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MOTOR DEVELOPMENT OF CHILDREN
BORN PRETERM AND FULLTERM

presented by

A-Ran Chong

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MOTOR DEVELOPMENT OF CHILDREN BORN PRETERM AND FULLTERM

By

A-Ran Chong

A DISSERTATION

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

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ABSTRACT

MOTOR DEVELOPMENT OF CHILDREN BORN PRETERM AND FULLTERM

By

A-Ran Chong

The purpose of this study was to investigate the motor skills levels of children ages 3.5 to 7 years born in the Preterm I (PT I, birthweight ≤1000 g and gestational age 24-28 weeks, n = 6), Preterm II (PT II, birthweight 1001-1500 g and gestational age 29-34 weeks, n = 6), and Fullterm (FT, birthweight 2300-3800 g and gestational age 38-41 weeks, n = 10) groups using the McCarron Assessment of Neuromuscular Development and Motor Performance Study instruments. Heights, weights, body mass indexes, and neurological soft signs were compared among the three groups. The study described the relationships between the motor skills scores and the potential influences on the motor skills scores, such as the physical growth of the children, heights of the parent(s), ABILITIES Index, and use of adjusted age. The criteria for children born in the PT groups were: being a singleton; having no moderate-to-severe neurological impairments present; and having received treatments of a full course of antenatal steroids and surfactants.

Statistical analyses included one-way ANOVAs and ANCOVAs (with chronological age as the covariate), as well as Pearson product-moment, partial, and semipartial correlations. When a significant difference was detected with ANOVA (ANCOVA), then the Scheffé (Pairwise comparisons) test was used for follow-up

analysis and effect sizes were calculated to find out the meaningfulness of the significance. The investigator gave descriptive data for neurological soft signs.

Significant differences as well as large effect sizes showed the strength of a relationship among the three groups for the gross and fine motor skills. When using chronological age, physical growth (including height, weight, and BMI) was significantly different among the three birthtypes as well. The children who were born in the PT groups were more likely to show neurological soft signs, such as extraneous movements, perseveration, falling after performance, and asymmetry, than the children who were born in the FT group. The heights and ABILITIES Indexes were moderately correlated to the motor skills scores. Data suggested that participating in regular physical activities may improve skills levels of children born preterm. However, this study used a small number of participants. Future studies need to acquire more participants, as well as consider using a longitudinal design, and developing intervention programs for the children who were born preterm.

Dedication

To my family;

To my father, Hae Chin Chong for teaching the meaning of hard work.

To my mother, Won Ho Nam for showing the meaning of sacrifice.

To my brother, Chae Yu Chong for supporting and believing in me.

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CHAPTER 1

INTRODUCTION

While the motor performance of normal healthy children is known to physical educators, preschool teachers, and researchers (Butterfield & Loovis, 1993; Isaacs, 1980), little information is available concerning the motor skills of children born prematurely. Determining how well these children perform motor skills using only medical data about birthweight, gestational age, or an Apgar score is little better than a weak prediction (Goldson, 1992). In addition, knowledge is lacking about the motor development of children born prematurely who received current medical treatments, such as surfactants and antenatal corticosteroids. Therefore, it was appropriate for this research to determine if there was a relationship between the degree of prematurity and the level of motor performance during childhood. A comparison of motor performances between children born preterm and children born fullterm could help to understand better the extent to which the population of children born preterm may need special services in order to remediate potential developmental delays.

The information acquired from this research is useful for neonatologists and pediatricians who have treated infants and children born prematurely. In addition, this study provides parents with the knowledge of motor skills problems their children born preterm often may possess. Thus, parents are placed in a better position to notice problems earlier and help their children at home with certain motor activities. The physical/occupational therapist who teaches children born preterm, especially children with physical problems, could acquire a greater understanding of how the birthweight, gestational age, and family characteristics may affect motor performance. Therefore, the results of this investigation may ultimately provide better teaching of motor skills to children born preterm. Finally, the results of motor skills performances are of direct benefit to educators, who usually have a diversity of children to teach. Educators are able to use data on the motor skills delays of children born preterm that may be imperative to developing sound intervention programs.

Need for Study

Decreases in perinatal and neonatal mortalities made in the last two decades (Deloian, 1997) have resulted in an increase in the population of infants who survived a preterm birth. Improved perinatal care has resulted in an increased number of survivors born very low birthweight (VLBW), or below 1500 g (Keily, Paneth, Stein, & Susser, 1981). There has been concern about the quality of survival for these infants. Lorenz, Wooliever, Jetton, and Paneth (1998) summarized the literature on mortality rates and prevalence of major neurodevelopmental disabilities in extremely premature neonates born from 1977 to 1994, using postconceptional age. They reported that the prevalence of disabilities has not changed among extremely immature (born at or before 26 weeks gestation) or extremely small (a birthweight of 800 g or less) survivors. Increasing the survival rate of these extremely immature and small infants has resulted in a steadily increasing number of children with disabilities, even though the rate of disabilities has remained stable. The number of children born with disabilities may make increasingly urgent the need to discover the extent to which children born preterm have certain motor skills problems, in order to develop intervention programs.

Children born preterm seem to have developmental delays despite demonstrating catch up (Goldson, 1992). Neurological development, poor physical growth, delayed intellectual development (particularly in children born VLBW), delayed language development, learning disabilities, and problems in conduct and socialization in later childhood and early adolescence have been reported in the population of children born preterm (Caputo, Goldstein, & Taub, 1981). Although there has been general agreement on a decreased incidence of major disabilities with the increasing gestational age/birthweight of the survivors, the incidence of "soft" neurological signs, such as minor neurodevelopmental abnormalities, learning disorders, or concerns about school performance, have been less well evaluated (Calame et al., 1986). Calame et al. reported that minor neurodevelopmental abnormalities happen with children born preterm, so these children need to have their motor skills evaluated in detail.

Breslau, Chilcoat, DelDotto, Andreski, and Brown (1996) studied 6-year-old children born low birthweight (LBW, ≤2500 g; $\underline{n}$ = 473) with the same age of children born normal birthweight (NBW, >2500 g; $\underline{n}$ = 350) on tests measuring specific neurological abilities. All participants were controlled for population site, race, maternal IQ, and education. In 1990 to 1992, the researchers randomly selected and evaluated the children born LBW and NBW who were born from 1983 to 1985. Some of the tests chosen included the Visual-Motor Integration (Berry, 1989), Judgment of Line Orientation (Benton, 1983), Grooved Pegboard (combined) (Knights & Moule, 1968), Finger Agnosia, and Fingertip-Writing Recognition (Reitan & Davison, 1974) instruments. The children born LBW scored significantly lower than the children born NBW for language (receptive syntax, verbal reasoning, and receptive phonologic awareness), spatial (visual motor and visual perceptual), fine motor coordination, tactile perception, and attention abilities. Further, the researchers found that there were significant differences between the children born LBW and NBW, with IQs above or equal to 80, detected on syntactic and phonologic receptive language, verbal reasoning, spatial skills, tactile perception, and focused attention tests. These researchers reported that the observed deficits associated with LBW were not confined to the subset with subnormal IQ. Despite the fact that Breslau et al. used a diversity of instruments in their study, they did not discuss any fine motor skills problems of their participants.

Prematurity and Motor Performance

Despite improvements in technology, neurological developmental (and/or motor developmental) concerns might be one of the most serious problems of young children born prematurely. Drillien, Thompson, and Burgoyne (1980) have reported a high prevalence of minor neurological dysfunction in school-aged children who were born VLBW, seen mainly as poor motor coordination and clumsiness. Greenspan and Porges (1984) claimed that children born LBW were at risk for neuromotor, learning, and cognitive problems. According to Luther, Edmonds, Luther, Lacy, and Asztalos (1996), most of the children born extremely low birthweight (ELBW, 720 g, 25.8 weeks, $n = 74$) displayed intelligence scores that increased steadily over time, up to 9 years of age. By age 9, however, the children were still performing poorly on a number of variables. Gross motor development was in the low to average range, and fine motor skills were below average. In contrast, intellectual functioning, spelling, reading, written expression, perception, language skills, and visual-motor functioning were average.

Children born VLBW seemed to have problems with fine motor skills (Klein, Hack, & Breslau, 1989) and on visual-perceptual and visual-motor tests (Klein, Hack, Gallagher, & Fanaroff, 1985), despite having benefited from modern neonatal intensive care. Jongmans, Mercuri, Dubowitz, and Henderson (1998) published a study that children born preterm, who had perceptual motor difficulties, were more likely to show co-occurring minor neurological signs and problems in cognition, reading, and/or behavior. They studied children born preterm (<35 weeks; n = 156) aged 73 to 93 months with reference children (n = different numbers for each test) on tests of perceptual-motor difficulties and contemporaneous problems in other domains of development (e.g., neurological functioning, intelligence, reading, and behavioral adjustment). The researchers reported that significant differences appeared between the test and reference children on all measures. Of the children who were born preterm, 48% had perceptual-motor problems and only 10% of children who born were preterm had no other problems. These researchers also reported that these children had been of shorter gestation and had more frequently shown a brain lesion on the ultrasound shortly before birth.

Limitations of Research on Motor Performance and Prematurity

The motor skills of children who were born preterm and/or VLBW, during the first few years of life, have been studied by a number of researchers (Commey & Fitzhardinge, 1979). However, few researchers have studied the motor development of children in detail once they have reached school age (MacDonald, Burns, & Mohay, 1991).

More global measures, related to the cognitive area, intelligence, and neurological development, have been used in studies of children born preterm and/or LBW. Some medical literature on abnormalities in the neurological examination of children born preterm included visual and auditory deficits (Forslund, 1992; Ounted, Moar, & Scott, 1983), but excluded gross and fine motor skills areas. The literature also lacks the qualitative manner in which motor tasks are undertaken, as opposed to the completion of a specific task. Utilizing a qualitative approach yields a greater understanding of motor development and functional performance (Gillberg, 1985) that might benefit the design of intervention services.

One problem with interpreting the research completed (Forslund, 1992; Luoma, Herrgård, & Martikainen, 1998; Michelsson & Noronen, 1983; Ohlweiler, Alfano, & Rotta, 1996) was that a variety of instruments (see Table 1) were used to determine the motor development of children. The neurological area/motor development of children born prematurely has been examined using a variety of motor skills and/or neurological measurements, as shown in Table 1. A commonly used instrument for testing motor skills was the Test of Motor Impairment (Stott, Moyes, & Henderson, 1972, 1984), used for studying motor performance and LBW.

Furthermore, many studies have even grouped children born LBW using different categories, as shown in Table 2. For instance, the categorization of children born LBW has varied from less than 2000 g (Pharoah, Stevenson, Cooke, & Stevenson, 1994; Sommerfelt, Ellertsen, & Markestad, 1996) to less than 2500 g (Bjerre & Hansen, 1976). These findings were further confounded because the studies included children with disabilities (Hertzig, 1981; Pharoah et al., 1994) or without major disabilities (Elliman, Bryan, Elliman, Walker, & Harvey, 1991; Sommerfelt et al., 1996) in their participant sample.

Professionals have carried out follow-up studies of infants born VLBW in many different countries with a variety of interdisciplinary interests. As a result, Kopp

Table 1

Instruments which Motor Performance Studies Have Used for Children Born LBW

Studies	Instruments	References
Sommerfelt, Ellertsen, & Markestad (1996)	Peabody Development Motor Scales	(Folio, 1983)
Pharoah, Stevenson, Cooke, & Stevenson (1994) and The Scottish Low Birthweight Study Group (1992)	Test of Motor Impairment	(Stott, Moyes, & Henderson, 1984)
Hertzig (1981)	Dr. Lawrence Taft -- muscle tone Several balance tests	(Birch & Gussow, 1970) (Rutter & Yule, 1970)
Drillien, Thomson, & Burgoyne (1980), longitudinal	Motor Impairment Test based on a revision and adaptation of the Oseretsky Tests and the Bender Gestalt Test	(Stott, Moyes, & Henderson, 1972) (Oseretsky, 1931) (Bender, 1938)
Elliman, Bryan, Elliman, Walker, & Harvey (1991)	Gross & fine motor coordination and balance modified	(Gubbay, 1975) (Touwen, 1979)

Note. LBW = Low birthweight.

Table 2

Description of Participants of Other Studies

Authors (Published yr)	Age (yr)	Birth yr	N	Number of participants by birthweight group (g) < 1000	1000-1250	1251-1500	1501-1750	1751-2000	Control group (n)	Disabilities present	SES	Parents' education
Sommerfelt, Ellertsen, & Markestad (Norway) (1996)	5	4/1/86 to 8/8/88	307	33	60		124		163	none major	varied	Fathers -- 11.9 to 12.9 years average
Pharoah, Stevenson, Cooke, & Stevenson (1994)	8-9	1980 to 1981	510	19	156		57		232	included	matched	Fathers' college -- 36% to 43%
The Scottish Low Birthweight Group (1992)	4.5	1984	611	60	<---------298--------->		253		None	included	varied	Not available
Elliman, Bryan, Elliman, Walker, & Harvey (England) (1991)	7	6/79 to 5/80	385	<-----------------------171----------------------->					214	free of significant disabilities	same	Not different

Note. SES = Socioeconomic Status.

(1983, p. 1110) insisted that "an unsystematic, un-cohesive, and decidedly atheoretical research literature" has accumulated. Kitchen et al. (1982) similarly concluded that international and interdisciplinary discrepancies in findings mean that dissimilar viewpoints have (similar to those reported in Benton's review article (1940) continued for over 4 decades. Information for children born preterm and/or LBW and concerning neurological development after the 1990s has been scarce.

Moreover, information regarding motor skills of children who have been treated using the most recent medical technology and drugs such as surfactants and antenatal corticosteroids, which have been shown to significantly reduce the risk of neonatal mortality, has been lacking. Other advances in neonatal technology, such as high frequency oscillation ventilation (HFOV), intrapartum antibiotic prophylaxis against group B streptococcal infection, and nitric oxide ventilation, have also been used (Rennie & Bokhari, 1999). The population of children treated has increased greatly and the number of morbidity cases has also increased. Comprehensive and improved systems are needed for follow-up of high-risk infants to detect and remediate problems early (Lindeke, Mills, Georgieff, Tanner, & Wrbsky, 1998).

The effectiveness of the current medical technology treatments of surfactants and antenatal corticosteroids on children born preterm could not have been known for 5-10 years. The reason was that the new treatment was not frequently being used until the 1990s, and the treatment required a sizable number of children born preterm to reach the preschool/school age at which evaluation of motor skills became possible. Because one must wait for any long-term effects to appear before determining the full value of the treatment, there has been little time for studies to be performed and published.

Another issue of importance was determining the impact on motor performance of using adjusted age for children who were born preterm. Some researchers, such as Ouden, Rijken, Brand, Verloove-Vanhorick, and Ruys (1991) and Palisano, Short, and Nelson (1985), suggested that correcting for prematurity was necessary. Palisano et al. suggested that such a correction was required "for equating healthy preterms to fullterm one-year-old infants." The adjusting of age was suggested only for the first year of life by Ouden et al. (1991), but Palisano et al. (1985) suggested that exploring other ages for children born preterm was necessary. Other researchers (Yvonne R. Burns & Bullock, 1985) indicated the need for adjusted age of a child born preterm for up to 5 years after birth.

In summary, the limitations in the previous research on prematurity included: (a) lack of follow-up study of school-aged children; (b) variety of test instruments; (c) inconsistency in definitions of levels of prematurity; (d) lack of information on the long term effects of new medical treatments and technologies; and (e) lack of consensus on the use of adjusted ages for children born preterm. This study was designed to address these limitations as best as possible and to provide both quantitative and qualitative information upon which intervention programs could be developed.

Purpose of the Study

The purpose of this study was to investigate the motor skills levels of children ages 3.5 to 7 years born in the Preterm (PT) and Fullterm (FT) groups. If the children born preterm showed a greater likelihood for problems with motor skills, then finding out at an early age would have been beneficial because it would have been a good time to improve the motor skills through practice. In a collaborative study, infants born preterm enrolled in the early intervention program had mean IQ scores that were significantly higher than the control group at the 5-year follow-up (Cecelia M. McCarton, Wallace, & Bennett, 1995). Recognition and intervention of clumsiness or disabilities at an early age may have prevented many emotional and behavioral complications later on (Drillien & Drummond, 1977). For instance, the clumsy child may have had difficulty learning motor skills, and repetitively failing in a task may make him or her frustrated, as well as may not be helpful in developing self-esteem in motor skills.

Three groups were defined in this study and these groups were stratified as follows: the children born in the Preterm I (PT I) group ($\underline{n} = 6$) included birthweights ≤ 1000 g and gestational ages of 24 to 28 weeks; the children born in the Preterm II (PT II) group ($\underline{n} = 6$) included birthweights from 1001 to 1500 g and gestational ages of 29 to 34 weeks; and the children born in the FT group ($\underline{n} = 10$) included birthweights from 2300 to 3800 g and gestational ages of 38 to 41 weeks.

The hypotheses (H) and research questions (RQ) were developed to answer specific objectives in this study for the PT I, PT II, and FT groups. These objectives were to determine the differences in motor skills levels among the three groups and the relationship of the heights of the parents and the physical growth of the children.

In addition, other questions arose to answer issues not handled by the hypotheses and research questions. The assessment of neurological soft signs among the three groups was used to determine if there were any differences in the types of neurological soft signs and their frequencies. The potentially influencing variables (e.g., physical growth, adjusted age, total ABILITIES Index, and duration of participation in preschool) to motor skills scores beside birthtype were also answered.

Hypotheses and Research Questions

Hypotheses were designed when the investigator found supportive information in the review of literature. Research questions were designed when the data were equivocal or unavailable. The motor skills instruments used included the McCarron Assessment of Neuromuscular Development (MAND) and Motor Performance Study (MPS). The physical growth measurements included the heights, weights, and Body Mass Indexes (BMIs) of the children.

Motor Skills

H1. The children born in the PT I and PT II groups perform less well than the children born in the FT group on the MAND score of general motor skills (Neuromuscular Development Index, or NDI).

RQ 1. Are there differences between the children born in the PT I, PT II, and FT groups in the MAND subtests (total scaled score of fine motor skills and total scaled score of gross motor skills)?

H2. The children born in the PT I and PT II groups perform less well than the children born in the FT group on the total score of MPS.

RQ2. Are there differences between the children born in the PT I, PT II, and FT groups on MPS subtests (total score of locomotor skills and total score of object control skills)?

Physical Growth

H3. The children born in the PT I and PT II groups are shorter than the children born in the FT group.

H4. The children born in the PT I and PT II groups weigh less than the children born in the FT group.

H5. The children born in the PT I and PT II groups possess a smaller BMI than the children born in the FT group.

Delimitations

This study was delimited to qualitative and quantitative analyses of gross and fine motor skills and to the physical growth of children aged 3.5 to 7 years, who were born PT or FT. The birthweights and gestational ages were used to define the children who were born PT or FT. The children who were born in the PT groups included birthweights ≤1500 g and appropriate for their gestational age (AGA). The children who were born in the FT group included birthweights between 2300 and 3800 g and were AGA.

Limitations of Study

1. The sample set selected for this research was not random, but consisted of subjects born in Sparrow Hospital, located in the Midwest, who were matched on the basis of the following criteria. The children who were born PT included birthweights ≤1500 g and AGA. The children who were born FT included birthweights from 2300 to 3800 g and AGA. All of the children were from 3.5 to 7 years old. Generalization of this study may therefore be limited by characteristics unique to the individuals that participated in this study.

2. Environmental influences, such as seasonal and daily variations in temperature and humidity, time of day, test order, and the presence of other individuals while testing was in progress, may have influenced individual performances differently.

3. The testing in this study was limited to the late winter and early spring of 2001.

Definitions of Key Terms

Adjusted (corrected) age – The chronological age minus the weeks of prematurity.

Appropriate for Gestational Age (AGA) – The range of birthweights (10% – 90%) that are considered appropriate for an infant of a certain gestational age.

Apgar score – Evaluation of the general condition of a newborn soon after birth; numerical values are assigned to the status of heart rate, respiratory effort, reflex irritability, muscle tone, and skin color. A total score of 8 - 10 denotes a newborn in excellent condition, while a total score of 0 - 2 denotes a newborn in poor condition (Apgar, 1953). Apgar suggested that an observer, other than the person who delivered the infant, be the one to assign the score, and that an automatic method of announcing the passing of 60 seconds after birth be used.

Children born in the FT group – The children who were born on or after 38 weeks from the first day of the mother's last menstrual period. In the current research, they were called "children born in the FT group" or "children born fullterm" so that the human aspect was emphasized first, even though many researchers have used the term "fullterm children." The children born in the FT group in this research were defined using a gestational age from 38 to 41 weeks and a birthweight from 2300 to 3800 g and AGA.

Children born in the PT group – The World Health Organization (WHO) (1980a) defined as the children who were born prior to 37 weeks (less than 259 days) from the first day of the mother's last menstrual period. In the current research these children were called "the children born in the PT group," "children born preterm," or "children born prematurely" so that the human aspect was emphasized first, even though many researchers have used the term "preterm children." The children born in the PT groups (PT I and PT II) in this research were defined using a gestational age <34 weeks and a birthweight ≤1500 g.

Disability – The loss or reduction of functional ability and/or activity as defined by the WHO (1980b). A more detailed review has been presented in Chapter 2.

Fine motor skills – The involvement of the small muscle systems of the fingers, hands, and arms (Payne & Isaacs, 1999).

Gestational age – The best estimated gestational age assigned by the obstetrician and/or pediatrician as based on the last menstrual period to delivery and corrected by ultrasound imaging and/or physical examination (Dombrowski, Wolfe, Brans, Saleh, & Sokol, 1992).

Gross motor movement – The involvement of the large muscle systems of the body (Gallahue, 1989).

High-risk infants – Including infants of very low birthweight, those born preterm and under-grown (LBW); those with prior central nervous system symptomatology (infections, seizures, and hemorrhages), chronic respiratory disease, or significant congenital or recurrent infections; and those with slow progress in reaching milestones appropriate for their postconceptional age (Desmond & Thurber, 1988).

Locomotor skills – Movements that involve a change in location of the body relative to a fixed point on the surface, for instance walking, jumping, running, hopping, skipping, sliding, leaping, and galloping (Gallahue, 1989).

Moderate-risk infants – Including infants who were born following adverse perinatal circumstances (e.g., prolonged rupture of the membrane), and those with illness who nevertheless made good physiological progress prior to discharge (e.g., birth asphyxia requiring resuscitation but stable at 30 minutes). The infants born at great psychosocial disadvantage (e.g., lethargy, irritability) would also fit into this category (Desmond & Thurber, 1988).

Neurological soft signs - Including behavioral, perceptual, and motor indicators of central nervous system (CNS) dysfunction that cannot be substantiated through hardware, such as an electroencephalogram (Sherrill, 1998). General categories include the following, with additional details discussed in Chapter 2.

- Behavioral soft signs - Pertaining to hyperactivity, conceptual rigidity, attention deficits, inappropriate reactions, and emotional liability (instability).
- Perceptual soft signs - Including defective visual discrimination of letters (confusion of b and d; p and q; u and n; b and h) and words (reversals like saw for was, dog for god), auditory discrimination problems, and deficits in organizing, remembering, and repeating sequences.
- Motor soft signs - Including static and dynamic balance deficits, associated and choreiform (twitching) movements, awkwardness, and agnosias. Educators often consider motor soft signs to be perceptual-motor difficulties.

CHAPTER 2

REVIEW OF LITERATURE

Premature birth can have long term effects on children in both the cognitive and neuromuscular domains. The degree of consequences resulting from prematurity depends upon numerous factors, including birthweight, gestational age, complications from medical illness, and advanced medical care. This review summarizes the information related to: (a) how children who were born prematurely have been defined in current medical literature; (b) medical advances that have made improvements in long term outcomes of children who were born prematurely; (c) definitions of disabilities and neurological soft signs; (d) cognitive and social/emotional characteristics of children who were born prematurely; (e) what was known about the relationship among prematurity, neuromotor development, and motor performance; (f) current studies in which new technology has been used to treat the developmental outcomes of children who were born prematurely; and (g) the consideration of methodological ways of studying children who were born prematurely.

<u>Definition and Classification of Infants Born Prematurely</u>

Traditionally, a birthweight of 2500 g or less was used to define infants born preterm (Stanley, 1977). In 1950, the WHO was instrumental in introducing the term "low birth weight" for infants weighing less than or equal to 2500 g in place of the term "premature" (Ensher & Clark, 1994). LBW has been specifically classified in research and medical information as: (a) ELBW, defined as birthweight ≤ 1000 g (2.2 lb); (b) VLBW, defined as 1001 – 1500 g (2.2 - 3.3 lb); and (c) LBW, defined as 1501 – 2500 g (3.3 - 5.5 lb) (Deloian, 1997).

Also, because precise gestational age has been difficult to know with certainty, most studies of prematurity have used a birthweight definition equating birthweights of 2500 g or less with preterm (Boldman & Reed, 1976; Stubblefield, 1984). The number of infants born LBW has usually been larger than the number of infants born preterm, making national or international comparisons difficult (Bragonier, Cushner, & Hobel, 1984). By recent international agreement, an infant born preterm is one born prior to 37 weeks (less than 259 days) from the first day of the mother's last menstrual period (World Health Organization, 1980a).

Many researchers and other professionals in the medical field have used both gestational age and birthweight when they dealt with infants who were born preterm. The identification of the newborn group using gestational age information as well as birthweight information was utilized in order to define high-risk, sick infants easily and to take care of them at an optimal level (Battaglia & Lubchenco, 1967; Pernoll, Benda, & Babson, 1986). Battaglia and Lubchenco (1967) have provided a practical classification of newborn infants by birthweight and gestational age data from the University of Colorado Medical Center. However, their data might not be appropriate for use in other states given that Colorado has such a unique environment, being approximately 1 mile or more above sea level, and the population in this study was Caucasian. Nevertheless, the current study used the University of Colorado Medical Center classification of newborns by birthweight and gestational age for categorizing the children, for lack of a more complete classification scheme at the time that the current study was conducted. In addition, the investigator cautiously omitted any children whose parents were not born in the USA, to restrict the influence of non-American environments (nutrition, standard of living, understanding English, etc.).

Since the current study was completed, the investigator came across an updated fetal growth chart. Alexander, Himes, Kaufman, Mor, and Kogan (1996) developed a fetal growth chart based upon over 3 million mothers in the United States during 1991. The data came from resident live births across the entire U.S. and demonstrated the average (50th percentile) as well as the upper (90th percentile) and lower (10th percentile) limits for children born AGA. The cut-offs for AGA were designated small for gestational age (SGA: 10th percentile) and large for gestational age (LGA: 90th percentile). Any data that appeared to be implausible were omitted to produce the trimmed growth curves presented in Figure 1. When compared to other fetal growth charts constructed, such as the one by Battaglia and Lubchenco, the other growth charts tended to underestimate the growth curve established by Alexander et al. Although the U.S. National Reference for Fetal Growth chart was not used for this study, it was included here as an admission that a more accurate and up-to-date reference chart was available to future researchers.

Medical Advances and Infants Born Prematurely

This section addresses significant variables, such as the use of surfactant therapy and antenatal steroids, that have increased the survival rate of infants born prematurely. The latter part of this section discusses problems of and concerns for infants born prematurely when considering advanced medical technology. Overall, this section provides some insight into why follow-up studies are beneficial and needed.

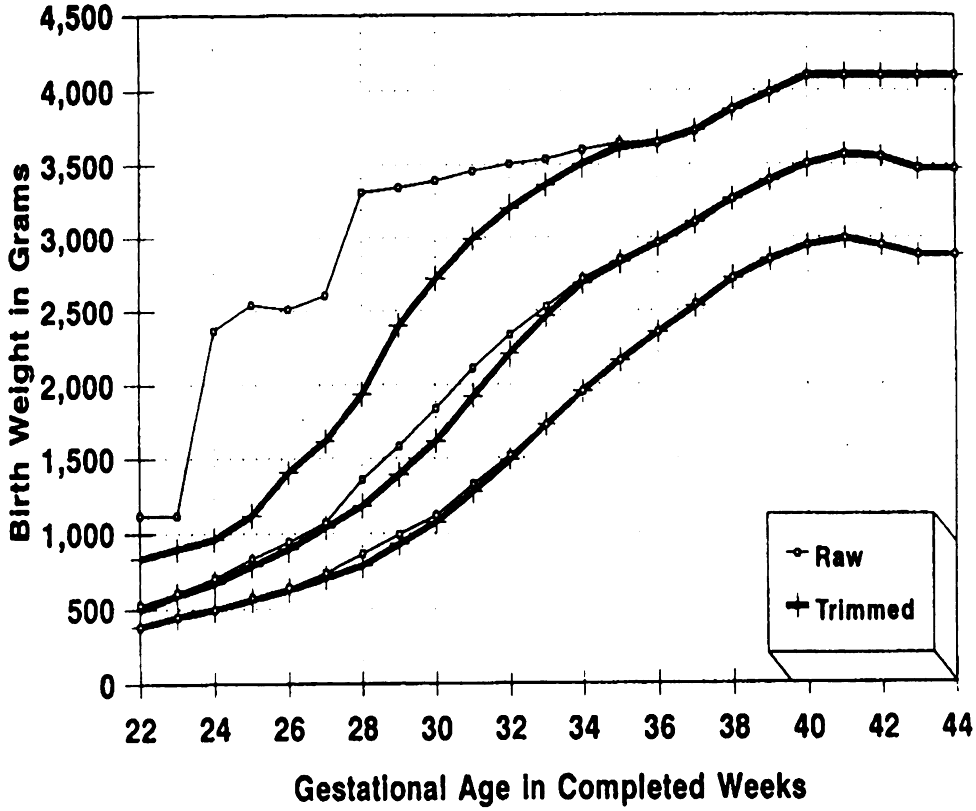


Figure 1. The 90th, 50th, and 10th percentiles, respectively, of birthweights for gestational ages before and after trimming implausible data. Data were taken from U.S. resident mothers (N = 3,134,879) from 1991. From "A United States National Reference for Fetal Growth," by Alexander, Himes, Kaufman, Mor, and Kogan, 1996, *Obstetrics & Gynecology, 87(2),* p. 165. Copyright 1996 by the American Psychology Association. Adapted with permission of the author.

Improvements in Medical Technology

Much advancement has taken place in the medical practice and technologies that have become available to infants born prematurely and their mothers. One such advancement is the better communication between the people of the intensive care nursery, the primary care physician, the child developmentalist, and the directors of community resources programs for education and rehabilitation (Desmond & Thurber, 1988). There have also been medical advances made in respirator design, monitor technology, reduction of the volume of blood necessary for specialized tests, and the sophistication of new diagnostic techniques. New drugs can be used to control premature labor, often preventing delivery for crucial days or weeks. Various types of steroids, such as betamethasone or dexamethasone, can be given to the mother in an attempt to prevent Respiratory Distress Syndrome (RDS) in infants. New imaging techniques like the CAT (computerized axial tomography) scan and ultrasound have provided a more accurate diagnosis and better treatment of infants born prematurely (Sammons & Lewis, 1985).

Neonatal Intensive Care Unit (NICU) Program

The NICU program is a cooperative, coordinated effort by health-care providers in a defined geographic region to intervene in the perinatal period to make available to every neonate (from birth to 28 days of age) a level of medical care that is proportional to the perceived risk of neonatal death or serious morbidity (Stahlman, 1984). In general, 5% to 6% of all newborns require intensive care (Deloian, 1997). Fifty percent of NICU admissions were LBW, 25% were VLBW, and 1% were ELBW, according to Deloian.

Many different methods of treatment have been utilized without using controlled clinical trials. In other words, treatment methods have not been uniformly applied in different units. Therefore, it is not surprising that differences in survival and morbidity have been reported among NICU programs (Avery et al., 1987; Horbar et al., 1988).

Effects on Mortality and Morbidity of NICU Program

Richardson et al. (1998) reported data from the same two hospitals during 1989 - 1990 and 1994 - 1995 (N = 739) with the following results. The NICU's mortality rates declined from 17.1% to 9.5% and the total mortality declined from 31.6% to 18.4% during that 5-year period. Specifically, mortality decreased nearly 50% for infants <1500 g in just 5 years.

During the most recent decade, the decreasing mortality rate has been correlated with a decreasing morbidity rate among infants. Sheth (1998) examined 4164 admissions to a contemporary NICU between 1986 and 1995. Despite the fact that a larger annual proportion of infants survived during this period (88% to 96%, 1986 and 1995), the percentage of infants with neurologic disorders had correspondingly decreased (from 27% to 12%, respectively). In contrast, Emsley, Wardle, Sims, Chiswick, and D'Souza (1998) studied infants born between 1984 and 1989 (cohort 1) and between 1990 and 1994 (cohort 2) for the rate of survival for 23- to 25-week gestational ages. They noticed that the discharge rate increased significantly from 27% to 42% and that the rate of disabilities in survivals increased from 38% to 68%; most of this increase was in mild disabilities. The proportion of survivors with cerebral palsy did not alter significantly (21% vs. 18%), but there were more survivors with blindness due to retinopathy of prematurity (4% vs. 18%), myopia (4% vs. 15%), and squints (8% vs. 13%) contributing to the rate of disabilities. Even though the rate of morbidity remained constant, the increasing rate of preterm survivals had led to an increase in the number of children who had disabilities.

Advanced Medical Technologies

Major therapeutic improvements have included the introduction of surfactant replacement therapy (Jobe, 1993; Vermont-Oxford Neonatal Network, 1996), high-frequency ventilation (Clark, Gerstmann, Null, & deLemos, 1992; Clark, Yoder, & Sell, 1994), and corticosteroid treatment for chronic lung injury (bronchopulmonary dysplasia, or BPD) (Rastogi, Akintorin, Bez, Morales, & Pildes, 1996). Examples of improved obstetric care include better ultrasound imaging for gestational dating and for measures of fetal well being (Manning, Harman, Menticoglou, & Morrison, 1991), and more aggressive use of steroid treatment (L. W. Doyle et al., 1986). Delay of delivery with tecolytics (Canadian Preterm Labor Investigators Group, 1992) and possibly more liberal use of cesarean section for preterm deliveries have also contributed to an increase of infants born preterm.

The National Institute for Child Health and Human Development (NICHD) has reported that the use of caesarean deliveries, antenatal steroids to treat chronic lung disease, and surfactants to treat RDS have positively contributed to the survival of babies who were born VLBW (Hack et al., 1995). The centers in the NICHD network began using surfactant therapy to treat respiratory problems in late 1989 (Hollander, 1995). Approximately 20% of women were given antenatal steroids, two-thirds of them receiving a full course of antenatal steroids, according to Hollander. One-half of all infants were delivered by caesarean section; slightly more than one-third of all infants weighing 750 g or less were delivered by caesarean section. Weight had a direct impact on the need for incubation with 75% of infants weighing 1000 g or less, 50% of infants weighing 1001 - 1250 g, and 33% of infants weighing more than 1,250 g being placed in incubators.

Using Surfactant Replacement Therapy

Since the first successful clinical use of bovine surfactant in 1980 by Fujiwara et al. (1980), surfactant replacement therapy has been shown to be effective in modifying the course of RDS in a number of clinical trials (Jobe, 1991). The administration of surfactants at birth has been the goal of preventing RDS. Although its use has reduced the severity of RDS, it has not appeared to prevent RDS completely nor consequently reduced the incidence of BPD, according to Jobe.

Giving surfactants soon after birth and then re-treating neonates who develop RDS results in less RDS and improved survival. These results generate a high benefit-to-risk ratio for this therapy, and although the safety of surfactants continues to be scrutinized intensely, it is encouraging that no side effects or adverse consequences of the therapy have been identified (Hoekstra et al., 1991).

Early use of a synthetic surfactant can improve the morbidity and mortality rates for premature infants with RDS (Long et al., 1991). A study was conducted of 789 neonates weighing 600 to 1750 g at birth and who developed RDS within 6 hours of birth. These infants were assigned randomly to receive either 100 mg of phospholipid/kg doses of Survanta, a modified bovine surfactant (n = 402), or a fake dosing (n = 396). Neonates who received Survanta had a greater improvement ($p < .001$) in their oxygenation and ventilatory status from baseline to 72 hours than did control neonates.

Survanta-treated neonates were also at a lowered risk for developing pulmonary interstitial emphysema (18.6% vs. 39.3%, $p < .001$) and other pulmonary air leaks (11.5% vs. 25.9%, $p < .001$). Liechty et al. (1991) concluded that multiple doses of Survanta given after diagnosis of RDS reduced mortality and morbidity. The beneficial use of surfactant therapy has yielded an almost universal positive finding among the controlled clinical studies and has been shown to be consistent with the airway stabilizing effect of a surface-active agent.

Using Antenatal Steroids

Chronic lung disease (CLD, includes RDS and BPD) is a common finding in neonatal intensive care, especially among infants born prematurely (Greenough, 1998). Halliday and Ehrenkranz (2002) conducted a meta-analysis of the literature and showed that moderately early (started between 7 and 14 days after birth) administration of antenatal corticosteroids significantly reduced the incidence of CLD and neonatal mortality. In addition, premature survivors who had received antenatal corticosteroid therapy had a lower frequency of RDS (Kuhn et al., 1982; Liggins & Howie, 1972) because antenatal corticosteroid therapy reduced the incidence of intraventricular hemorrhaging in infants born prematurely (Stonestreet, Petersson, Sadowska, Pettigrew, & Patlak, 1999).

Antenatal corticosteroid therapy has been documented as positively affecting physical growth. Doyle et al. (1986) investigated whether antenatal steroid therapy had any beneficial or harmful effects on mortality or morbidity over the first 2 years of life. Two-year survivors who had received the treatment were heavier ($p = 0.016$) and had larger head circumferences ($p = 0.029$) than the other children. These beneficial associations in the treated group were not at the expense of increased rates of infection or adverse neurological outcomes. Dore (2001) also reported positive growth effects on children born less than 1501 g who had been exposed to antenatal corticosteroids. The children (N = 130) were divided into two groups, those whose mothers had received a single course of antenatal corticosteroids shortly before giving birth and those whose mothers received no antenatal corticosteroids. The children were assessed at 14 years using the measurement of several physical growth factors, including height, and several tests, one of them based on cognition. Dore found that the children who had received a single course of antenatal corticosteroids (51%) were taller and scored better cognitively than children who had not received any antenatal corticosteroids.

A survey of consultants performed in 1994 revealed that the intention to treat using steroids had increased to 95%, compared with 66% who would have used steroids prior to 1992 (M. Doyle, Hamilton, Johanson, & O'Brien, 1994). However, several researchers do not agree with repeated uses of antenatal corticosteroids. Guinn et al. (2001) studied 502 pregnant women between 24 and 32 weeks gestation. All women were given one course of antenatal corticosteroids, with 256 receiving additional weekly courses of the antenatal corticosteroid until giving birth, and the remaining 246 women receiving a placebo each week until giving birth. Guinn et al. noted that weekly courses of antenatal corticosteroids did not reduce composite neonatal morbidity (which included severe RDS, BPD, severe Intraventricular Hemorrhage, and perinatal death, among other items) when compared with a single course. The National Institutes of Health released a consensus statement (2000) that supported the use of a single course of antenatal corticosteroids, but declared that repeat courses should be reserved for patients enrolled in clinical trials.

In contrast, antenatal corticosteroid therapy has also been documented as negatively affecting birthweight. Lam, Yuen, Lau, and Leung (2001) conducted a retrospective study to find a relationship between the number of courses of antenatal corticosteroids and the birthweight relative to gestational age. The birthweight ratio (actual birthweight over median birthweight for gestational age) was negatively correlated with the number of courses of antenatal corticosteroids. Moreover, being exposed to four or more courses of antenatal corticosteroids created a significant reduction in the birthweight ratio. Future studies may need to explore the effectiveness of antenatal corticosteroids given to infants who were born prematurely.

<u>Considerations of Advanced Medical Technology</u>

Technical advances and improvements in obstetric and neonatal care have been mainly responsible for the improved survival of high-risk neonates and for the accompanying improvement in the quality of the survivors (Amiel-Tison, Korobkin, & Klaus, 1986). With the advances in obstetrics and neonatology since the mid-1960s, there has been a tremendous improvement in the survival of infants born prematurely, a lowering of the limit of viability, and a decrease in the incidence of major disabilities and sensory impairments (Escobar, Littenberg, & Petitti, 1991). Also, the majority (>90%) of children born VLBW since the mid-1960s have attended regular schools (Drillien et al., 1980; Saigal, Szatmari, Rosenbaum, Campbell, & King, 1991). This improvement alone would appear to justify the tremendous amount of money, energy, and expertise required to obtain these outcomes (Allen, Donohue, & Dusman, 1993). However, these findings do not tell the whole story. A careful look at the various manifestations of minimal cerebral dysfunction (i.e., Attention Deficit Hyperactivity Disorder) in children born preterm has helped to clarify the true impact that prematurity has had on the child, his or her family, and society at large (Allen et al., 1993).

While preterm survival rates have improved, the population of infants with ever-lower birthweights has had an ever-higher incidence of neonatal morbidity and neurodevelopmental impairment during childhood (Ahmann, 1996). Richardson et al. (1998) have suggested that it is disappointing that the rate of VLBW births remained completely unchanged (25/1000 verses 26/1000) in the same two hospitals, 5 years apart (1989 - 1990 and 1994 - 1995; N = 739), even though the distribution of the severity of illnesses had improved strikingly. It may be necessary that follow-up studies of motor performance in this population be executed in order to understand the implications of preterm survival and LBW on motor performance.

Disabilitics

Disabilities could be interpreted using a diversity of meanings, especially where the society and economy influence who is not in the norm and thus considered to have disabilities. Therefore, this investigator reviewed the current definitions commonly used for disabilities, classifications, and ranges. Secondly, some researchers (Allen et al., 1993; Hunt, 1981) reported that children born preterm had more neurological soft signs than children born fullterm. The investigator then reviewed the relationship between soft neurological signs and mild spastic, athetoid, or ataxic cerebral palsy in order to understand the later review of different motor disabilities of children born preterm. Finally, Allen et al. (1993) also reported that children born preterm had a combination of learning disabilities (LD) and neurological soft signs. Thus, the investigator also looked at the relationship between neurological soft signs and Attention Deficit Disorder (ADD), Attention Deficit Hyperactivity Disorder (ADHD), LD, or cerebral palsy.

Definition of Disabilities

In general, a disability is characterized by a physical, cognitive, psychological, or social difficulty so severe that it negatively affects the person's learning (Friend & Bursuck, 1996). The WHO (1980b) defined disability as the loss or reduction of functional ability and/or activity.

The federal law uses categories of disabilities including autism, deaf-blindness, deafness, hearing impairment, mental retardation, multiple disabilities, orthopedic impairment, other health impairment, serious emotional disturbance, specific or language impairment, traumatic brain injury, and visual impairment including blindness (Sherrill, 1998). In 2001, the WHO (2001) published in International Classification of Human Functioning, Disability and Health (ICF) using several components to define disability: body functions and structures, activities and participation, and environmental factors. These three components classified in ICF are quantified using the same generic scale. The percentages are calibrated in different domains with reference to relevant population standards (in percentiles), as follows:

1. NO problem (0%-4%) uses terms such as "none, absent, negligible, etc."
2. MILD problem (5%-24%) uses terms such as "slight, low, etc."
3. MODERATE problem (25%-49%) uses terms such as "medium, fair, etc."
4. SEVERE problem (50%-95%) uses terms such as "high, extreme, etc."
5. COMPLETE problem (96%-100%) uses terms such as "total."

