decreases the chances for locked elbows. The examiner then states "now let me turn your head". Begin with the head in a neutral position; rotate it 90° so that chin and one shoulder are lined up. Observe the arm contralateral to the direction the head is facing. The head is held for 3-5 seconds at each position to allow for adequate observation of any tonal changes.

Responses: Very little flexion at the elbow is expected at this age; however, mild/slight responses may prove to be within normal limits for this age group. The response is observed as: when the head is turned to the right so that the chin approximates the shoulder, extensor tone is increased in the right arm and flexor tone in the left arm. When the head is turned to the left, extensor tone is increased in the left arm and flexor tone in the right. Responses in the lower extremities may vary. Most commonly reported is: increased extensor tone in the leg ipsilateral to the arm with increased extensor tone and increased flexor tone in the other leg. Subjective evaluation is used to determine the difference between slight and definite responses for this assessment. Generally, a slight response would be considered as mild flexion of the arm contralateral to the direction the head is turned. Definite responses would be considered as those flexion responses in the contralateral arm from the direction the head is turned, that are moderate to strongly evident. Shoulder girdle movement may also be observed and would be considered under the "trunk rotation" observation. Any degree of head resistance or loss of balance is also recorded.

NEONATAL FOLLOW-UP CLINIC - OCCUPATIONAL THERAPY (5 1/2 YEARS)

Classification code	Col. 1 / /
Glenrose patient number	2 / / / / /
Form number	6 / 1/ 6/
Assessment number	8 / / /
Card number	10 / 1/

Reflex Integration:

Coding for columns 51 to 54 inclusive:

1. no flexion response
2. slight flexion response
3. definite flexion response
4. untestable

ATNR (quadruped position): right	53 / /
left	54 / /

Explanation of Coding and Accepted Responses:

Item 1 - there is no degree of flexion response observed in the joint by the examiner.

Items 2 and 3 - the examiner must utilize qualitative judgement as to the difference between a slight and definite flexion response. Slight would be considered as a mild degree of flexion observed or detected by the examiner.

Item 4 - refer to initial description of "untestable" code given on page 2.

EXCERPT FROM NEUROLOGY SUPPLEMENT (8 YEARS)

Classification code	Col.1 / /
Glenrose patient number	2 / / / / /
Form number	6 / 2/ 8/
Assessment number	8 / / /
Card number	10 / 1/

STANDING BALANCE: One foot in seconds (one decimal) (If task cannot be done - record zeros) (Record using stopwatch, begin when child lifts foot and stop testing when a) child touches foot to floor, even momentarily, or b) hand is extended to give balance, or c) foot used for standing hops or moves i.e. displaces) (Slight foot muscle movement without displacement is accepted.)

Standing balance: Right foot: eyes open	24 / / / ./
Left foot: eyes open	27 / / / ./
Combined: eyes open	30 / / / ./
Standing balance: Right foot: eyes closed	33 / / / ./
Left foot: eyes closed	36 / / / ./
Combined: eyes closed	39 / / / ./
Standing balance: Both feet: eyes open (to be recorded if standing balance - either foot - cannot be done)	42 / / / ./
Both feet: eyes closed	45 / / / ./

HOPPING: One foot: eyes open:

(Record the hops the child hopping on the spot.

Under age seven the child can hop forward

if necessary)

Right leg (record number of hops) 48 /__/__/

Left leg (record number of hops) 50 /__/__/

Hopping: Both feet - to be recorded only if child cannot hop on right and left foot individually 52 /__/__/

Which leg does child prefer? 54 /__/

1. Right
2. Left
3. No preference

TANDEM WALKING OR WALKING A STRAIGHT LINE:

Coding for columns 55 to 58 inclusive:

1. Completing the distance without stepping off the line or using hands or arms to balance
2. Completing distance but uses arms to balance or curls hands
3. Completes distance but leans to left or right
4. Completes distance but steps off the line (deviations from the line) once
5. Completes distance but has two to four deviations
6. Completes distance but has five or six deviations
7. Child cannot walk three steps successively without deviating from the line
8. Cannot do task

Tandem walking: Eyes open: forward 55 /_/

(2 1/2 inch line for 5 1/2 year olds)

(1 inch line for 8 year olds)