On the other hand, the government decided that the lowest 16% of the population, based upon motor skills tests, were eligible for special services (Sherrill, 1998). Adapted physical activity professionals advocated for special help for any student whose test scores repeatedly fell below the mean (50th percentile) or whose performance looked clumsy to an expert observer, according to Sherrill. However, Sherrill reported that disability has been a relative term that changes with federal legislation and school policy, and appears to be tied in with the current state of the economy. Sherrill reported severe disabilities as an IQ under 35 (i.e., a mental age between 0 and 3 years), serious emotional disturbance, or autism and multiple disabilities included such combinations as deaf-blindness and cerebral palsy/mental retardation, and were considered as severe disabilities.

Sensorimotor Integration Problems

People who have cerebral palsy (damaged parts of the brain controlling body movements and posture), movement difficulties, or clumsiness of unclear origin were reported to have sensorimotor integration problems (Sherrill, 1998). Sensorimotor integration (or called sensory integration) is defined as the organization of sensory information for use (Ayres, 1980). This organization occurs within the brain and spinal cord (CNS) and is called central processing. Sherrill reported that damage to the CNS includes disease, injury, or activity deprivation of normalcy of function of environmental factors, the other body systems, and aspects and motivation of psychosocial factors that influence persistence and effort.

The normal adult has approximately 100 billion nerve cells, called neurons. There are many kinds of neurons; in general, functions of neurons are described as motor, sensory, or associative (Sherrill, 1998). Developmental motor problems/disorders are typically caused by damage to motor neurons in the brain. These conditions are defined as upper motor neuron syndromes, to distinguish them from motor problems that have their origin in the spinal cord (i.e., lower motor neuron syndromes), that are the result of spinal cord lesions and cause weakness or paralysis.

Cerebral Palsy

Cerebral palsy is a nonprogressive movement or posture disorder that developed in the immature brain. Spasticity, athetosis, and ataxia are different types of cerebral palsy. Spasticity is primarily a problem of over excitation or too much tightness in the muscles. Athetosis is a problem of excessive movement (i.e., inhibition is impaired). Ataxia, or general incoordination, interferes with kinesthesis (Pellegrino, 1997).

Clumsiness

The severity of the CNS conditions determines whether the person is called clumsy or cerebral palsied. Clumsiness, or the inability to perform culturally normative motor/movements' activities with acceptable proficiency, is caused by delayed or abnormal CNS development, musculoskeletal limitations, and/or other constraints. Without sophisticated laboratory equipment, determining the CNS site and other contributing factors is difficult. Certainly sound motor functioning cannot occur without intact sensory and central nervous processing systems (Sherrill, 1998).

Perceptual Motor Learning Problems

Diagnoses of clumsiness, developmental dyspraxia, or developmental coordination disorder (DCD) could be caused by problems in perceptual motor learning. Perceptual motor learning is the acquiring of knowledge about the self and environment through the integrated processes of sensation, perception, and action during spontaneous or teacher-guided movement exploration. Perceptual motor learning is an appropriate physical education goal for children who are from 2 to 7 years old without disabilities as well as for individuals capable of cognition at the 2-year-old level or higher who are not able to perform culturally normative motor activities with acceptable proficiency. Individuals who meet the latter criterion are commonly diagnosed as being clumsy or having DCD (Sherrill, 1998).

Perceptual motor learning consists of many overlapping components that constitute center processing, and everything memory, cognition, perceptual motor, sensorimotor, perception decoding, and attention is influenced by environmental conditions, which manifest themselves through skill movements (Sherrill, 1998). For example, without cognition area, processing cannot yield perceptual motor learning.

Learning Disabilities

Learning disability is defined as a disorder in one or more of the basic psychological processes involved in understanding or using language, spoken or writing, which may manifest itself in an imperfect ability to listen, think, speak, read, write, spell, or do mathematical calculations (Individuals with Disabilities Education Act, 1990, section 1401; federal legislation). It also includes such disorders as perceptual disabilities, brain injury, minimal brain dysfunction, dyslexia, and developmental aphasia (caused by disease or injury, resulting in loss of ability to speak or understand written or spoken language). Children who have learning problems that are primarily the result of visual, hearing, or motor disabilities, mental retardation, emotional disturbance, or environmental, cultural, or economic disadvantage are not included. Sherrill (1998) suggested that experts believe that a higher than average number of individuals with LD have perceptual-motor, motor coordination, and other movement related problems that require intensive work.

Developmental Coordination Disorder

The American Psychiatric Association (APA) and WHO officially recognized Developmental Coordination Disorder (DCD) in 1987 and 1989, respectively. In the most recent edition of the Diagnostic and Statistical Manual of Mental Disorder, published by the APA (1994), the diagnostic criteria for DCD were performances in daily activities that require motor coordination, which is substantially below that expected given the person's chronological age and measured intelligence. This might be manifested by a marked delay in achieving motor milestones (e.g., walking, crawling, sitting), dropping things, "clumsiness," poor performance in sports, or poor handwriting. A diagnosis of DCD is made only if the condition significantly interferes with academic achievement or activities of daily living.

The description of DCD by the APA (1994) could be diagnosed separately from other disabilities. DCD may be associated with coordination problems if caused by specific neurological disorders (e.g., cerebral palsy, progressive lesions of the cerebellum), but definite neurological damage and abnormal findings must occur during a neurological examination. If mental retardation is present, DCD can be diagnosed only if the motor difficulties are in excess of those usually associated with mental retardation. An individual with ADHD may fall down, bump into objects, or knock things over, but this is usually due to distractibility and impulsiveness, rather than motor impairment. If criteria for both disorders are met, both diagnoses can be given. The term from the APA is DCD, but the WHO (1993) has given the title of "Specific developmental disorder of motor function" (Sugden & Wright, 1998).

Neurological Soft Signs

Sherrill (1998) reported that many researchers indicated that children with LD demonstrated neurological soft signs not present in the general population. Neurological soft signs have been called by many names by different researchers. Over the past century or so, neurological soft signs have been called soft signs, equivocal signs, nonfocal neurologic signs, and minor neurological signs. The name "neurological soft signs" has been the dominating term in recent literature (Tupper, 1987). Therefore, this investigator decided to use "neurological soft signs."

Neurological soft signs were originally defined in relation to the more traditional pathognomonic signs, and represented signs that were 'nonpersisting over time or gradually improving with development' (Tupper, 1987). Although usually considered indicative of minor brain damage, neurological soft signs are temporary in that they go away with time and/or age.

The categorization of neurological soft signs have been as unorganized and fractured as the definition. One reason was that some categorizations included signs that were considered normal for young children but eventually disappeared as the child aged. Examples included right-left discriminations (sometimes mistaken for "mirroring"). In addition, the subjective nature of attempting to identify neurological soft signs made quantification difficult. Soft signs have problems with lack of reliability of appearance over time, and future research needs to focus on longitudinal studies and address the issue of stability of soft signs, while identifying in factors associated with their persistence or disappearance (McMahor & Greenberg, 1977). Soft neurological signs are sometimes used to diagnose clumsiness, but they consist of unstandardized, unreliable, and highly subjective items and are incapable of measuring accurately either clumsiness or any other learning disability (Connolly, 1984).

Hall (1988) made clear the point that children who are diagnosed with clumsiness should not be treated as though they have a disease. It was therefore generally recognized that the symptoms of clumsiness were signs that could have been improved through practice and/or age (Drillien & Drummond, 1977; Hall, 1988; Hertzig & Shapiro, 1987; Tupper, 1987). Age was not considered in determining the appropriateness of recording neurological soft signs. The reader may decide for him/herself whether what was shown for a child was considered normal or lagging in normal motor development.

Learning Disorder and Attention Deficit Hyperactivity Disorder

Not all children with LD have perceptual motor problems, such as an immature body image and agnosia, poor spatial orientation, associated or overflow movements, and motor proficiency problems. Sherrill and Pyfer (1985) studied learning problems of children diagnosed by school psychologists as having LD, reporting that 12% demonstrated no problems, 75% scored average on some tests but below average on others, and 13% scored 2 to 3 years below normative standards for their age group on all tests. Many children with LD have difficulty decoding, or making sense, of their bodies and space, and LD causes are neurological, but problems are often confounded by environmental conditions (Sherrill, 1998).

Attention deficit hyperactivity disorder (ADHD) is a combination of inattention and/or hyperactivity, impulsive symptoms that are present in at least two settings and interfere with academic, social, and occupational functioning (American Psychiatric Association, 1994). A higher than average percent of individuals with LD have ADHD and related problems (Sherrill, 1998). Other behavior problems are inadequacies of social imperceptions, perseveration/stubbornness associated with neurological soft signs (e.g., conceptual rigidity, inappropriate reactions, perseveration), and misunderstandings that stem from deficits in listening, thinking, and speaking skills.

Activity deficit phenomenon, recently verified by research (Bouffard, Watkinson, Thompson, Dunn, & Romanow, 1996) is a sedentary lifestyle that results from avoidance coping strategies that people with movement difficulties use to preserve self-esteem and manage emotional pains related to clumsiness. Sherrill (1998) reported that early intervention is needed before activity deficit behavior becomes a permanent lifestyle.

Characteristics of Children Born Prematurely

An infant born prematurely who does not develop a major disability or sensory impairment is still at risk for subtle abnormalities of CNS functioning (Kitchen, Ford, Doyle, Rickards, & Kelly, 1990). Research has indicated that sometimes children born prematurely are not diagnosed as having problems in infancy, as such problems may not show up until the preschool or school years (Hunt, Cooper, & Tooley, 1988; Hunt, Tooley, & Halvin, 1982; Teplin, Burchinal, Johnson-Martin, Humphry, & Kraybill, 1991). These deviations are not limited to school and behavior problems, according to Kitchen et al. (1990). These later developmental problems can include language delay, learning disability, minor neuromotor dysfunction, attention deficit, hyperactivity, emotional inability, and behavior problems (Allen et al., 1993). Thus, this section reviewed literature on the long-term developmental outcomes of children born preterm.

Cognitive Characteristics

Children born VLBW/ELBW showed variability in their test scores and a slightly lower range of IQ scores than did children born NBW (Klein et al., 1989; Ornstein, Ohlsson, Edmonds, & Asztalos, 1991; Saigal et al., 1991; Vohr, Garcia-Coll, & Oh, 1989). Although neurologically normal children born preterm with birthweights less than (or equal to) 800 g experienced significant problems in the early school years, which was reflected in their early cognitive assessment performance, these deficits did not appear in their later assessments (Luther et al., 1996). For most children born preterm and ELBW in this study, intelligence scores increased steadily over time. By 9 years of age, intellectual functions were considered normal.

Ornstein et al. (1991) have provided an overview of the literature on children born ELBW and VLBW who were then school age children. They examined nine studies of children born ELBW and 16 studies of children born VLBW. The majority of children had average IQ scores; however, there was a great variability in the test scores. Additionally, populations of children born at ELBW, VLBW, and LBW demonstrated a normal range of IQs, but the mean IQ was generally lower (Klein et al., 1989; Saigal et al., 1991; Vohr et al., 1989).

Preschoolers born VLBW ($\leq$1500 g, n = 36) with no major disabilities (cerebral palsy, hydrocephalus, epilepsy, mental retardation, major sensory loss) differed from a control group of children in cognitive development (gestational age 37 - 40 weeks, NBW >2500 g, n = 40), matched for gender, ethnic origin, birth order, maternal age, and social class (Lie, 1994). At 36 months, the VLBW group scored a mean IQ of 101.6 points (SD = 8.8), significantly lower than the mean of 111.9 points (SD = 7.8) of the NBW groups

($F = 29.28$, df = 1.75, $p < 0.0001$). Comparisons of children born ELBW and VLBW with control children born fullterm found that the children born ELBW and VLBW had a significantly lower mean IQ than the control group, even when controlling for socioeconomic status (SES) (Kitchen et al., 1980; Saigal et al., 1991; Teplin et al., 1991). In other words, SES may not affect many children born ELBW and VLBW. However, children born prematurely and/or LBW, from middle to higher SES, had positively affected IQ scores compared to those from lower SES (Escalona, 1982). Children born premature and/or LBW and from low SES, on average, scored 14 points lower in IQ than groups of typically developing children born prematurely and/or LBW from middle to upper class groups at 4 to 10 years of age (Escalona, 1982).

Compared to children born fullterm (>36 weeks, $n = 264$), children born very preterm (<32 weeks, $n = 264$; both groups born in 1985), at 6 years of age, scored significantly lower (approximately 1 SD) in cognitive measures (Wolke & Meyer, 1999). Children born very preterm have particular problems processing complex information requiring logical reasoning and spatial orientation and had major cognitive deficits (>2 SD lower) 10 to 35 times more often, and mild impairment (>1 to ≤2 SD) between 2 and 2.5 times more often, than the controls. For instance, using the mental processing composite scale and simultaneous processing score, 26.1% and 34.8%, respectively, of children born very preterm had serious problems, but only 0.8% and 1.1%, respectively, of the control group had serious problems. Also, Hack et al. (1994) reported that children with weights under 750 g had significantly poorer cognitive ability (according to the Kaufman Assessment Battery for Children Mental Processing Composite Short Form, (Kaufman & Applegate, 1988) than children weighing 750 to 1499 g and children born fullterm. Fifty percent of children born under 750 g had below 85 points on their mental processing composite score, 28% of those weighing 750 to 1499 g at birth were below 85 points, and only 16% of children born fullterm scored likewise.

From the review of the cognitive area of children who were born preterm, children born ELBW, VLBW, and LBW showed generally a normal range but lower IQs than the children who were born fullterm (Klein et al., 1989; Saigal et al., 1991; Vohr et al., 1989). Later in childhood, children born preterm and ELBW showed normal intelligence functions despite below average indications earlier in childhood (Luther et al., 1996). Some studies (Kitchen et al., 1980; Saigal et al., 1991; Teplin et al., 1991) reported that SES did not affect the IQ of the children born ELBW/VLBW, but Escalona (1982) reported that middle to upper class groups showed higher IQs among the children who were born preterm/LBW.

Behavioral and Emotional Characteristics

Children born ELBW have been diagnosed with behavior problems. Rickards et al. (1987) longitudinally studied 60 children, who were born at birthweights from 500 – 999 g (including those with disabilities) and delivered in one tertiary perinatal center from 1977 to 1980. A multidisciplinary team assessed 59 of these 60 children at 2 years of age (corrected for prematurity), and 3 years later 58 children were evaluated, at 5 years of age. The psychologist noted behavioral problems during later assessment for 50% of the children, while 29% of the mothers reported behavioral problems with their child that could have interfered with their schooling.

A later study by Hack et al. (1994) reported that children born ELBW (<750 g; $\underline{n} = 68$, 45 females; $\underline{M}$ age = 6.7 years, $\underline{SD} = 0.9$) had significantly inferior outcomes in behavior, social skills, and adapted behavior than did both children born weighing 750 to 1499 g (n = 65, 43 females; M age = 6.9 years, SD = 0.9) and children born fullterm (n = 61, 39 females; M age = 7.0 years, SD = 0.9). Behavioral tests used included the Manual for the Teacher's Report Form (Achenbach, 1991b) and the Manual for the Child Behavior Checklist (Achenbach, 1991a), among numerous other instruments; individual behavioral attributes and instruments were not described in detail in the article. Thirty-seven percent of children born <750 g, 21% of those weighing 750 to 1499 g, and 21% of children born fullterm showed behavior problems. However, children born <750 g (26%) showed an adaptability function 13 times more often than did children born fullterm (2%) and almost double the amount of children born weighing between 750 – 1499 g (14%). The results of this study showed that children born with less weight seemed to have more problems with their behavior. A review of literature by Ornstein et al. (1991) also reported that school age children born ELBW and VLBW experienced difficulties. They reported information from 9 studies of children born ELBW and 16 studies of children born VLBW. The studies indicated that behavioral difficulties were common among children born VLBW and ELBW.

Impulsiveness, aggressiveness, and disorganization were symptoms of disturbances that appeared in children born preterm and below NBW (gestational age up to 37 weeks 6 days and weighing less than 2500 g). In a study by Ohlweiler et al. (1996), these symptoms were found more in children born preterm and LBW than in children born fullterm and NBW (38 - 42 weeks, >2500 g, including disabilities). Thirteen children born preterm showed impulsiveness compared to no children born fullterm; 12 children born preterm showed aggressiveness compared to 2 children born fullterm; and

18 children born preterm were disorganized compared to 6 children born fullterm. Marlow, Roberts, and Cooke (1989) reported that children born VLBW were more overactive, were more easily frightened (all typical of emotional disorders), were inattentive, were more distractible, and had behavioral problems than children born fullterm. The study examined 6-year-old children (n = 53) with birth weights below 1,251 g and compared them to typical classmates matched by age and sex. The results suggested that teachers felt the children born VLBW were more overactive than the comparison group and displayed characteristics typical of emotional disorders. In addition, parents of children born VLBW were more likely to report that their children had behavioral problems than parents of the children in the control group. Examiners also felt that the children born VLBW were more inattentive or distractible than the control group of children.

In a more recent study, Sajaniemi, Salokorpi, and von Wendt (1998) reported that 2-year-old infants born preterm (n = 80, M birthweight = 1205 g) from 1989 to 1991 and possibly treated using modern medical technology were significantly less active, more adaptive, more positive in mood, less intense, and lower in threshold response than infants born fullterm (n = 80). They suggested that the infants born with preterm temperament profiles found in their study might reflect an underlying constitution characterized by passivity, low energy, lack of initiative, and a lack of intellectual curiosity.

Hack et al. (1994) reported that children born preterm had behavioral and social problems, and Ohlweiler et al. (1996) reported impulsiveness and aggressiveness for children born preterm. However, Sajaniemi et al. (1998) reported that less active, more adaptive, more positive in mood, and less intensive described 2-year-old infants who were born preterm who may have received new treatments such as antenatal steroids and surfactants. The current investigation asked questions relative to the ABILITIES Index, whether there were differences in behavior between children born preterm and fullterm.

Learning Characteristics and School Performance

Several researchers have reported high frequencies of learning disabilities in children born preterm. In a longitudinal study of children born VLBW from 1965 to 1978, Hunt et al. (1988; 1982) found that a 14% to 17% incidence of learning disability in children born preterm with IQs > 84 at 8 and 11 years. Additionally, children with birthweights of 1250 g or less and no major impairments had a higher frequency of learning disabilities compared with classmates matched by age, sex, and race. Thus, learning disabilities became more apparent with advanced age (Marlow, Roberts, & Cooke, 1993).

Children born preterm with ELBW and VLBW have also shown attention deficits and lower levels of memory retention (N. Breslau, Klein, & Allen, 1988; H. G. Dunn et al., 1980; Hack & Fanaroff, 1988). Dunn et al. reported that children born preterm who weighed <2000 g at birth, most of whom had IQ scores in the average range, were clinically diagnosed with attention deficits. Literature by Hack and Fanaroff, and Breslau et al. suggested a relationship between a child's birthweight and attention. Hack and Fanaroff found that children weighing <750 g had significantly lower outcomes than children weighing 750 to 1499 g or born fullterm with regard to attention skills, as noticed by parents or teachers.

Another area in which children born preterm seemed to have less than desirable outcomes was that of academic achievement. Hack et al. (1994) studied the academic skills of children born LBW and NBW. Twenty-seven percent of the children with birthweights <750 g had significantly lower outcomes, while 9% of the children weighing 750 to 1499 g and 2% of the children born fullterm revealed limited academic skills.

Academic difficulties have been reported in 23% to 48% of children born VLBW and ELBW (Hunt et al., 1982; Klein et al., 1985; Lefebvre, Bard, Veilleux, & Martel, 1988; Saigal et al., 1991; Steiner, Sanders, Phillips, & Maddock, 1980; Victorian Infant Collaborative Study Group, 1991). Bennett (1988) suggested (from reviewing literature for children born LBW and VLBW) that even though most children born preterm and LBW were not functionally impaired, they appeared to perform and score lower on the measure of scholastic achievement throughout childhood when compared on a group basis to children born fullterm or NBW. This finding has been particularly true for children born VLBW who often should have been considered at a higher risk, developmentally. Complete "catch-up" may never have occurred in terms of group differences.

Saigal and colleagues (1991) discovered that 8-year-old children born ELBW ($\underline{n}$ = 113) and fullterm controls ($\underline{n}$ = 145), matched for sex, age, and social class, performed lower on reading, spelling, and arithmetic tests. These differences persisted even when 19 of the children who had neurological abnormalities or an IQ less than 70 points were excluded from the analysis. The children born ELBW had a lower mean of reading (86.4 vs. 95.0), spelling (83.8 vs. 93.1), and arithmetic (90.0 vs. 98.3) than the children born fullterm.

Children born VLBW (Klein et al., 1989) and children born ELBW had difficulty with computational arithmetic (Saigal et al., 1991). Vohr and Garcia-Coll (1985) reported that 45% of children born VLBW had difficulty with one or more school subjects compared with 11% of the control group, and that 26% of children born VLBW had difficulties in two or more areas compared with 5% of the control group. In general, the children born VLBW appeared to have difficulty in some aspects of reading, math, and spelling.

Children born prematurely were more likely to repeat a grade, require remedial programs, and need special education assistance than their fullterm counterparts (Klein et al., 1989; Michelsson & Noronen, 1983). Klein et al. noted that by 9 years of age, 40% of children born weighing less than 1500 g had repeated a grade. This rate was compared to 11% for a matched group of fullterm, normal controls. Therefore, it appeared that children born LBW have had difficulty progressing through the graded school systems of the United States. According to teachers' assessments, by age 9 years, 32% of the children born LBW were in need of special education, compared with 12% of the control group (Michelsson & Noronen, 1983). Saigal et al. (1991) studied 8-year-old children born ELBW ($\underline{n}$ = 129) with respect to school performance. They found that 14% were far below grade level and another 14% were somewhat below the expected level. Thirty-three percent were in full-time special education classes, and 52% required special education resources. A follow-up study was conducted of children born ELBW between 1976 and 1979, a period when aggressive intervention was not routine practice, and the survival rate was only 19%. Among 37 children in school or in remedial programs, 9 required special education and another 12 in regular classes had either failed, obtained very poor results, or needed extra professional help. Only 16 of the children had no significant problems in school. These findings indicated that being born ELBW represented a major risk to cognitive development and learning potential (Lefebvre et al., 1988).

Developmental Characteristics in Physical and Motoric Areas for Children Born Prematurely

Because prematurity is a major risk factor leading to developmental disturbance in the lives of children born preterm (Reed & Stanley, 1977), motor development in these children is of interest (Largo, Kundu, & Thun-Hohenstein, 1993). The following information reviewed the literature relative to physical characteristics, visual perceptual motor skills, gross and fine motor skills, balance skills, and involuntary movements for children born preterm and/or LBW, VLBW, and ELBW in comparison with children born fullterm and/or NBW.

Physical Characteristics

Various studies contradicted each other in describing the differences in physical growth among the children born LBW and NBW. A 9-year follow-up study investigated children born with birthweights of 1500 g or less (n = 41; 26 girls), who did not have severe disabilities. There were no significant differences for children born VLBW compared to the control group for head circumference, height, and weight (Michelsson, Lindahl, Parre, & Helenius, 1984). In contrast, the Scottish Low Birthweight Study Group (1992) showed that there was an excess of children with a Body Mass Index (BMI) below the 50^{th} percentile; that is, they were light in weight for their height. They have also suggested that children born weighing 1500 – 1749 g, 1000 – 1499 g, and

<1000 g showed smaller average head circumferences than the standard population. The heights and weights of 4.5-year-old children weighing <1750 g who were originally small for gestational age (SGA) did not differ significantly from the heights and weights of the other children ($p > 0.005$). Hirata et al. (1983) investigated the outcomes of children with birthweights from 501 to 750 g ($n = 18$; 15 girls), who were admitted to neonatal intensive care over a 6-year period. The researchers found that mean head circumferences always remained between the 10^{th} and 5^{th} percentiles until 6 years of age. On the other hand, mean height and weight were near the 5^{th} percentile until 3 years of age, and then increased to between the 10^{th} and 50^{th} percentiles between 4 and 6 years. Spady, Joffers, and Robertson (1988) reported data describing the growth from birth until age 8 years ($N = 107$; 56 girls) for neonates born AGA with birthweights <1500 g. In both sexes, mean head circumference in early life was similar to the standard but then became significantly smaller (about 0.5 cm) and remained so until the end of the study.

However, genetic factors must be accounted for in the physical growth of children born LBW and preterm. Studies (Strauss & Dietz, 1998) of children born LBW (<2550 g; $n = 2719$; 59% female) against children born NBW ($n = 43,104$; 49% female) and also against NBW ($n = 220$; 61% female) and LBW siblings ($n = 220$; 61% female) for growth and development were controlled for genetic and environmental factors by including the heights and weights of the infants' mothers. Variables of the mothers included their height and pre-pregnancy weight. The results of this study showed that children born <2500 g remained significantly lighter (1.6 kg), shorter (2 cm), and possessed smaller head circumferences (31.7 vs. 34.0 cm) than the 7-year-old children who were born NBW. These researchers also found that the mothers of the infants born

LBW (called intrauterine growth retarded, or IUGR) were both shorter and lighter than the mothers whose infants were born NBW. The NBW siblings of the shorter mothers remained smaller than their unrelated counterparts. However, the siblings born with IUGR remained significantly lighter and shorter than siblings without IUGR. Nevertheless, there were no differences in IQ or Bender-Gestalt scores between siblings born with and without IUGR. These researchers suggested that many infants labeled as "IUGR" were genetically short. These researchers suggested that the growth deficits associated with IUGR were independent of the severity of IUGR or other prenatal and postnatal factors, including low Apgar scores, but were related to genetic factors.

One more possible reason why children born preterm were IUGR was poor nutrition during the mother's pregnancy. Udipi, Ghugre, and Antony (1998) explained how nutritional deficiencies during pregnancy can cause IUGR. They emphasized the need for specific nutrients (zinc, iodine, and folate) that were required for proper development of the fetus. Udipi et al. made the point that a continual lack of nutrition during pregnancy can affect the neonate's birthweight.

Infants born preterm also tended to be at a disadvantage compared with infants born fullterm according to their nutritional needs. Whereas infants born fullterm acquired adequate nutrition from human milk, infants born preterm had nutritional needs that breast milk cannot sufficiently provide (Kuschel & Harding, 2001). Kuschel and Harding acknowledged the needs for additional protein of an infant born preterm, in order to attain adequate growth rates. They found that human milk supplemented with protein led to increases in short term weight gain, as well as linear and head growth.

Another nutrient that children born preterm begin life with was Vitamin A. Darlow and Graham (2001) acknowledged that Vitamin A was necessary for normal lung growth and healthy respiratory tract epithelial cells. Without enough Vitamin A, these infants were more likely to develop a chronic lung disease. The researchers noticed that when infants born preterm received Vitamin A supplements, they needed less supplemental oxygen.

Visual and Perceptual Motor Skills

A number of studies have found deficits in perceptual motor functioning in children born VLBW between the ages of 5 and 11 (Hunt et al., 1982; Klein et al., 1989; Teplin et al., 1991). Further, children born VLBW were found to perform significantly lower than a demographically matched group of children born fullterm on perceptual-motor tests at 5 years of age (Siegel, 1983). Jacob (1981) studied a sample of children born preterm (<2500 g, <38 weeks gestation; $\underline{n}$ = 40, 18 females), who were graduates of a regional NICU. The children who were born prematurely were matched with fullterm controls ($\underline{n}$ = 40) based on sex, race, SES, and post-conceptual age. The children born preterm ($\underline{M}$ = 48.4) did not perform as well as the controls ($\underline{M}$ = 53.6) on perceptual performance tasks, particularly on items that were sensitive measures of visual-motor coordination such as copying a design ($\underline{M}$ = 2.7 vs. 3.7). The study suggested that impaired visual-motor coordination accounted for this finding.

A recent study by Liebhardt, Sontheimer, and Linderkamp (2000) reported that children born VLBW scored significantly lower in almost every visual-motor skills test item compared to their fullterm peers. Liebhardt et al. studied children born VLBW ($\leq$1500 g and/or gestational age <32 weeks; $\underline{n}$ = 40; 22 girls) from 1988 to 1989 and children born healthy and fullterm (n = 83; 42 girls) at ages 3 ½ to 4 years by means of a simple and short test for visual-motor deficits. Most children born VLBW scored within 1 standard deviation of the test mean, but on average children born VLBW scored significantly lower than children born fullterm in the copying of nine figures (M = 3.2 vs. 5.1), cutting out lines that zigzag (M = 17.2 vs. 7.2), building of models (M = 7.2 vs. 9.1), and overall concentration and cooperation during the test (M = 4.2 vs. 5.1).

Despite controlling confounding variables, children born preterm had more problems in visual-motor functions than did their fullterm counterparts (Klein et al., 1985; Luoma et al., 1998). Klein et al. (1985) conducted a recent investigation in preschool performance of 5-year-old children (n = 46; 18 females) who were born VLBW, had "average" intelligence, showed no neurologic impairment, and were matched with children born fullterm by race, sex, and family background. The authors described significant deficiencies showing that children born VLBW performed less well on specific visual-motor integration measures (M = 8.5) as compared to children born fullterm and NBW (M = 9.5). These researchers emphasized the importance of continuing the follow-up of high-risk neonates until school age or later, in order to facilitate the early identification of such dysfunctions, which may be associated with eventual school learning problems, and the potential to provide intervention to ameliorate these dysfunctions. In another study, intellectually normal children born preterm ($\leq$32 weeks; n = 46; 22 girls), without major neurological disabilities, and a control group of fullterm children (n = 46) matched by age, sex, and parental educational and occupational status were assessed at the age of 5 years (Luoma et al., 1998). The children born preterm achieved lower mean scores in tests where coordination and voluntary control of hands in combination with tactile, kinesthetic, and visuospatial perception were needed. They had more difficulty with drawing directions of lines and in integration of two or more forms. They also had problems with visual perception of rotated shapes or slopes of lines as well as 3-dimensional constructions.

Children born LBW (<2000 g, n = 137, gender was not reported) without major disabilities (cerebral palsy, blindness, deafness, multiple malformations, or chromosomal aberrations) were compared to children born NBW (>3000 g and length of gestation >37 weeks, n = 152) aged 5 years on neuropsychological performance (Sommerfelt, Markestad, & Ellertsen, 1998). The children born LBW showed significantly lower mean scores on tests of visuo-spatial and visuo-motor abilities than the children born NBW. The researchers reported that there were no statistically significant correlations between the presence of squint, the use of glasses, or visual mediated cognitive and neuropsychological tests between the children born LBW and NBW.

A number of studies have found deficits in visual motor functioning in children born VLBW and ELBW (Hunt et al., 1982; Klein et al., 1989; Ornstein et al., 1991; Teplin et al., 1991). Some studies have indicated a higher incidence of visual-motor problems independent of IQ scores and/or neurological impairment in children born preterm or ELBW (Hunt, 1981; Saigal et al., 1991). Klein et al. (1985) studied children born VLBW and children born NBW for preschool performance of visual motor skills. The children born VLBW performed significantly lower compared to the children born NBW on the Spatial Relations subtest of the Woodcock-Johnson Psycho-Educational Battery (Woodcock, 1978) and on the Visual-Motor Integration test (Beery & Butenika, 1982), even though no differences in IQ were found. These researchers suggested that early recognition of these perceptual and visual-motor problems might permit appropriate early remedial intervention and prevent the compounding of these difficulties.

Robertson, Etches, and Kyle (1990) studied a cohort (N = 144; 72 females) of children aged 8 years born preterm and fullterm. These researchers attempted to eliminate other confounding variables by controlling for height, SES, education of the mother, and sex. They found that the children born fullterm performed significantly better than the children born preterm on visual-motor ability. In contrast, Goyen, Lui, and Woods (1998) studied children born VLBW (<1000 g, n = 39; 1000 - 1500 g, n = 44; total of 45 females) who were 5 years of age and neurologically and intellectually normal (IQ > 84), and tested them on visual perception and visual motor skills. Only 17% had below average scores in visual motor skills, and 11% had below average scores in visual perception skills (<1 SD below the mean and <1.5 SD below the mean, respectively).

Children with birthweights under 750 g had significantly less desirable outcomes than those weighing 750 to 1499 g with regard to visual motor function (Hack et al., 1994). Those groups were not different in their composite indexes of social disadvantage. Foreman, Fielder, Minshell, Hurrion, and Sergienko (1997) examined a group of school-age children (N = 16 preterm and 16 fullterm, 6 females for each group, no disabilities), born at 27 - 32 gestational weeks, who had performed normally on pediatric screening tests. They showed no deficits on tests of visual form extraction and closure. Foreman et al. suggested that, in the absence of any clinically detectable disability, prematurity results in a cluster of small but significant visual-motor impairments that persist into middle childhood.

Prematurity and Motor Performance

The motor skill development of children born preterm and/or LBW, VLBW, and ELBW compared to that of children born fullterm and/or NBW is important to understand. If the children born preterm possessed specific lower levels of certain motor skills compared to the children born fullterm, then such information could help educators, therapists, medical doctors, and parents to develop intervention programs. This part of the review addresses gross motor skills, fine motor skills, balance skills, motor coordination, and involuntary movements.

Studies of motor performance for children born preterm and/or LBW, VLBW, and ELBW have used a diverse array of subject criteria (e.g., including or not including severe/mild disabilities; different birthweights and gestational ages, and a diversity of instruments). The studies examined here used matched or unmatched social economic backgrounds and a diversity of instruments (Tables 3 and 4). Despite different methods of studying motor performance in the subjects, many researchers have indicated that the children born preterm and/or LBW, VLBW, and ELBW showed more motor performance problems than the children born fullterm and/or NBW (Bjerre & Hansen, 1976; Yvonne R. Burns & Bullock, 1985; Klein et al., 1989; Marlow et al., 1989; Ornstein et al., 1991). Children born less than or equal to 800 g with disabilities have displayed gross motor problems (Luther et al., 1996). Bjerre and Hansen (1976) reported that gross motor functions were awkward statistically more often in the 7-year-old children born LBW ($\underline{n}$ = 288, gender was not reported), without severe mental retardation but including other disabilities, than in the control group ($\underline{n}$ = 28 vs. 12, respectively,

Table 3

Summary of Classification of Participants Born Prematurity

Authors (Published yr)	Age (yr)	Birth yr	N	Number of participants by birthweight group (g) <1000	1000-1250	1251-1500	1501-1750	1751-2000	2001-2500	Cg (n)	Disabilities present	SES	Parents' education
Burns & Bullock (1985)	5	1975	209	<-----	-----	-----	106	-----	----->	103	included	matched	NA
Marlow, Roberts, & Cooke (1989)	6	1/80 to 6/81	106	<-----	53 ----->					53	no cerebral palsy	NA	NA
Ohlweiler, Alfano, & Rotta (1996)	7	before 1989	95	1	<----- 3	----->	<----- 14	----->	33	44	included	NA	NA
Klein, Hack, & Breslau (1989)	9	1976	130	<-----	65	----->				65	no neurological disabilities	matched; high risk	Mothers: same for both
Forslund & Bjerre (1989)	4	11/76 to 12/77	69	<-----	-----	-----	44	-----	----->	25	included	matched	NA

Note. Cg = Control group; SES = Socioeconomic Status; NA = Not Available.

Table 4

Summary of Instruments of Motor Performance

Studies	Standardized	Instruments for Motor Skills
Bjerre & Hansen – 1976	NS	Questionnaires from parents and teachers
Burns & Bullock - 1985	Sd	Physiotherapy evaluation of motor and neurological aspects of development (Burns, 1983)
	NS	McCarthy Scales of Children's Abilities (McCarthy, 1972)
Marlow, Roberts, & Cooke -1989	Sd	The Test of Motor Impairment (Stott, Moyes, & Henderson, 1984)
	Sd	Neurological Examination (Touwen, 1979)
	NS	Cerebral inhibition examination by movements (Fog & Fog, 1963)
Black, Brown, & Thomas -1977	Each skill is Sd	Motor balance: walk beam task and standing balance on one leg (Black et al., 1977)
		Fine motor coordination: a pegboard, a tapping test, and a tracking task (Black et al., 1977)
Ohlweiler, Alfano, & Rotta -1996	Sd	Evaluational neurological evaluation (Lefévre, 1972)
Klein, Hack, & Breslau -1989	NS	Purdue Pegboard (Wilson, Iaconviella, Wilson, 1982)
Elliman, Bryan, Elliman, Walker, & Harvey -1991	NS	Gross and fine motor coordination & balance modified from Gubbay (1975) and Touwen (1979)
Bjerre -1975	NS	Special references to motor coordination (Touwen & Prechtl, 1970) with certain modifications on neurological examination
Forslund & Bjerre - 1989	NS	Neurological Examination (Touwen, 1979)

Note. NS = Not Specified; Sd = Standardized.

matched by sex and age). This study was used to measure gross motor skills with a questionnaire filled in by the subjects' parents and teachers (subjectively judging the function of the children's motor skills). Burns and Bullock (1985) compared the motor abilities of adjusted age 5-year-old children born preterm (27 to 35 weeks; n = 106; 47.6% female) to children born fullterm (>38 to <42 weeks; n = 103; 48% female). The children born fullterm were matched to the children born preterm in sex, birthplace, race, and residential location. No children with cerebral palsy were included in either subject group. Burns and Bullock indicated that this allowed an accurate comparison of gross and fine motor function. The children born preterm were significantly less competent in gross motor ability (jumping two feet together, jumping a moving rope, balancing on one leg, kicking and catching a ball, and synchronizing a jump-clap activity) than their fullterm peers. The mean of the gross motor skills for the children born preterm was 2.96 and for the children born fullterm it was 3.15. These researchers suggested that motor performance was unrelated to socioeconomic and environmental factors.

Children born ELBW had significantly lower scores than children born NBW on several gross motor tasks (Marlow et al., 1989). Marlow et al. studied children 6 years of age (n = 53; 20 girls) who had weighed less than 1251 g at birth and were without cerebral palsy, and were receiving mainstream education, and compared them to children born fullterm (n = 53), matched by age, sex, and school. There were no significant differences between the two groups in SES. On the test of motor impairment, children born less than 1251 g had significantly lower scores than the control children on several gross motor tasks (such as catch, goals, standing on the dominant leg, standing on the other leg, and toe walking). The median (interquartile range) for the children born

ELBW was 6.0 (4.0 - 8.75) compared with 3.0 (1.5 - 4.5) for the children born fullterm in the scores from the test of motor impairment (Stott et al., 1984).

Children born LBW performed lower on tests of gross motor coordination than children born NBW. Elliman et al. (1991) conducted a study on 7-year-old children born at birthweights of 2000 g or less (n = 171, gender not reported clearly) with no major disabilities and compared them to children born NBW (n = 214, matched by gender). These groups possessed no differences in SES. The children born LBW performed significantly lower on tests of gross motor coordination, such as moving from a lying to a sitting position (44% vs. 73%) and jumping over a knee-high cord (87% vs. 96%), than the children born NBW. Bjerre (1975) reported that at 5 years of age the children born LBW (N = 139; 69 girls), which included children with disabilities, developed lower gross motor coordination (walking along a straight line, standing on one leg, hopping on one leg, and standing with the arms extended) than expected in their age group. In the Forslund and Bjerre (1989) study, at 4 years of age, children born preterm (<35 weeks; n = 44; 19 girls) and fullterm (AGA and >3000 g; n = 25; 12 girls) were tested on a neurological assessment. Both groups of children included disabilities, and although the children born preterm had more cases of disability, no significant differences existed between the two groups. The children born preterm were less skilled in certain gross motor skills (walking on tiptoes, walking on the heels, and standing on the right leg) than the children born fullterm. There were no significant differences in hopping, standing on the left leg, heel-toe gait, and rising into a standing position from lying in the supine position. However, scores of hopping were given only in quantitative ways; the researchers did not look at the qualitative attributes of the children's hopping movements.

Children born VLBW and ELBW have been reported as having a normal range of fine motor skills (Black, Brown, & Thomas, 1977), in contrast to some studies that have reported below normal ranges for fine motor skills (Luther et al., 1996). Black et al. conducted a study of children born VLBW and ELBW, including disabilities (4 to 6 years old; N = 58; 32 females), who were found to have exhibited a normal range of fine motor skills on pegboard, tapping, and tracking tasks. Bjerre and Hansen (1976) used questionnaires from parents and teachers to examine psychomotor development of 7-year-old children. The children born LBW, including those with disabilities, (n = 144, gender not reported) were matched by sex and age to the children who served as the control group (n = 144). Fine motor coordination was judged as clumsy more often in the children born LBW (n = 18) than in the control group (n = 10), but was not statistically significant.

In contrast, the children born ELBW (n = 74, gender not reported) at 8 years and a subgroup (n = 24) at 9 years, including disabilities, were studied for school outcome (Luther et al., 1996). This study showed that even "neurological-normal" children by 9 years of age had problems in fine motor skills. Klein et al. (1989) studied 9-year-old children born VLBW (n = 65; 25 females), who were free of neurological impairment (e.g., moderately retarded, congenital cataracts, cerebral palsy, fetal alcohol syndrome) and were beneficiaries of modern NICU, and compared them to children born NBW (n = 65) who had been matched for race, sex, age, and SES on fine motor abilities. They found significant differences between the two groups in fine motor abilities as measured by the Purdue Pegboard (Wilson, Iaconviella, Wilson, & Risucci, 1982), with the children born VLBW performing worse than the children born NBW.

Furthermore, several studies reported fine motor skills problems for children born preterm and LBW/VLBW/ELBW (Forslund & Bjerre, 1989; Lie, 1994). At 5 years of age, the children born LBW showed delayed fine motor coordination (finger-nose, threading of small wooden beads on a string, and drawing tests) in relation to their expected age group (Bjerre, 1975). In a study by Elliman et al. (1991), the children born LBW performed significantly lower than the children born NBW in tests of fine motor coordination such as finger opposition using both hands, finger nose pointing, diadochokinesis, pouring, bead threading, and clapping while tossing a ball in the air. Specifically, only 54% of children born LBW had successful diadochokinesis, while 91% of children born NBW displayed this skill. Marlow et al. (1989) reported that 6-year-old children born ELBW had significantly more fine motor difficulties, such as posting coins with the dominant hand and threading 12 cubes, than children born fullterm. Goyen et al. (1998) reported that children born VLBW at 5 years of age who were neurologically and intellectually normal (IQ > 84) were tested on fine motor skills and 71% had below average scores in fine motor skills.

Research has indicated that children born preterm and LBW/VLBW/ELBW with and without disabilities have had more problems with balance skills than did children born fullterm and/or NBW (Yvonne R. Burns & Bullock, 1985; Elliman et al., 1991; Ornstein et al., 1991). Burns and Bullock (1985) reported that 5-year-old (adjusted age) children born preterm showed difficulties in postural control and balance when compared to children born fullterm. In addition, there was some evidence of clumsiness on motor balance tests for children born VLBW and ELBW with disabilities. Significant differences were found for walking on a beam among 5- and 6-year-old children (Black et al., 1977). Ohlweiler et al. (1996) studied 7-year-old children born preterm, including those with disabilities, and compared them with age-matched children born fullterm. The children born preterm (59%) showed significantly less dynamic, but not static, balance than the children born fullterm (79%), as measured by the Evolutional Neurological Evaluation (Lefévre, 1972).

A large proportion of infants born preterm might have some form of developmental delay once they reach school age, which was not identified earlier, even though such major disabilities as cerebral palsy can be diagnosed within the first 2 years (Piek, 1998). Further, Ohlweiler et al. (1996) reported that the children born preterm differed from the children born fullterm in appendicular coordination (or coordination of their limbs) (24.5% vs. 52%; $p = 0.05$), trunk-limb coordination (80.9% vs. 95.5%; $p = .032$), and motor persistence (55.2% vs. 86.4%; $p = 0.001$).

Children born preterm have a higher incidence of small and tremor-like involuntary movements than do children born fullterm. Burns and Bullock (1985) reported that the children born preterm had a significantly high incidence of small and tremor-like involuntary hand movements during activity (irregular, jerky, and overshoot). Forslund and Bjerre (1989) reported that the 4-year-old children born preterm displayed poorer muscle tone, more spontaneous movements, and more involuntary movements than the children born fullterm during certain gross motor functions, such as sitting, standing, walking, and lying. The children born preterm often manifested moderate movements and turned around, and one of them could not stay in the same place. For example, 20 of the 43 children born preterm showed a moderate amount of minor hand and foot movements, but only 5 of the 24 children born fullterm showed the same amount of movement during standing. These movements were extraneous movements, which were different from children with cerebral palsy, who had more severe movement problems that actually may have interfered with certain normal daily activities.

Current Studies and Consideration for Studying Children Born Prematurely

This review covered current studies in which children who were born preterm and treated with new medical technology, such as surfactant therapy, for improving developmental outcomes were compared to children born fullterm. Further consideration as to how to better study children born preterm focused on methodological perspectives. Lastly, instruments that were designed for testing motor skills were addressed.

Current Studies for Children Born Preterm Treated Using Surfactant Therapy

There was very little information available for neurological outcomes of children born preterm who were treated using advanced medical technology, such as surfactant therapy and antenatal steroids treatment. However, no differences have been reported in the neurodevelopmental outcomes between treated and untreated infants using surfactant therapy who were born VLBW (Ferlauto, Walker, Martin, & Crane, 1998). Ferrara et al. (1994) studied the effect on neurological outcomes of surfactant therapy for infants born from 23 to 26 weeks and compared surfactant-treated and untreated infants. As a follow-up, no differences in neurological outcomes were detected between surfactant-treated (M adjusted age = 23 months) and non-treated infants (M adjusted age = 32 months).

No differences existed between surfactant-treated and untreated infants for growth and mental and psychomotor development. Saigal et al. (1995) studied a total of 114 infants who received a synthetic surfactant and 118 infants who received an air placebo (born from 750 to 1249 g), and then evaluated them after 1 year for growth and development. Growth and development in the two groups were equivalent. Scores on the Bayley Scales of Infant Development were within the normal range for both groups (mental development index, 90 ± 22 vs. 92 ± 22; psychomotor development index, 81 ± 19 vs. 87 ± 22; air placebo and synthetic surfactant groups, respectively). However, the researchers have reported that an equal number of placebo and surfactant recipients scored below the 5th percentile on the growth chart of the National Center for Health Statistics (however, the year of publication was not mentioned) at the 1-year follow-up examination. Twenty-one percent of the placebo recipients and 11% of the surfactant recipients had a Psychomotor Development Index of 2 SD below the average score of 100 points. The Survanta Multidose Study Group (1994) reported that the surfactant treated group of infants born preterm (700 - 1750 g) at 2 years of adjusted age had the same outcome of psychomotor development and mental development as the untreated control infants.

Regardless of whether or not the infants born ELBW were treated with surfactant, they still showed significant developmental problems (Blitz, Wachtel, Blackmon, & Berenson-Howard, 1997). Blitz et al. assessed the outcome of infants born ELBW (N = 100) born in 1990 and analyzed factors that may have contributed to their outcomes at one year corrected age. Eighteen percent of the children were more than one standard deviation below the cognitive mean, 30% were below normal for motor abilities, and 33% were below normal for language ability. Of the infants, 56 received a surfactant. The analysis demonstrated no significant differences in developmental outcome between those who received a surfactant and those who did not. The researchers reported that the infants born ELBW were at risk for significant developmental problems regardless of whether treated with a surfactant or not. They have suggested the need for targeted outreach, developmental monitoring, parental support and education, and early intervention services. Dezoete, MacArthur, and Aftimos (1997) studied the developmental outcome at 18 months for infants weighing less than 1000 g at birth during 1990 - 1992 inclusive (N = 119). Ten and one-half percent of infants born ELBW were classified as having a severe disability, 10.5% had a lesser disability, and 15.2% had a motor delay or tone disorder. Sixty-seven percent were classified as within the average range for mental and motor development and normal on neurological evaluation.

No detectable growth, physical, motor, or developmental deficiencies within the first 3 years of life can be attributed to antenatal dexamethasone therapy delivered to the mothers prior to delivery. Infants (n = 206; <2036 g) whose mothers received the steroid shortly before birth, and infants (n = 200; <1930 g) whose mothers had received a placebo shortly before birth were evaluated at each infant's birth, then at 4 weeks, 9 months, 18 months, and 36 months (Collaborative Group on Antenatal Steroid Therapy, 1984). Follow-up evaluations during the first 3 years of life were carried out on infants born to women enrolled in a double blind, randomized trial to evaluate the safety and efficacy of antenatal dexamethasone for the prevention of RDS. The findings of this study were that no statistically significant differences were observed between the placebo and steroid groups with regard to head circumference and neurologic abnormalities.

Schendel et al. (1997) compared children born VLBW (<1500 g, n = 367) against children born moderately low birth weight (MLBW: 1500 - 2499 g, n = 553), then compared both against children born NBW (>2499 g, n = 555) for developmental delay.

All subjects were without obvious developmental disabilities and were born from 1989 to 1991. Participants were tested between 9 and 34 months. The results of the study were that children born VLBW manifested delay in all areas of functioning (personal-social, language, fine motor-adapted, and gross motor) compared to children born MLBW and NBW; and the children born VLBW had the greatest risk for delay associated with the gross motor domain.

Regardless of whether or not infants born preterm and LBW were treated using surfactant or antenatal steroid treatment, they still showed developmental disabilities compared to children born fullterm and NBW. Children born VLBW after 1988 showed developmental delay, including gross motor, more often than children born NBW. Few studies have been completed examining neurological outcomes, including gross and fine motor skills, on children born preterm. Thus, further studies on developmental outcomes are needed for children born preterm after 1989 who received current treatments.

Important Considerations in the Study of Children Born Preterm

Making direct comparisons between different studies of LBW infants with respect to motor impairment was difficult (Kitchen et al., 1980) because of differences in the method of sample selection, range of birthweights included, proportion of infants who were SGA, patterns of neonatal intensive care, age at follow-up, and method of later assessment. However, the research literature indicated a wide variability in the degree of neurological impairment including motor, visual, and perceptual development exhibited by children born LBW (Bjerre, 1975; Bjerre & Hansen, 1976; Elliman et al., 1991; Hertzig, 1981). Piek (1998) also suggested that there was strong evidence to suggest that infants born preterm and LBW/VLBW/ELBW had a substantially higher risk of later developmental delay than did infants born fullterm. Therefore, Piek indicated a need to identify these at-risk infants at an early age, as it was only through early identification that one could have determined any benefits of early remedication.

It was important to be aware of the different degrees of motor performance outcomes among children born preterm and/or LBW/VLBW/ELBW. Children born ELBW/VLBW demonstrated poorer outcomes on motor skills tests than did children born LBW (Hack et al., 1994). Hack et al. reported that the children born weighing less than 750 g had significantly poorer outcomes than those weighing 750 to 1499 g with regards to gross motor skills. Additionally, the Scottish Low Birth Weight Group (1992) studied 4.5-year-old children (including those with disabilities) born less than 1750 g (below 1000 g, 1000-1499 g, and 1500-1749 g; $\underline{N}$ = 890), for growth, sensory, and neuromotor impairment. On the overall score, all of the children studied performed significantly less well than the population on whom the test was standardized, even in the absence of neuromotor disability, with 40% of those below 1000 g being considered impaired compared with 20% and 16% in the heavier groups (1000-1499 g and 1500-1749 g, respectively).

This trend was statistically significant with respect to performance on the tasks of bead threading, one leg balancing, and jumping the cord. Where there was no trend by birthweight, the children born ELBW performed less well on catching a beanbag and rolling a ball into a goal. Nearly a fifth of all the study children could not jump a cord at knee height, but in children who had birthweights less than 1000 g, 36% failed this task, whereas 90% of the standardized population were able to achieve the task. In tests of fine motor skills the study children performed less well, for example, controlling a pencil to draw between two lines (the bicycle trail task), with nearly a quarter of those over 1000 g and 30% of the children born ELBW scoring below the 10^{th} percentile for the tests (Scottish Low Birthweight Study Group, 1992). This study also supported that children born LBW/VLBW/ELBW may have been strongly influenced by different degrees in the deviations of development of motor skills performance.

Additionally, it was important to study and characterize the demographic and perinatal characteristics of both the normative and study samples as fully as possible, and to use a SGA standard based on clearly cut off weights at each gestational age (Cecelia M. McCarton, Wallace, Divon, & Vaughan, 1996). McCarton et al. compared the neurological and cognitive outcomes of infants born premature and SGA ($\underline{n}$ = 129) with infants born premature and AGA ($\underline{n}$ = 300) through 6 years of age. These researchers decided that infants born ≤37 weeks gestational age and ≤2500 g with birthweights 2 standard deviations or more below the mean birth weight were to be categorized as SGA.

The result of this study was that children born preterm and SGA had significantly lower cognitive scores at each age through 6 years when compared with AGA infants born of similar gestational age. Additionally, normal neurologic status was more likely at all assessments for the AGA than SGA infants of comparable gestational age. However, there were no differences between the children born premature and SGA or AGA in cognitive or neurological outcomes at any age when grouped by birthweight. The researchers in this study emphasized that the infants born preterm and SGA were at a greater risk for neurodevelopmental impairment than children born equally preterm and AGA. Except for both weight and head circumference at birth, the AGA and SGA groups were similar in demographic characteristics, perinatal status, and neonatal morbidity, and that these data showed that the developmental differences were linked to intrauterine brain growth rather than other factors.

Further, Paz et al. (1995) assessed the cognitive and academic performance of adolescents who were born fullterm. The results of children born SGA (weight at fullterm birth below the third percentile) were compared to children who were born AGA. The mean (± standard error) intelligence test scores were 103.1 ± 2.9 versus 105.8 ± 1.5 points ($p = .03$) for the males and 100.3 ± 2.5 versus 104.7 ± 1.6 points ($p < .03$) for the females. Forty percent of SGA males attained less than 12 years of schooling or attended vocational school compared to 23.2% of AGA males ($p < .03$). This finding remained statistically significant after controlling for the possible influence of confounding factors such as SES. The studies by Paz et al. and McCarton et al. suggested that children born AGA and SGA might have had different cognitive and neurological developments.

Children born preterm with no/mild disabilities (of any type of disability) should be separated from children born preterm with moderate/severe disabilities, since moderate/severe disabilities might give rise to different conditions, thus affecting motor skills. For instance, children with moderate/severe mental disabilities may not be able to follow directions even if physically healthy. On the other hand, if the child has moderate/severe physical disabilities, s/he may not be able to perform motor skills well compared to children without moderate/severe disabilities. Research showed there to be significant differences in the motor skills of children born fullterm and preterm regardless of the inclusion of children born preterm with disabilities (Black et al., 1977), or whether neurological disabilities were not included (Klein et al., 1989). Pharoah et al. (1994)

reported that among 8-year-olds in a total sample of 232 matched pairs, 27 children ($\leq$1000 g; 1001 – 1500 g; 1501 – 2000 g; including disabilities) had definite motor impairment, and 49 had a moderate motor problem. Among the control group (same birthweight, without disabilities), 2 had a definite and 21 a moderate motor problem. These differences were statistically significant between both groups. Both groups were matched by birth date (as near as was possible), sex, school, and social index.

Issues of Instrumentation in Assessing Motor Performance

Choosing good instruments for finding a standard level of motor performance for children born prematurely is important. Therefore, determining with which specific motor skills children born preterm are having problems is an important first step in providing early intervention. Seaman and DePauw (1989) suggested that using appropriate instruments is critically important because accurate and meaningful decisions can be made for intervention, placement, program planning, and performance objectives. Thus, it is imperative to review the instruments for investigating motor performance of children born preterm.

Instruments should not only provide cut-off points of dysfunction in motor performance, but also determine the level of motor skills performance. The Test of Motor Impairment (Stott et al., 1984) and the Riley Motor Problems Inventory (Riley, 1976), which have been used in studies involving children born preterm, have as their focus measuring the extent to which children fall below the level of peers, not on ranking children on their motor ability. The average child is not distinguished from the highly skilled child. The Bruininks-Oseretsky Test of Motor Proficiency (BOTMP), which is a popular instrument in studying motor performance in adapted physical education (Miles, Nierengarten, & Nearing, 1988), used only quantitative ways of measuring gross and fine motor skills.

The Test of Gross Motor Development (TGMD) (Ulrich, 1985) is a "popular criterion- and norm-referenced instrument" that is used by many adapted physical educators to assess students for service eligibility (Burton & Miller, 1998, p. 241). The TGMD is one of the process-oriented assessment instruments that evaluate the qualitative aspect of one's movement behavior (Gallahue, 1989). Langendorfer (1986) indicated that the TGMD focuses on measuring performance levels, yet does not screen performance levels well at lower developmental levels. In the 2nd, current edition of TGMD (Ulrich, 2000), which appears to be more sensitive to lower developmental motor skills, the scoring of each motor skill still may be limited in distinguishing among the lowest levels of each motor skill. As an example, in the striking a stationary ball task, check boxes are used to determine if a child has fulfilled an aspect of the striking movement. The 'yes or no' approach does not take into account gradual developments of each aspect of a movement.

Although not sensitive enough at lower levels, the Scale of Intra-Gross Motor Assessment (SIGMA) (Loovis & Ersing, 1979) assessed various motor skills by stages. Each stage (for the most part) displayed criteria to be fulfilled. However, the SIGMA did not always have clearly established criteria for certain motor skills, such as the running item. This insensitivity to the lower levels of development made the SIGMA unattractive for determining the motor skills abilities of the younger children in the current study.

Instruments that are more useful in this regard are the McCarron Assessment of Neuromuscular Development (MAND) (McCarron, 1997) and the Motor Performance

Study (MPS) (Seefeldt, Haubenstricker, and/or Branta, 1972 - 1982). The MAND is standardized and provides norms to compare general motor skills (NDI), four factor scores, and ten individual motor skills items. The MPS scores children on their patterns of movement. Both instruments might be useful in finding out how well children born preterm perform motor skills because both instruments accumulate points when the child performs a motor skill better than average.

Using standard instruments is important because children born preterm can also be compared with a national or regional norm, even though this study planned to compare them to actual children born NBW. Furthermore, using current, revised, or updated standards of instruments is important in that children born in recent times might show different levels of motor skills than did children born 10 or 20 years ago. This could be due to different cultural experiences, number of siblings, and popular toys. For example, children today may have greater experience with computers than a decade ago. Therefore, the recently revised MAND instrument with a high test-retest reliability (over .90 using 31 mentally retarded individuals) and a population of over 2000 children from several states across the U.S., aged from 3 ½ to 17 years old for standardization of each age group, was a good choice for research. Furthermore, Tan (1998) suggested that the MAND was the more accurate discriminator of children with and without DCD than the BOTMP-short form.

Understanding the motor performance of children via qualitative assessment is important in addition to quantitative scores. For example, a child may not throw the ball far because of a lack of muscular development or decreased motivation to throw, but the child might still use a mature throwing form. Investigators need to determine the pattern of movement that is used in a performance in order to compare developmental levels. Therefore, the MAND and MPS developmental stages assessments are appropriate to use in determining patterns of movement. Additionally, the MPS lists specific criteria for even the most fundamental aspects of every motor skill. The MPS instrument evaluates the qualitative aspects of the motor skills movements from immature pattern to the most mature patterns of movements. These stage descriptions are more likely to ascertain the poorer levels of a motor skill.

The MAND and MPS test instruments also can measure motor performance levels for 4- to 7-year-old children born preterm and fullterm. Both instruments are appropriate for those age groups and easily compare age differences because the test items do not change among different age groups, as seen in the Test of Motor Impairment (Stott et al., 1972, 1984). By using both the MAND and MPS test instruments, it would be possible to determine how children born preterm and fullterm differed in motor skills.

Summary

The literature review attempted to put into perspective several factors that impact the study of motor skills and development of children born preterm. Discussion is centered around: (a) how children born prematurely have been defined in the medical literature; (b) medical advances that made improvements in long-term outcomes of children born preterm; (c) cognitive and social/emotional characteristics of children born preterm; (d) disabilities and neurological soft signs of preterm children in order to understand children born preterm with disabilities; (e) what has been known about the relationship among prematurity, neuromotor development, and motor performance; and (f) current studies in which new technology has been used to treat the developmental outcomes of children born preterm; and (g) the consideration of instruments for studying children born preterm.

The definition of preterm has been historically controversial. Traditionally, a birthweight of 2500 g or less was used to define infants born preterm (Stanley, 1977). By recent international agreement, a preterm infant is one born prior to 37 weeks (less than 259 days) from the first day of the mother's last menstrual period (World Health Organization, 1980a). Many researchers and other professionals in the medical field have used both gestational age and birthweight when they dealt with preterm infants. The identification of the newborn group using gestational age and birthweight information was utilized in order to define high-risk, sick infants easily and to take care of them at an optimal level (Battaglia & Lubchenco, 1967). Because of the apparent approximation with reality, the investigator decided to use the birthweight/gestational age combination for the children in the study.

Recent medical technologies, such as the use of surfactant therapy and antenatal steroids, have increased the survival rate of infants born prematurely. The use of antenatal steroids, caesarean deliveries, steroids to treat CLD, and surfactants to treat CLD (including RDS and BPD) have positively contributed to the survival of infants born VLBW. However, the beneficial associations were at the expense of increased rates of infection or adverse neurological outcomes in certain cases.

The term "disability" has had multiple meanings, and multiple ways to classify it. The WHO's (2001) definition was a reduction or loss of functional ability. Sensory motor problems include LD, perceptual motor learning, clumsiness, or DCD, as well as severe sensorimotor problems like cerebral palsy (Sherrill, 1998). Neurological soft signs attempt to give clumsiness a foundation upon which can be built a system of identification, and eventually treatment (Tupper, 1987).

An infant born premature who did not develop a major disability or sensory impairment was still at risk for subtle abnormalities of the CNS (Kitchen et al., 1990). Later developmental problems included language delay, learning disability, minor neuromotor dysfunction, attention deficit, hyperactivity, emotional inability, and behavior problems (Allen et al., 1993). Children born VLBW/ELBW showed variability in their test scores and a slightly lower range of IQ scores than did children born NBW (Klein et al., 1989; Ornstein et al., 1991; Saigal et al., 1991; Vohr et al., 1989). Hack et al. (1994) reported that children born ELBW had significantly less cognitive ability than children born weighing 750 to 1499 g and children born fullterm. Hack et al. also reported that the children born ELBW had significantly lower outcomes in behavior, social skills, and adapted behavior than did the children born weighing 750 to 1499 g and the children born fullterm. Ohlweiler et al. (1996) pointed out impulsiveness, aggressiveness, and disorganization as symptoms of disturbances that appeared in children born preterm and below NBW. Sajaniemi et al. (1998) reported that 2-year-old infants born preterm were significantly less active, more adaptive, more positive in mood, less intense, and lower in threshold response than infants born fullterm. Bennett (1988) suggested that even though most children born preterm and LBW are not functionally impaired, they appeared to perform and score lower on the measure of scholastic achievement throughout childhood when compared on a group basis to children born fullterm or NBW.

Prematurity was a major risk factor leading to developmental disturbance in the lives of children born preterm (Reed & Stanley, 1977). Thus, motor development in these children was of interest (Largo et al., 1993). Various studies contradicted each other in describing the differences in physical growth among the children born LBW and NBW. In demonstrating that genetics did need to be considered, Strauss and Dietz (1998) found that mothers of infants born LBW (or IUGR) were both shorter and lighter than mothers whose infants were born NBW. A number of studies found deficits in perceptual motor functioning in children between the ages of 5 and 11 who were born VLBW (Hunt et al., 1982; Klein et al., 1989; Teplin et al., 1991). Despite controlling for several confounding variables, the children born preterm had more problems in visual-motor functions than did the children born fullterm (Klein et al., 1985; Luoma et al., 1998). If the children born preterm possessed specific lower levels of certain motor skills compared to the children born fullterm, then such information could help educators, medical doctors, therapists, and parents develop intervention programs. Studies of motor performance for children born preterm and/or LBW/VLBW/ELBW used a diverse array of subject criteria (e.g. a diversity of instruments, different birthweights and gestational ages, and including or not including severe/mild disabilities). Children born ELBW had significantly lower scores than children born NBW on several gross motor tasks (Marlow et al., 1989). Studies reported fine motor skills problems for children born LBW/VLBW/ELBW and preterm (Forslund & Bjerre, 1989; Lie, 1994). Children born preterm had a higher incidence of small and tremor-like involuntary movements than children born fullterm.

There was very little information available about the neurological outcomes of children born preterm who were treated using advanced technology such as surfactant therapy and antenatal corticosteroids treatment. No differences were reported in the neurodevelopmental outcomes between treated and untreated infants using surfactant therapy, who were born VLBW (Ferlauto et al., 1998). Regardless of whether or not infants born preterm and LBW were treated using surfactant or antenatal corticosteroids treatments, they still showed developmental disabilities compared to children born fullterm and NBW. Few studies were completed with children who were born preterm for neurological outcomes including gross and fine motor skills. Thus, further studies in developmental areas were needed for children born preterm after 1989 who received current treatments. Children born preterm with no/mild disabilities should be studied separately from children born preterm with moderate/severe disabilities, because moderate/severe disabilities might affect motor skills as a different environment.

Choosing good instruments for finding a standard level of motor performance for children born prematurely is important. Instruments should do more than simply provide cut-off points of dysfunction in motor performance, such as the TOMI (Stott et al., 1984) and the Riley Motor Problems Inventory (Riley, 1976). The BOTMP uses only quantitative ways for measuring gross and fine motor skills. The TGMD (Ulrich, 1985) and the SIGMA (Loovis & Ersing, 1979) may be too insensitive to the lower levels of motor skills items. Instruments that are more useful in this regard are the MAND (McCarron, 1997) and the MPS (Seefeldt, Haubenstricker, and/or Branta, 1972 - 1982). These instruments are good at determining how well children born preterm perform various motor skills because both instruments accumulate points when the child performs a motor skill better than average/appropriate for their age group, and the instruments easily compare age differences because the test items do not change with age.

The MAND is standardized and revised, and uses qualitative and quantitative ways to measure some necessary gross and fine motor skills. It is a more accurate discriminator of children with and without DCD than the BOTMP-short form, stated Tan (1998). The MPS test instrument evaluates the qualitative aspects of the motor skills movements from the least to most mature patterns of movements, which may be sensitive enough to measure low levels of movement.

CHAPTER 3

RESEARCH METHODS

The purpose of this study was to compare motor development levels and physical growth among the children born in the Preterm I (PT I), Preterm II (PT II), and Fullterm (FT) groups ranging in age from 3.5 to 7 years. Furthermore, this study examined how some variables (from duration of child participation in preschool, physical growth of the children, as well as the heights of the parents, and/or use of adjusted age for motor development levels) were correlated with motor performance levels. This study also investigated the child's neurological signs during the motor skills testing through observations of videotapes in order to find any associations among different neurological soft signs and birthtypes as well as the frequencies of certain neurological soft signs. This study also provided descriptive data results of using adjusted age for motor performance levels, as well as family/demographic information.

Hypotheses and Research Questions

Hypotheses were designed when the researcher found the review of literature to support a direction for the hypothesis (Table 5). Research questions were created when the researcher was not sure about predicting the direction of a hypothesis and if not much support was found in the review of literature.

Motor Skills

H1. The children born in the PT I and PT II groups perform less well than the children born in the FT group on the MAND score of general motor skills (NDI).

RQ 1. Are there differences between the children born in the PT I, PT II, and FT groups in the MAND subtests (total scaled score of fine motor skills and total scaled

Table 5

Hypotheses and Research Questions

Categories	Hypotheses/Research Questions
Motor Skills	
MAND	H1. PT I and PT II < FT on NDI
	RQ 1. Differences between PT I, PT II, and FT on MAND subtests (total scaled score of fine motor skills and total scaled score of gross motor skills)?
MPS	H2. PT I and PT II < FT on total score of MPS
	RQ 2. Differences between PT I, PT II, and FT on MPS items & subtests (total score of locomotor skills and total score of object control skills)?
Physical growth	H3. PT I and PT II < FT on height
	H4. PT I and PT II < FT on weight
	H5. PT I and PT II < FT on BMI

Note. Hypothesis: H; Research Question: RQ.

score of gross motor skills)?

H2. The children born in the PT I and PT II groups perform less well than the children born in the FT group on the total score of MPS.

RQ2. Are there differences between the children born in the PT I, PT II, and FT groups on MPS and subtests (total score of locomotor skills and total score of object control skills)?

Physical Growth

H3. The children born in the PT I and PT II groups are shorter in stature than the children born in the FT group.

H4. The children born in the PT I and PT II groups weigh less than the children born in the FT group.

H5. The children born in the PT I and PT II groups possess a smaller BMI than the children born in the FT group.

Additional questions were designed to increase understanding of how the birthtype was related to the motor skills levels as well as what other potential factors may have influenced the motor skills abilities of the children. These questions were neither hypotheses nor research questions, but certainly were exploring the data and understanding motor skills, birthtype, and other potentially influential variables to motor skills: (a) Are there any differences among the types of neurological soft signs by birthtype; (b) Are there any differences among the frequencies of neurological soft signs by birthtype; (c) What are the other variables beside birthtype (adjusted age, chronological age, physical growth, total ABILITIES Index, heights of the parents, and duration of participating in preschool) for motor skills; and (d) What do family characteristics for different birthtypes show for interactions.

Rcsearch Design

This study used a non-experimental cross-sectional design to compare motor skills performances and physical growth using chronological age for children ages 3.5 to 7 years who were born preterm or fullterm. This study was also structured to compare neurological soft signs during the motor performance with the family/demographic information. Additionally, this study sought to answer how motor performance levels related to the use of adjusted age, physical growth, and ABILITIES Index, as well as how physical growth of the children related to heights of parents. The children from the three different birthtypes were tested in motor skills using the MAND and MPS instruments.

The MAND instrument measured using both qualitative and quantitative components for six of the ten motor skills, and only quantitative components for the remaining four motor skills. The MPS instrument qualitatively measured ten motor skills. These two instruments were more likely to uncover any differences in motor skills performances among the different birthtypes.

There were three birthtypes defined in this study: (a) PT I - birthweight ≤ 1000 g and gestational age from 24 to 28 weeks; (b) PT II - birthweight of 1001 to 1500 g and gestational age from 29 to 34 weeks; and (c) FT - birthweight of 2300 to 3800 g and gestational age from 38 to 41 weeks.

Independent Variables and Dependent Variables

The independent variable of primary interest in this study was birthtype, PT I or II or FT. The other independent variable was chronological age, 3.5 to 7 years, for the MPS data as well as the heights and weights of the children. The MAND instrument is an age-standardized instrument; therefore, chronological age was not used when statistical analyses were performed with the MAND. This research used mainly chronological age for children instead of adjusted age, because after the first 2 years of life differences between birthweight and gestational age become less important (Sansavini, Rizzardi, Alessandroni, & Giovanelli, 1996). Some researchers (Ouden et al., 1991) also suggested that at 2 years of age and after correction is not necessary. Conversely, others (Palisano et al., 1985) suggested that exploring other ages for the children born in the Preterm group is needed and some researchers used adjusted age even for 5-year-old children born preterm in their studies (Yvonne R. Burns & Bullock, 1985; Cheung, Barrington, Finer, & Robertson, 1999). Therefore, this research answered with descriptive data analyses about using adjusted age in the differences in motor performance levels among the children born in the PT groups and the children born in the FT group, as well as how adjusted age and chronological age related to motor performance levels and physical growth. Dependent variables are listed in Table 6.

Table 6

Dependent Variables

Instruments	Dependent variables
Physical growth	Child's height
	Child's weight
	Child's BMI
MAND	NDI
	Total scaled score of fine motor skills
	Total scaled score of gross motor skills
MPS	Total score of MPS
	Total score of locomotor skills
	Total score of object control skills

Threats to Validity

Threats to both internal and external validity were considered, and measures were taken in the design of the study to counteract these threats as much as possible.

Internal Validity

The following were several potential threats in internal validity.

History. Although this study was mainly interested in the effects of birth type on motor skills levels, other factors such as early intervention, household income, education of parents, number of siblings, and nursery school and preschool experiences may have influenced these motor skills levels. Therefore, this study also examined information given on the survey and interview questions about the types of treatments and/or interventions the child had received, the education of the parent(s), family income, etc.

Maturation. Maturation might have been a threat to internal validity. All participants were from 3.5 to 7 years of chronological age. The children born in the PT I group were born earlier than the children born in the PT II group, who were born earlier than the children born in the FT group. Thus, all three groups of children actually had different gestational ages as well as birthweights. For example, some of the children born in the PT groups may have been born very small and weighed less than the children born in the FT groups. Children born in the PT groups may have performed less well on certain motor skills such as long jump or hand strength because their physical growth may have affected their motor skills. Because some researchers (Ouden et al., 1991; Sansavini et al., 1996) suggested not using adjusted age past 2 years, while others (Palisano et al., 1985) suggested using adjusted age, this investigator studied using adjusted age for the children born in the PT groups, compared their motor skills scores to the children born in the FT group, and also used chronological age for all birthtypes.

Testing. Testing was also a threat in that exposure to one motor skills test (e.g., skipping) might have affected scores on another motor skills test (e.g., galloping). The counteracting force to this threat was to randomize each motor skills task in the gross motor skills and fine motor skills sections of the MAND and locomotor skills and object control skills sections of the MPS for each child.

During the motor skills test, if the child appeared comfortable in the testing environment, the parent(s) were invited to leave the laboratory and come into the video room to watch his/her child's motor skills performances. If the child was looking for her/his parent(s), despite assurances of where the parent(s) were located, the parents were asked to stand or sit in a corner of the laboratory but were not allowed to speak words of encouragement to their child during her/his motor skills testing (e.g., "Good job," "Excellent," and so on).

Instrument decay. Tester boredom or her/his increased expertise in using an instrument over time might have been a threat. The reduction of this threat was achieved through randomization of the order of individual tests throughout the day. The video camera was set up in nearly the same position every time. Any deviations from its stated location and position would have been negligible because the camera always moved to follow the participant as s/he performed the motor skills. Calibration of the weighing scale was performed once at the beginning of each day, but was not necessary afterward. Randomization of the order in which the videotapes of the motor performances of each child were watched and scored by the scorer also decreased instrument decay.

Selection-maturation interaction. The main characteristic for determining the different birthtypes was the gestational age/birth weight combination. The differences in motor skills abilities between the birthtypes could have been due to such factors as the SES of the parent(s) or the physical activities of the child, or even the height or weight of the child. Therefore, this study examined the family survey among the different groups through figures and how motor performance levels correlated with physical growth. Knowledge of the specific sports/physical activities at home/school was unknown.

Expectancy effect. If the scorer knew that the child was from the PT I or PT II or FT group, the scorer might have had preconceived notions about the motor skills levels of the child while watching the performance. In order to decrease the expectancy effect, the scorer only knew the participant's ID number and first name. The tester of the motor skills as well as the interviewer of the parent(s) did not know from which group the child was selected. The tester might have expected that the child who was short, thin, and linear would perform at a certain level; this expectation could have been a threat. Thus, the investigator limited contact with the personal information of each participant (such as the survey, formal phone interview, etc.) until after finishing the grading of the motor skills tests. This procedure helped to minimize the expectancy effect.

External Validity

The results from this study could be generalized to other children who had the same characteristics as the participants. This was because the participants in this study were chosen from a very specific population. Furthermore, generalization might be better applied to similar family/demographic backgrounds as well as physical growth of the children. The children born in the PT I, PT II, and FT groups were selected from the majority of the population. In other words, the upper 10% of birthweights for a particular gestational age (LGA) were not chosen. Likewise, any children whose birthweights put them in the lower 10% for their gestational age (SGA) were excluded. Therefore, these children were considered to represent the majority of children from each birthtype.

When the child and parent(s) came to the motor skills testing in the laboratory, despite decorations in the laboratory such as animal pictures on the walls to give the child a comfortable environment, a limitation of this study was that the testing environment was necessarily lab-like; thus, poor external validity was present in this study. In addition, having a visible video camera may have made some of the participants overly aware that they were being watched, a potential reactive effect to the laboratory environment. Nonetheless, only two of the children reacted to the video camera, such as waving a hand or making funny faces at the video camera (they acted during break time).

In addition, the number of people, such as the tester, the investigator, and/or the parents involved in the testing influenced whether the child followed the directions of the tester. Therefore, this accommodation created a limitation when trying to provide the same testing environment for each child.

The gross motor skills tasks tested were considered, for the most part, to be representative of the diversity of physical activities or sports. The fine motor skills tasks tested were considered to represent the diversity of ways that fine motor skills are used in everyday life. The threat of non-representative movements was considered minimal. However, testing motor skills only one time might have been a threat to representing the motor skills of the child because of the effects of the weather, time of testing, and location, even though a diversity of motor skills were tested.

Participants

Participant Criteria

Three groups were defined by their birthweight and gestational ages in this study: PT I, PT II, and FT. PT I, PT II, and FT participants of appropriate gestational age (AGA) on the currently utilized population growth curve at birth (Battaglia & Lubchenco, 1967) were used in this study in order to ensure satisfactorily similar participant characteristics (Figure 2).

Infants who were born SGA and LGA, which represent 20% of the preterm population curves at birth, were excluded from this study. By leaving out the extremes, one may better qualify the results of the study with the majority of the population. Therefore, the results for the children born in the PT groups could be applied more to the majority of the population of children born preterm, but not to the extremes. As an example, children who were born preterm at 750 g and a gestational age of 28 weeks, which put them in the SGA category, were more likely to have mental or motor skills problems than children who were born preterm and weighed 1000 g with a gestational age of 28 weeks, which would place them in the AGA category.

Dr. Karna, neonatologist from Sparrow Hospital, identified children who met the following selection criteria through a confidential search of medical records:

1. Children who were from 3.5 to 7 years old, chronological age.
2. Children born as singletons, excluding twins, triplets, etc.
3. Children who were diagnosed at Grades III-IV of periventricular-intraventricular hemorrhage (PIVH) at birth were excluded. PIVH is defined as the bleeding that occurs in the capillary vessels surrounding the ventricles of the brain.

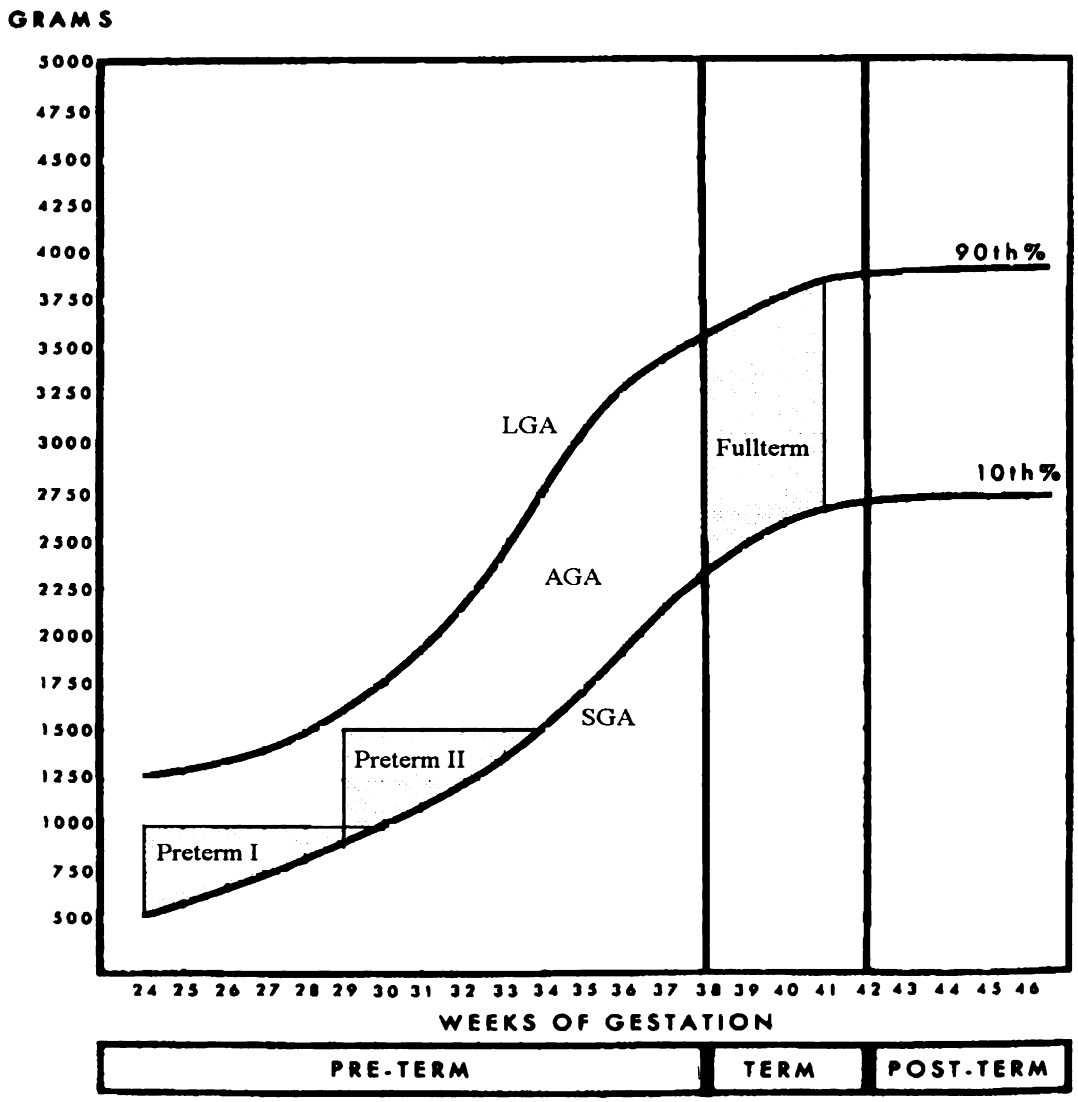


Figure 2. Birthweight vs. gestational age used as criteria for the participant groups. Fullterm = Fullterm group; Preterm II = Preterm II group; Preterm I = Preterm I group; LGA = Large for Gestational Age; AGA = Appropriate for Gestational Age; SGA = Small for Gestational Age. From "A Practical Classification of Newborn Infants by Weight and Gestational Age," by F. C. Battaglia & L. O. Lubchenco, 1967, *The Journal of Pediatrics*, *71(2)*, p. 160. Copyright 1967 by the American Psychological Association. Adapted with permission of the author.

Small hemorrhages (Grades I-II) are common in premature infants and generally have little adverse effect on the infant's development. Larger hemorrhages (Grade III) and bleeding into brain tissue (Grade IV) can result in long-term disabilities. These grades of III and IV may have an increased risk of cerebral palsy and mental retardation (Krishnamoorthy et al., 1990).

4. English was the dominant language in the home; thus, when the children came to the lab to have their skills tested, they were familiar with the language of the tester.

5. Children who were born preterm whose mothers received a full course of antenatal corticosteroids were included in this study. Doyle et al. (1994) reported that use of antenatal corticosteroid treatments among the children who were born preterm decreased the morbidity rates compared to those who did not receive the treatment. Receiving antenatal corticosteroid treatments would ensure that the participants from the preterm groups possessed a similar background of prenatal treatment.

6. Children born preterm who received surfactant treatments were included in the study. Long et al. (1991) and Hoekstra et al. (1991) indicated that a synthetic surfactant reduced the morbidity and mortality rates for infants born premature with RDS. Thus, the children born preterm had a similar background of neonatal treatment.

7. Participants were free from any mention in clinical records of moderate-to-severe neurological conditions/impairments, cerebral palsy, sensory loss (i.e., deafness, blindness), or mental retardation. If any children who were born preterm or fullterm did not perform well in the motor performance, it would not be because of their disabilities. Therefore, a disability would not be a confounding variable for motor performance levels of children who were born preterm or fullterm.

8. Children who had physical therapy because of mild-to-moderate motor delay during the past and current periods were included.

9. Children who had heart defects that were corrected by heart surgery, vision defects that were corrected by eyeglasses or contact lenses, and hearing defects that were corrected by surgery or hearing aids were included in this study. These participants were included because corrective surgery and physical aids were not expected to affect motor skills performances for the present time.

Method of Recruiting and Selecting Participants

Sample Size

The optimal number of participants desired was decided using a power calculation in Minitab (McKenzie & Goldman, 1998). The calculation used the expected difference in mean scores and some population to determine the probability of finding a significant difference (Table 7). The minimum probability chosen was 80%, and the expected lowest mean differences were 10.0 points between groups (SD = 0.67); the optimal number of participants calculated was 35 for each birthtype. It was expected that some of the potential participants might not come for the testing, so it was determined safe to use a sample size of at least 40 for each birthtype.

The ideal sample size was 120, based upon power calculations (see Table 7). The number of children theoretically available from Sparrow Hospital was small. Sparrow Hospital had a limited number of children born in the PT groups who matched the qualifying criteria. The total population of potential participants who were born preterm in Sparrow Hospital numbered 398 in their database. Out of this population, 64 had died around the time of birth, and 14 had been transferred to another hospital (thus making

Table 7

Power Calculations for Mean Score Differences

MAND M differences		Sample size (n) for each group						
SD	NDI	10	15	20	25	30	35	40
1.33	20.00	.89	.97	.99	1.00	1.00	1.00	1.00
1.00	15.00	.69	.85	.93	.97	.99	.99	1.00
0.67	10.00	.42	.56	.67	.76	.82	.87	.91
0.50	7.50	.28	.38	.46	.54	.61	.66	.72

Note. NDI = Neuromuscular Development Index. Power values were estimated using Minitab, 1-tailed 2-sample t-test. Significant level = .05; values listed as "1.00" were actually slightly less than 1.00 but were rounded to two decimal places.

them unreachable). The resulting 320 were further reduced by application of the study's definition of PT I and PT II: the birthweight by gestational age restriction reduced the number of eligible children by an additional 64, who would have been considered either SGA or LGA. The remaining 256 infants born PT saw a reduction of 68 because of multiple births. Those who remained (188) could then be divided into 128 children who were born in the PT II group and 60 children who were born in the PT I group. Four children who were born PT I did not receive any antenatal steroids, while 30 children who were born PT II did not receive any antenatal steroids. Ten children who were born PT I had received only a half course (1 time) of antenatal steroids, whereas only 19 children who were born PT II had received a half course of antenatal steroids. With only 125 potential participants left, the use of surfactants ruled out over half of the population

– 68 infants did not receive any surfactants. Two children who were born PT I and one child who was born PT II were reported as having grade III of intraventricular hemorrhage, so the groups contained only 27 each, for a total of 54 potential participants for the PT groups.