Classification code	Col. 1 /_/
Glenrose patient number	2 /_/_/_/_/
Form number	6 /2/8/
Assessment number	8 /_/_/
Card number	10 /2/

EQUILIBRIUM REACTIONS:

Coding for columns 20 to 21 inclusive:

1. Normal
2. Deficit posterior
3. Deficit lateral - right and posterior
4. Deficit lateral - left and posterior
5. Deficit lateral - both and posterior
6. Deficit all directions
7. Cannot be tested

Sitting	20 /_/
Standing	21 /_/

REFLEXES:

Coding for columns 22 to 36 inclusive:

1. Absent
2. Slightly present
3. Definite
4. Obligatory, interfering with activity
5. N/A because of severity of handicap
6. N/T because of normal development

ATNR (quadruped) - face to right 22 /_/

ATNR (quadruped) - face to left 23 /_/

FINGER-NOSE TESTING:

Coding for columns 44 and 45:

1. Normal
2. Slight unsteadiness
3. Ataxia
4. Cannot do

Right 44 /_/

Left 45 /_/

ALTERNATING FINGER MOVEMENT:

Coding for columns 48 and 49:

1. Normal, smooth
2. Movement normal, but apparent difficulty in understanding
3. Abnormal because of apparent lack of awareness
4. Slow deliberate movements but complete

5. Incomplete - partial
6. Overflow movement to opposite hand
7. Overflow movement beyond hands
8. Cannot do

Forward - right 48 /_/

Forward - left 49 /_/

GENERAL OBSERVATIONS:

Coding for columns 54 to 56 inclusive:

1. Normal
2. Poor quality but to age level
3. Mild delay up to six months
4. Moderate delay greater than six months
5. Severe delay greater than two years
6. Cannot do task

(Describe if normal)

Running 54 /_/

Stairs - up 55 /_/

Stairs - down 56 /_/

APPENDIX F

DATA DICHOTOMIZATION

1. ATNR

(a) 3 1/2 Year Assessment

ATNR (quadraped position): for right and left scoring:

No response:	1. No flexion response
Response:	2. Slight flexion response 3. Definite flexion response

(b) 5 1/2 Year Assessment

ATNR (quadraped position): for right and left scoring:

No response:	1. No flexion response
Response:	2. Slight flexion response 3. Definite flexion response
Search Form 28; if no data delete case from study	4. Untestable

(c) 8 Year Assessment

ATNR (quadraped position): for right and left scoring:

No response:	1. Absent
Response:	2. Slight present 3. Definite 4. Obligatory, interfering with activity
Exclude case from study:	5. Not applicable because of severity of handicap 6. N/T because of normal development

2. Motor Outcome

(a) STANDING BALANCE: measured in seconds (Eyes Open)

If the task could not be done it was recorded as zero. Recorded using a stopwatch, began when the child lifted foot and stopped when:

(i) the child touched foot to floor, even momentarily, or

(ii) hand was extended to give balance, or

(iii) foot used for standing hops or moves, i.e. displaced (slight foot muscle movement without displacement was accepted).

SCORING:

	Right Leg	Left leg
Normal:	15+ seconds	15+ seconds
Abnormal:	-14 seconds	-14 seconds

As adapted from the Test of Motor Impairment: borderline scores were divided for higher borderline to pass scores interpreted as a normal and lower borderline-fail scores interpreted as abnormal.

(b) HOPPING: measured in number of hops (eyes open). The number of hops were recorded for both the right and left leg separately. Hopping on both feet was recorded only if the child could not hop on the right and left foot individually.

The child is asked to demonstrate continuous hops in place. The free foot must not touch the ground. An occasional momentary loss is allowed. The child must finish in a balanced controlled position.

<u>SCORING</u>:

Normal - 10 consecutive hops

Abnormal - 9 or less consecutive hops

As adapted from the Learning Staircase Assessment Inventory System: at 6 - 7 years a child hops ten steps on each foot; this will be considered a minimum pass for an eight year old.

(c) <u>TANDEM WALKING</u>: qualitative measure according to predetermined criteria outlined on code sheet.

At eight years, tandem walking forward was done on a one inch line, dark green tape on light colored tile. Tandem walking is defined as placing the heel of the forward foot directly in front of the toe of the back foot stepping forward with the back foot to place the heel in front of the toe of the other foot. The heel and the toe must touch.