This study screened all of the infants who were born preterm to select the AGA of the population with the data available at the time of discharge from the Neonatal Intensive Care Unit. Children who were born SGA or LGA were not considered representative of the general population. Additionally, the children who were born SGA were more likely to have a disability. Another reason for the small number of participants was that this study tried to choose children who were born preterm and well treated medically; therefore, this study could represent the participants as having been treated with new medical treatments without confounding other variables which might affect lower levels of motor performances.

Dr. Karna and her office assistant needed to contact potential participants if they did not send back the contact card to the hospital. Either Dr. Karna or her office assistant called the home of the parent(s) only during daytime hours, which was when many parents were not at home. This initial contact was difficult, even though Dr. Karna and her office assistant were extremely helpful in contacting as many people as possible; but the time required of the office to obtain the ideal number of participants was unrealistic.

Also, the children born in the FT group had to wait for Dr. Karna to give a contact card to the nurse, who gave it to some parents whose child fit the criteria. The parents returned the card back to the nurse who gave it to Dr. Karna, who gave it to the investigator. This process took 2 months and yielded a small number of potential participants.

The third reason was that parents who did agree to come and have their child tested did not necessarily come for their scheduled testing session. A fourth reason was that the spring was much colder with more snow than was normal during the spring season. Even with reminder letters and telephone calls, appointments were missed far more often than predicted when this study was initially conducted. The final reason was the minimal response to the letters requesting that parents return the contact card. Many initial contact letters were returned to the hospital because some parents might have remarried, thus possibly having changed their last name, or moved from their original address without notifying the hospital. Therefore, this investigator decided to conduct a more in-depth study focused on a smaller sample size. Because of the small sample size, this investigator could not create separate age groups for the participants.

Recruiting Participants (Informed Consent)

Dr. Karna screened the potential participants from the medical records in the hospital, after the investigator had received approval from the Institutional Review Boards of Michigan State University (Appendix A) and Sparrow Hospital (Appendix B). After several approvals from both Michigan State University and Sparrow Hospital, acceptance came late because of different criteria that needed to be satisfied.

Initial contact for children who were born preterm was accomplished by sending a short letter from Dr. Karna, who introduced the investigator in the letter. Then the investigator wrote a short letter to the parent(s) explaining what the study was about and asking if the parent(s) and child were interested in participating. A contact card and self-addressed stamped envelope were included in the mailing to the 54 potential participants for the PT I and PT II groups (Appendix C).

Participants from the FT group obtained their introduction research letters and return cards by Dr. Karna via a nurse at Sparrow Hospital. The letter and return card were the same as those that the parents of the participants from the PT groups received. The nurse reviewed the participant selection criteria, selected potential participants, and gave the introduction research letters and return cards to the potential participants. When the parents of the potential participants filled out and returned the return cards to the nurse at Sparrow Hospital, the nurse gave the cards to Dr. Karna, whom gave the cards to the investigator.

If the children/parent(s) wanted to participate in this study, the parent(s) typically returned the contact cards within 2 weeks. After the investigator received a contact card from Dr. Karna, the investigator responded to the parent(s) with a contact letter, consent form, family/demographic survey, and map of the testing location. All of this material, except for the campus map, is in Appendix D. After a few days, the parent(s) were contacted via telephone for a formal interview.

If the parent(s) did not send back the contact card after three weeks, Dr. Karna called the parents of the potential participants and asked if they wanted to participate. The parents were informed that they were allowed to refuse to participate in any part of the study. If the parent(s) decided not to participate in the study, they were not contacted again. If the parent(s) agreed to participate in the study, the investigator sent a letter, survey, consent form, and map to the parent(s).

Therefore, there were other reasons for a smaller sample size in this study. The first was that the hospital had a limited number of qualifying children who were born PT, and that the investigator would have to wait much longer for an increasing number of potential participants from the children who were born FT. The second reason was the time-consuming, multi-step method used for contacting the potential participants.

Selecting Participants

A telephone interview with a parent determined whether his/her child could participate in the study. The telephone interviewer called the parent and asked whether his/her child had any disabilities and asked questions from the ABILITIES Index (Simeonsson & Bailey, 1991) (Appendix E). The interview usually lasted from 5 to 10 minutes. The range of time often depended on how much the parent(s) wanted to discuss their child's physical, mental, and social characteristics. All of the interview questions relative to disabilities, including seeing a physical and/or occupational therapist, were used in selecting potential participants.

The ABILITIES Index included the categories of development which were scored: audition/hearing (A), behavior and social skills (B), intellectual function/thinking and reasoning (I), limbs/use of hands, arms, and legs (L), communication with others and intentional communication/understanding (I), tonicity/muscle tone (T), integrity of physical health/overall health (I), eyes/vision (E), and structural status/shape, body form, and structure (S). These categories covered all of the aspects of disabilities. Some categories had subcategories, such as right and left eyes for the eyes/vision category. Each subcategory was scored on a scale of 1 to 6, where 1 represented normal functioning, 3 represented a mild disability, and 6 represented a profound disability. If the children had moderate to severe disabilities in the areas of audition/hearing (A), intellectual function/thinking and reasoning (I), communication with others and intentional communication/understanding (I), and eyes/vision (E), namely scores of 4, 5, and 6, they were excluded. Children who had scores of 6 in the areas of behavior and social skills (B), limbs/use of hands, arms, and legs (L), tonicity/muscle tone (T), integrity of physical health/overall health (I), and structural status/shape, body form, and structure (S) were also excluded.

The main purpose of using the ABILITIES Index to screen potential participants was to be able to exclude children who had moderate to severe disabilities. The moderate to severe disabilities might have acted as confounding variables in determining the motor performance levels of children. This study did not include moderate to severe disabilities in areas of audition/hearing, which may have interfered with the child's understanding of instructions for certain motor performance skills tasks. This explanation also applied to areas of eyes/vision. If the child had moderate to severe disabilities in areas of intentional communication/understanding and communication with others, or even intellectual function/thinking and reasoning, this child might have performed worse because of difficulties in understanding and/or applying the instructions of the tester.

However, children who had moderate disabilities of a body part were still allowed to understand what the tester instructed. This study did not include children who had severe disabilities of a body part because such a child may not be able to perform a motor skill, or the disability could be a confounding variable when trying to find the effects of motor skills among different birthtypes.

Informed Consent and Participant Assent

After Dr. Karna returned the contact card, the investigator sent the letter, family survey, and consent form to the parent(s). When the parent(s) and child came to the motor skills laboratory to be tested, they brought their consent form and survey with them, and then the parents had their heights and weights measured, with verbal consent. The height of one parent was measured with verbal assent, and s/he then voluntarily provided the other parent's height. If both parents came to the lab, the investigator measured both heights, with verbal consent. When the child was to be tested, the investigator asked for consent in some physical activities. When the child was to be measured for height and weight, the investigator asked if it was okay to measure her/him.

Participants Characteristics

The number of participants who were born in the PT I group was 6, the number of participants who were born in the PT II group was 6, and the number of participants who were born in the FT group was 10; therefore, the total number of participants was 22. Table 8 illustrates the number, gender, race, and age of the participants. The summary of the average ABILITIES Index categories for the three groups is in Table 9. According to the ABILITIES Index through the parent(s) interview by telephone, the average score of the categories for the children born in the PT I group were normal or somewhat normal. The average scores of most categories for the children born in the PT II group were somewhat normal, but the average scores of behavior/social skills ($\underline{M} = 4.3$) and integrity of physical health/overall health ($\underline{M} = 2.8$) were suspected of having disabilities. The

Table 8

Characteristics of Participants

		Race		Age (years)	
Groups	n (Gender)	Male	Female	M	SD
Preterm I	6 (3M, 3F)	3C	3C	5.08	1.40
Preterm II	6 (4M, 2F)	2C, 2A	1C, 1H	5.00	0.90
Fullterm	10 (5M, 5F)	1C, 4A	3C, 2A	5.44	1.08

Note. C = Caucasian (non-Hispanic); A = African-American; H = Hispanic.

Table 9

Participant Characteristics of Individuals

Participants	Gender	Study age (months)	A-audition/hearing	B-behavior/social skills	I-intellectual function/thinking and reasoning	L-limbs/use of hands, arms, and legs	I- intentional communication/understanding and communication with others	T-tonicity/muscle tone	I-integrity of physical heath/overall health	E-eyes/vision	S-structural status/shape, body form, and structure	Total ABILITIES Index
Preterm I												
I-1	M	65.8	2.0	3.0	1.0	7.0	2.0	5.0	1.0	2.0	1.0	24.0
I-2	M	43.2	2.0	2.0	1.0	6.0	2.0	2.0	1.0	2.0	1.0	19.0
I-3	M	48.0	2.0	2.0	1.0	6.0	2.0	2.0	1.0	2.0	1.0	19.0
I-4	F	48.6	2.0	2.0	1.0	6.0	2.0	2.0	1.0	2.0	1.0	19.0
I-5	F	75.8	2.0	2.0	1.0	6.0	2.0	5.0	1.0	2.0	2.0	23.0
I-6	F	84.1	2.0	2.0	1.0	6.0	2.0	2.0	1.0	2.0	1.0	19.0
Average		60.9	2.0	2.2	1.0	6.2	2.0	3.0	1.0	2.0	1.2	20.5
Preterm II												
II-1	F	63.1	2.0	6.0	1.0	8.0	2.0	2.0	4.0	2.0	4.0	31.0
II-2	M	77.9	2.0	2.0	1.0	6.0	2.0	2.0	1.0	2.0	1.0	19.0
II-3	M	49.5	4.0	5.0	2.0	6.0	4.0	4.0	4.0	2.0	1.0	32.0
II-4	F	64.6	6.0	7.0	2.0	10.0	5.0	7.0	1.0	2.0	2.0	42.0
II-5	M	50.0	2.0	2.0	1.0	6.0	2.0	2.0	4.0	2.0	1.0	22.0
II-6	M	55.0	2.0	4.0	1.0	6.0	2.0	3.0	3.0	2.0	1.0	24.0
Average		60.0	3.0	4.3	1.3	7.0	2.8	3.3	2.8	2.0	1.7	28.3
Fullterm												
III-1	F	51.7	2.0	2.0	1.0	6.0	2.0	2.0	1.0	2.0	1.0	19.0
III-2	F	64.6	2.0	2.0	1.0	6.0	2.0	2.0	1.0	2.0	1.0	19.0
III-3	F	51.5	2.0	2.0	1.0	6.0	2.0	2.0	1.0	2.0	1.0	19.0
III-4	M	48.0	2.0	2.0	1.0	6.0	2.0	2.0	1.0	2.0	1.0	19.0
III-5	M	65.6	2.0	2.0	1.0	6.0	2.0	2.0	1.0	2.0	1.0	19.0
III-6	M	65.2	2.0	2.0	1.0	6.0	2.0	2.0	1.0	2.0	1.0	19.0
III-7	F	75.3	2.0	2.0	1.0	6.0	2.0	2.0	1.0	2.0	1.0	19.0
III-8	M	84.8	2.0	2.0	1.0	6.0	2.0	2.0	1.0	2.0	1.0	19.0
III-9	F	84.1	2.0	2.0	1.0	6.0	2.0	2.0	1.0	2.0	1.0	19.0
III-10	M	62.2	2.0	2.0	1.0	6.0	2.0	2.0	1.0	2.0	1.0	19.0
Average		65.3	2.0	2.0	1.0	6.0	2.0	2.0	1.0	2.0	1.0	19.0

Note. The categories of development scored included: A - audition/hearing (2x); B - social skills and behavior (2x); I - intellectual function/thinking and reasoning (1x); L - limbs/use of hands, arms, and legs (6x); I - intentional communication/understanding and communicating with others (2x); T - tonicity/muscle tone (2x); I - integrity of physical health/overall health (1x); E - eyes/vision (2x); S - structural status/shape, body form, and structure (1x). Certain categories are further subdivided into subcategories, thus yielding numbers other than 1 for their lowest possible values. Each subcategory is based on a six point scale where 1 = normal, 2 = suspected disability, 3 = mild disability, 4 = moderate disability, 5 = severe disability, and 6 = profound (or total) disability. In order to arrive at the lowest possible value for a category, use the multiplier mentioned at the end of each category name in this Note.

average scores of all of the categories for the children born in the FT group were normal.

From the telephone interview, the following information provided some details of the history of the participants regarding ailments (Table 10). A 5 ½-year-old boy who was born in the PT I group (I-1) had an Individualized Family Service Plan because he had mild cerebral palsy that affected his legs. He went to see a physical therapist once a week because of tension in his legs (the hamstrings in particular), and had an intervention program during much of his life because of mild cerebral palsy. When he was an infant, he suffered from retinopathy of prematurity (ROP), but underwent laser surgery to correct the condition. ROP is an abnormal growth of the blood vessels around the eyeballs during the first 2 months after a premature birth; typically this condition goes away on its own, otherwise surgery may be required to prevent blindness (Bernhaum & Batshaw, 1997).

A 3 ½-year-old boy who was born in the PT I group (I-2) attended a local county intermediate school, but his father reported that the boy did not show any developmental delay problems, except that he was very stubborn. A 4-year-old boy who was born in the PT I group (I-3) had seen a physical therapist for his legs (in particular his extremities), but stopped less than 2 years before. A 4-year-old girl who was born in the PT I group (I-4), up to 2-3 years of age, suffered from ROP, attended a special education service for her prematurity, but stopped about 2 years prior to the study and attended an intervention program for children who were born preterm at a hospital center in the past year. A 6 ½-year-old girl who was born in the PT I group (I-5), was on oxygen support for the first year of her life, and had experienced tension in the cords behind her knees and in her pubic area but never went to see a physical therapist.

Table 10

Developmental Concerns/Therapy of Each Child

Birthtype	Study age (mo.)	Developmental concerns/therapy, etc.
Preterm I		
I-1	65.8	Individualized Family Service Plan because he had mild cerebral palsy that affected his legs Saw a physical therapist once a week because of tension in his legs (the hamstrings in particular), and had an intervention program during much of his life. When he was an infant, he suffered from retinopathy of prematurity (ROP), but underwent laser surgery to correct the condition.
I-2	43.2	Attended a local county intermediate school, and he was very stubborn; his father assumed he did not have any developmental problems.
I-3	48.0	Had seen a physical therapist for his legs (in particular his extremities), but stopped less than 2 years ago
I-4	48.6	Up to 2-3 years of age, she suffered from ROP. Attended a special education service for her prematurity, but stopped about 2 years prior to the study and attended an intervention program for children who were born preterm at a hospital center in the past year.
I-5	75.8	Was on oxygen support for the first year of life. Experienced tension in the cords behind her knees and in her pubic area but never went to see a physical therapist
I-6	84.1	Normal
Preterm II		
II-1	63.1	Physical and occupational therapies because of delays in gross motor skills and not wanting to eat, respectively, but stopped 2 years ago.
II-2	77.9	Caught up to normality by one year after birth, using the Developmental clinic.
II-3	49.5	A special education service at a local pre-primary school during 2000. Did go to see a physical therapist for his legs when he was little and his upper body when he was older, but his visits ended 2 or fewer years ago. Attended an intervention program for speech therapy at age 3, which lasted for less than 1 year.

II-4	64.6	Attended a local pre-primary school at the time of testing and had been there for 4 months. Had been in a speech therapy program at a hospital for a few months. Had seen a physical therapist more than 2 years ago to correct a condition of bowed legs.
II-5	50.0	Saw a physical therapist but stopped 2 or more years ago.
II-6	55.0	Normal
Fullterm		
III-1	51.7	Normal, shy in the strange lab environment
III-2	64.6	Normal
III-3	51.5	Normal
III-4	48.0	Normal
III-5	65.6	Had allergies.
III-6	65.2	Normal
III-7	75.3	Normal
III-8	84.8	Normal
III-9	84.1	Normal
III-10	62.2	Normal

A 5 ½-year-old girl born in the PT II group (II-1) formally went to physical and occupational therapies because of delays in gross motor skills and not wanting to eat, respectively, but stopped 2 years ago. A 4-year-old boy born in the PT II group (II-3) attended a special education service at a local pre-primary school during 2000. He did go to see a physical therapist for his legs when he was little and his upper body when older, but his visits ended 2 or fewer years prior to testing. He also attended an intervention program for speech therapy at age 3, which lasted for less than 1 year. A 5 ½-year-old girl born in the PT II group (II-4) attended a local pre-primary school at the time of testing and had been there for 4 months. She was also in a speech therapy program in a hospital and had been there for a few months. She had seen a physical therapist more than 2 years prior to the testing to correct a condition of bowed legs. A 4-year-old boy born in the PT II group (II-5) had seen a physical therapist but stopped 2 or more years prior to the testing.

A 7-year-old girl who was born in the PT I group, a 4 ½-year-old boy who was born in the PT II group, a 6 ½-year-old boy who was born in the PT II group, and all of the children who were born in the FT group did not have an Individualized Family Service Plan or Individualized Education Plan. In addition, they did not participate in an intervention program nor saw a physical therapist because of body tension.

Instrumentation

Quantitative data were collected when the child and parent(s) visited the laboratory and the child was tested using the MAND and MPS testing instruments.

Family/Demographic Survey

The family/demographic survey pertained to home family background and SES. Survey numbers 1, 2, 3, 4, and 7 came from the unpublished Family Information Questionnaire by Brophy-Herb, Lee, and Stollak (1999). Item number 1 asked who filled out the survey, item number 2 asked how many siblings the child had, item numbers 3 & 4 asked how much education the mother and father each had, and item number 7 asked for the family income.

Survey item numbers 5 & 6, which asked about the occupations of the mother and father, were modified from the Family Information Questionnaire by Brophy-Herb et al. The investigator developed the items concerning the involvement of the child in nursery school and preschool, and the request to assess the motor skills levels of the child and measure her/his physical growth (item numbers 8 to 10). The survey is in Appendix D.

A simple survey of family/demographic information was administered to gather descriptive data. The survey, investigator's letter, and consent form were sent to the parent(s) after the investigator received a return card stating willingness to participate in this study. After the parent(s) were interviewed by telephone, knew that his/her child satisfied the participant's criteria, filled out the survey and brought it with them to the testing, then the child and parent(s) came to the laboratory for testing of the motor skills. Two separate parents did not bring their surveys, so they filled out additional surveys when they were in the video room prior to watching their child's motor skills testing.

McCarron Assessment of Neuromuscular Development (MAND)

The MAND is designed as a standardized assessment of motor abilities (McCarron, 1997). The MAND has ten motor skills, namely hand strength, finger-nose-finger, jumping, heel-toe walking, standing on one foot, beads in box, beads on rod, finger tapping, nut and bolt, and rod slide. The descriptions of each motor skill are found in Appendix F. The developmental norms for ages 3.5 through 12 years are presented at 6-month intervals. Appropriate age-related tables of norms are used to convert the raw scores to scaled scores for each motor skill. The range of scaled scores of each motor skill is between 1 and 20 points. The entire MAND test takes approximately 15 to 30 minutes for each child to complete.

The sum of two specific motor skills represents certain factor scores, which describe the level of functioning among important groups of motor behaviors. Eight of the ten MAND motor skills items are statistically grouped into four factor scores (based on an orthogonal factor analysis of data from a non-disabled population): (a) persistent control - rod slide and finger-nose-finger items; (b) muscle power - hand strength and jumping items; (c) kinesthetic integration - heel-toe walk and standing on one foot items; and (d) bimanual dexterity - beads on rod and nut and bolt items. The two motor skills items that make up each factor are related to each other by common behavioral, anatomical, and/or neurophysiological considerations. The sum of the two scaled scores of the motor skills items is converted to the factor score using the table "Conversion of Summed Scaled Scores to Factor Scores Children < 11 Years of Age" (Appendix F). The converted factor scores are based on a distribution with a mean of 100 points and a standard deviation of 15 points. The range of the factor scores in the manual is 30 to 155 points. An individual's factor scores can be directly compared to each other and/or to the NDI to determine relative strengths and/or deficits in specific neuromuscular skills.

The total scaled score of fine motor skills was derived from the sum of the scaled scores of five motor skills such as the beads in box, beads on rod, finger tapping, nut and bolt, and rod slide items. The total scaled score of gross motor skills was derived from the sum of the scaled scores of five motor skills such as the hand strength, finger-nose-finger, jumping, heel-toe walk, and stand on one foot items.

The sum of scaled scores from the ten motor skills of the MAND determines the NDI, which can be interpreted as a general measure of motor skills ability. The sum of the ten scaled scores is converted to the NDI by using the table "Conversion of Summed Scaled Scores to the Neuromuscular Development Index (NDI) for Children < 11 Years of Age" (Appendix F). The NDI can be considered a "motor quotient" and is comparable to similar quotients measuring other factors (e.g., IQ). The highest possible score for the NDI is 190 points, with a score greater than 145 points being exceptional (i.e., 3 standard deviations above the average). The NDI is based on a distribution with a mean of 100 points and a standard deviation of 15 points.

The MAND was standardized with 2000 individuals between 3.5 and 18 years of age. Data were collected from children in seven states and the ratio of males to females was 1:1. The ethnic background of the standardization sample consisted of white (78%), black (10%), and Mexican-American (12%). In addition, the socio-economic classes were divided as lower class (35%), middle class (45%), and upper-middle class (20%) (McCarron, 1997). The MAND manual reported high test-retest reliability with a coefficient of .99 for the complete battery. Content validity was established through comparison of the MAND test items to psychomotor skills that psychologists use. Construct validity was established through use of factor analysis, establishing that key categories of psychomotor skills were being covered by the MAND test. McCarron (1997) suggested that MAND scores be an acceptable criterion of psychomotor skills as established by concurrent validity, which involves a measuring instrument being correlated with some criterion that is administered at about the same time. These established psychometrics of validity and reliability indicate that MAND is a reliable and valuable instrument capable of measuring motor skills levels, whether they are general, gross, fine, or individual motor skills.

This instrument can be used as one component of an early childhood assessment battery to provide useful information in prescribing specific intervention techniques (McCarron & Dial, 1975b). When McCarron and Dial contacted school teachers to identify children for potential learning disabilities, not only were the means of the MAND scores low, but also other instruments used for other areas such as verbal-cognitive from the Peabody Individual Achievement Test (L. Dunn, 1974), and sensory from the Haptic Visual Discrimination Test (McCarron & Dial, 1975a) and the Bender Visual Motor Gestalt Test (Bender, 1938). The MAND was used not only for children born within the normal range of gestation, Apgar scores, height, and weight, but also for hyperactive children (McCarron, 1997), and children who had learning and/or mental disabilities (McCarron & Dial, 1975b). The retest reliability of the Total MAND was .99, where the Gross Motor Skills section was .96 and the Fine Motor Skills section was .98. This set of retest reliabilities came from testing 31 mentally disabled adults over a 1-month interval. The children born in the PT groups, which many researchers insisted can catch up by 2 years of age (Matilainen, 1987; Ouden et al., 1991), can use this instrument as well as the children born in the FT group. A limitation of this instrument was that it did not have reliability and validity for children who were born preterm, but the MAND has been tested using individuals with diverse disabilities including adults with mental disabilities and children with hyperactivity (McCarron, 1997). Therefore, this investigator assumed that it was acceptable to use children born in both the PT and FT groups.

Motor Performance Study (MPS)

One of the two instruments of motor skills in this study came from the Motor Performance Study (MPS) of Michigan State University, which was used to assess qualitative performance on each of ten motor skills. The motor skills included the long jump (Seefeldt, 1972), running (Seefeldt, Reuschlein, & Vogel, 1972), hopping (Seefeldt & Haubenstricker, 1976b), galloping (Sapp, 1980), skipping (Haubenstricker & Seefeldt, 1976), throwing (Seefeldt & Haubenstricker, 1976b), catching (Seefeldt, 1972), kicking (Seefeldt & Haubenstricker, 1974), punting (Seefeldt & Haubenstricker, 1975), and striking (Seefeldt & Haubenstricker, 1976a) items. The long jumping, running, hopping, galloping, and skipping items were treated as locomotor skills. Object control skills included the throwing, catching, kicking, punting, and striking items. The total score of locomotor skills in this research used the sum of the raw scores of the long jumping, running, hopping, galloping, and skipping items. The total score of object control skills in this research used the sum of the raw scores of the throwing, catching, kicking, punting, and striking items. The total score of MPS used the sum of the raw scores of the ten motor skills.

Each motor skill score was attained in an analysis based on the configuration of the total body during the performance of a motor skill. This assessment technique had evolved from the identification of a developmental sequence within selected skills. Each sequence consisted of three to five stages of observable behaviors, with a higher number being a more mature form of the particular motor skill behavior. The score of each of the ten motor skills was taken from observing the children performing the skills, who were then classified according to their level of development. For instance, stage 1 of running, which is the most immature running form, is characterized by arms in the "high-guard" position, flat-footed contact, and a short and shoulder-width stride. On the other hand, stage 4 of running, which is the most mature running form, is characterized by heel-toe contact (toe-heel when sprinting), arm-leg opposition, high heel recovery, and elbow flexion. Detailed descriptions of each motor skill from the MPS are in Appendix G.

During childhood, throwing and catching reached a mature level at stage 5; kicking, punting, striking, long jumping, running, and hopping reached a mature level at stage 4; and galloping and skipping reached a mature level at stage 3. Therefore, during each participant's motor performance in the study the investigator categorized his/her performances from stages 1 to 3, 4, or 5. If a participant showed a performance greater than stage 1 but less than stage 2, which is a transition stage, the scorer added "+" to the lower stage number (for example, if the child showed a level of maturity above stage 2 but below stage 3, then the child's level was denoted "stage 2 +").

Stages of motor skills were converted to strict numerical scores in order to perform data analysis (Appendix G). If the child received a stage 5 for running, the score recorded was 5. If the child received a stage 3 + for catching, then the score recorded was 3.5. If the child was asked to perform a certain skill at the tester's directions and performed another, then the score of this skill was given as a "0". For instance, a child who was asked to gallop but instead hopped received a score of "0" for galloping. If the child did not want to perform a particular task, then the score was denoted as refused/not wanted to perform. The child performed two times; the better score was chosen because the investigator desired the most mature performance of which the subject was capable.

The tester had randomized the order of gross and fine motor skills for each child and the tester followed this order. The testers demonstrated each task and the child performed twice. All of the motor skills of the MPS were administered following the specific directions of the Test of Gross Motor Development (TGMD) Manual (Ulrich, 2000). The MPS did not have clear instructions on how to administer each motor skill, and because TGMD test items were almost the same as well as analyzed the qualitative aspect of the motor skills, the investigator thought it was best to follow the directions of the TGMD manual. In the TGMD manual, the instruction for throwing includes "Throw the ball as hard as you can," therefore, the scorer can grade the throwing performance of the child that is most likely the best. Because the TGMD manual did not include punting, the tester demonstrated and said, "Hold the ball and kick it."

The motor skills from the MPS did not have established reliability as well as validity. However, Fountain et al. (1981) collected data for 3 years from a mixed longitudinal sample with running speed measured during a 30-yard dash as well as assessed using the stages of running (Seefeldt et al., 1972). Total running times for 153 boys and 106 girls were correlated with developmental stages and yielded correlation coefficients of .44 and .54 for the boys and girls, respectively. Preliminary validations of developmental sequences for long jump (Haubenstricker, Seefeldt, & Branta, 1983b), kicking (Haubenstricker, Seefeldt, Fountain, & Sapp, 1981), throwing, and catching (Haubenstricker, Branta, & Seefeldt, 1983) reported that as stage numbers rose, which showed the maturity of performance, the chronological age rose as well. Each motor skill represented well a child's physical activities in daily life as well as in school.

Haubenstricker (1983a) reported on the ages at which 60% of the boys and girls could perform at specific developmental levels of motor skills (Figure 3). Data obtained from the laboratory programs of the MPS, Remedial Motor Clinic, and Early Childhood Motor Development Program of Michigan State University supported early development of and great variance in the motor behaviors of children. These data provided reference information for understanding when a child was more likely to perform specific motor skills at particular levels of development.

The MPS did not report validity or reliability, especially concerning children who were born preterm. The MPS tested children from the normal population as well as from the Remedial Clinic at MSU. Thus, the MPS was able to detect all levels of motor skills, from immature to fully mature. The current study included children of various motor skills levels. Therefore, this investigator assumed that the MPS was able to evaluate the

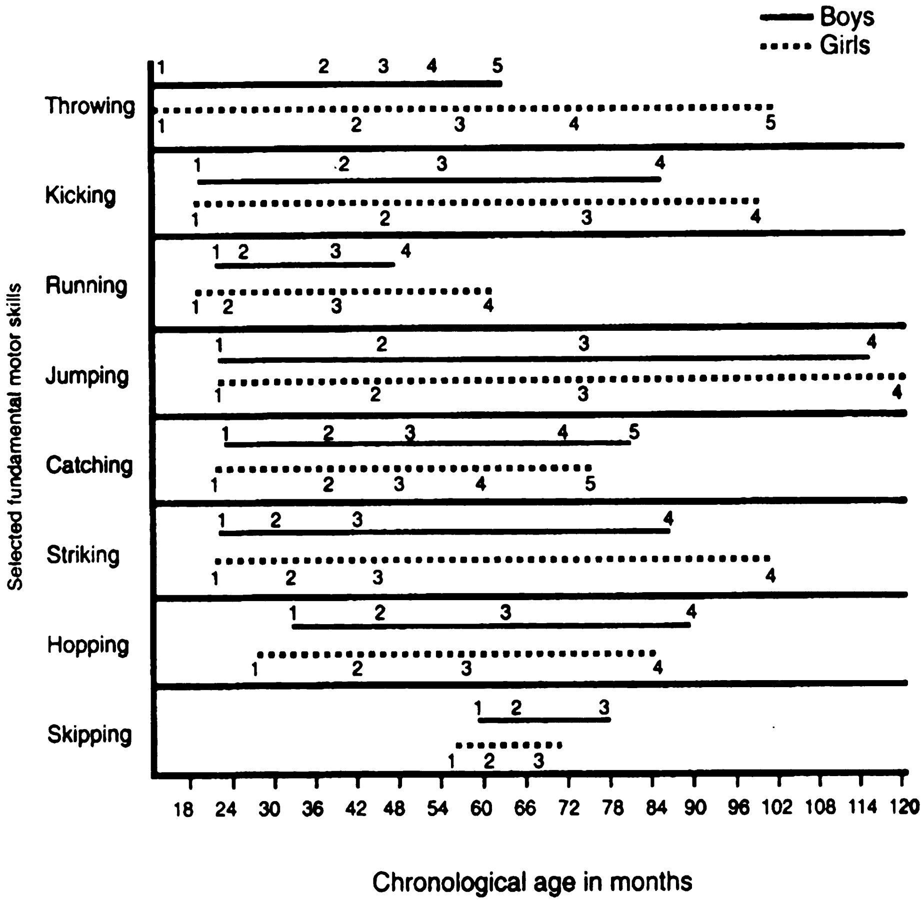


Figure 3. Ages at which 60% of children were able to perform at specific levels of development for selected motor skills. From "Patterns, Phases, or Stages: An Analytical Model for the Study of Developmental Movement," by V. Seefeldt and J. Haubenstricker, 1982, *The Development of Movement Control and Coordination*, p. 314. Copyright 1982 by Wiley, New York. Reprinted with permission of the author.

motor skills capabilities of the participants in this study.

Height and Weight

The height and weight of the child, as well as the height of at least one parent, were measured when the child and parent(s) came to the laboratory for testing motor skills. Both measurements of height and weight were measured with socks on but no coats. The measurement of height was measured with feet together, heels against a wall, head in the Frankfort plane ("look straight ahead"), and standing erect ("stand up tall" or "stand up real straight" with some assistance and a demonstration when necessary).

Identifying Soft Neurological Signs

Neurological soft signs in this study were defined using ten differentiating characteristics from Haubenstricker (1982). He reported that these characteristics are not necessarily mutually exclusive and a child may exhibit one or more of these but not necessarily all of them. He also did not report reliability or validity.

The motor skills of each child were observed through videotape and occurrences of neurological soft signs were identified. Each soft sign was counted when the child performed it during a motor skills task, with no more than one of each neurological soft sign per task, although several different neurological soft signs per task were possible. It was more important to distinguish which signs were abnormally present than to keep an absolute count of every neurological soft sign, and with younger individuals, having an abnormally high number of neurological soft signs may be normal for the child's age (Rutter & Yule, 1970). The investigator also summarized what types of neurological soft signs were common with each group. The following list includes ten neurological soft signs and how they were defined from observations of the motor skills performances:

1. Inconsistency in performance, in which the child performs at various levels of development among consecutive trials in a specific motor skills task.

2. Perseveration, which involves the continuance of a task or behavior after having been told to stop and/or after the end has been reached. For instance, a child bouncing a ball continues bouncing even though the tester has requested the child to stop; or taking a series of jumps when only one has been requested.

3. Mirroring, when the child is unable to separate her/his directional movements from those of a leader, such as a tester.

4. Asymmetry of body parts in activities that normally require bilateral use of the limbs. For instance, one of the body limbs moves very little when compared to the other limb in a similar action, such as running or skipping.

5. Loss of dynamic balance, where the inability to maintain postural control over the body is in relation to gravity. An example would be during heel-toe walking when the child falls down while still moving in the forward/backward direction.

6. Falling after performance, which occurs during gross motor skills such as hopping, jumping, throwing, and striking and happens as its name implies.

7. Extraneous movements, which incorporate movements that disrupt the execution of the motor skill, appearing uncoordinated. The inclusion of unnecessary movements disrupts both the temporal and serial organization of a motor skill so as to appear rough and/or inefficient.

8. Inability to maintain a rhythmical pattern, which is considered a disruption of a pattern and/or being out-of-sync with the leader's pattern. For instance, the child tries to

perform a series of hops, and may only be able to perform three or four hops before the pattern of movement is disrupted.

9. Inability to control force, during a motor skills performance when the child produces an inappropriate amount of force. The extremes are too much force on a skill requiring control, such as dribbling a ball, or too little force on a skill that requires power, like in jumping.

10. Inappropriate motor planning, where the misapplication of force and/or responses is delayed or premature and/or inappropriate responses to complex sequences of stimuli. Such a neurological soft sign may be noticed when the child attempts to punt.

Data Collection Procedure

Research Team

Student investigator. The responsibilities of the student investigator included being in charge of data collection such as training testers in both the MAND and MPS test instruments, measuring the heights and weights of the children and parents, training the interviewer, and setting up the optimal places for data collection as well as scoring motor skills and transcribing raw data through observations of the videotapes. A-Ran Chong, who was the student investigator, whose major was Kinesiology in a doctoral degree program in the College of Education at Michigan State University, had experience in assessing several instruments of motor performance and was trained to score the motor skills for the MPS and MAND instruments after reading the manuals of the instruments. Dr. Vern Seefeldt, who was a faculty mentor, provided training and qualification in the use of both the MAND and MPS instruments (asking questions and watching several pilot study videotapes), and in measuring height and weight. The faculty mentor came to the testing place, and verified the investigator's ability and competence to measure height and weight after observing the investigator obtaining both types of measurements.

An inter-rater reliability between the investigator and the faculty mentor and an intra-rater reliability between the first and second time scores from the investigator for the MAND and MPS instruments were achieved prior to the commencement of scoring the children in the study. The investigator obtained inter-rater and intra-rater reliabilities using three videotaped children, and the investigator was considered qualified with inter-rater and intra-rater reliabilities over .80.

<u>Intra-rater and inter-rater reliabilities.</u> In order to confirm the reliability of scores obtained by this investigator, intra-rater and inter-rater reliabilities were obtained from one participant of each of the three birthtypes of this study, before scoring all of the children. For obtaining intra-rater reliability, the investigator scored the performances by watching a random selection of one child from each group on videotape (Time 1). The investigator then re-scored these three children again 1 week later (Time 2).

The faculty mentor then asked specific questions about the MPS motor skills to the investigator. The specific items of the MAND were very specific in grading, such as exactly identifying the performance of the child, with specific description grades for each motor skill. The faculty mentor reviewed specific questions relative to the MAND motor skills items with the investigator and was satisfied with the responses.

For obtaining inter-rater reliability, the professor watched the same three children's motor skills for the MAND and MPS on videotape and scored them. Next, the investigator's Time 1 and Time 2 total sums of scaled scores for each motor skill and the professor's total sums of scaled scores for each motor skill from MAND (for a single child as well as the sum of the three children) were compared. Inter-rater and intra-rater reliabilities for MAND used scaled scores because scaled scores have the same variance.

Likewise, the investigator's Time 1 and Time 2 sums of raw scores and the faculty mentor's sums of raw scores for each motor skill of MPS (for an individual child as well as the sum of the three children) were compared. However, MPS was not standardized; therefore, raw scores were used in the calculations.

The inter-rater and intra-rater correlation coefficients were over .900 (see Table 11). The ranges of inter-rater and intra-rater reliability coefficients for MAND were .956 and .996. The ranges of inter-rater and intra-rater reliability coefficients for MPS were .971 and 1.000. These coefficients indicated that the investigator was reliable in scoring the motor skills performed in the MAND and MPS test instruments. The correlations among the motor skills scores from the investigator's Time 1/Time 2 and the professor/investigator at Time 1 and Time 2 determined which scores were used in the data analysis of this study, based on the highest reliability coefficients.

Faculty mentors. There were four faculty mentors that provided their expertise and experience to this study. Dr. Crystal Branta was responsible for advising the investigator in data collection situations, such as finding good testers or a familiar environment for the laboratory, and discussing behaviors of some participants through watching the videotapes; she also trained the investigator in how to diagnose neurological soft signs through observing the videotape by Dr. Vern Seefeldt (1974) as well as through the article by Dr. John Haubenstricker (1982). Dr. Crystal Branta was qualified because she had many experiences testing and scoring motor skills, and taught in the Kinesiology department.

Table 11

Reliability Coefficients

	Investigator Time 1/ Time 2	Investigator Time 1/ Professor	Investigator Time 2/ Professor
Child 1 MAND	0.996	0.993	0.991
Child 2 MAND	0.996	0.984	0.987
Child 3 MAND	0.956	0.960	0.975
Sum of three children MAND	0.980	0.968	0.969
Child 1 MPS	1.000	0.990	0.990
Child 2 MPS	0.976	1.000	0.976
Child 3 MPS	0.936	0.937	0.960
Sum of three children MPS	0.972	0.971	0.976

Dr. Vern Seefeldt, one faculty mentor, was responsible for determining whether the student investigator was qualified for administration and data collection as well as whether the testers were of sufficient proficiency to test the children. His qualifications included being in the area of motor behavior and being an experienced tester of motor skills for many years. He developed some motor skills for and was highly experienced in the use of the MPS instrument and other motor skills instruments. He reviewed the manual of how to administer and score the MAND instrument. He was an expert in the measurement of physical growth and was retired from the Kinesiology department. Dr. Padmani Karna, another faculty mentor, shared literature concerning children who were born preterm and decided on the participants' criteria and initial contact for potential participants. The qualifications of this faculty mentor included being a neonatologist in Sparrow Hospital for a long time.

Dr. Gail Dummer, who was the fourth faculty mentor, was responsible for specific data collection process organization and giving suggestions for choosing children who had mild disabilities before data collection began. This faculty mentor was qualified because she had many experiences in testing and teaching motor skills of children with and without disabilities and taught in the Kinesiology department.

<u>Testers.</u> The two testers were responsible for administering the MAND and MPS instruments to each child. The qualifications of the testers included being Kinesiology majors with prior experience in leading children in physical activities for at least one year and experience in administering motor performance tests. The testers were trained by reading the MAND manual (McCarron, 1997), and using the same administration for the MPS as was used in the Test of Gross Motor Development manual (Ulrich, 2000),

because there were no specific administration directions for the MPS, and most of the TGMD measurements were the same as those in the MPS. After the investigator gave the manuals to the testers, she later explained how to use the instruments and the performance locations of each motor skills task, because the performances had to be recorded on videotape. Each of the testers were provided with 3 hours of training on the MAND and MPS instruments until the student investigator, as well as the faculty mentor, were satisfied at how the tester administered the test. An adequate level of proficiency was reached when the faculty mentor agreed with the tester's administration of the tests.

Interviewer. The responsibilities of the interviewer included speaking with a parent on the telephone and administering the ABILITIES Index and interview questions to determine the eligibility of a potential participant. The qualifications for the interviewer included being able to speak clear and fluent English and an ability to listen well to other people. The student investigator suggested the introduction and ending to the conversations with the parent, including thanking the parent for her/his time. The investigator trained the interviewer in the use of the ABILITIES Index as well as how to record the answers given by the parent for the interview questions. The interviewer trained for 1.5 hours and had reached what was considered an acceptable level of proficiency when the investigator felt satisfied with the interviewer's progress.

Videographer. The videographer was responsible for setting up, operating, and disassembling all equipment designed for the recording of the motor skills testing. The qualifications of the videographer included familiarity and proficiency with the parts of the recording system as well as its operation. Training of the videographer came from an experienced person in the field of media devices, and training lasted 3 hours. The acceptable level of proficiency for the videographer was acquired via expert testing.

Test Administration

Pilot Study

A pilot study was conducted in order to determine the optimal facilities, equipment, position of video camera, and test administration. Detailed descriptions about how this pilot study was accomplished as well as the final decisions concerning how the testing of the children was to be completed are included in Appendix H.

Test Administration

Facilities and layout. The dimensions of the laboratory were approximately 22 feet x 54 feet. The video camera was placed approximately 18 feet from the left (or camera room) side wall. The dimensions of the camera room were approximately 5 feet x 22 feet. The map of the laboratory and camera room is in Figure 4.

Location of testing stations. Locations for the fine motor skills tasks from the MAND took place at the table and chairs. The distance from the participant to the video camera was 6 feet on average. The gross motor skills tasks from the MAND occurred either at the table, at the "0" mark on the floor ruler, or along the blue line that ran parallel to the floor ruler. The distance from the "0" mark to the video camera was 14 feet on average, while the distance from the camera to the blue line averaged 18 feet.

The MPS task locations varied by the task as well as by the sub-group, locomotor skills, or object control skills. Among the object control skills, striking, kicking, punting, and throwing took place at or near the "0" mark on the floor ruler. Participants who performed a task using the right side of their body moved toward the right side of the

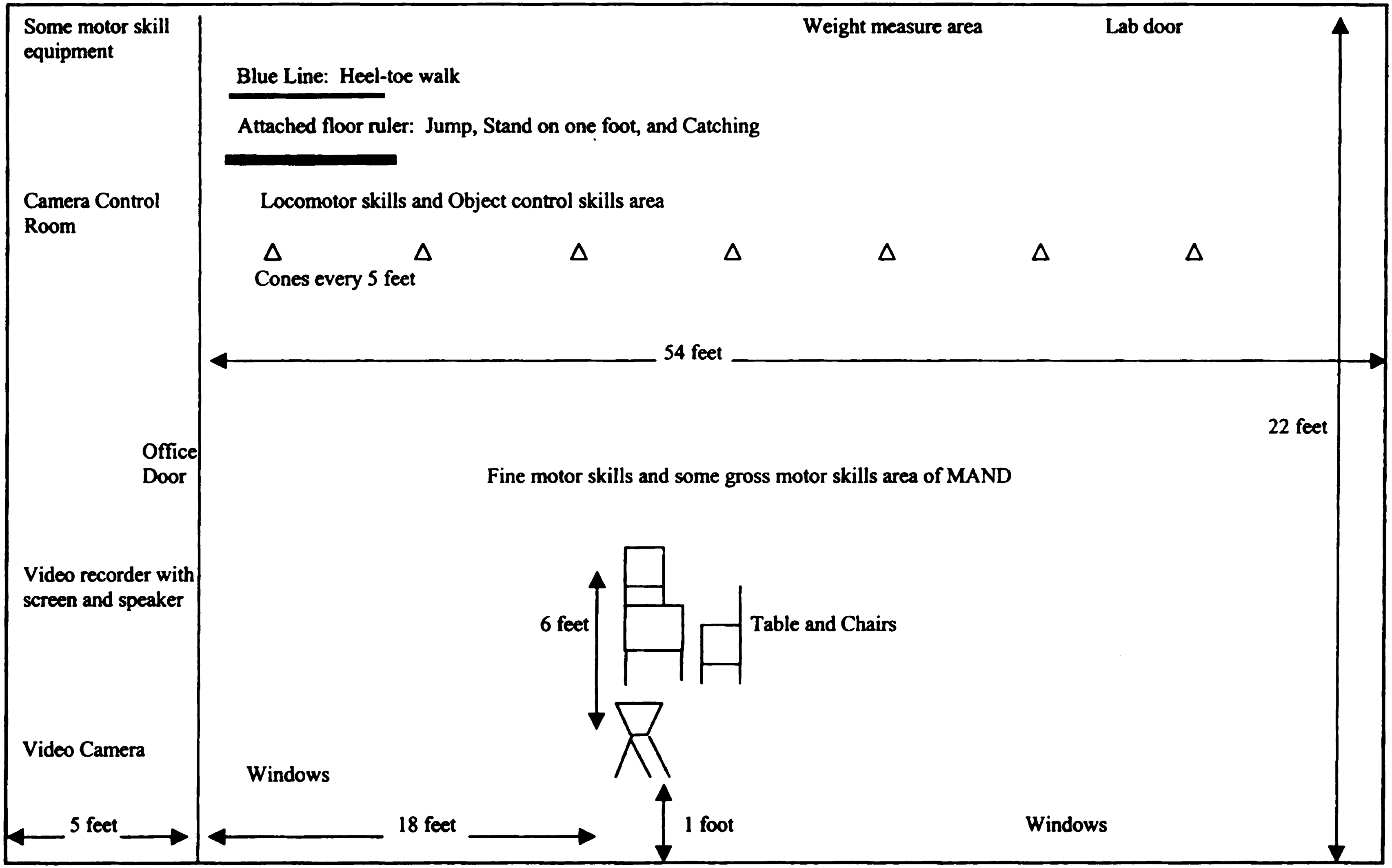


Figure 4. Motor skill testing area. If the child was right-handed, the child would kick, strike, and throw to the right side (toward the lab door side); if the child was left-handed, the child would kick, strike, and throw to the other side.

laboratory, while participants who performed a task using the left side of their body moved toward the left side of the laboratory. Catching also was performed at the "0" mark but there were no differentiations between the right and left sides. While the child stood more or less in front of the video camera, the tester stood just 6 feet from the video camera (and off to the side) to toss the ball to the child. The locomotor skills of running, galloping, and skipping were performed from one side of the laboratory to the other and back again. The distance from the video camera to the farthest point was 31 feet. The long jump occurred next to the floor ruler, while hopping on either foot was assessed on the left side of the laboratory, hopping back and forth.

Order of tests. A random number generator in an Excel spreadsheet calculated the order of the tests for any particular participant. The random number generator randomized the tasks according to each of three levels. The first level was whether the MAND instrument or the MPS instrument was used first. The second level considered which sub-group of tasks for a particular instrument was used first (object control skills vs. locomotor skills for the MPS, or fine motor skills vs. gross motor skills for the MAND). The third level randomized the individual tasks within their groups.

Videography procedures. The video camera used to record the motor performance testing was a Sony EVI-D30. The video camera was positioned against the wall with the windows, 18 feet from the left side of the laboratory, while the height of the lens was set to approximately 3 feet from the floor. The video camera was vertically angled near 0° from parallel with the floor for nearly all tasks. Any deviation from this angle was minor and not consistently applied. The video camera's horizontal angle remained steady during the MAND tasks, the tester and/or investigator moving the table and chairs out of the way when necessary (such as for standing on one foot).

During the object control skills tasks, the video camera generally remained fixed on the place that the participant occupied. During the locomotor skills the videographer moved the video camera as the participant moved, attempting to keep the participant in the center of the viewing field. The MAND tasks tended to be closer to the video camera, while the MPS tasks tended to be farther away. The videotape used for recording was Sony's DVM60PR2, a type of mini digital videocassette. The videocassette recorder was a Sony GV-D900. When the investigator later scored the performance, she used a digital videocassette recorder, a Sony DSR-30, because it had frame-by-frame, slow, and double speed features, which made the investigator's scoring easier when counting finger taps or observing other motor skills movements. The investigator also used a 39" screen monitor for watching, a Samsung Dyna Flat ED.

Data Collection

Prior to a Testing Session

Once the parent(s) returned the card to Dr. Karna, she gave the card, including a mailing address and a good time to call, to the investigator (Table 12). The investigator mailed a short letter with the family survey and consent form to the parent(s). At least 1 week after having mailed out the survey and consent form, the interviewer called the parent(s). The interviewer asked questions regarding the child's experiences with any disability services or therapies, referring to the interview sheet and the ABILITIES Index, lasting about 5 to 10 minutes on average. The main purpose of the interviewer was to establish eligibility status of the potential participants. If a child was deemed eligible for

Table 12

Chronological Order of Typical Testing Session

Activity	Approximate duration	Responsible research team member(s)
Prior to a Testing Session		
Send by mail		Investigator
a) Family/demographic information survey	5 – 10 min	
b) Consent form		
Formal interview by phone	5 – 10 min	Interviewer
a) Interview		
b) ABILITIES Index		
During the Testing Session		
a) Greeting	1 – 2 min	Investigator
b) Informed consent	1 – 2 min	Investigator
c) Motor performance tests		
MAND	25 – 35 min	Tester
MPS (or vice versa)	25 – 35 min	Tester
d) Height and weight	1 – 2 min	Investigator
e) Thanks, debriefing, and gifts	1 – 5 min	Investigator/Tester
Post-observation of the Videotape		
a) MAND and MPS scoring	1-2 hours	Investigator

b) Identify a child's neurological soft signs during the motor skills performances	1-2 hours per child	Investigator

the study, then the interviewer and parent(s) set up a date and time for testing.

During a Testing Session

Greeting. When the parent(s) and child arrived at the laboratory, the investigator greeted them and showed them the laboratory. The investigator also introduced the tester for that particular session and the videographer. The investigator then collected the survey and consent form, if completed, and showed the child and parent(s) to their respective positions. The child went with the tester while the parent(s) went with the videographer into the camera room.

Informed consent. Most of the parents brought the signed consent forms along with the surveys, and gave them to the investigator when they came to the laboratory. Two parent(s) did not bring the family/demographic survey and/or consent form, so the investigator gave a copy of the missing papers to be completed before testing motor skills. Before testing the motor skills, the child was asked if it was okay to play physical activities as well as video taped with verbal consent.

Motor performance tests. The child and tester commenced the testing session, typically taking only one break time for juice between the MAND and MPS testing sessions. The order of the tests were randomized on three levels: MAND vs. MPS; fine vs. gross motor skills (for the MAND) and locomotor vs. object control skills (for the MPS); and individual skills tasks. Using this 3-level approach kept the order of the tasks fairly randomized while maintaining enough consistency from one task to the next so as not to confuse the child.

The tester administered each motor skill for a child by following the specific administration in the MAND manual (McCarron, 1997). However, some of the children born in the PT groups did not want to perform certain motor skills such as the finger-nose-finger or finger tapping tasks. In such cases, the tester administered other motor skills and came back to the skipped skill later.

The children performed the MPS tasks twice, unless the child wanted to practice the skills more, then the child was allowed to practice the tasks one or two more times. Catching involved catching the big ball (11" diameter) first and, if the catch went well, the small ball (3 ½" diameter) was used second. Isaacs (1980) suggested that large balls improve younger children's catching performance while small balls show truer success in catching. Striking started with striking a stationary ball twice then the tester tossed the ball to the participant twice. All of the children appeared to enjoy the motor skills of the MPS. All of these tasks were videotaped by the investigator for later scoring, as were the observations of the child's behavior/actions during the motor skills tests.

The parents usually remained in the video room during the time that the child was being tested. The parent(s) were only asked to enter the laboratory during testing if the child was looking for the parent(s) or did not want to do the motor skills.

Height and weight. After completing the testing of motor skills, the investigator led the child to the scale for weight measurement and to the nearby wall for height measurement. The investigator asked the child to "measure how much you grew?" or "how much you weigh?" with verbal consent. The investigator asked the parent(s) for consent to measure their height and provide the other parent's height. If the other parent was present, then the investigator also asked him/her for consent to measure her/his height. All measurements of heights required verbal consent.

Conversations with parent(s), debriefing, and gift. The investigator provided verbal assessment to the parent concerning how well the child performed in general and if the child followed directions well; however, if the child did not want to do some motor skills or did not follow the tester's directions, the investigator asked the parent if the child normally followed other people's directions? Or was the child's behavior unusual? Thus, the investigator knew if the laboratory environment made the child uncomfortable.

When the investigator said to the parent(s) that their child followed directions well or did well with any ball activities, some parents provided information about how his/her child was doing in physical activities at home or in a program. If the parent(s) provided information about physical activities, then the investigator asked how long the child had been participating. In general, when the investigator talked to the parent(s), the tester was involved with the child in catching, striking, etc. The investigator thanked the parent(s) for coming, gave the gift card to the parent(s), said that the child did a very good job, and gave a small soft ball to the child.

Observation of Videotapes

MAND and MPS scoring, and counting neurological soft signs. After all videotapes had been collected for all of the participants, the investigator randomized the tapes. Each tape, or two tapes in some cases, represented one child. The investigator scored the motor skills from the MAND according to the MAND manual through the videotape. All of the data were recorded in SPSS for statistical analysis (2001). Raw scores were converted into scaled scores. The scaled scores were used to calculate the factor scores, the total scaled scores of fine and gross motor skills, and the NDIs. The investigator scored the MPS tasks according to the descriptions of motor skills from the TGMD manual. These raw scores were used to calculate the total scores of locomotor and object control skills, and the total MPS scores. Observations of neurological soft signs during motor skills performances through the video were counted and recorded in the data sheet.

Data Analysis

The statistical procedures used in this study were both descriptive and inferential. Statistical procedures used in analyses of Research Questions/Hypotheses are in Table 13. All statistical analyses used came from SPSS software (2001). Descriptive statistics included means, standard deviations, maximum possible scores for each birthtype, and scatter plots. Gender/race effects were not used because the main focus was birthtype, and because of the small number of participants from each group in the study. Inferential statistics included Pearson product-moment correlations, partial correlations, semipartial correlations, several one-way analyses of variance (ANOVAs), and several one-way analyses of covariance (ANCOVAs). Research Questions/Hypotheses were answered using several one-way ANOVAs and one-way ANCOVAs. Additionally, several types of correlations added additional information to this study.

Decision of α value

Hypotheses and Research Questions used a total of 4 one-way ANOVAs and 5 one-way ANCOVAs. Because several tests were computed, the alternative Hypotheses/Research Questions were more likely to be accepted. Despite the possibility

Table 13

Statistical Procedures Used in Analyses of Hypotheses, Research Questions

Hypotheses/Research Questions	Data analyses
Motor Skills	
H1. PT I and PT II < FT on NDI (MAND)	1 one-way ANOVA, If significant, post hoc Scheffé test, and effect size
RQ 1. Differences between PT I, PT II, and FT on MAND subtests?	2 one-way ANOVAs If significant, post hoc Scheffé test, and effect size
H2. PT I and PT II < FT on total score of MPS (MPS)	1 one-way ANCOVA with covariate of chronological age. If significant, pairwise comparisons test, and effect size
RQ 2. Differences between PT I, PT II, and FT on MPS subtests?	2 one-way ANCOVAs with covariate of chronological age. If significant, pairwise comparisons test, and effect size
Physical Growth	
H3. PT I and PT II < FT on height	1 one-way ANCOVA with covariate of chronological age. If significant, pairwise comparisons test, and effect size
H4. PT I and PT II < FT on weight	1 one-way ANCOVA with covariate of chronological age. If significant, pairwise comparisons test, and effect size

H5.	PT I and PT II < FT on BMI	1 one-way ANOVA. If significant, post hoc Scheffé test, and effect size

that Type I errors were more likely to occur, this research decided to use $\alpha < .05$. One reason was that, if there were differences for the motor skills, then this research was likely to catch those differences among the birthtypes. Another reason was that finding a significant difference might be easier with increasing sample sizes, but the small sample size in this study was less likely to see a significant difference. If there were significant one-way ANOVAs/ one-way ANCOVAs, the appropriate post hoc tests were performed, then the effect sizes were calculated to provide an interpretation of the meaningfulness of the significance.

Effect Sizes

According to Cohen (1988) effect sizes for the ANOVA can be classified into one of three categories: (a) small effect size f = .10; (b) medium effect size f = .25; and (c) large effect size f = .40. When an effect size is small, it means that the relationship between the independent and dependent variables may be of little practical importance. The effect size used to calculate is $f = \eta^2/(1-\eta^2)$ and is based on the calculation of eta-squared (η^2).

η^2 = Sum of Squares $_{between}$/ Sum of Squares $_{total}$.

H 1 and RQ 1

H 1 (dependent variable: NDI) and RQ 1 (2 dependent variables: total scaled score of fine motor skills and total scaled score of gross motor skills) used three separate one-way ANOVAs to directly answer if there were any significant differences among the groups for each dependent variable. H 1 and RQ 1 tested for homogeneity of variance, one-way ANOVA assumption, using the Levene test. All of the tests were accepted as having equal variances for each dependent variable ($p > .05$). Therefore, H 1 and RQ 1 were run using three separate one-way ANOVAs.

The dependent variable for H 1 was the NDI of the MAND, which was an age-standardized test; therefore, chronological age did not have to be controlled among the different ages of the children in this research. The two scores of RQ 1 were the subtests of the MAND, and the subtests were age standardized; therefore, age was not controlled.

If the one-way ANOVA did not show significant differences among the groups, then the statistical analysis was halted. On the other hand, if the one-way ANOVA showed a significant difference among the groups, then the Scheffé post hoc test was performed to see which group pairs, if any, were significantly different. Afterward, the effect size was calculated in order to provide how meaningful is the p value of the one-way ANOVA.

The Scheffé test was chosen for the follow-up to the one-way ANOVA because it was the most conservative post hoc test (Vincent, 1999). The Scheffé test was also useful because the sample sizes of each group were not the same (Aczel, 1996). The commonly used Tukey test would have been better to use if the same sample sizes of each group were more equal (Aczel, 1996).

<u>H 2 and RQ 2</u>

An one-way ANCOVA was used for H 2 because it used the total MPS score as the dependent variable. The MPS instrument was not age standardized, so age needed to be controlled as a covariate. The participants in this study ranged between 3.5 and 7 years, thus chronological age became the appropriate covariate of the one-way ANCOVA. Also, two separate one-way ANCOVAs with covariates of chronological were used for RQ 2. As dependent variables subtest scores of the MPS, age needed to be controlled because the MPS instrument was not age standardized.

H 2 (dependent variable: total MPS score) and RQ 2 (dependent variables: total score of locomotor skills and total score of object control skills) were tested for the homogeneity of slopes and homogeneity of variance assumption tests before any one-way ANCOVA was run. The slopes of the linear correlations between the covariate and the dependent variables were tested and the results showed that the homogeneity of slopes assumptions were not rejected. All of the tests accepted that the variances of the dependent variables among the groups were equal from Levene tests ($p > .05$).

If there were significant differences for the one-way ANCOVA, then the pairwise comparisons test analyzed the differences among the groups (Hair, Tatham, Anderson, & Black, 1998), and the effect size was provided to ascertain the meaningfulness of the level of significance.

H 3, H 4, and H 5

H 3, H 4, and H 5 were related to the physical growth of children. H 3 and H 4 used two separate one-way ANCOVAs with the covariates of chronological age. Before running any one-way ANCOVAs, though, the assumptions tests were checked. The slopes of the linear correlations between the covariate and the dependent variables were tested and showed that the homogeneity of slopes assumption tests were not rejected. The hypotheses satisfied the tests of homogeneity of variance using the Levene tests. The chronological ages needed to be controlled for the one-way ANCOVA because the participants in this study were 3.5 to 7 years old. If there were significant differences for the one-way ANCOVAs, then the pairwise comparisons tests analyzed the differences among the groups and the effect sizes were calculated.

H 5 was related to the BMI, which was not dependent on age; therefore, age did not need to be controlled and an one-way ANOVA was run. The assumption test of homogeneity of variance by the Levene's test was satisfied before running the one-way AVOVA. If there were significant differences for the one-way ANOVA, then the Scheffé test was performed and the effect size was calculated.

Additionally, each child was compared to the children of the National Center for Disease Control and Prevention for height, weight, and BMI of boys and girls in collaboration with the national Center for Chronic Disease Prevention and Health Promotion (2000a; 2000b; 2001a; 2001b). These were also adding information as to how children were growing in comparison to the norm of the nation.

Additional Data Analyses for Exploring Data

This research also used descriptive data analyses if there were any differences in the frequencies of neurological soft signs for the different birthtypes, and if there were any neurological soft signs that appeared to be more associated with the PT groups than with the FT group. Counting the frequencies of each neurological soft sign as well as the types of each neurological soft sign happened with the PT groups.

Exploring the data analyses, the investigator also looked at what factors might have influenced the MAND and MPS scores of the children besides birthtype. Therefore, the correlations among potentially influencing variables were meant to answer some important and meaningful concerns about the MAND and MPS scores. However, correlations between the NDI and total scaled score of gross motor skills/total scaled score of fine motor skills were not performed because both total scaled scores were components of the NDI. It also applied between the total score of MPS and total score of locomotor skills/total score of object control skills.

Variables in the correlation used the NDI, total scaled score of gross motor skills, total scaled score of fine motor skills, total score of MPS, total score of locomotor skills, total score of object control skills, the chronological age, the adjusted age, the heights of the children, the weights of the children, the BMIs of the children, the heights of the mothers, the heights of the fathers, the ABILITIES Indexes, and the duration of preschool participation for the children. All variables in the correlations were presented in the correlation matrix table in the results section in order to easily look at the relationships among the potential variables influenced with the motor skills scores despite using different types of correlations.

If a correlation is statistically significant, which means there are relationships between the two variables, it does not mean that the relationship is necessarily meaningful but rather that its magnitude and direction is important (Williams, 1992). This research reported $\underline{p} = < .05$ and $\underline{p} = < .01$. However, the significances were not discussed, but the higher correlations between variables were discussed. The population correlation coefficient is denoted by r (Aczel, 1996). If r is zero then there is no linear relationship between the two variables. If r = 1 then there is a perfect, positive linear relationship between the two variables. If r = -1, there is a perfect negative linear relationship between the two variables. When the absolute value of r is between 0 and 1, then the value denotes the relative strength of the linear relationship between the two variables. The following range of correlation coefficients is used as a rough guide by Guilford (1956):

1. Slight correlation coefficients are <.20 and mean an almost negligible relationship.

2. Low correlation is defined as the range of correlation coefficients between .20 - .40, and mean a small relationship.

3. Moderate correlation is defined as the range of correlation coefficients between .40 - .70 and mean a substantial relationship.

4. High correlation is defined as the range of correlation coefficients between .70 - .90 and mean a marked relationship.

5. Very high correlation is defined as the range of correlation coefficients >.90 and mean a very dependable relationship.

The Pearson product-moment correlation (Thomas & Nelson, 1996), which did not need to control age, among any two variables included the NDI, total scaled score of fine motor skills, total scaled score of gross motor skills, adjusted age of NDI, adjusted age of total scaled score of fine motor skills, adjusted age of total scaled score of gross motor skills, BMI, mother's height, father's height, total ABILITIES Index, or duration of preschool attendance.

The semipartial correlation is a technique in which one variable is partialed out from just one of the two variables in the correlation (Thomas & Nelson, 1996). For instance, if a correlation is desired between two variables, in which one variable needed to be controlled by age because it was not age standardized and the other variable did not need to be controlled by age because it was age standardized, then a semipartial correlation was used. Semipartial correlations were used for the height or weight and MAND scores because height or weight were not age standardized, unlike the MAND scores. Thomas (1996) suggested that semipartial correlations be used such that the relationship between variables 1 and 2 is determined after the influence of variable 3 on variable 2 has been partialed out. In this case, variable 1 was any MAND score, variable 2 was the height or weight, and variable 3 was the age.

Thus, semipartial correlations in this research were used between the NDI, total scaled score of fine motor skills, total scaled score of gross motor skills, age-adjusted NDI, age-adjusted total scaled score of gross motor skills, BMI, mother's height, father's height, or duration of preschool attendance, and the total score of MPS, total score of locomotor skills, total score of object control skills, child's height, or child's weight.

Partial correlations, which mean the correlation between variables 1 and 2 with variable 3 held constant (Thomas & Nelson, 1996), were used in this study. For instance, partial correlations were used for the height/weight and the MPS scores because all of the variables needed to be controlled by either the chronological age or adjusted age. The MPS scores were not age standardized and participants in this study ranged from 3.5 to 7 years old. Thomas (1996) suggested that many attributes such as weight, height, and mental performance increased regularly with age until 18 years, so there was a need to control the effects of age when the subjects were minors. He gave an example of shoe size and achievement in mathematics being highly correlated, which may in fact be due to the common influence of another variable (age or maturation). When the effect of the third variable (age) was removed, the correlation between shoe size and achievement in mathematics diminished completely. Partial correlations were used in this study between the total score of MPS, total score of locomotor skills, total score of object controls skills, child's height, and child's weight while either chronological age or adjusted age were partialed out.

Chapter 4

RESULTS

This chapter deals with the qualitative and quantitative results derived from answering the Hypotheses and Research Questions presented in Chapter 3. Chapter 4 is divided into five sections. The first section deals with the motor skills abilities of the PT I, PT II, and FT groups as determined by the MAND and MPS tests, using descriptive results. The second section covers the correlations between the motor skills abilities and the potential variables that may have influenced the motor skills abilities during the MAND and MPS tests. The third section addresses the quantitative motor skills differences for the MAND and MPS tests of the three groups. The fourth section summarizes what types of and how many neurological soft signs occurred during the MAND and MPS test performances of the three groups. The final section covers the descriptive results of the family characteristics and graphs the family characteristics with the motor skills abilities for the three groups.

Descriptive Results of MAND and MPS

Table 14 provides the descriptive results of the MAND and MPS tests. The descriptive results are presented using both chronological age (Table 14) and adjusted age (Table 15) for the MAND scores since Palisano et al. (1985) suggested using adjusted age for children born preterm, while others suggested using chronological age after children born preterm passed 2 years of age (Sansavini et al., 1996). Descriptive results reported the means and standard deviations for the NDI, total scaled scores of gross and fine motor skills, four factor scores, and 10 motor skills items of the MAND test. In addition, descriptive results reported the means and standard deviations for the total MPS

Table 14

Means and Standard Deviations of the MAND and MPS Tests Using Chronological Age

	Max. score possible (points)	Preterm I (n = 6)	Preterm II (n = 6)	Fullterm (n = 10)
		MAND test		
Neuromotor Development Index	200	72.00±16.24	76.17±18.35	104.80±15.28
Total Scaled Score of Fine Motor Skills	100	26.67±18.00	31.17±18.04	52.90±11.81
Total Scaled Score of Gross Motor Skills	100	36.17±10.69	37.33±10.76	52.10±9.20
Persistent Control Factor Score	200	71.76±22.51	64.17±19.85	98.50±14.73
Rod slide	20	7.33±5.75	4.33±5.72	11.70±3.43
Finger-nose-finger	20	3.33±3.39	4.17±2.64	8.30±1.95
Muscle Power Factor Score	200	85.00±18.97	88.33±13.66	102.50±13.99
Hand strength	20	6.00±3.26	5.67±2.07	9.20±2.82
Jump	20	8.50±4.85	10.33±4.41	12.30±3.56
Kinesthetic Integration Factor Score	200	94.17±14.63	90.83±15.94	106.00±17.45

Heel-toe walk	20	9.83±3.55	8.67±5.57	13.20±3.82
Stand on one foot	20	8.50±1.87	8.50±1.38	9.10±2.96
Bimanual Dexterity Factor Score	200	50.00±22.14	84.17±34.56	101.00±30.71
Beads on rod	20	5.33±3.88	8.33±2.58	10.60±4.45
Nut and bolt	20	1.50±2.81	7.67±7.53	9.90±4.77
Other test items				
Beads on box	20	6.67±7.86	3.50±3.27	10.20±4.39
Finger tapping	20	5.83±2.79	7.33±2.94	10.50±3.03
		MPS test		
Total Score of MPS	40	19.67±4.82	19.83±5.20	28.10±6.40
Total Score of Locomotor Skills	18	9.58±2.80	9.08±2.19	13.20±2.67
Jumping	4	2.08±0.49	2.17±0.41	2.70±0.63
Running	4	3.42±0.58	3.25±0.52	3.85±0.24
Hopping	4	1.08±0.96	1.50±0.82	2.75±0.51
Galloping	3	1.67±0.41	1.33±0.41	1.90±0.96

Skipping	3	1.33±1.37	0.83±0.75	2.00±1.05
Total Score of Object Control Skills	22	10.08±3.02	10.75±3.14	14.90±4.15
Throwing	5	1.92±1.56	2.50±1.05	3.30±1.27
Catching	5	2.67±1.21	2.92±0.80	3.80±0.92
Kicking	4	1.83±0.68	1.75±0.69	3.05±0.86
Punting	4	1.33±0.61	1.17±0.98	2.10±1.10
Striking	4	2.33±0.88	2.42±0.92	2.65±0.85

score, total scores of gross and fine motor skills, and the scores of each of ten items of the MPS test.

From the MAND test, the mean NDI for the PT I group was 72.00 (SD = 16.24), the PT II group was 76.17 (SD = 18.35), and the FT group was 104.80 (SD = 15.28). The mean total scaled score of fine motor skills for the PT I group was 26.67 (SD = 18.00), the PT II group was 31.17 (SD = 18.04), and the FT group was 52.90 (SD = 11.81). The mean total scaled score of gross motor skills for the PT I group was 36.17 (SD = 10.69), the PT II group was 37.33 (SD = 10.76), and the FT group was 52.10 (SD = 9.20). Both PT groups had lower mean total scaled scores of fine motor skills than gross motor skills. The FT group had similar mean total scaled scores of both fine and gross motor skills.

For the four mean factor scores from the MAND test, persistent control and bimanual dexterity showed larger differences than kinesthetic integration and muscle power between the PT I/II and FT groups. The differences of the mean persistent factor scores between the PT I/II and FT groups were 26.74/34.33, respectively. The mean persistent control factor scores for the PT I, PT II, and FT groups were 71.76, 64.17, and 98.50, respectively (SDs = 22.51, 19.85, and 14.73, respectively). The mean bimanual dexterity factor score differences for the PT I/II and FT groups were 51.00/16.83, respectively. However, the mean kinesthetic integration factor score differences between the PT I/II and FT groups were 11.83/15.17, respectively. The mean muscle power factor score differences between the PT I/II and FT groups were 17.50/14.17, respectively.

The FT group had higher mean scores in the 10 individual motor skills of the MAND test than the PT groups. Both of the PT groups had similar mean scores for the individual motor skills items. For instance, the PT II group had slightly higher mean scores on 5 motor skills items than the PT I group; while the PT I group had slightly higher mean scores on another 4 motor skills items than the PT II group. The PT groups had the same mean score of stand on one foot item.

On the MPS test, the mean total score of MPS for the PT I group was 19.67 (SD = 4.82), the PT II group was 19.83 (SD = 5.20), and the FT group was 28.10 (SD = 6.40). The mean total score of locomotor skills for the PT I group was 9.58 (SD = 2.80), the PT II group was 9.08 (SD = 2.19), and the FT group was 13.20 (SD = 2.67). The mean total score of object control skills for the PT I group was 10.08 (SD = 3.02), the PT II group was 10.75 (SD = 3.14), and the FT group was 14.90 (SD = 4.15). The FT group had higher mean scores in the 10 individual motor skills items of the MPS test than either PT group; however, either PT group showed some mean individual motor skills items scores to be somewhat closer to the mean scores of the other PT group.

Mean scores on the MAND test for the PT groups increased when using adjusted age as compared with using chronological age (Table 15). Despite using adjusted age, the PT I group (M = 78.17, SD = 17.36) and the PT II group (M = 83.83, SD = 21.79) had lower mean adjusted age NDIs than the FT group (M = 104.80, SD = 15.28). The mean adjusted age total scaled score of fine motor skills for the PT I group was 30.33 (SD = 18.44), the PT II group was 35.00 (SD = 18.18), and the FT group was 52.90 (SD = 11.81). The mean adjusted age total scaled score of gross motor skills for the PT I group was 41.00 (SD = 11.58), the PT II group was 43.33 (SD = 15.07), and the FT group was 52.10 (SD = 9.20).

Using adjusted age for the PT groups increased the mean muscle power and kinesthetic integration factor scores. The PT groups had lower mean adjusted age muscle

Table 15

Means and Standard Deviations of MAND Test Using Adjusted Age

	Max. score possible (points)	Preterm I (n = 6)	Preterm II (n = 6)	Fullterm (n = 10)
Neuromotor Development Index	200	78.17±17.36	83.83±21.79	104.80±15.28
Total Scaled Score of Fine Motor Skills	100	30.33±18.44	35.00±18.18	52.90±11.81
Total Scaled Score of Gross Motor Skills	100	41.00±11.58	43.33±15.07	52.10±9.20
Persistent Control Factor Score	200	75.00±20.98	67.50±19.43	98.50±14.73
Rod slide	20	7.83±5.38	5.00±5.37	11.70±3.43
Finger-nose-finger	20	4.00±3.35	4.67±3.08	8.30±1.95
Muscle Power Factor Score	200	90.83±15.94	95.00±18.71	102.50±13.99
Hand strength	20	7.50±2.59	7.50±4.04	9.20±2.82
Jump	20	9.33±4.37	11.33±4.80	12.30±3.56
Kinesthetic Integration Factor Score	200	100.00±20.00	98.33±21.37	106.00±17.45

Heel-toe walk	20	11.17±4.75	10.67±6.98	13.20±3.82
Stand on one foot	20	9.00±2.28	9.17±1.17	9.10±2.96
Bimanual Dexterity Factor Score	200	59.17±25.18	94.17±37.74	101.00±30.71
Beads on rod	20	6.33±4.41	9.17±2.56	10.60±4.45
Nut and bolt	20	2.83±3.43	9.33±7.92	9.90±4.77
Other test items				
Beads on box	20	7.00±7.98	3.83±3.31	10.20±4.39
Finger tapping	20	6.33±2.94	7.67±3.01	10.50±3.03

Note. All of the MAND scores were adjusted age scores.

power factor scores compared to the FT group as well as to the norm of the MAND test. The mean adjusted age kinesthetic integration factor score for the PT I group was 100.00 (SD = 20.00), the PT II group was 98.33 (SD = 21.37), and the FT group was 106.00 (SD = 17.47). Both PT groups had lower mean adjusted age persistent control factor scores than the FT group, with the PT I group at 75.00 (SD = 20.98), the PT II group at 67.50 (SD = 19.43), and the FT group at 98.50 (SD = 14.73). The PT I group had a larger mean adjusted age bimanual dexterity factor score difference with the FT group (41.83) than the PT II group had with the FT group (6.83); the PT I group was 58.17 (SD = 25.18), the PT II group was 94.17 (SD = 37.74), and the FT group was 101.00 (SD = 30.71). The PT groups had lower mean adjusted age scores for all 10 individual motor skills items than the FT group, with the exception of the stand on one foot item. The PT groups showed very similar mean individual motor skills scores using adjusted age when compared to each other.

The MPS tests were not standardized for age; thus, Figures 5 to 7 are used to provide the relationship of the total score of MPS, total score of locomotor skills, and total score of object control skills with the birthtype. From the figures, most of the children from the PT groups showed lower MPS scores than the children from the FT group, despite exact comparisons being difficult. All of the motor skills of the MPS test with birthtypes are presented in Appendix I.

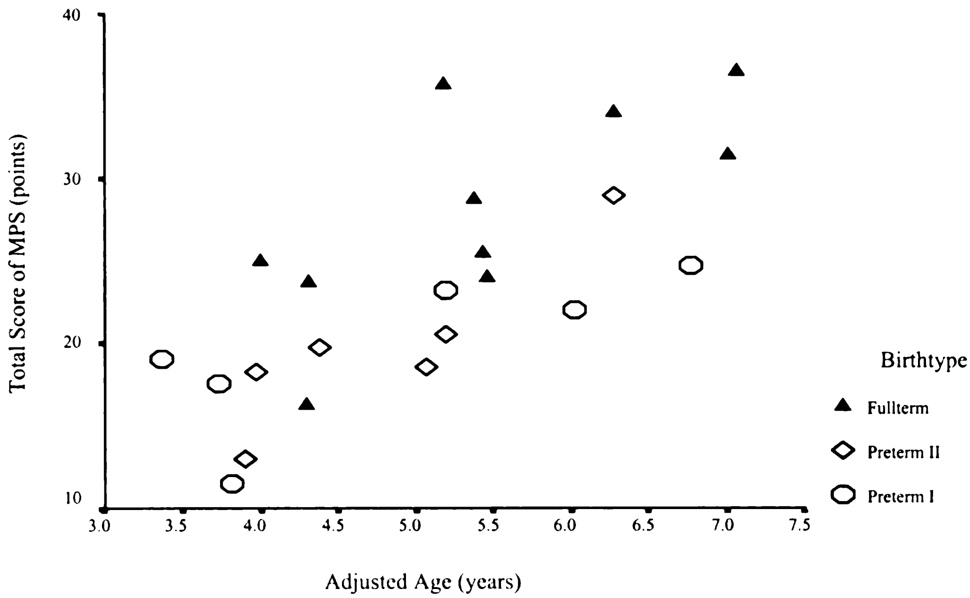


Figure 5. The total score of MPS from the Motor Performance Study (MPS) as determined by the birthtype and adjusted age.

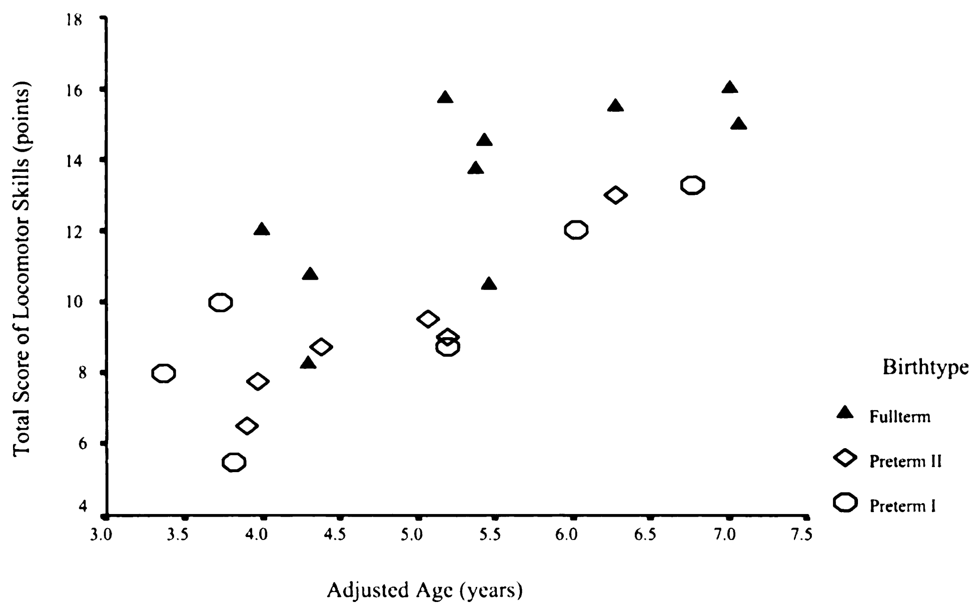


Figure 6. The total score of locomotor skills from the Motor Performance Study as determined by the birthtype and adjusted age.

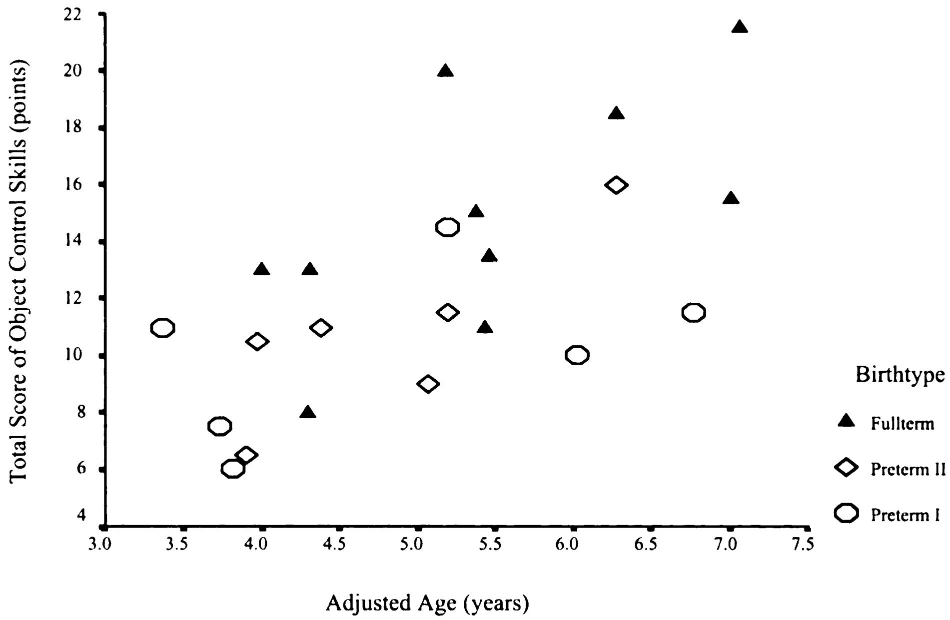


Figure 7. The total score of object control skills from the Motor Performance Study as determined by the birthtype and adjusted age.

Factors that Influence MAND and MPS Scores

The correlation matrix showed relationships between motor skills scores and other variables (Table 16). The following described the correlations among the motor skills and other variables. The NDI was moderately to highly correlated with the MPS scores using the semipartial correlation as was expected. The NDI and the age-adjusted MAND scores were highly/very highly correlated using the Pearson product-moment correlation, as was expected. The NDI and the height of the child were moderately correlated using

Table 16

Correlations Among Variables

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1. NDI	–	–	–	.63 **	.75**	.44 *	.29	.35	.48 *	.19	.14	.13	.28	-.53 *	.17	.95 **	.86 **	.87**
2. Fine		–	.63**	.47 *	.59**	.32	.48*	.53 *	.34	.36	.09	.17 **	.15	-.44 *	.27	.93 **	.98 **	.65**
3. Gross			–	.68 **	.80**	.49 *	-.04	.27	.58 **	.37	.16	.04	.42	-.56 **	.00	.68 **	.43 *	.91**
4. MPS Total				–	–	–	.69**	.74 **	.51 *	.54 *	.41 *	.02	.47 *	-.43	.03	.52 *	.37	.53*
5. Locomotor					–	.63 **	.72**	.77 **	.45 *	.36	.22	.00	.36	-.50 *	.11	.68 **	.52 **	.69**
6. Object						–	.60**	.64 **	.47 *	.58 **	.47 *	.03	.48 *	-.32	.13	.33	.22	.33
7. Chr. Age							–	.99 **	.82 **	.66 **	.35	.11	-.10	-.08	.39	.18	.44	-.24
8. Adj. Age								–	.85 **	.71 **	.40	.07	-.09	-.12	.40	.24	.49 *	-.19
9. Height									–	.66 *	.33	.30	.63 **	-.54*	.31	.36	.23	.45*
10. Weight										–	.87 **	.02	.44	-.36	.12	.10	-.07	.31
11. BMI											–	-.14	.17	-.21	-.02	.08	.05	.07
12. Mothers ht												–	.38	-.31	.30	.18	.20	.11
13. Fathers ht													–	-.34	-.00	.29	.15	.43
14. ABILIT														–	-.28	-.55*	-.47 *	-.53*
15. Preschool															–	.07	.23	-.16
16. Adj. NDI																–	–	–
17. Adj. fine																	–	.52 *
18. Adj. gross																		–

Note. *: p < .05, **: p < .001. Abbreviation of column list: MAND/NDI: Neuromuscular Development Index of MAND test; Fine: Total scaled score of fine motor skills of MAND test; Gross: Total scaled score of gross motor skills of MAND test; MPS Total: total MPS score of MPS test; Locomotor: Total score of locomotor skills of MPS test; Object: Total score of object control skills of MPS test; Chr.: Chronological; Adj.: Adjusted; ht: height; ABILITIES: Total ABILITIES Index; Preschool: Duration of preschool attendance; adj. NDI. Pearson product-moment correlations were used among: MAND/NDI, Fine, Gross, Adj. NDI, Adj. fine, Adj. gross, Chr. Age, Adj. Age, BMI, Mothers ht, Fathers ht, ABILITIES, or Preschool.; Partial correlations were used among: MPS Total, Locomotor, Object, Height, or Weight; Semipartial correlations were used among: MAND/NDI, Fine, Gross, Adj. NDI, Adj. fine, Adj. gross and MPS Total, Locomotor, Object, Height, or Weight; BMI, (or Mother ht, Father ht, ABILITIES, Preschool) and MPS total, Locomotor, Object, Height, or Weight. The correlations of the Gross/Fine with the NDI, the Locomotor/Object with the MPS Total, and the Adj. gross/fine with the Adj. NDI are not shown because the total scores are comprised of the subtest scores.

the semipartial correlation. The NDI and ABILITIES Index were negatively moderately correlated using the Pearson product-moment correlation. The total scaled score of fine motor skills and MPS scores were lowly to moderately correlated using the semipartial correlation. The total scaled score of fine motor skills and ABILITIES Index were negatively moderately correlated using the Pearson product-moment correlation. The total scaled score of gross motor skills and height of the child were moderately correlated using the semipartial correlation. The total scaled score of gross motor skills and ABILITIES Index were negatively moderately correlated using the Pearson product-moment correlation. When using adjusted NDI/total scaled score of fine motor skills, the ABILITIES Index was negatively moderately correlated using the semipartial correlation. The adjusted total scaled score of gross motor skills and height of the child were moderately correlated. From these results, the height of a child and the ABILITIES Index could be somewhat related with the motor skills.

As the MPS scores were not age standardized, both the chronological and adjusted ages were moderately to highly correlated with the MPS scores using the Pearson product-moment correlation, as was expected. The total scores of MPS/object control skills were moderately correlated with the height and weight using partial correlations. The total scores of MPS/object control skills were moderately correlated with the BMI using semipartial correlations. The total scores of MPS/locomotor skills was negatively moderately correlated with the ABILITIES Index using semipartial correlations. The total scores of MPS/locomotor skills and height of the father were moderately correlated using the semipartial correlation.