SCORING:

Normal:

1. Completing the distance without stepping on the line or using hands and arms for balance.
2. Completing distance but uses arms to balance or curls hands.
3. Completes distance but leans to left or right.

Abnormal:

4. Completes distance but steps off the line once.
5. Completes distance but has two to four deviations.
6. Completes distance but has five or six deviations.
7. Child cannot walk three steps successively without deviating from the line.
8. Cannot do task.

(d) EQUILIBRIUM REACTIONS: qualitative measure according to predetermined criteria outlined on code sheet. Equilibrium was tested in sitting and standing. With the child on the floor sitting, legs crossed, used a slight push to displace weight forward, lateral and backward. Instructions: "Don't let me push you over". In standing, Romberg position, the child's weight was displaced in the same manner as in sitting. Instructions: "Don't let me push you over". Two trials were allowed.

SCORING:

Normal:

1. Normal.

Abnormal:

2. Deficit posterior.
3. Deficit lateral - right and posterior
4. Deficit lateral - left and posterior
5. Deficit lateral - both and posterior
6. Deficit all directions
7. Cannot be tested

(e) FINGER-NOSE TESTING: qualitative measure according to predetermined criteria outlined on code sheet. The child extends their arm to touch examiner's finger then brings their finger to their nose and repeats the movement. Both sides were tested.

SCORING:

Normal:

1. Normal

Abnormal:

2. Slight unsteadiness

3. Ataxia
4. Cannot do

(f) <u>ALTERNATING FINGER MOVEMENT</u>: qualitative measure according to predetermined criteria outlined on the code sheet. The subject touches the thumb to each of the fingertips moving from the index finger to the little finger and then from the little finger to the index finger. Each hand is tested. Two trials given.

<u>SCORING</u>:

<u>Normal</u>:

1. Normal, smooth
2. Movement normal but apparent difficulty with understanding

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<u>Abnormal</u>:

3. Abnormal because of apparent lack of awareness
4. Slow deliberate movement but complete
5. Incomplete-partial
6. Overflow movement to opposite hand
7. Overflow movement beyond hands
8. Cannot do

(g) RUNNING: qualitative measure according to predetermined criteria outline on code sheet. The child is asked to run. Posture, balance and gait are observed with awareness of whether the child moves with steady, coordinated movements.

(h) STAIRS-UP: qualitative measure. The child climbs one flight of stairs. Stairs used are free-standing without any side rails. At age eight the child is expected to ascend the stairs without support and in a coordinated manner, alternating feet. More than one chance could be given.

(i) STAIRS-DOWN: qualitative measure. The child walks down one flight of stairs. Stairs used are free-standing without any side rails. At age eight the child is expected to descend the stairs without support and in a coordinated manner, alternating feet. More than one chance could be given.

SCORING:

Normal:

1. Normal

Abnormal:

2. Poor quality but to age level
3. Mild delay up to six months
4. Moderate delay greater than six months
5. Severe delay greater than two years
6. Cannot do task

TEST OF MOTOR IMPAIRMENT (TMI)

The Test of Motor Impairment was developed by D.H. Stott, F.A. Moyes and S.E. Henderson and published by Brook Educational Ltd., Canada, 1984. It was designed to measure motor impairment in children 5 years and over. The test provides norm-based scores with pass-fail criteria fixing the level of fail at the point at which it would begin to handicap children in everyday life. It was chosen as test administration and scoring matched that was used in the Neonatal Follow-Up Clinic.

The test is straight forward. It has face and content validity. Validity of the TMI was established in two ways: the extent to which teacher's ratings of motor ability correlated with TMI scores ($p < .001$); and, the extent to which mildly retarded subjects differed from the control group ($p < .0001$). Mean correlations of test-retest reliability reported for test-retest reliability in one subtest as .91; inter-rater reliability was .91.

LEARNING STAIRCASE ASSESSMENT INVENTORY SYSTEM

The Learning Staircase Assessment Inventory System was compiled by Lila Coughran and Marilynn Goff and published by Learning Concepts, 1976. The protype of the norm-referenced inventory was field tested. The age levels used were derived from numerous and widely accepted references and represents the age at which most children are able to succeed at the task (Coughran & Goff, 1976).

For the purposes of this study the norm of ten hops on each foot at 5 - 7 years will be used as the minimum cut-off for normal.