Chronological age and the MAND scores correlated below .50 using the Pearson product-moment correlation; this was expected since the MAND test scores were already standardized using chronological age. Since the MPS scores were not standardized using chronological age, they correlated higher, between .60 and .72 using the Pearson product-moment correlation. Chronological age and adjusted age were well correlated at .99 using the Pearson product-moment correlation; this was expected since adjusted age was calculated directly from chronological age. Despite adjusted age and chronological age being very highly correlated, the MPS scores correlated slightly higher with adjusted age than with chronological age. For instance, adjusted age and the MPS scores correlated between .64 and .77, whereas chronological age and the MPS scores correlated between .60 and .72. Correlations between chronological or adjusted age and the MAND scores would not be meaningful since the MAND scores were already standardized using chronological or adjusted age.

The heights of the fathers were moderately correlated with the total score of object control skills and the heights/weights of the children using semipartial correlations. The heights of the mothers were lowly correlated with the heights of the children. However, no meaningful differences among the mean heights of the parents by group were found in the current study. The mean height of the mothers for the PT I group was 168.68 cm (SD = 3.45), the PT II group was 164.62 cm (SD = 6.54), and the FT group was 164.01 cm (SD = 6.72). The mean height of the fathers for the PT I group was 178.83 cm (SD = 5.12), the PT II group was 178.08 cm (SD = 9.17), and the FT group was 180.82 cm (SD = 7.83).

Hypotheses and Research Questions Results

H1. The children born in the PT I and PT II groups perform less well than the children born in the FT group on the MAND score of general motor skills (NDI).

An one-way ANOVA indicated that there was a significant birthtype effect for the NDI, F (2, 19) = 9.68 and p = .001 (Table 17). The post hoc Scheffé test indicated that the PT I and PT II groups had significantly lower mean NDIs than the FT group, ps = .004 and .011, respectively. However, the PT I group did not have a significantly lower mean NDI than the PT II group, p = .908. From Figure 8, although it was not clear comparing children of different ages, the children from the PT groups tended to have lower mean NDIs than the children from the FT group, except for one child. The effect size was 1.01, which was a large effect.

Table 17

Analysis of Variance for NDI of MAND Test

	df	F	p	Effect size
Contrast	2	9.68	.001	1.01
Error	19			

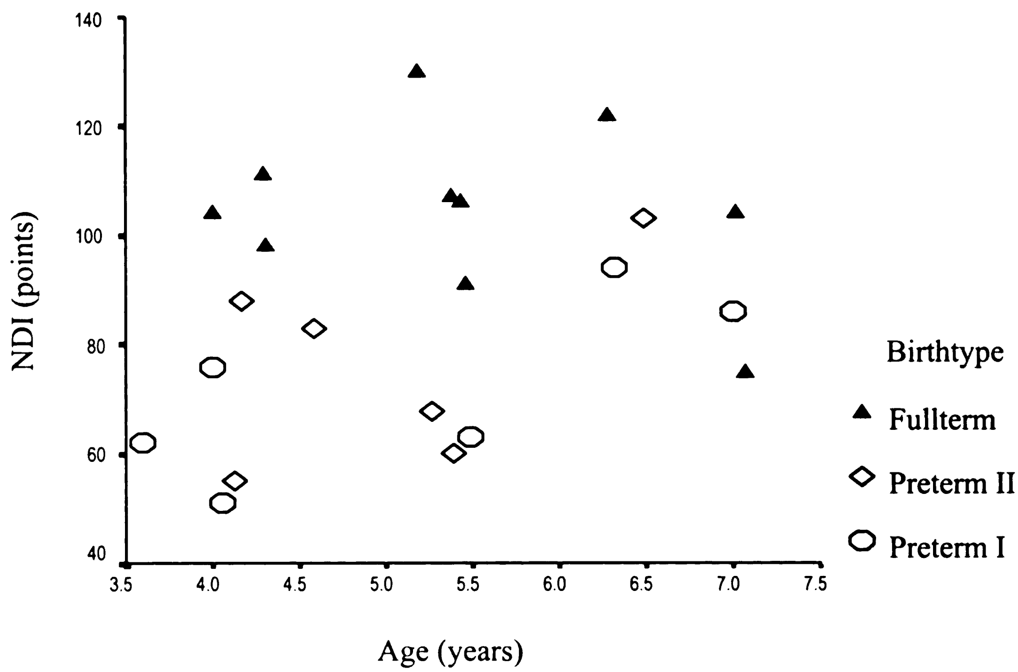


Figure 8. The Neuromuscular Development Indexes (NDIs) from the McCarron Assessment of Neuromuscular Development test as determined by the birthtype and chronological age.

RQ 1. Are there differences between the children born in the PT I, PT II, and FT groups in the MAND subtests (total scaled scores of fine and gross motor skills)?

From two separate one-way ANOVAs, a significant birthtype effect was indicated for the mean total scaled score of fine and gross motor skills, Fs (2, 19) = 6.81 and 6.41, and ps = .006 and .007, respectively (Tables 18 and 19). The post hoc Scheffé tests indicated that the PT I/II groups had significantly lower mean total scaled scores of fine and gross motor skills than the FT group, ps = .013 and .021/.042 and .034, respectively. The mean total scaled scores of fine and gross motor skills between the PT I group and the PT II group were not significantly different, ps = .880 and .980, respectively. From Figure 9, the children from the PT I group and the PT II group tended to have lower mean total scaled scores of fine motor skills than the children from the FT group, except for one child. The children from the PT I group and the PT II group tended to have lower mean total scaled scores of gross motor skills than the children from the FT group (Figure 10). The effect size for the total scaled score of fine and gross motor skills was 0.846 and 0.821, respectively, which were large effects.

Table 18

Analysis of Variance for Total Scaled Score of Fine Motor Skills of MAND Test

	df	F	p	Effect size
Contrast	2	6.81	.006	0.846
Error	19			

Table 19

Analysis of Variance for Total Scaled Score of Gross Motor Skills of MAND Test

	df	F	p	Effect size
Contrast	2	6.41	.007	0.821
Error	19			

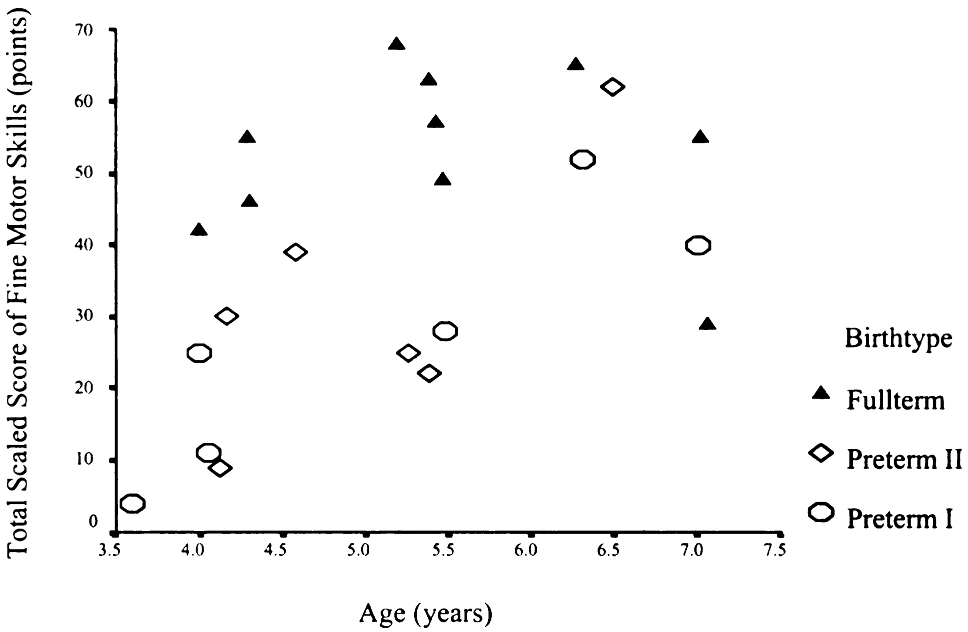


Figure 9. The total scaled score of fine motor skills from the McCarron Assessment of Neuromuscular Development test as determined by the birthtype and chronological age.

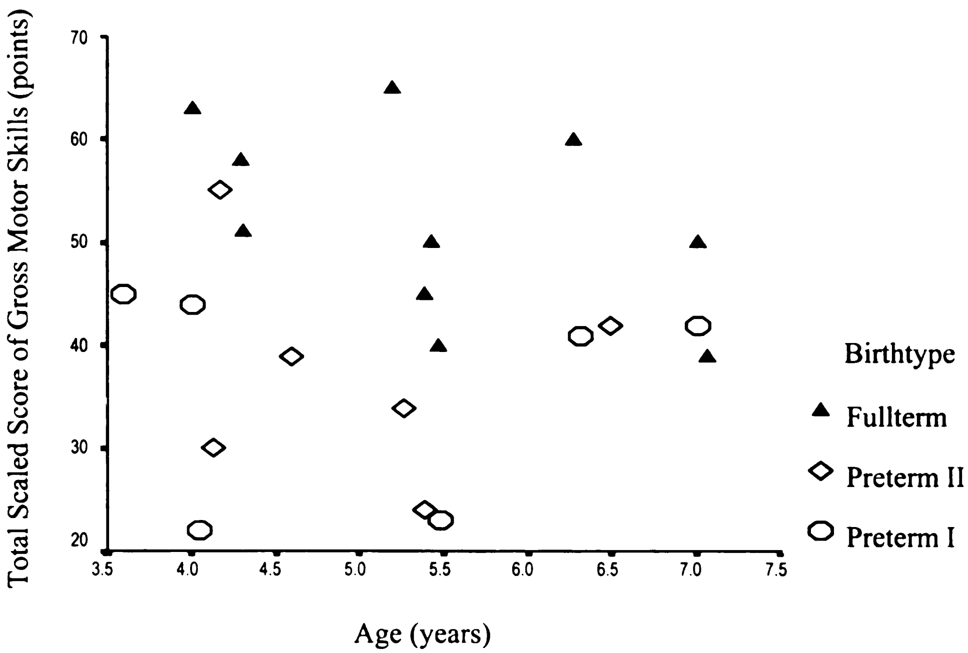


Figure 10. The total scaled score of gross motor skills from the McCarron Assessment of Neuromuscular Development test as determined by the birthtype and chronological age.

H2. The children born in the PT I and PT II groups perform less well than the children born in the FT group on the total score of MPS.

An one-way ANCOVA analyses, with chronological age as the covariate, indicated a significant difference for the total scores of MPS among the groups, F (2, 18) = 8.05 and p = .003 (Table 20). Pairwise comparisons tests indicated that the PT I and PT II groups had significantly lower mean total MPS scores than the FT group, ps = .003 and .005, respectively. The difference for the mean total scores of MPS between the PT I and PT II groups was not significant, p = .847. The PT groups tended to have lower total scores of MPS than the FT group for all ages tested despite exact age comparisons being difficult (Figure 11). The effect size was 1.62, which was a large effect.

Table 20

Analysis of Covariance for Total Score of MPS Test

	df	F	p	Effect size
Contrast	2	8.05	.003	1.62
Error	19			

Note. Covariate: Chronological age

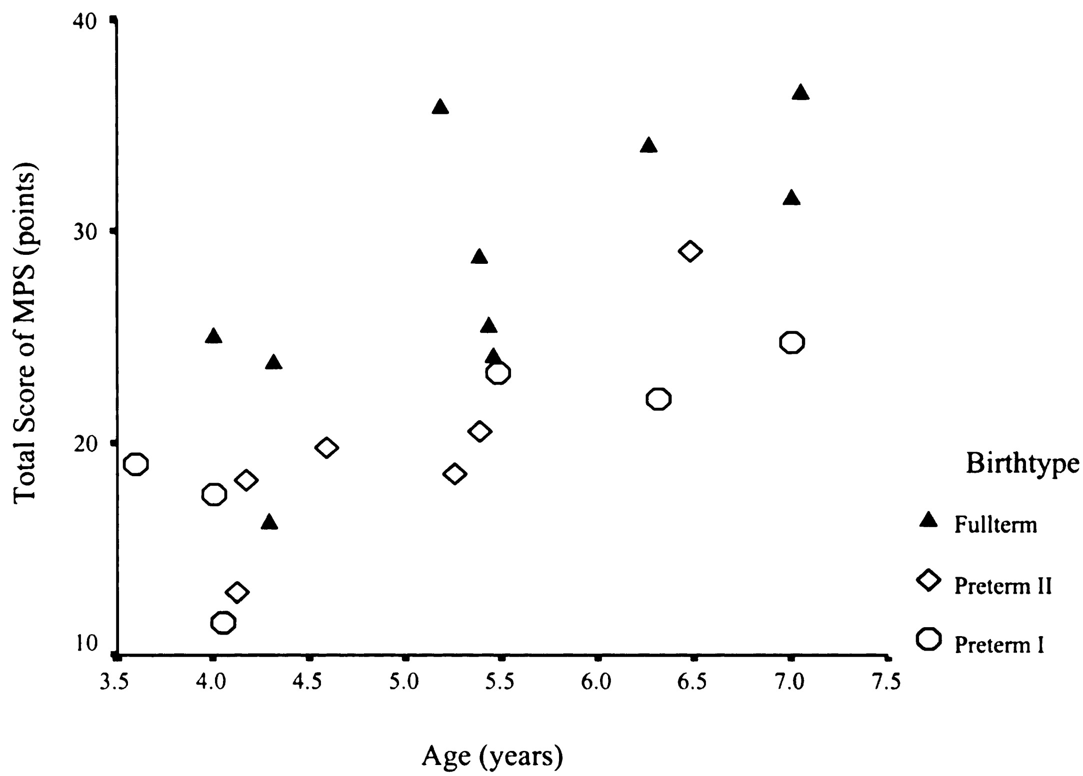


Figure 11. The total score of MPS from the Motor Performance Study (MPS) test as determined by the birthtype and chronological age.

RQ2. Are there differences between the children born in the PT I, PT II, and FT groups on MPS subtests (total scores of locomotor and object control skills)?

Two separate one-way ANCOVAs, with chronological age as the covariates, indicated significant differences for the total scores of locomotor and object control skills among the groups, Fs (2, 18) = 9.70 and 4.25, and ps = .001 and .031, respectively (Tables 21 and 22). Pairwise comparisons tests indicated that the PT I/II groups had significantly lower mean total scores than the FT group for the locomotor and object control skills, ps = .003 and .016/.001 and .047, respectively. The mean scores between the PT I and PT II groups were not significantly different. The children from the PT I and PT II groups tended to have lower total scores of locomotor skills than the children from the FT group (Figure 12). Most of the children from the PT I and PT II groups tended to have lower total scores of object control skills than the children from the FT group, despite exact age comparisons being difficult (Figure 13). The effect size for the total score of locomotor and object control skills were 1.82 and 1.14, respectively, which were large effects.

Table 21

Analysis of Covariance for Total Score of Locomotor Skills of MPS Test

	df	F	p	Effect size
Contrast	2	9.70	.001	1.82
Error	18			

Note. Covariate: Chronological age

Table 22

Analysis of Covariance for Total Score of Object Control Skills of MPS Test

	df	F	p	Effect size
Contrast	2	4.25	.031	1.14
Error	18			

Note. Covariate: Chronological age

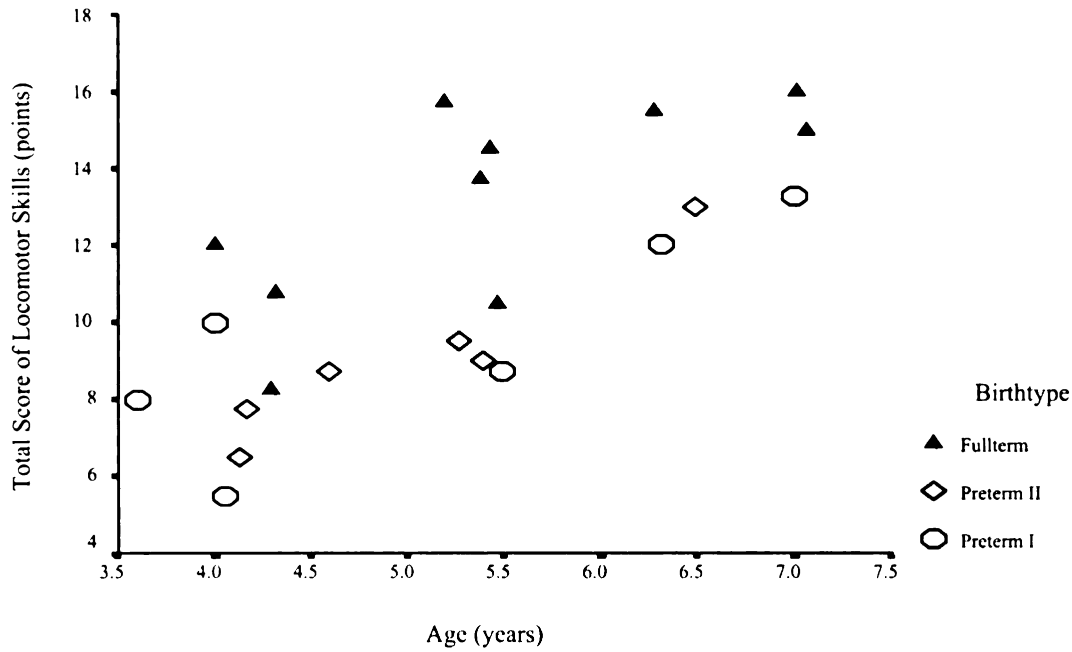


Figure 12. The total scores of locomotor skills from the Motor Performance Study test as determined by the birthtype and chronological age.

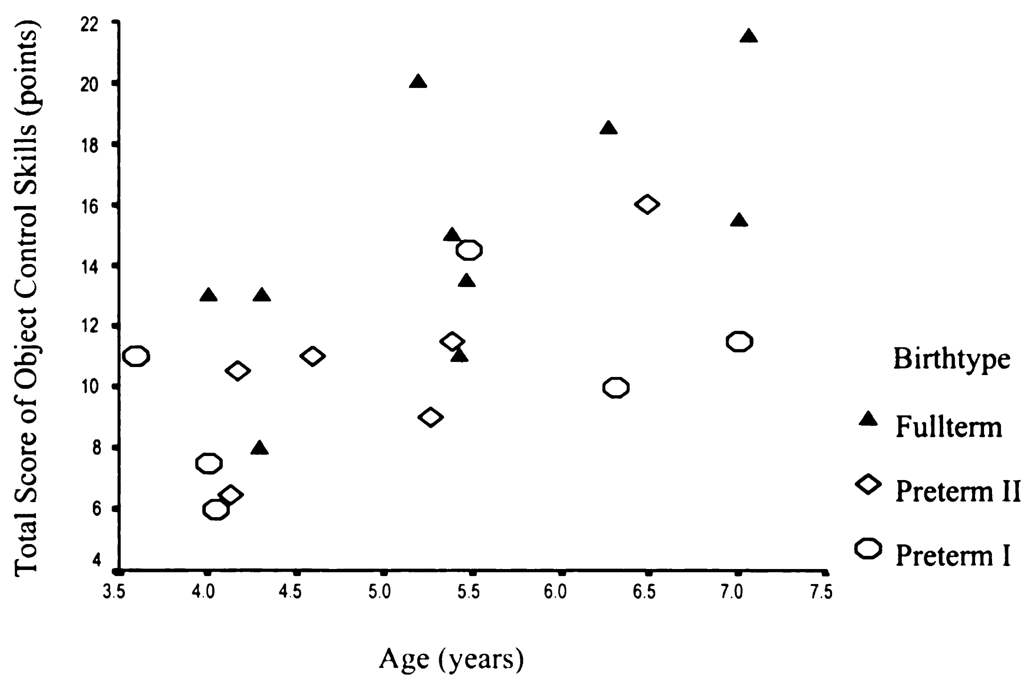


Figure 13. The total scores of object control skills from the Motor Performance Study test as determined by the birthtype and chronological age.

H3. The children born in the PT I and PT II groups are shorter than the children born in the FT group.

From an one-way ANCOVA, with chronological age as the covariate, there was a significant difference among the three groups for height, $F(2, 18) = 4.36$ and $p = .029$ (Table 23). Pairwise comparisons tests indicated that the PT I and PT II groups were significantly shorter than the FT group, ps = .016 and .039, respectively. The mean heights between the PT groups were not significantly different, $p = .709$. The PT groups tended to be shorter than the FT group for all ages tested (Figure 14). The effect size was 1.88, which was a large effect.

Table 23

Analysis of Covariance for Height of Children

	df	F	p	Effect size
Contrast	2	4.36	.029	1.88
Error	18			

Note. Covariate: Chronological age

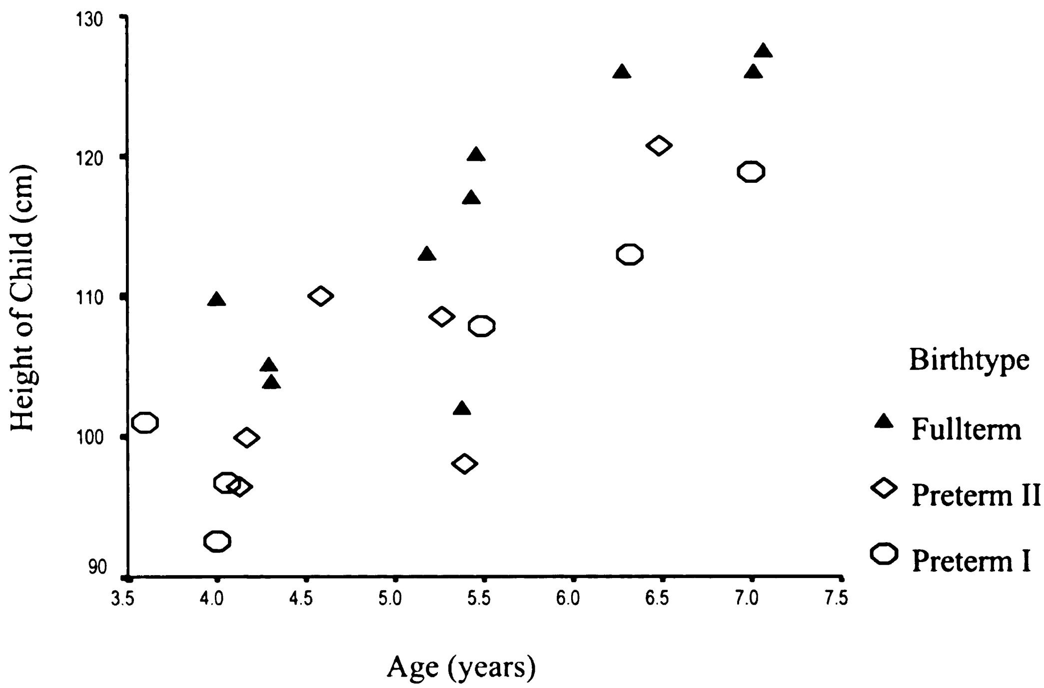


Figure 14. The heights of the children by birthtype and chronological age.

From the height comparison data for boys of the Centers for Disease Control and Prevention (CDC) (2001a) (See Appendix J), the boys from the FT group ranged between the 50th and 97th percentiles. Two boys from the PT II group ranged between the 50th and 90th percentiles, and the other two boys ranged between the 3rd and 25th percentiles. One boy from the PT I group was over the 50th percentile, another boy ranged between the 10th and 25th percentiles, and the remaining boy was below the 3rd percentile.

From the height comparison data for girls of the CDC (2001b), four girls from the FT group ranged between the 50th and 97th percentiles, while one girl ranged between the 3rd and 10th percentiles. One girl from the PT II group ranged between the 25th and 50th percentiles while the other girl was under the 3rd percentile. The girls from the PT I group ranged between the 10th and 50th percentiles.

H4. The children born in the PT I and PT II groups weigh less than the children born in the FT group.

From an one-way ANCOVA, with chronological age as the covariate, there was a significant difference in mean weights among the groups, $\underline{F}$ (2, 18) = 4.74 and $\underline{p}$ = .022 (Table 24). Pairwise comparisons tests indicated that the PT I and PT II groups had significantly lower mean weights than the FT group, $\underline{p}$s = .019 and .020, respectively. The PT I and PT II groups did not show a significant difference in the mean weights between each other, $\underline{p}$ = .983. The PT I and PT II groups tended to weigh less than the FT group for each age tested (Figure 15). Additionally, two children who were born in the FT group appeared to be outliers because they weighed much more than the other children in the study. The effect size was 1.31, which was a large effect.

Table 24

<u>Analysis of Covariance for Weight of Children</u>

	df	$\underline{F}$	$\underline{p}$	Effect size
Contrast	2	4.74	.022	1.31
Error	18			

<u>Note.</u> Covariate: Chronological age

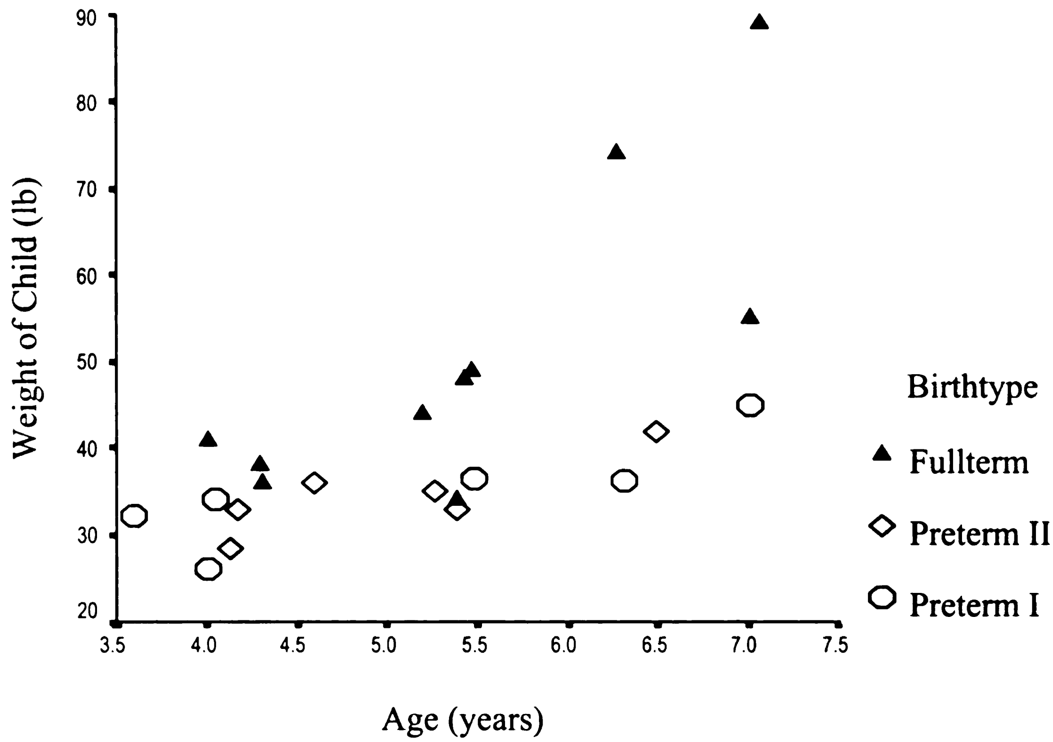


Figure 15. The weights of the children by birthtype and chronological age.

From the weight comparison data for boys of the CDC (2001a), in Appendix J, four boys from the FT group ranged between the 50th and 90th percentiles, except for one boy who was over the 97th percentile. Three boys from the PT II group ranged between the 10th and 50th percentiles, except for one child who was below the 3rd percentile. One boy from the PT I group ranged between the 25th and 50th percentiles, one boy ranged between the 3rd and 10th percentiles, and one boy was below the 3rd percentile.

From the weight comparison data for girls of the CDC (2001b), one girl from the FT group was over the 97th percentile, two girls ranged between the 50th and 75th percentiles, one girl ranged between the 25th and 50th percentiles, and one girl ranged between the 3rd and 10th percentiles. Two girls from the PT II group ranged between the

3rd and 25th percentiles. Two girls from the PT I group ranged between the 10th and 50th percentiles, while one girl was below the 3rd percentile.

H5. The children born in the PT I and PT II groups possess a smaller BMI than the children born in the FT group.

An one-way ANOVA indicated a significant birthtype effect for the BMI among the groups, F (2, 19) = 3.60 and p = .047 (Table 25). The post hoc Scheffé test indicated, however, that none of the combinations of birthtype pairs were significantly different. Figure 16 showed that both of the PT groups tended to have similar/lower BMIs than the FT group. The FT group also seemed to show two participants as being outliers in the figure. The effect size was 0.615, which was a large effect.

Table 25

Analysis of Variance for BMI of Children

	df	F	p	Effect size
Contrast	2	3.60	.047	0.615
Error	18			

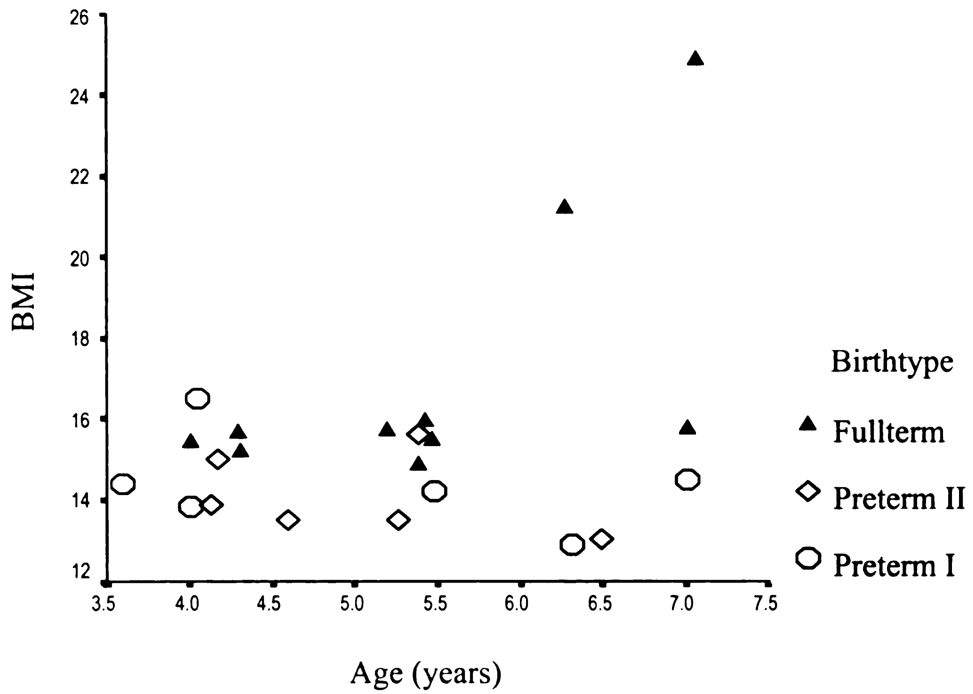


Figure 16. The Body Mass Indexes (BMIs) of children by birthtype and chronological age.

From the Body Mass Index (BMI) comparison data for boys of the CDC (2000a), in Appendix J, one boy from the FT group was over the 97th percentile while the remaining four boys ranged between the 25th and 75th percentiles. One boy from the PT II group ranged between the 25th and 50th percentiles, one boy was determined to be right on the 3rd percentile line, and the remaining two boys were below the 3rd percentile. One boy from the PT I group was below the 3rd percentile while the remaining two boys ranged between the 3rd and 25th percentiles.

From the BMI comparison data for girls of the CDC (2000b), four girls from the FT group ranged between the 25th and 75th percentiles and one girl was over the 97th percentile. One girl from the PT II group ranged between the 50th and 75th percentiles and the other girl ranged between the 3rd and 10th percentiles. One girl from the PT I group ranged between the 75th and 85th percentiles, one girl ranged between the 10th and 25th percentiles, and the remaining girl was below the 3rd percentile.

Neurological Soft Signs

The children who were born in the PT I group and the PT II group tended to show a greater variety of neurological soft signs than the children who were born in the FT group (Table 26) during the performances of the motor skills. The children who were born in the PT I group and the PT II group also showed a greater number of neurological soft signs per child. The children who were born in the FT group averaged only 1.90 soft signs per child, as opposed to 5.67 and 8.17 for the children who were born in the PT I group and the PT II group, respectively. The most common soft signs were inappropriate motor planning and mirroring, regardless of the birthtype. The children who were born in the PT I group were more likely to show extraneous movements. The most frequent soft signs for the children who were born in the PT II group were perseveration, falling after performance, and asymmetry.

Table 26

Frequency of Neurological Soft Signs by Birthtype and Signs

Participants number	Inconsistency in performance	Perseveration	Mirroring	Asymmetry	Loss of dynamic balance	Falling after performance	Extraneous movements	Inability to maintain a rhythmical pattern	Inability to control force	Inappropriate motor planning	Total	Per Child
PT I												
1			1				3				4	
2			2						1	2	5	
3	1	1	1				2		1	1	7	
4	1		1				1	1		6	10	
5	1		1				2				4	
6			1				1	1		1	4	
Total	3	1	7				9	2	2	10	34	5.67
PT II												
1			1				1		1	1	4	
2	1									1	2	
3	1	7	2			2				1	13	
4	1	1	1				2	1	1	3	10	
5				3		4	1	2		2	12	
6				3	1	1		2		1	8	
Total	3	8	4	6	1	7	4	5	2	9	49	8.17
FT												
1			1			1	1	1		2	6	
2										1	1	
3		1	1			1				1	4	
4						1		1		1	3	
5										1	1	
6										0	0	
7										1	1	
8			1								1	
9			1							1	2	
10											0	
Total		1	4			3	1	2		8	19	1.90

Note. PT I = Preterm I group; PT II = Preterm II group; FT = Fullterm group.

Family Characteristics

A summary of the number of siblings for the participants as assessed by their group is provided in Table 27. Figures 17 to 19 show possible interactions of the birthtype and the number of siblings on the NDI, total scaled score of gross motor skills, and the total scaled score of fine motor skills that may have existed, as the groups' lines were not parallel and at least two lines crossed.

Table 27

Number of Siblings by Birthtype

# of Siblings	Preterm I n (%)	Preterm II n (%)	Fullterm n (%)
1	3 (50%)	2 (33%)	0 (0%)
2	3 (50%)	2 (33%)	4 (40%)
3	0 (0%)	2 (33%)	2 (20%)
4	0 (0%)	0 (0%)	4 (40%)
Total	6 (100%)	6 (100%)	10 (100%)

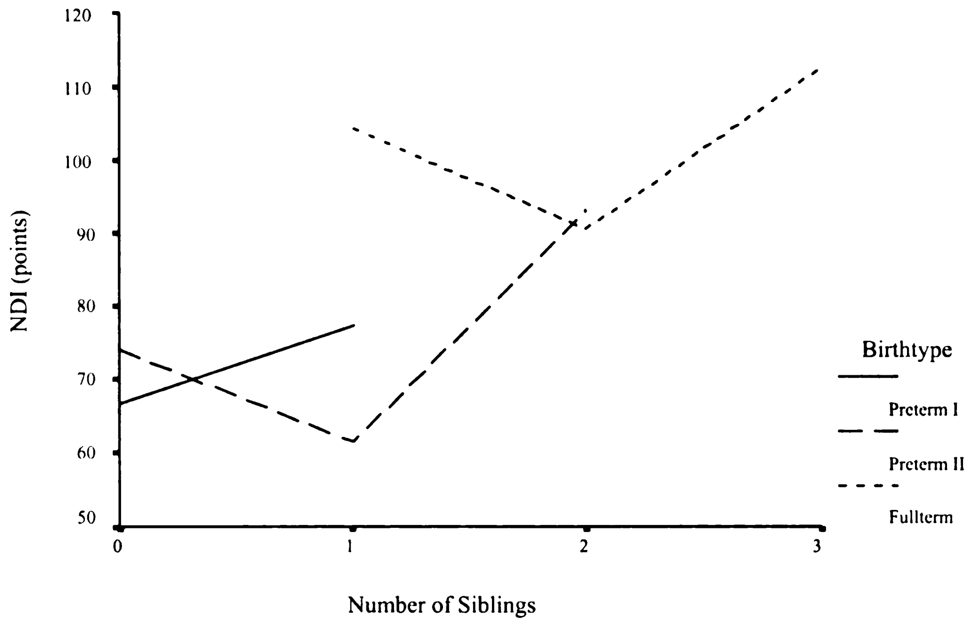


Figure 17. The mean Neuromuscular Development Indexes (NDIs) from the McCarron Assessment of Neuromuscular Development test as determined by the birthtype and the number of siblings.

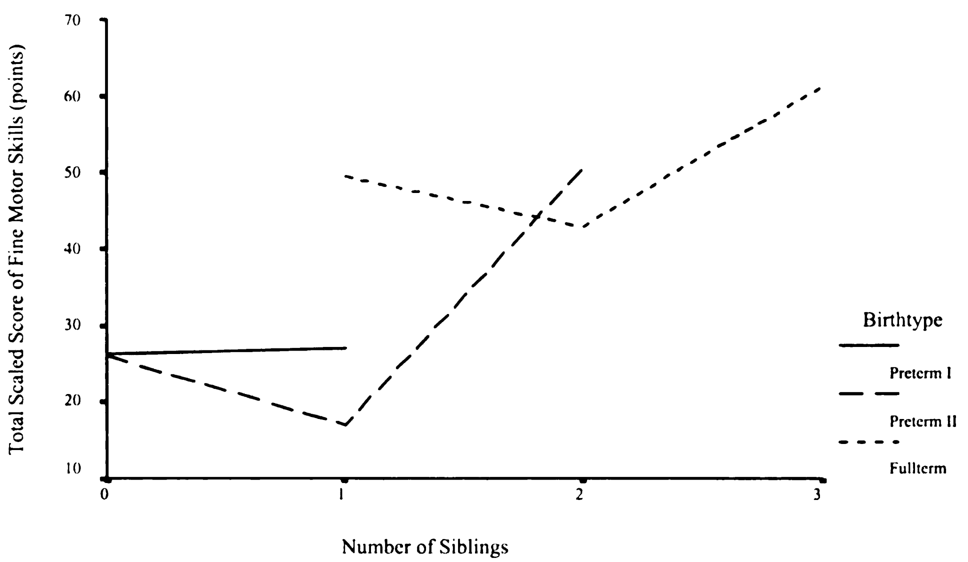


Figure 18. The mean total scaled score of fine motor skills from the McCarron Assessment of Neuromuscular Development test as determined by the birthtype and the number of siblings.

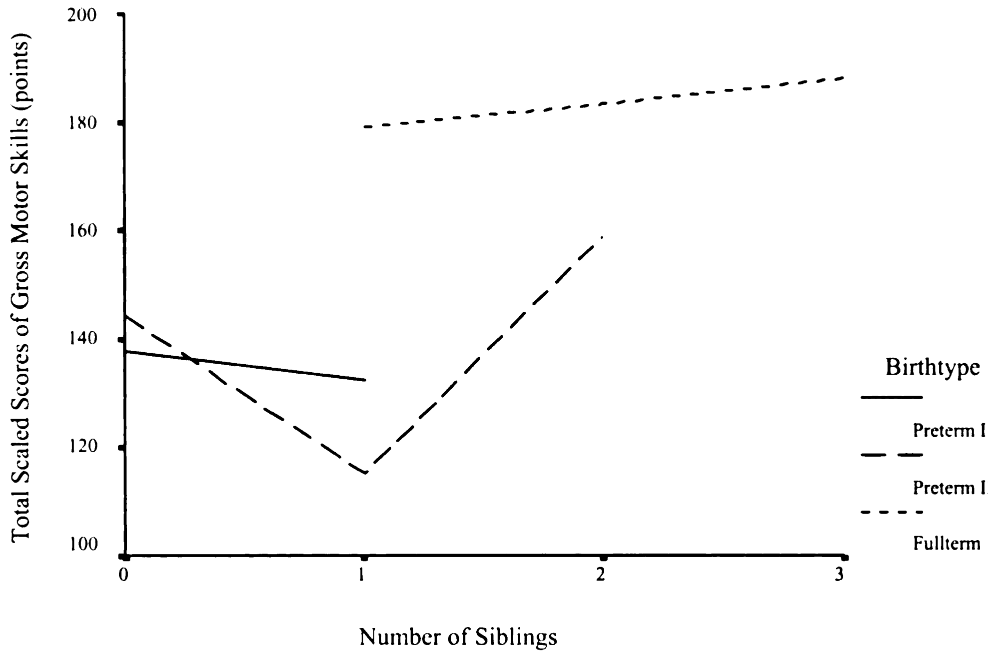


Figure 19. The mean total scaled score of gross motor skills from the McCarron Assessment of Neuromuscular Development test as determined by the birthtype and the number of siblings.

A summary of the parents' education by group is displayed in Table 28. Potential interaction of the birthtype and father's education on MAND scores may have existed as at least two groups' lines crossed each other (Figures 20 to 22). An interaction of the birthtype and mother's education on the MAND scores may have existed as at least two groups' lines crossed each other.

Table 28

Education of Parents by Birthtype

	Father			Mother		
	Preterm I	Preterm II	Fullterm	Preterm I	Preterm II	Fullterm
Education	n (%)*	n (%)*	n (%)*	n (%)	n (%)	n (%)
Some high school	0 (0%)	1 (20%)	0 (0%)	0 (0%)	1 (17%)	2 (20%)
High school degree	1(20%)	0 (0%)	1 (11%)	0 (0%)	0 (0%)	1 (10%)
Some college/technical school	1 (20%)	2 (40%)	3 (33%)	2 (33%)	2 (33%)	2 (20%)
Colleague/technical school degree	3 (60%)	2 (40%)	2 (22%)	4 (67%)	3 (50%)	1 (10%)
Graduate/Professional degree	0 (0%)	0 (0%)	3 (33%)	0 (0%)	0 (0%)	4 (40%)
Total	5 (100%)	5 (100%)	9 (100%)	6 (100%)	6 (100%)	10 (100%)

Note. * the parent of a participant from the group did not fill out this question.

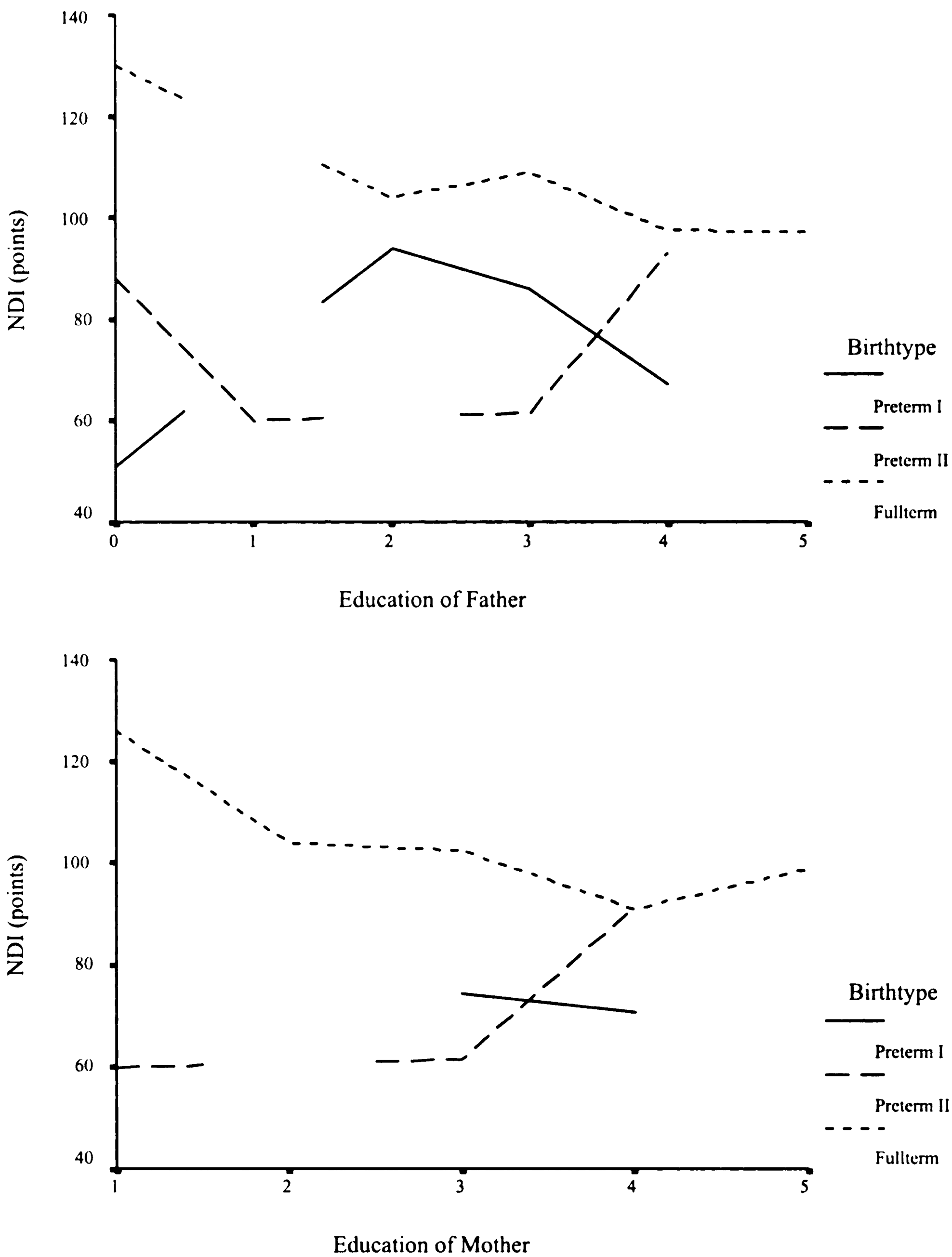


Figure 20. The mean Neuromuscular Development Indexes (NDI) from the McCarron Assessment of Neuromuscular Development test as determined by the birthtype of the children and the educational experiences of their parents. Horizontal list: 0 = missing value; 1 = some high school; 2 = high school degree; 3 = some college/technical school; 4 = college or technical school degree; 5 = graduate/professional degree.

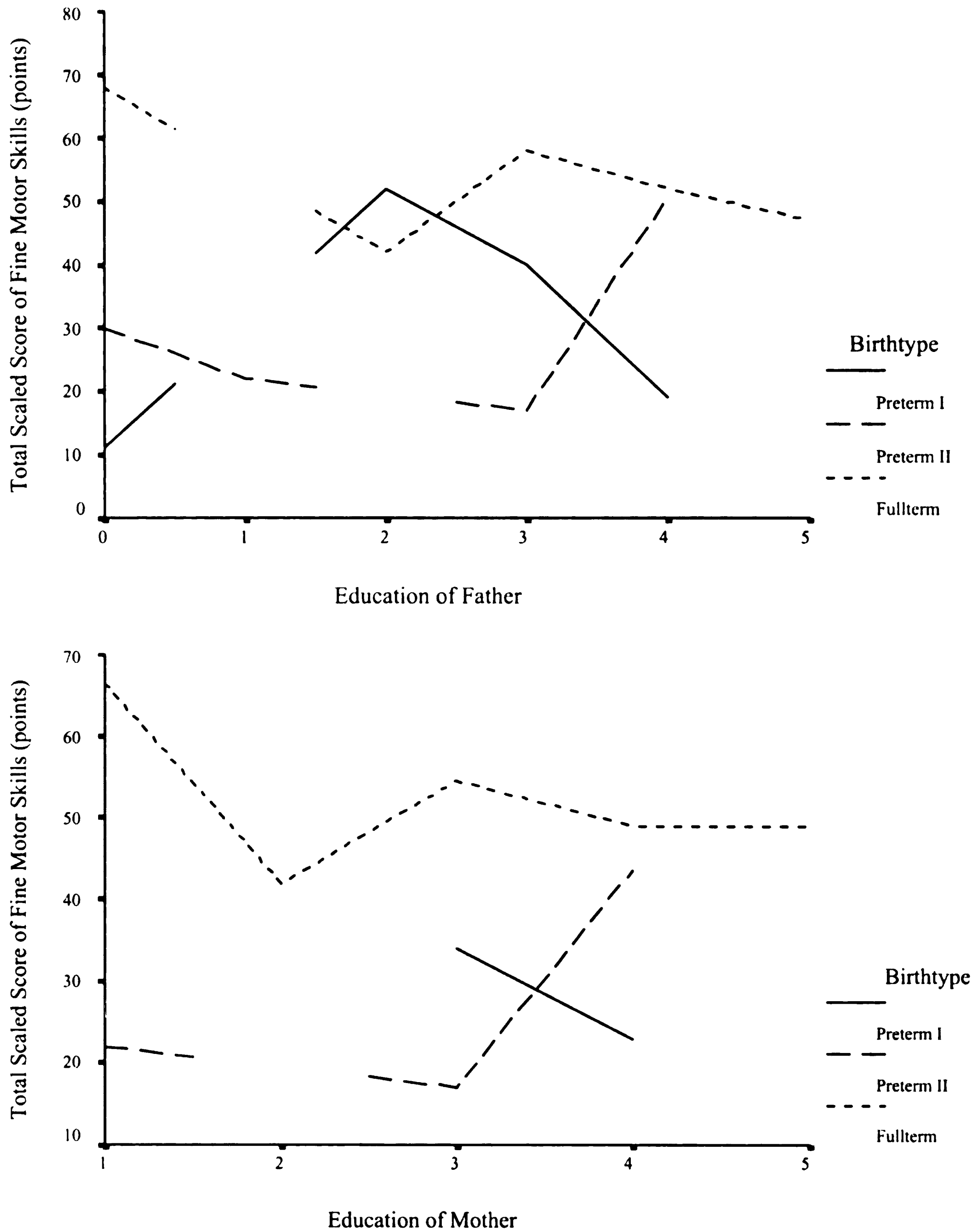


Figure 21. The mean total scaled score of fine motor skills from the McCarron Assessment of Neuromuscular Development test as determined by the birthtype of the children and the educational experiences of their parents. Horizontal list: 0 means missing value; 1 = some high school; 2 = high school degree; 3 = some college/technical school; 4 = college technical school degree; 5 = graduate/professional degree.

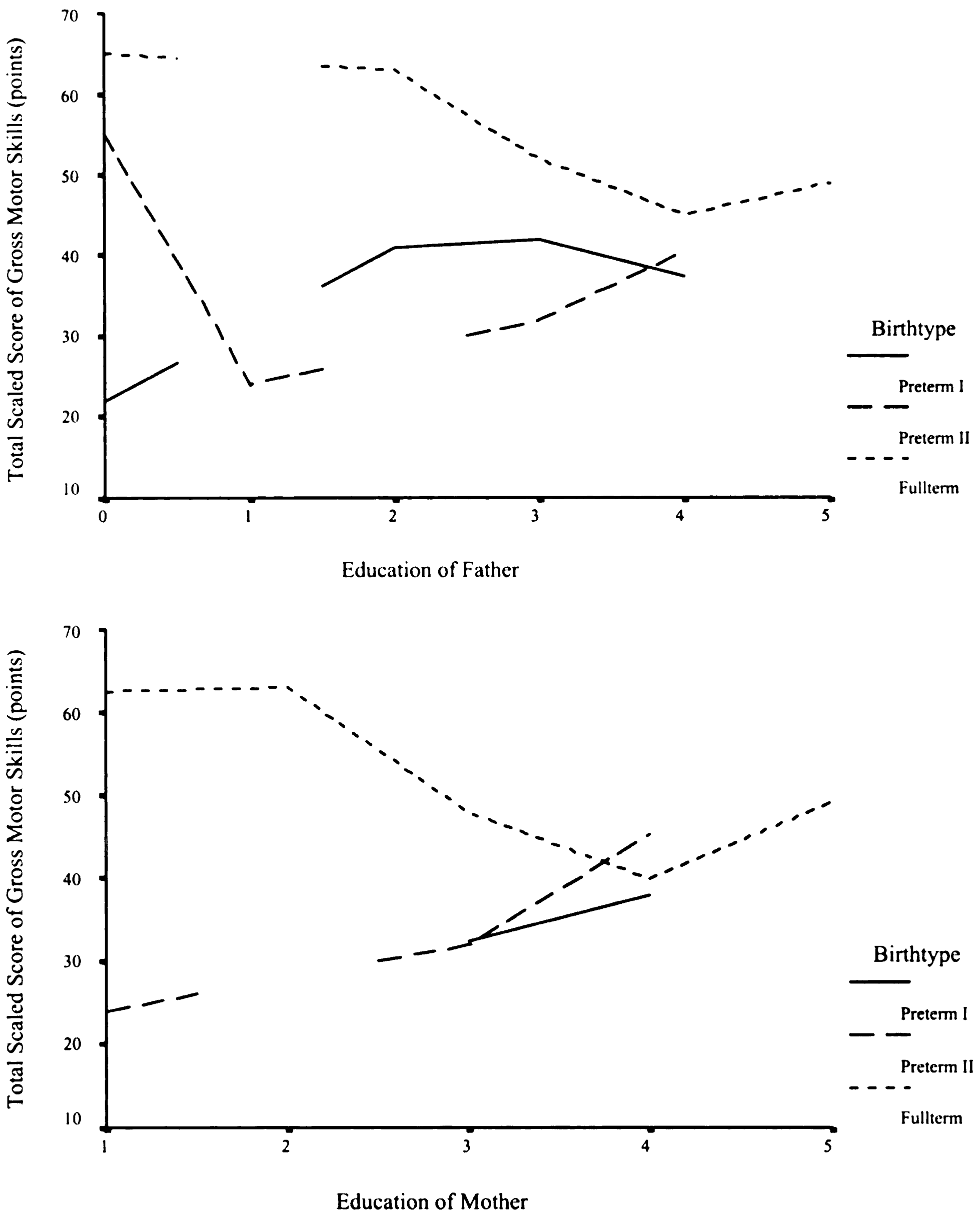


Figure 22. The mean total scaled score of gross motor skills from the McCarron Assessment of Neuromuscular Development test as determined by the birthtype of the children and the educational experiences of their parents. Horizontal list: 0 = missing value; 1 = some high school; 2 = high school degree; 3 = some college/technical school; 4 = college or technical school degree; 5 = graduate/professional degree.

A summary of the occupations of the parents is presented in Table 29. An interaction of the birthtype and the occupation of the fathers on the MAND scores may have existed, as the lines of the two groups crossed; an interaction of the birthtype and the occupation of the mothers on the MAND scores may also have existed, as the lines of the two groups crossed (Figures 23 to 25).

Table 29

Occupations of Parents by Birthtype

	Father			Mother		
	Preterm I	Preterm II	Fullterm	Preterm I	Preterm II	Fullterm
Occupations	n (%)*	n (%)*	n (%)*	n (%)	n (%)	n (%)
Corporate manager	0 (0%)	1 (33%)	5 (56%)	0 (0%)	1 (17%)	0 (0%)
Middle manager	2 (40%)	1 (33%)	2 (22%)	3 (50%)	1 (17%)	4 (40%)
School teacher	0 (0%)	0 (0%)	1 (11%)	0 (0%)	0 (0%)	0 (0%)
Service worker	3 (60%)	1 (33%)	0 (0%)	2 (33%)	3 (50%)	4 (40%)
Farmer	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Homemaker	0 (0%)	0 (0%)	0 (0%)	1 (17 %)	0 (0%)	0 (0%)
Other	0 (0%)	0 (0%)	1 (11%)	0 (0%)	1 (17%)	2 (20%)
Total	5 (100%)	3 (100%)	9 (100%)	6 (100%)	6 (100%)	10 (100%)

Note. *Father of PT I group: one did not fill out; fathers of PT II group: three did not fill out; father of FT group: one did not fill out; because of rounding, percentages may not add up to 100%.

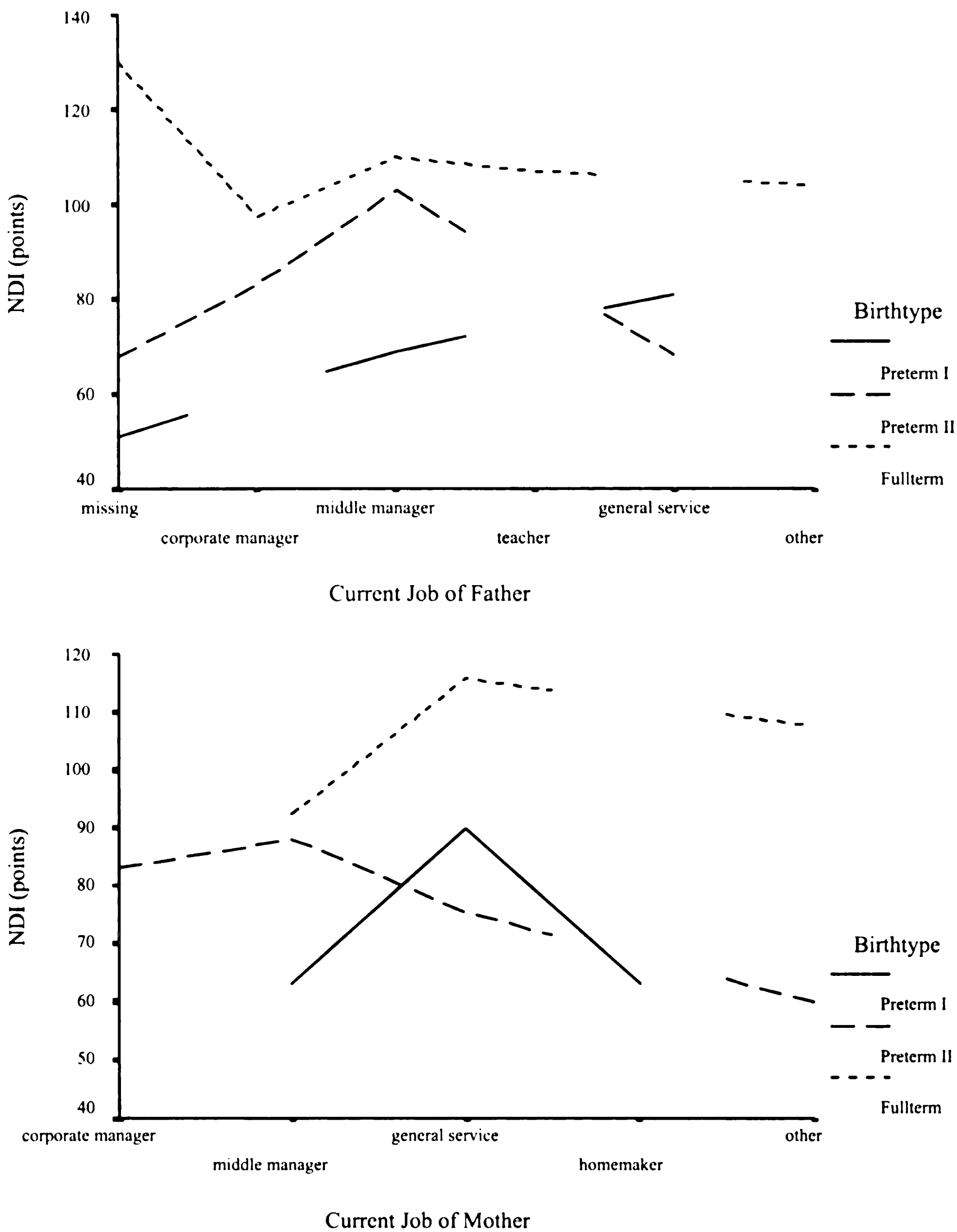
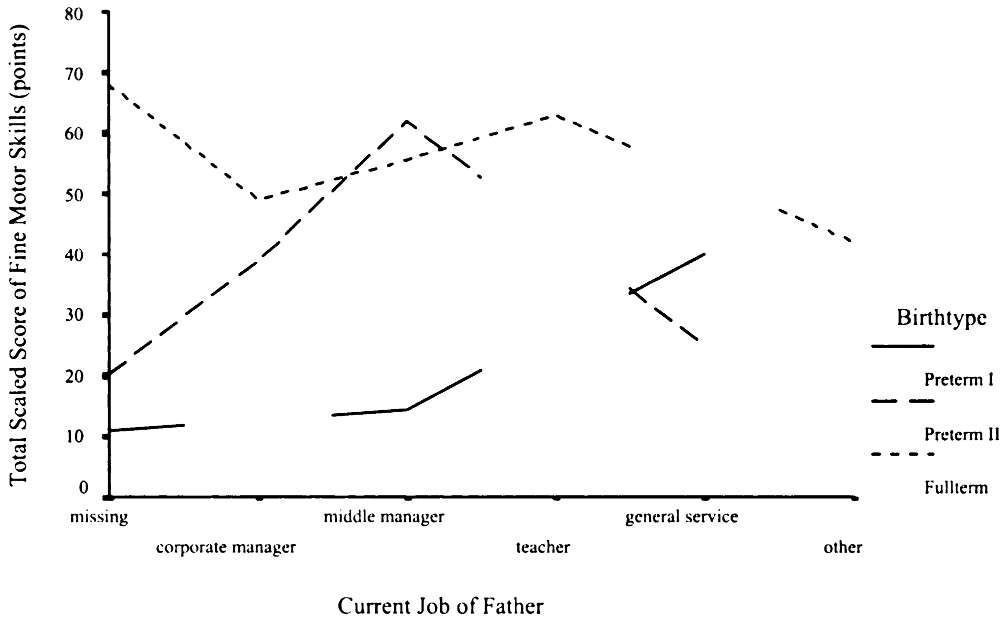


Figure 23. The mean Neuromuscular Development Indexes (NDI) from the McCarron Assessment of Neuromuscular Development test as determined by the birthtype of the children and the occupation of their parents.



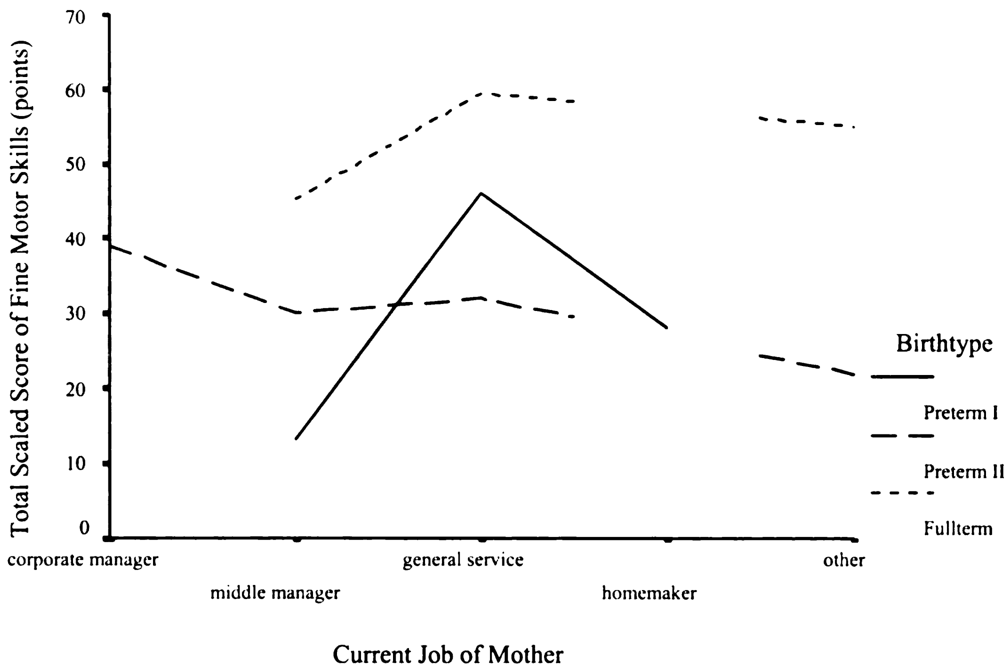
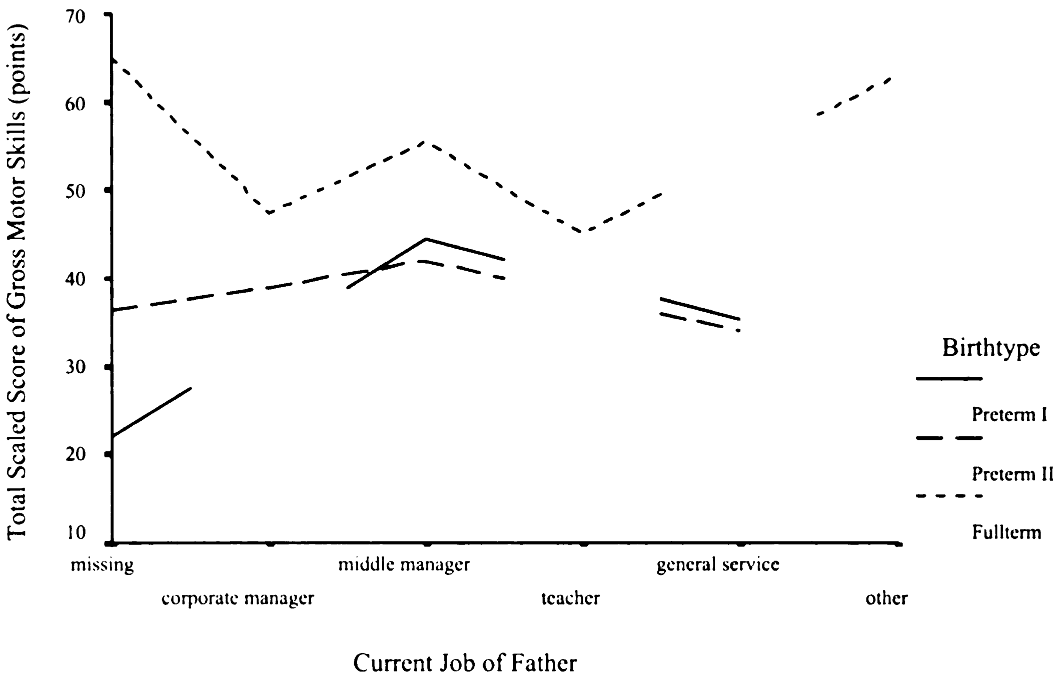


Figure 24. The mean total scaled score of fine motor skills from the McCarron Assessment of Neuromuscular Development test as determined by the birthtype of the children and the occupation of their parents.



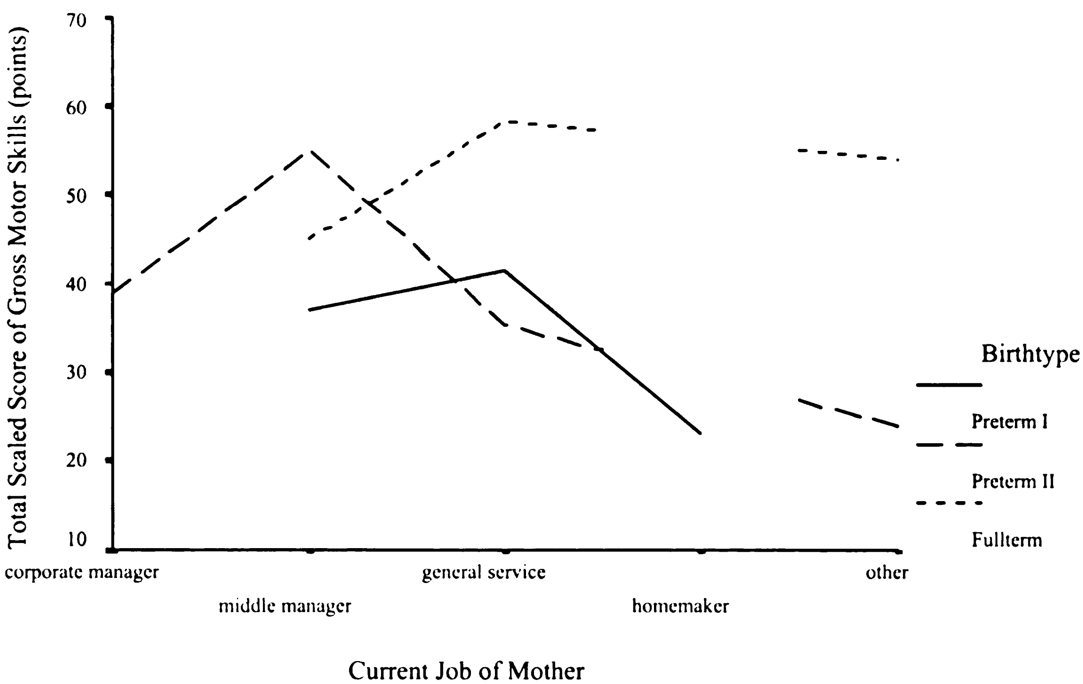


Figure 25. The mean total scaled scores of gross motor skills from the McCarron Assessment of Neuromuscular Development test as determined by the birthtype of the children and the occupation of their parents.

A summary of the family income among different birthtypes is presented in Table 30. A weak interaction of the birthtype and family income on the NDI may have existed as the lines were not parallel (Figure 26). An interaction of the birthtype and family income on the total scaled score of fine motor skills may have existed since crossed lines were shown (Figure 27). The children born in the PT groups whose family income was $60,000 - $100,000 had the highest total scaled score of fine motor skills within their group, but the children born in the FT group whose family income was $10,000 - $30,000 had the highest total score within their group. In Figure 28, an interaction of the birthtype and family income on the total scaled score of gross motor skills may have existed since the lines crossed.

Table 30

<u>Family Income by Birthtype</u>

	Preterm I	Preterm II	Fullterm*
Family Income Level ($)	n (%)	n (%)	n (%)
Under 10,000	0 (0%)	0 (0%)	1 (11%)
10,000 - 30,000	1 (17%)	2 (33%)	3 (33%)
30,000 - 60,000	1 (17%)	2 (33%)	0 (0%)
60,000 - 100,000	3 (50%)	1 (17%)	2 (22%)
Above 100,00	1 (17%)	1 (17%)	3 (33%)
Total	6 (100%)	6 (100%)	9 (100%)

<u>Note.</u> * The parents of one child from the FT group had not filled out this question; because of rounding, percentages may not add up to 100%.

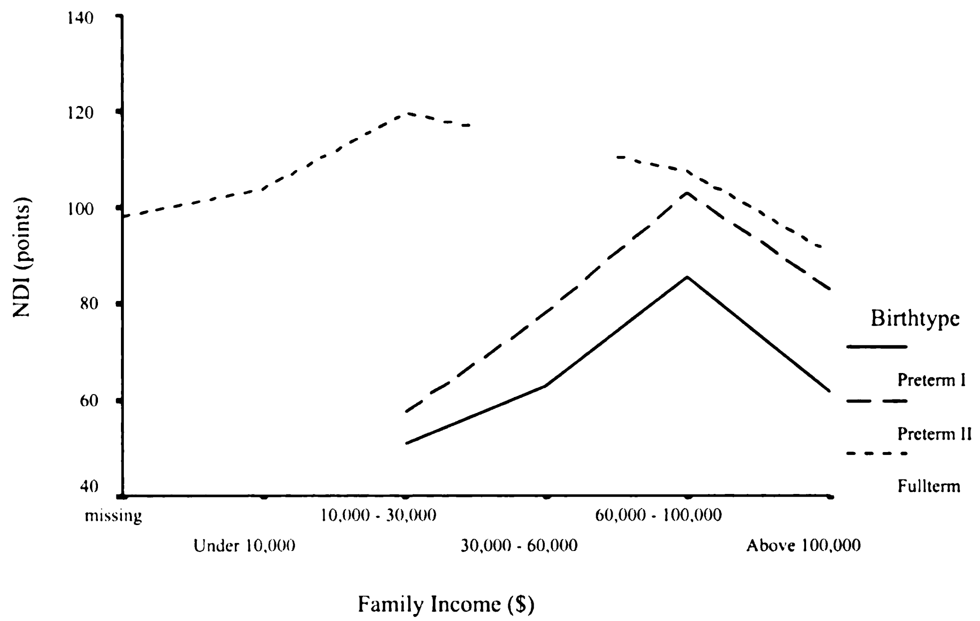


Figure 26. The mean Neuromuscular Development Indexes (NDIs) from the McCarron Assessment of Neuromuscular Development test as determined by the birthtype and the family income of each participant.

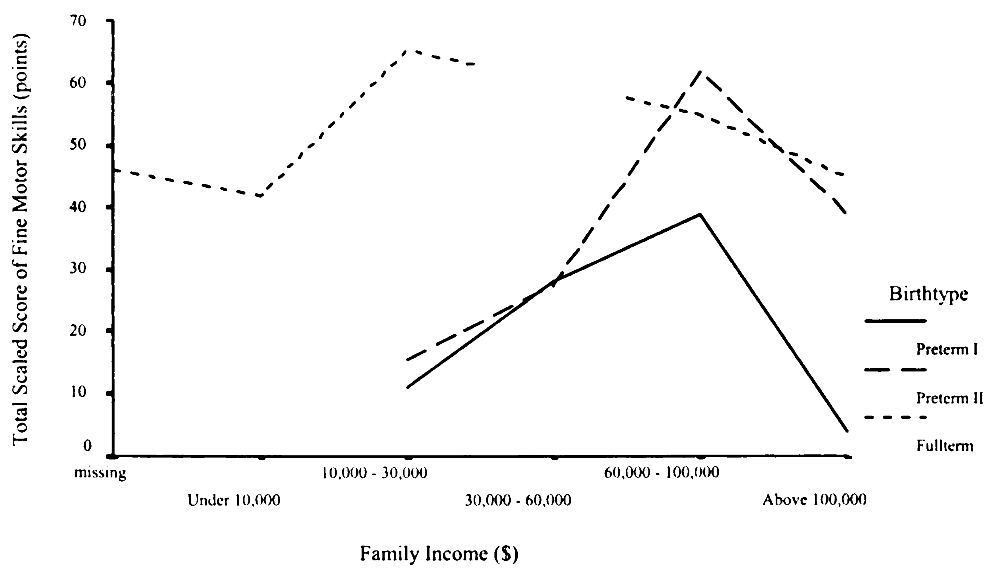


Figure 27. The mean total scaled score of fine motor skills from the McCarron Assessment of Neuromuscular Development test as determined by the birthtype and the family income of each participant.

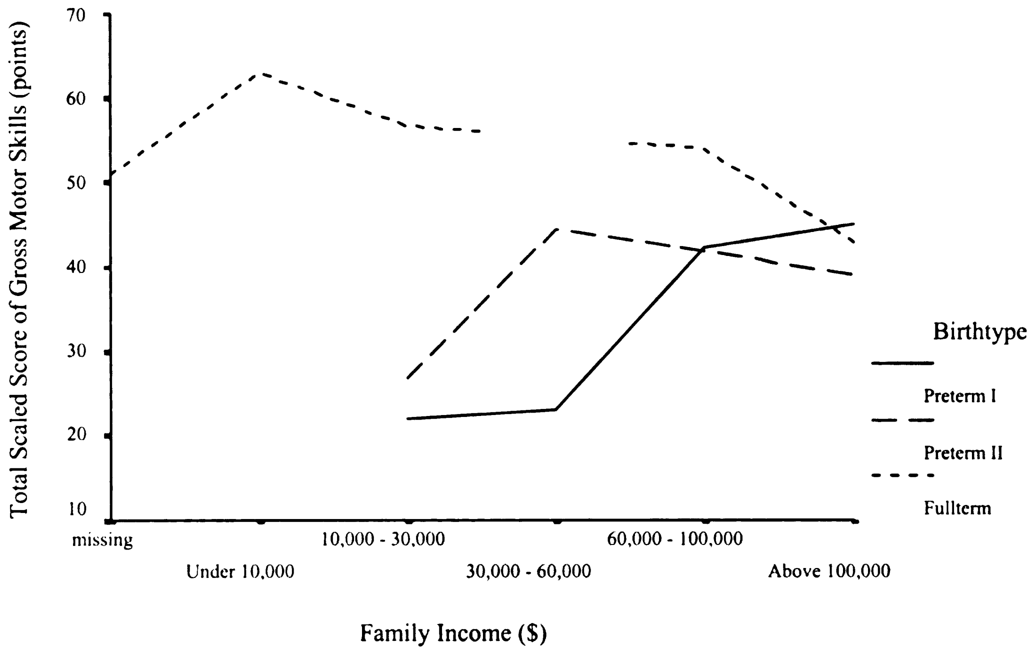


Figure 28. The mean total scaled score of gross motor skills from the McCarron Assessment of Neuromuscular Development test as determined by the birthtype and the family income of each participant.

A summary of preschool attendance and duration for different birthtypes is provided (Tables 31 and 32). No one in the PT I group went to nursery school. One PT II child at the age of 2.5 years went for 6 months to a nursery school, while another child at the age of 3 years went for 15 months to a nursery school. One child from the FT group at the age of 3 years went to nursery school for 9 months, but the parents of one child did not fill out this question. An interaction of the birthtype and the age of preschool attendance on the MAND scores may have existed since crossed lines were shown or the lines were not parallel (Figures 29 to 31). In addition, an interaction of the birthtype and the duration of preschool attendance on the MAND scores may have existed since crossed lines were shown or the lines were not parallel (Figures 32 to 34).

Table 31

Age of Preschool Attendance by Birthtype

Age of Preschool Attendance (years old)	Preterm I n (%)	Preterm II n (%)	Fullterm n (%)*
No Attendance	0 (0%)	2 (33%)	1 (11%)
2.0	0 (0%)	0 (0%)	1 (11%)
2.5	1 (17%)	0 (0%)	0 (0%)
3.0	3 (50%)	2 (33%)	5 (56%)
3.5	1 (17%)	0 (0%)	0 (0%)
4.0	1 (17%)	1 (17%)	2 (22%)
4.5	0 (0%)	0 (0%)	0 (0%)
5.0	0 (0%)	1 (17%)	0 (0%)
Total	6 (100%)	6 (100%)	9 (100%)

Note. *: The parents of one child born in the FT group did not fill out this question; because of rounding, total percentages may not equal 100.

Table 32

<u>Period of Participating in Preschool by Birthtype</u>

Period of Participating in Preschool (months)	Preterm I <u>n</u> (%)	Preterm II <u>n</u> (%)	Fullterm <u>n</u> (%)*
0	0 (0%)	2 (33%)	1 (11%)
1 – 6	2 (33%)	2 (33%)	2 (22%)
7 – 12	0 (0%)	2 (33%)	4 (44%)
13 – 18	3 (50%)	0 (0%)	0 (0%)
19 – 24	1 (17%)	0 (0%)	0 (0%)
25 – 30	0 (0%)	0 (0%)	1 (11%)
31 – 36	0 (0%)	0 (0%)	1 (11%)
Total	6 (100%)	6 (100%)	9 (100%)

<u>Note.</u> *: The parents of one child born in the FT group did not fill out this question; because of rounding, total percentages may not equal 100.

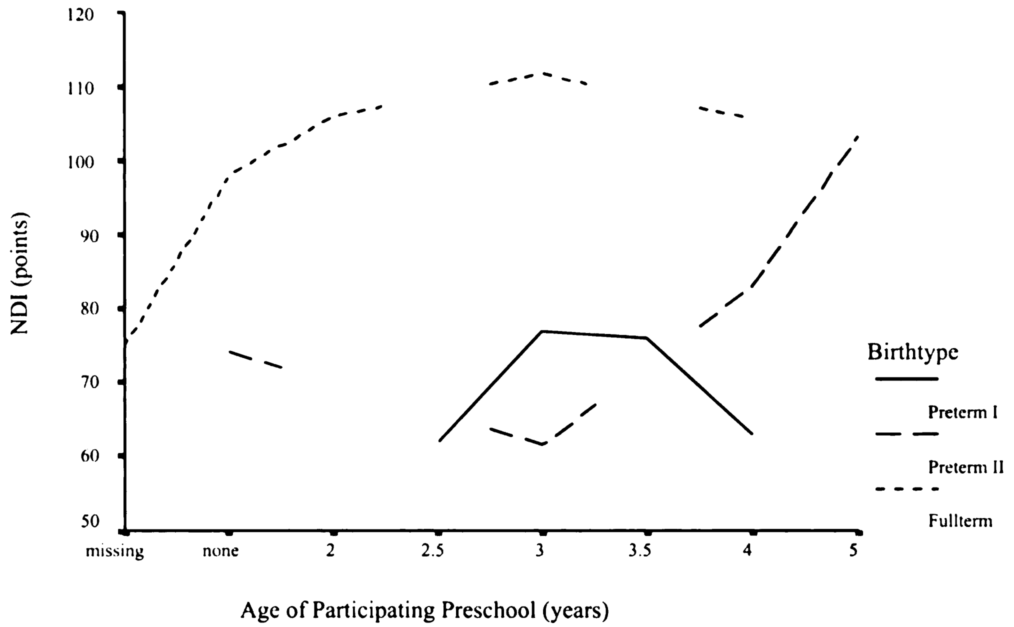


Figure 29. The mean Neuromuscular Development Indexes (NDIs) from the McCarron Assessment of Neuromuscular Development test as determined by the birthtype and at what age the child attended preschool.

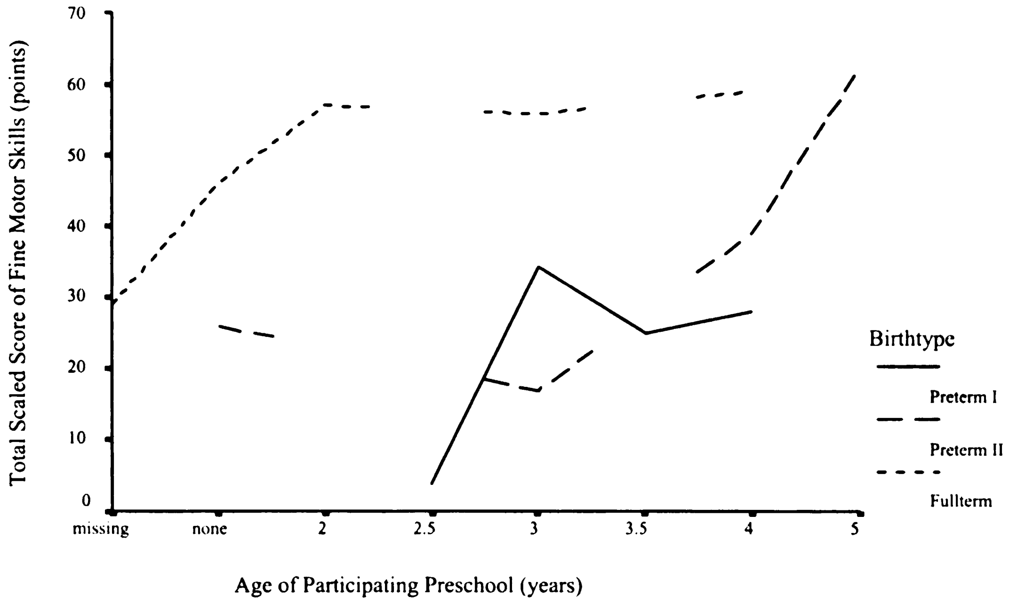


Figure 30. The mean total scaled scores of fine motor skills from the McCarron Assessment of Neuromuscular Development test as determined by the birthtype and at what age the child attended preschool.

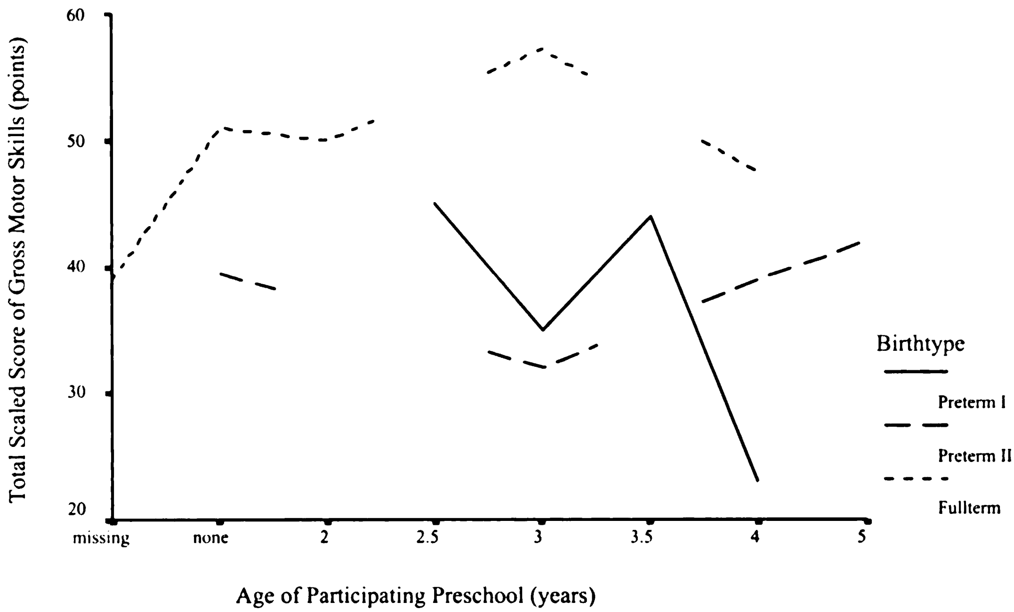


Figure 31. The mean total scaled scores of gross motor skills from the McCarron Assessment of Neuromuscular Development test as determined by the birthtype and at what age the child attended preschool.

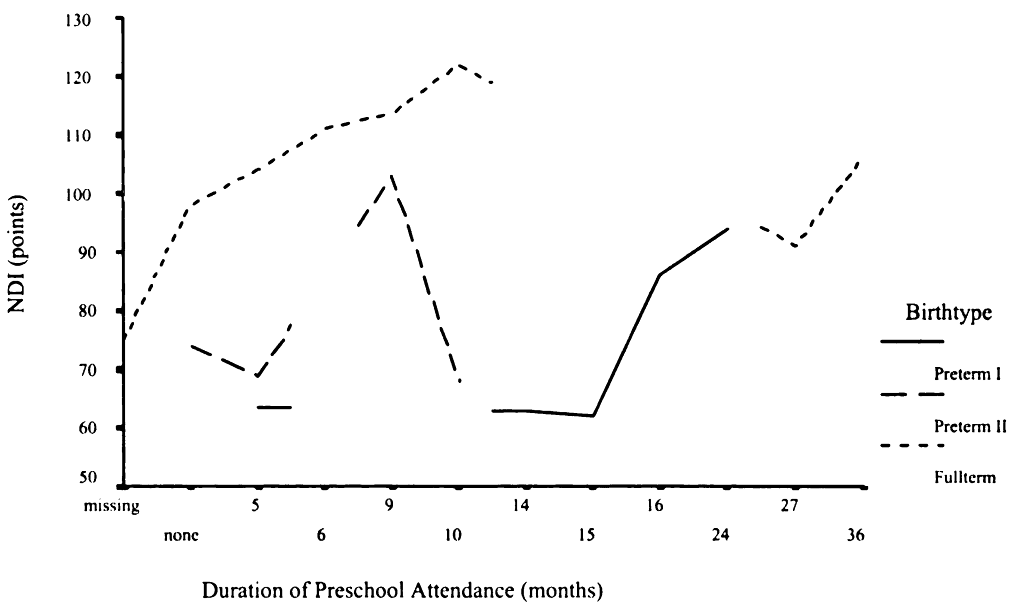


Figure 32. The mean Neuromuscular Development Indexes (NDIs) from the McCarron Assessment of Neuromuscular Development test as determined by the birthtype and the duration of preschool attendance.

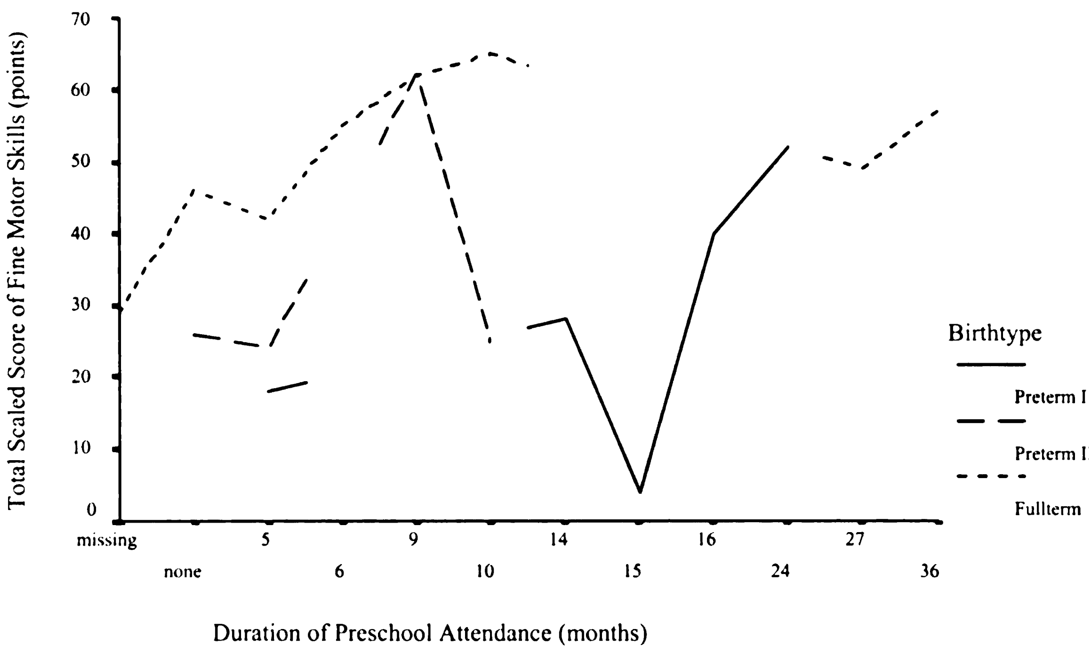


Figure 33. The mean total scaled scores of fine motor skills from the McCarron Assessment of Neuromuscular Development test as determined by the birthtype and the duration of preschool attendance.

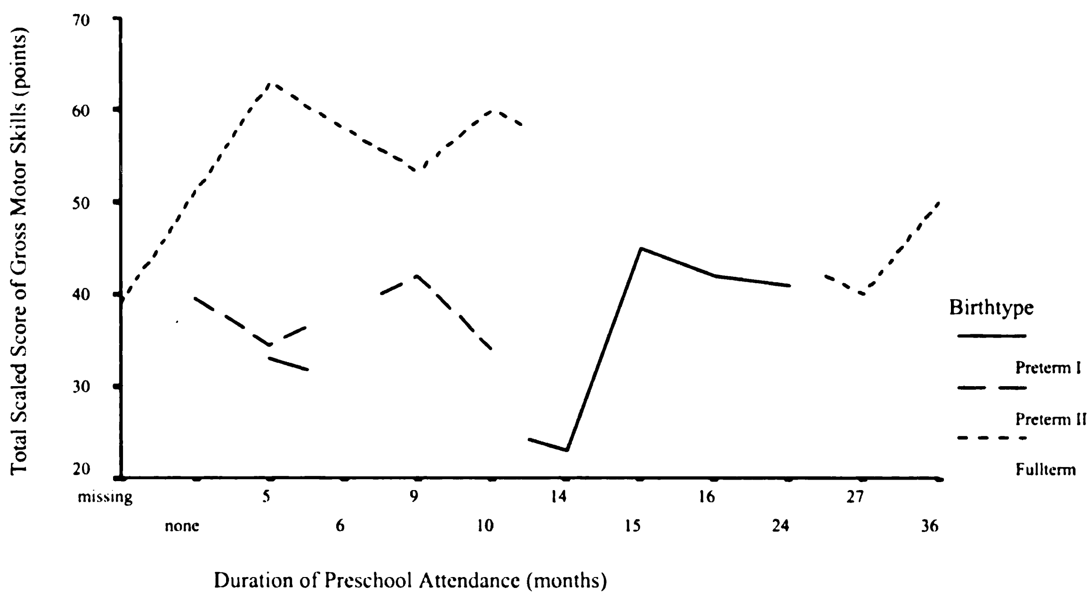


Figure 34. The mean total scaled scores of gross motor skills from the McCarron Assessment of Neuromuscular Development test as determined by the birthtype and the duration of preschool attendance.

CHAPTER 5

DISCUSSION

The purpose of this experiment was to determine the differences in the effects of motor skills, if any, of the current medical treatments on young children who were born preterm and fullterm. Beyond this purpose, formal and informal analyses were performed to aid in creating a more complete picture of the children in relation to their motor skills abilities. The possibility that the advanced neonatal treatments might have affected the motor skills of the children born preterm in the long term, compared to the children born fullterm, was the rationale. From this thinking came the methodology, testing the children of three defined birthtype groups in their motor skills abilities.

The design of the present study improved upon previous methodologies by using quantitative and qualitative data analyses of motor skills by videotaped observations. Because children were identified as AGA for each group, the children were considered to represent better the majority of children from each birthtype. However, the small sample size, large range of ages, inclusion of only homes that spoke English predominantly, and identification of children with disabilities by parents over the telephone limited this study, and made it necessary to use caution in interpreting the results. Despite these limitations, the present findings are considered beneficial information about motor skills, children born preterm who got full treatments of surfactants and neonatal steroids, and other variables beyond that of previous studies. Any future study should consider the strengths of this kind of study while attempting to minimize its weaknesses, as well as cautiously generalize the results better to the population.

The discussion in this investigation is organized under these major headings: (a) MAND; (b) MPS; (c) using adjusted age; (d) physical growth; (e) ABILITIES Index; (g) neurological soft signs; (f) family characteristics; (g) behavior during testing; and (h) experiences of motor skills testing. The current investigation helped to answer how recent neonatal medical treatments affected the long-term motor skills and behaviors of the children who were born in the PT groups in relation to the children who were born in the FT group.

Motor Performance (MAND)

This investigation found that the children born in the PT groups who had received both new medical treatments, surfactant replacement therapy and a full course of antenatal corticosteroids, had significantly lower mean NDIs and total scaled scores of gross and fine motor skills than the FT group, as determined using three separate one-way ANOVAs. As the effect sizes of the three ANOVAs were large, it meant that the relationship between the MAND scores and birthtypes might have been important. In other words, the birthtype was an important effect on the MAND scores.

The children born in the PT I group had more motor skills problems than the children born in the PT II and FT groups. The finding of this discrepancy for the children born in the PT groups, despite the use of surfactant treatments, mirrored the study by Blitz et al. (1997). Blitz et al. reported that infants born ELBW, even when corrected for age, were at risk for significant developmental problems regardless of whether they were treated with surfactants. The author speculates that those children may need to be tested for targeted outreach such as early intervention services, developmental monitoring, and parent support and education.

In the current investigation, the NDI, which is considered a measure of the general motor skills level, varied by group with the PT I (M = 72.00) and PT II (M = 76.17) groups having significantly lower mean values than the FT group (M = 104.80). Results from the current investigation are similar to many early studies (Yvonne R. Burns & Bullock, 1985; Klein et al., 1989; Marlow et al., 1989; Ornstein et al., 1991), despite children born preterm in this study were treated to new technologies and excluded those born SGA/LGA. These early studies reported that the children born preterm and/or LBW/VLBW/ELBW had more motor performance problems than the children who were born fullterm and/or NBW. McCarron (1997), who developed the MAND instrument, indicated that large discrepancies (greater than 15 points) between the NDI and the norm (100 points), or a particular factor score and its norm (100 points), should be interpreted in the clinical report as symptoms of a mild disability (values of 70 to 85 points) of neuromuscular development.

The children in this study born in the PT groups had similar scores for the NDI, MAND subtests, and each item. Although similar, the children born in the PT I group tended to receive slightly lower scores in many of the motor skills items than the children born in the PT II group. The reason might be that lower birthweights and gestational ages are related to later development of motor skills. Some researchers (Kitchen et al., 1980; Saigal et al., 1991; Teplin et al., 1991) also indicated that the children who were born weighing <1000 g had more problems in some areas, including motor skills, than the children who were born weighing 1000 - 2000 g.

The current investigation found that the children born in the PT I (M = 26.67) and PT II (M = 31.17) groups had significantly lower mean total scaled scores of fine motor skills than the children born in the FT group (M = 52.90). The current study provided evidence of children who were born in the PT groups who received modern treatments and still had problems with fine motor skills. Previous studies of children born preterm (Goyen et al., 1998; Klein et al., 1989; Schendel et al., 1997) found that some problems with fine motor skills persisted even into later childhood.

However, in the current study, the children born in the PT groups included children with mild disabilities, and all of them appeared not to have any major problems in physical activities, such as running, galloping, and fine motor skills, during the testing. However, two of the children born in the PT group had plenty of energy. The parent of one child reported that the child did not have any disabilities, while the mother of the other child told the investigator that the child showed the best behavior during the testing. Both children appeared to understand only about half of the instructions when the tester asked the child to perform the finger tapping, beads in box, and rod slide tasks. These children tried those motor skills tasks two or three times before their attention prematurely shifted elsewhere. The investigator first thought that these items might be difficult for children only 3 and a half to 4 years old. However, the pilot study showed that 3-year-old children born in the FT group did not have any problems understanding the instructions from the testers on any of the testing items.

Likewise, Goyen et al. (1998) reported that 71% of the children born VLBW who were considered neurologically and intellectually normal (IQ > 84) had below average fine motor skills scores. Another study showed that the 9-year-old children born preterm and free of neurological impairments still had fine motor skills problems (Klein et al., 1989) compared to the children born NBW. Luther (1996) reported that even "neurological-normal" children born ELBW had fine motor skills problems by 9 years of age. These studies supported the finding that children born in the PT groups had problems with fine motor skills, whether or not the children may not have been treated with surfactants and/or antenatal steroids.

The current study also supported previous studies that reported children born in the PT groups, who had modern treatments of surfactants and antenatal steroids, showed lower mean persistent control factor scores than the children born in the FT group. Elliman (1991) showed that the children born LBW performed significantly lower than the children born NBW in tests of fine motor coordination. In addition, Breslau et al. (1996) reported that children born LBW, with and without disabilities, scored significantly lower on fine motor coordination than the same age children born NBW.

The children born in the PT I ($\underline{M}$ = 50.00) and PT II ($\underline{M}$ = 84.17) groups showed lower mean bimanual dexterity factor scores than the children born in the FT group ($\underline{M}$ = 101.00). All of the children who were born in the PT I group had bimanual dexterity factor scores that were much lower than average, except for one child who was a little below the norm. The investigator indicated that the children born in the PT I group had problems with the bimanual dexterity skills, a subset of the fine motor skills. Two of the children born in the PT II group had above average bimanual dexterity factor scores. From the survey results, both of these children had similar family environments, such as parental education, two older siblings, and a higher family income. The children born in the PT II group tended to have fewer bimanual dexterity skills problems than the children born in the PT I group. However, this study involved a small number of participants, and any generalizations would require a much larger number of participants from each birthtype for any future study.

The current study found that the children born in the PT I (M = 36.17) and PT II (M = 37.33) groups had significantly lower mean total scaled scores of gross motor skills than the children born in the FT group (M = 52.10). This study also noted that the fine motor skills problems occurred more often than the gross motor skills problems. In contrast with this study, Schendel et al. (1997) stated that the gross motor skills problems occurred more often than the fine motor skills problems for children born preterm.

The children born in the PT groups in this study tended to have slightly lower mean muscle power and kinesthetic integration factor scores than the children born in the FT group. When a participant did very well on the motor skills test, the investigator mentioned the accomplishment to the parent. On a number of occasions, the parent replied that the child participated in sports. For instance, the children born in the PT groups who participated in sports and dance programs may have benefited in the motor skills that are characteristic of the programs. The heel-toe walk and the stand on one foot items are characteristic of dance programs, and participants who had been involved in dance scored higher than any of the other children born in either of the PT groups. These children may have improved gross motor skills from participating in such programs. One girl, who participated in tap dance for 3 years, had slightly above normal motor skills, such as the heel-toe walk and stand on one foot items, and those skills scores were typically higher than her other motor skills scores. Previously, Haubenstricker and Seefeldt (1986) indicated that early participation in sports and dance programs would be beneficial to the motor skills improvement of children as well as to develop the good habits of participation in physical activities. Future studies should include a survey of participation in physical activities or programs and what kinds of physical activities or programs participants have utilized. This information would be helpful in determining whether environmental factors such as the physical activities or programs had influenced the child's motor skills levels.

The children born in the PT groups tended toward lower scores for all of the MAND motor skills items compared to the children born in the FT group. The children born in the PT I group had lower mean finger tapping, nut and bolt, and finger-nose-finger scores than the children born in the FT group. The children born in the PT II group tended toward lower mean rod slide and finger-nose-finger scores than the children born in the FT group.

There were similar mean scores for jumping, heel-toe walk, and stand on one foot among the groups in the study. The study was supported by Forslund and Bjerre (1989), who stated that there were no significant differences in standing on the left leg and the heel-toe gait between the children who were born preterm and fullterm, with both groups including children born with disabilities. Conversely, the Burns and Bullock (1985) study was not supported by the current study, and reported that the children who were born preterm had significantly lower gross motor skills than the children who were born fullterm. Also, Stott (1984) reported that children born less than 1251 g had significantly lower scores than children born fullterm on several gross motor skills tasks, such as standing on the dominant leg, standing on the other leg, and toe walking. The influence of participation in sports and/or dance programs by two children who were born in the PT groups, plus the small number of participants, might have accounted for the results from this investigation.

The current investigation did not have items testing spatial orientation, but some children from the PT groups tended to have problems understanding where they had to place their finger for the finger-nose-finger item, and how they had to tap for the finger tapping item. Wolke (1999) reported a spatial orientation problem with children born very preterm with mild disabilities compared to fullterm peers. Breslau et al. (1996) studied 6-year-old children born LBW who had significantly lower spatial abilities with the same age children born NBW. Another group of researchers (Sommerfelt et al., 1998) also reported that the children born LBW without major disabilities had visuo-spatial and visuo-motor abilities problems. Sommerfelt et al. (1998) reported no statistically significant correlations between the presence of squint, the use of glasses, or performance on visual mediated cognitive and neuropsychological tests for children born LBW or NBW in their studies.

Motor Performance (MPS)

The current investigation found that the children born in the PT groups had significantly lower mean total scores of MPS and total scores of locomotor and object control skills than the FT group, using three separate ANCOVAs with the chronological age as the covariate. In addition, the effect sizes for all of them were large, which means that the birthtype affected the MPS scores. The children born in the PT groups tended to have lower means of each MPS motor skills score than the children born in the FT group, but were considered affected by the different age distributions of the groups. This investigation provided additional evidence that children born preterm had significant gross motor skills problems, for both locomotor and object control skills. Elliman et al. (1991) reported that 7-year-old children born at birthweights of 2000 g or less performed significantly lower on tests of gross motor coordination, such as being able to move from a lying to a sitting position and jumping over a knee-high cord, than the children born NBW.

This investigation found that the children born in the PT groups tended to have lower mean kicking and hopping scores than the children born in the FT group, despite direct comparisons being difficult because MPS was not an age-standardized test. These motor skills require that one leg move while the other leg is needed for support, balance, or force production, possibly creating difficulty for the children born in the PT group. The current study may be supported by Bjerre (1975), who stated that the children born preterm had problems with dynamic balance, particularly hopping. Ohlweiler et al. (1996) also found that 59% of the children who were born preterm with disabilities showed significantly less dynamic, but not static, balance as compared to the children who were born fullterm (79%). Burns and Bullock (1985) reported that the children who were born in the PT group were significantly less able to perform the kicking a ball task than the children who were born in the FT group. In contrast, Forslund and Bjerre (1989) did not support the current study of differences in the hopping task among the groups even though they included children with disabilities. However, the MPS testing instrument was not age-standardized and the mean ages among the groups in this study, were not significant, even though the FT group tended to have higher mean scores, direct comparisons were difficult. A small number of participants in this study should make careful any application of any causal generalization to other children who were born in preterm.

Using Adjusted Age

The PT groups tended to have lower mean NDI than the FT group despite using adjusted age. The PT groups had much lower total scaled scores of fine motor skills than total scaled scores of gross motor skills, using adjusted age. It could be interpreted that the children born in the PT groups had more problems with fine motor skills. Both PT groups had problems with persistent control factor scores compared to the FT group, but only the PT I group showed much lower bimanual dexterity factor scores, using adjusted age. However, using adjusted age may be a problem with the MAND instrument because it is an age-standardized test with each age interval at six months. Only some of the children born in a PT group could take advantage of their adjusted age, even then improving only some scores but not others. It would be questionable to say that adjusted age could beneficially be used with the MAND scores of the children born in the PT groups.

This investigator believed that educators and parents should consider using both the chronological and adjusted ages when analyzing scores of the children born in the PT groups. Adjusted age could provide a more accurate indicator of motor skills levels than chronological age alone. One group of researchers (Palisano et al., 1985) suggested exploring other ages for the children born preterm as needed, while Ouden et al. (1991) stated that at 2 years of age and afterward correction no longer became necessary. Despite the differing views of other researchers, Figures 14 to 16 (refer to pp. 159 – 163 in this study) showed that most of the children from the PT groups were still behind in their heights, weights, and BMIs than the FT group using chronological age. The delayed physical growth may have affected their motor skills.

Using the Pearson product-moment correlation, the height/weight with adjusted age had high correlations, while the height/weight with chronological age had moderate to high correlations. In addition, MPS skills with adjusted age had higher correlations than MPS scores with chronological age using the semipartial correlation. Using adjusted age, many children in the PT groups still had lower mean total scores of MPS and locomotor skills than the children born in the FT group (Figures 5 and 6). In other words, using adjusted age for the MPS scores still showed that the children born in the PT groups had lower MPS scores, mostly in locomotor skills.

The graph of the total scores of object control skills by adjusted age showed that the majority of the children born in the PT groups tended toward lower mean total scores of object control skills than the children born in the FT group (Figure 7). However, some children from the PT group showed better total scores of object control skills than some children born in the FT group. For the majority of children, 8 to 10 years is the peak age range for development of object control skills, whereas the peak for locomotor skills is during ages 2 to 6 (Seefeldt & Haubenstricker, 1982). In other words, some children may show more immature motor skills performances for the object control skills in this study because they were young; therefore, further longitudinal studies may be needed and/or other instruments, which could better screen for younger children, used to measure object control skills for young children.

Motor Skills and Other Variables Relationships

The MAND motor performance of the children might be related to how severe were the disabilities as well as how tall the children were in this study. The ABILITIES Index and MAND scores (using chronological age and adjusted age) were negatively moderately correlated, using the Pearson product-moment correlations. It means that disabilities may somewhat account for motor skills performance abilities, with more severe disabilities of the child showing poorer performances in the motor skills. Additionally, the height may also need to be considered for the gross motor skills performance abilities. Height and NDI/total scaled score of gross motor skills (using chronological age) were moderately correlated, using semipartial correlations. Height and adjusted age of the total scaled score of gross motor skills were moderately correlated, using semipartial correlation.

The total score of MPS and the heights of the children were moderately correlated using partial correlation. In addition, the total score of MPS and the heights of the fathers were moderately correlated by using partial correlation. The ABILITIES Index was only negative moderately correlated with the total score of locomotor skills using semipartial correlation. The weight was moderately correlated with the total score of MPS and total score of object control skills using partial correlations. It means that the ABILITIES Index and the height and weight might be related to the MPS scores. Future studies need to test the effects of physical growth and disabilities on motor performance scores along with different birthtypes.

Physical Growth and Motor Performance

The investigator found that children who were born in the PT groups were significantly shorter and weighed less than the children who were born in the FT group, using ANCOVA with chronological age as the covariate. The effect size showed that this difference was of practical significance. The BMIs among the groups were significantly different, using ANOVA. The current study was supported by Hirata et al. (1983), but not by Michelsson, Lindahl, Parre, and Helenius (1984). The investigator thought that delayed physical growth may have influenced the motor skills levels of the children who were born in the PT groups, such as the long jump task, which favors taller children. Comparing data from the CDC (2000a; 2000b; 2001a; 2001b), most of the children from the FT group were taller, weighed more (over the 50th percentile), and possessed greater BMIs (between the 25th and 75th percentiles) than most of the children of the PT group. Most of the children were below the 50th percentile when compared to the CDC data for height, weight, and BMI.

When looking at Figures 15 and 16, two of the children were outliers that may have adversely affected the calculations. One child was a boy who had the worst NDI among the children in the FT group but did well on the MPS total score compared to approximately 7-year-old children. However, this boy seemed to enjoy the testing too much, including pretending to be Buddha and appearing to be too relaxed. The other child was a girl who had a high NDI among the children and compared similarly on the MPS total score to other approximately 7-year-old children. However, other factors such as genetic and environmental factors, as well as how the child felt that particular day of testing, or the weather, could have affected the child's motor skills level. Therefore, more participants in the future study may be needed.

Not many differences among the mean heights of the parents by birthtype were found in the current study. This study did not support Strauss and Dietz (1998), who published that parents of the children born preterm were shorter than the parents of the children born in the FT group. However, semipartial correlations in the current study showed the heights of the mothers to be correlated lowly with the heights of the children, and showed a moderate correlation between the heights of the fathers and the heights of the children.

Interviewing Parents Using the ABILITIES Index

The parents aided in completing the ABILITIES Index during a telephone interview with the interviewer. The parents were asked to judge their children by certain general categories of disabilities. Despite the telephone interviews to identify children with disabilities by the parents, parents may have been too subjective toward his/her own children. For instance, one parent explained that his child was very stubborn. However, when the tester tested, she and the investigator thought that the child might have had learning disabilities. Future studies may need to identify children with disabilities using professional experts.

Neurological Soft Signs

The PT groups showed more frequent neurological soft signs than the FT group, although the PT II group appeared to have more incidents than the PT I group. The much lower number of neurological soft signs present in the FT group should be considered a more definitive body of evidence in support of the idea that birthtype was not the only significant difference for the MAND and MPS sessions.

Children in the present investigation born in the PT groups displayed extraneous movements when they performed motor skills. For example, Joseph opened and closed his mouth a little in rhythm with the finger tapping item as well as moving the finger on the non-performing hand. Burns and Bullock (1985) indicated that the age-adjusted 5-year-old children born preterm had a significantly higher incidence of small and tremor-like involuntary hand movements during activities (irregular, jerky, and overshoot) than the control group, compared to the same age children born fullterm. Forslund (1989) reported that 4-year-old children born preterm displayed more spontaneous and involuntary movements than children born fullterm.

Some neurological soft signs, like asymmetry and falling after performance, occurred more often in the PT II group while extraneous movements occurred more often in the PT I group. Loss of dynamic balance appeared once for 1 child in the PT II group while inappropriate motor planning appeared for 16 children a total of 27 times among all three groups. Neurological soft signs were 'nonpersisting over time or gradually improving with development' (Tupper, 1987); therefore, age also should be considered relative to the motor skills. For instance, extraneous movements among PT groups showed in all ages and it could be more questionable if it were found in later childhood. On the other hand, inappropriate motor planning might be common to young children regardless of the birthtype and it may disappear after later childhood if the motor skills items were used in normal daily life or through many experiences.

The FT group did not show any occurrences of several neurological soft signs, such as inconsistency in performance, asymmetry, loss of dynamic balance, falling after performance, and inability to control force. Only 2 out of the 22 children did not show any neurological soft signs, both of them being from the FT group. On the other side, the closest that a child came to having all the neurological soft signs was seven, who was from the PT II group and showed the greatest number of one neurological soft sign under the heading of perseveration. Unfortunately, not only was there too small a sample size, but finding neurological soft signs should be handled cautiously. Still, the types and frequencies of neurological soft signs could be considered in future studies. The symptoms of neurological soft signs (or clumsiness) can be improved through practice and/or age (Drillien & Drummond, 1977; Hall, 1988; Hertzig & Shapiro, 1987; Tupper, 1987). Therefore, to find out the neurological soft signs that often occur with children who were born preterm, there may be the need to do a longitudinal study of motor skills performances, with a larger sample size.

Family Environment

From the family characteristics in this study, the children in the FT group had more siblings than the children in the PT groups (Table 27). Most of the other family characteristics items appeared to be similar. More than half of the mothers and fathers from each group had more than some college or technical school. Sixty-seven percent of the PT I group reported at least $60,000 of household income, 35% of the PT II group reported $60,000 or more, as did 55% of the FT group. Most of the children from each group participated in preschool before 12 months. It appeared that the families involved in the study were well-educated and possessed average/above average income. On the other hand, the parents who responded to the survey may have been so interested in their child's motor development that they were willing to spend the time and effort to read the five pages of the consent form, with specific directions from Sparrow Hospital, and participate in the study. The children who were born in the PT groups still showed motor skills problems, even though they had parents who were more highly educated, came from a good income family background, and underwent new medical treatments as neonates. Figures 17 to 34 show that at least one pair of lines crossed each other for the birthtype and an item on the family characteristics list. Future studies may need to analyze statistically for interactions between the birthtype and the family characteristics using a much larger sample size.

Behavior during Motor Skills Testing

The investigator felt that the children from the PT groups either were more likely to be shy, quiet, and non-expressive, or were more likely to be hyperactive than the children born in the FT group. Sajaniemi et al. (1998) partially supported the current study by reporting that 2-year-old infants born preterm (1989 - 1991, and possibly treated using modern medical technology) were significantly less active, more adaptive, more positive in mood, less intense, and lower in threshold response than infants born fullterm.

The investigator also felt that two children from the PT group showed impulsiveness, aggressiveness, and disorganization, noted as being symptoms of disturbances, while none of the children born in the FT group appeared to exhibit these behaviors. The hyperactive children born in the PT groups in the current study also displayed a diversity of emotions from happiness to crying, and changed their emotions nearly continuously throughout the testing. They showed aggressive behavior, like breaking equipment, and did not always follow directions during the motor skills testing (despite the parent of one child who was extremely happy and told the investigator that she saw her son's "best behavior" during the testing). The emotional instability of the children who were born preterm was supported by Allen, Donohue, and Dusman (1993). Moreover, the children who were born VLBW were more overactive, more easily frightened (all typical of emotional disorders), and more behaviorally problematic than the children who were born fullterm (Marlow et al., 1989).

The investigator found, from the data analysis of the motor performance testing, that the children born in the PT groups were less likely to follow directions during motor skills testing, more likely to lose their concentration by talking about things unrelated to the motor skills tasks, or more likely to be distracted from the current task, than the children born in the FT group. Previous studies of children born LBW (Naomi Breslau et al., 1996) or preterm (Allen et al., 1993) supported the current study in that the children born LBW/preterm were reported as having attention deficits. Breslau et al. (1996) also reported that 6-year-old children born LBW scored significantly lower than the children born NBW on attention abilities. Dunn et al. (1980) stated that most of the children born preterm, who weighed less than 2000 g at birth, had IQ scores in the average range, and were clinically diagnosed with attention deficits.

The investigator observed behaviors while watching the videotape of the testing that might prove beneficial to future studies for analysis of behavior during the motor skills testing. Shyness, crying, and distraction appeared with the children of the PT groups who received some of the lowest motor performance scores. Future studies should include analysis of the behaviors during motor skills testing and clarify whether certain behaviors may be correlated to specific motor skills problems or identify difficult motor skills associated with certain behaviors among younger age children.

Experience of Motor Skills Testing

This study was originally based on results from a pilot study. Even though the pilot study only included children born in the FT group, the investigator believed that the testing environment had remained very much the same for all of the children. The diversity of behaviors, such as running away, not following directions, looking for the parents, and wanting to do other motor skills activities suggested that the reaction to the testing environment might have been different for each individual child. The strongest behaviors, such as crying, yelling, and aggressiveness, came from the children born in the PT groups, and required more effort on the part of the tester to manage.

When the testers used sounds for certain motor skills tests, such as the galloping item (neighing like a horse) or the beads on rod item (saying "Whoop" for each bead placed on the rod), the children who had not been following instructions before started following directions far better. The testers would then continue using the sounds to induce the children to participate in the remainder of the testing. Using sounds with activities could be advantageous for children learning motor skills with more enjoyment.

The investigator speculates that all of the children could benefit from participating in a dance and/or sports program early in their young lives. Despite what was learned in the study, the investigator believes that more participants are needed for an even clearer understanding of motor skills development and other variables tested. A cross-sectional and/or longitudinal study may also be needed, and a specific program for intervention may need to be developed. Future studies should determine how children born in the PT group develop motor skills as they age. In addition, the fine motor skills remain a problem for the children born in the PT groups, so participating in a program with fine motor skills intervention might be beneficial to the children born in the PT groups.

Through informal conversations with the parent(s), the investigator also found that the children who participated in a motor skills program and were from either the PT or FT groups were less frustrated if their performance was inconsistent at times. For instance, the girl or boy from the PT groups who participated in sports/dance programs missed the ball when striking or kicking, but did not mind. This was in contrast to the children from the PT groups who were frustrated or did not want to perform after failing at the same task. Future studies may need to consider a survey of physical activities (programs) that the child participates in, both at home and away from home, including a family characteristics survey, in addition to motor skills testing.

Children who participate in sports/motor skills programs may gradually learn skills as well as a diversity of ways to practice those motor skills. During intervention programs, the researchers may be able to figure out how behavioral problems occur and whether they are partially solvable through active programs. For example, one mother told the investigator that her child experienced his best behavior during the motor skills test, and the mother was very happy. Gillberg (1985) suggested that utilizing a qualitative approach yielded a greater understanding of motor development and functional performance that might benefit the design of intervention services.

Children from the PT groups who did participate in specific dance or sports programs tended to show positive results with specific gross motor skills scores, yet their fine motor skills scores appeared not to be affected. Therefore, children born in the PT group may either need to participate in an intervention program that emphasizes more fine motor skills, or the educators or physicians could give some fine motor skills activities instructions to the parents for the children to practice at home.

Future studies need to test for potentially influential variables separately or in combination with the birthtype on motor skills scores. There is a need to identify at-risk infants at an early age, as it is only through early identification that one can determine any benefits of early remedication (Piek, 1998). In addition, Seaman and DePauw (1989) suggested that using appropriate instruments is critically important because accurate and meaningful decisions can be made for intervention needs, program planning, performance objectives, and placement. Therefore, it is imperative to review the instruments for investigating motor performance of children who were born preterm. Both the MAND and MPS test instruments seemed to distinguish motor skills levels well enough to find significant differences among the groups despite that the investigator assumed that early age differences for object control skills may be difficult to tell using the MPS test.

Some of the children born in the PT groups had difficulty understanding and/or performing some motor skills, but not one of them appeared to have any severe disability with their physical activities or body movement. The children typically tried several times before losing concentration. Therefore, the investigator believed that few children born in the PT groups might have some cognitive area problems or slight learning disabilities. However, the children born in the FT group did not have any problems understanding the motor skills items from both testing instruments explained by the tester. Lie (1994) indicated that preschoolers born VLBW with no major disabilities differed in cognitive development from NBW. The children born ELBW and VLBW had significantly lower mean IQs than the children born in the Fullterm group, (Kitchen et al., 1980; Saigal et al., 1991; Teplin et al., 1991). Wolke (1999) also reported preterm cognitive problems, whereas Hack et al. (1994) reported that children born VLBW and ELBW had cognitive area problems. In future studies, it may be relevant to obtain a measure of cognition to determine if there is a correlation with motor skills development.

CHAPTER 6

SUMMARY AND RECOMMENDATIONS

The purpose of this study was to investigate the motor skills levels of children ages 3.5 to 7 years born in the PT (who received a full course of antenatal corticosteroids and surfactants) and FT groups. Three groups were defined in this study: (a) The children born in the PT I group ($\underline{n} = 6$) included birthweights equal to or below 1000 g and gestational ages of 24 to 28 weeks; (b) the children born in the PT II group ($\underline{n} = 6$) included birthweights from 1001 to 1500 g and gestational ages of 29 to 34 weeks; and (c) the children born in the FT group ($\underline{n} = 10$) included birthweights from 2300 to 3800 g and gestational ages of 38 to 41 weeks.

The hypotheses (H) and research questions (RQ) were developed to answer specific objectives in this study for the PT I, PT II, and FT groups. These objectives were to determine the differences in motor skills levels among the three groups and the relationship of the physical growth of the children. In addition, what kinds of neurological soft signs appeared among the three groups were used to determine if there were any differences in the types of neurological soft signs and their frequencies. The potentially influencing variables (e.g., physical growth, adjusted age, total ABILITIES Index, the heights of the parents, and duration of participation in preschool) to motor skills scores beside birthtype were also answered.

All of the child participants satisfied the criteria of being between 3.5 and 7 years old, singletons at birth, with no moderate-to-severe neurological impairments present (as determined by the ABILITIES Index). The children with short-term physical therapy or minor surgery were included, but those who were given grades III – IV of intraventricular hemorrhage as infants were excluded.

The McCarron Assessment of Neuromuscular Development (MAND) and the Motor Performance Study (MPS) were used to test participants in their motor skills abilities. The MAND was divided into the total scaled score of fine motor skills and the total scaled score of gross motor skills, in addition to the composite Neuromuscular Development Index (NDI). The MPS had its own total score of MPS, plus it was divided into the total score of locomotor skills and the total score of object control skills.

Procedures in this study included: (a) obtaining permission to test participants from Michigan State University and Sparrow Hospital; (b) identifying participants by Dr. Karna and other physicians from Sparrow Hospital; (c) sending letters from Dr. Karna and the investigator with self-addressed stamped envelopes and participant return cards; (d) following up with surveys and consent forms, and telephone interviews to determine if the children satisfied the criteria; and (e) testing the children, measuring their heights and weights, and measuring the heights of the parents in the laboratory.

Statistical analyses included one-way ANOVAs and ANCOVAs, as well as correlations (including the Pearson product-moment, partial, and semipartial). Significance for each of the tests was taken at $p < .05$. The NDI, total scaled scores of gross and fine motor skills for the MAND, and BMI used four separate one-way ANOVAs. Because the MAND instrument was age standardized and the BMI did not need to be controlled by age, they used ANOVAs. When a significant difference was detected with an ANOVA, the post hoc Scheffé test for pairwise differences was used as for follow-up analysis, and then the effect size was calculated to provide an idea of the practical significance of the result.

The total score of MPS, total scores of locomotor and object control skills, height, and weight used ANCOVAs, with chronological age as the covariate. The MPS instrument was not age standardized and height and weight did change with age, thus the use of chronological age as a covariate was necessary. When a significant difference was detected with an ANCOVA (with chronological age as the covariate), then a pairwise comparisons analysis was used, and the effect size was calculated to provide an idea of the practical significance of the result.

The Pearson product-moment correlations were used with the MAND scores, adjusted age of MAND scores, BMI, ABILITIES Index, heights of the parents, and duration of participation in preschool. Partial correlations were used with the MPS scores, height, and weight. Semipartial correlations were used between the MAND scores/BMI/ABILITIES Index/heights of the parents and the MPS scores/height/weight.

Conclusions

Significant differences existed within the areas of the MAND and MPS. The MAND scores showed significant birthtype differences. The NDIs and total scaled scores of fine and gross motor skills were significantly different between the PT and FT groups. The effect sizes for the MAND scores were large, which meant that birthtype was an important effect on the MAND scores. The MPS scores displayed significant birthtype differences. The total scores of MPS, locomotor, and object control skills were significantly different between the PT and FT groups. The effect sizes for the MPS scores were large, which meant that birthtype was an important effect on the MPS scores.

The PT groups used adjusted ages and tended to remain different from the FT group in certain areas. The children born in the PT I group (M = 78.17) had a tendency to have lower mean NDIs than the children born in the FT group (M = 104.80), using adjusted age. The children born in the PT I group (M = 30.33) had a lower mean total scaled score of fine motor skills than the children born in the FT group (M = 52.90), using adjusted age. The PT groups still tended to have lower mean total scores of MPS and total scores of locomotor skills than the FT group, looking at the figures despite the difficulty in direct comparisons.

Adjusted age was more correlated with the MPS scores, height, and weight than was chronological age. The heights of the fathers and heights and weights of the children were moderately correlated. In general, birthtype was an important factor for the motor skills scores, but the height and ABILITIES Index could not be ignored as factors, showing height and weight to be moderately related to some of the MAND scores as well as MPS scores. A future study is still needed to determine how much of a role these factors play.

The children who were born in the PT group tended to possess more evidence of neurological soft signs than the FT group. Inappropriate motor planning was the most prevalent neurological soft sign for all three birthtype groups. The children who were born in the PT I group were more likely to show extraneous movements. The most frequent soft signs for the children who were born in the PT II group were perseveration, falling after performance, and asymmetry.

The investigator's experiences with the behavior of the children during the motor skills testing were as follows: the PT groups were more likely to be shy, quiet, and non-expressive, or were more hyperactive than the FT group; and the PT groups were less likely to follow directions during the testing, or more likely to lose their concentration from the current task, than the FT group.

Educational Implications

Implications for Teachers

The children who were born in the PT group had some motor skills problems, such as asymmetry of movement. Future studies need to explore the experiences of the motor skills that the children enjoyed and performed well. Some ideas to keep in mind:

1. Striking seemed to motivate many children. Some of them made sounds when they struck the ball, and they appeared to enjoy the task (usually smiling, sometimes executing a small jump).

2. Incorporating some sounds during the motor skills activities seemed to help the children participate, such as in galloping (neighing like a horse in our case).

3. A combination of factors such as not participating in motor skills programs, poverty, and an absent father appeared to influence the children born in the PT group toward delayed maturity in some motor skills.

4. Preschool and early elementary school teachers should include physical activities in their regular curricula so that the children born preterm and fullterm who may or may not have participated in dance and/or sports programs would be facilitated in the development of certain motor skills.

5. The assessment of motor skills, cognitive maturity, and behavior for the children born preterm needs to consider chronological and adjusted ages in order to understand overall development of children born preterm.

Implications for Parents and Caregivers

1. The parents must be educated about the importance of physical activity for their children. The parents of the children born preterm should know that their children need to be involved regularly in systematic physical activities.

2. The caregivers should be instructed in the types of activities in which they and the children could engage in at home.

3. Parental involvement in exercising with their children may have a positive influence, encouraging children to participate in, and develop, their motor skills.

Implications for Administrators

1. The school administrator should try to provide current information relative to the children born preterm and the motor skills to the teachers and parents.

2. The school administrator should try to encourage the teachers, researchers, and parents to work with the children born preterm who have delayed motor skills.

3. The school administrator should encourage the teachers and parents to participate in their children's intervention programs.

Implications for Parents, Educators, Researchers, and Therapists

1. The medical and special education practitioners need to know the relationship between prematurity and birthweight. For example, a physical therapist who teaches a child who was born preterm but only knows that the child was born preterm does not fully understand all the ramifications. The physical therapist should ask the parents for detailed information relative to the prenatal condition and any birth defects. This detailed medical information will help the therapist understand the child and give better directions.

2. Everyone involved needs to integrate working together to better teach and educate the children born preterm. For example, a physical therapist may have assisted many individual children who were born preterm; this information may be helpful to physical activity specialists in developing intervention programs for the children.

<u>Recommendations for Studies</u>

Suggestions for future research that are based on the experience and findings of the present study are:

1. A larger sample size is required for studying the children born in preterm, to represent the population more appropriately.

2. A selection of some case studies with very similar environmental, socioeconomic, and physical growth backgrounds might be necessary to illustrate better the differences in motor skills levels of the children born preterm and fullterm.

3. Testing the children born preterm after having participated in a motor skills intervention program may help to find out what motor skills are still delayed and/or which can be quickly improved.

4. Longitudinal studies for the children born preterm are necessary as this research studied 3.5- to 7-year-old children born preterm and fullterm. It is uncertain whether the children born preterm will catch up to the children born fullterm for their ages in some motor skills that they did not perform well at their current ages. If the children born preterm show no catch up in certain underdeveloped motor skills, then the educators or parents should more actively teach the skills to the children.

5. More study of motor development, cognitive, and behavioral areas for the children born preterm using adjusted and chronological ages is needed. These studies are

to aid in understanding better the role that adjusted age plays in comparison to chronological age. For example, before identifying any child who was born preterm with labels such as mild mental retardation, professionals review results based on adjusted age.

6. Good intervention and motor development programs for the children born preterm need to be developed. Research needs to include surveys of detailed personal experiences from the children born preterm for the occupational therapists, doctors, physical therapists, parents, teachers, and other educators who may be involved.

7. This study included only one category of the participant, children born preterm who were treated with surfactants and a full course of antenatal steroids. Future studies need to find out the level of motor skills for the children born preterm treated without antenatal steroids but including surfactant treatment in order to compare to the previous group, or even without any treatment.

8. The effects of various types of physical activities on the motor skills scores of the children born preterm needs to be examined. Examples include structured sports activities, free play, dance classes, and recreational programs.

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APPENDICES

APPENDIX A

Approvals from the Institutional Review Board of Michigan State University

MICHIGAN STATE
UNIVERSITY

September 8, 2000

TO: Crystal F. BRANTA
134 I.M. Sports Circle

RE: **IRB# 00-540** CATEGORY:2-E,F

APPROVAL DATE: September 8, 2000

TITLE: PILOT STUDIES: MOTOR PREFORMANCE OF CHILDREN BORN PRETERM AND FULLTERM

The University Committee on Research Involving Human Subjects' (UCRIHS) review of this project is complete and I am pleased to advise that the rights and welfare of the human subjects appear to be adequately protected and methods to obtain informed consent are appropriate. Therefore, the **UCRIHS approved this project.**

RENEWALS: UCRIHS approval is valid for one calendar year, beginning with the approval date shown above. Projects continuing beyond one year must be renewed with the green renewal form. A maximum of four such expedited renewals possible. Investigators wishing to continue a project beyond that time need to submit it again for a complete review.

REVISIONS: UCRIHS must review any changes in procedures involving human subjects, prior to initiation of the change. If this is done at the time of renewal, please use the green renewal form. To revise an approved protocol at any other time during the year, send your written request to the UCRIHS Chair, requesting revised approval and referencing the project's IRB# and title. Include in your request a description of the change and any revised instruments, consent forms or advertisements that are applicable.

PROBLEMS/CHANGES: Should either of the following arise during the course of the work, notify UCRIHS promptly: 1) problems (unexpected side effects, complaints, etc.) involving human subjects or 2) changes in the research environment or new information indicating greater risk to the human subjects than existed when the protocol was previously reviewed and approved.

If we can be of further assistance, please contact us at 517 355-2180 or via email: UCRIHS@msu.edu. Please note that all UCRIHS forms are located on the web: http://www.msu.edu/user/ucrihs

Sincerely,

Ashir Kumar, MD
Interim Chair, UCRIHS

AK: bd

cc: A-Ran Chong
PO Box 144
Okemos, MI 48805

OFFICE OF
RESEARCH
AND
GRADUATE
STUDIES

University Committee on
Research Involving
Human Subjects

Michigan State University
246 Administration Building
East Lansing, Michigan
48824-1046

517/355-2180
FAX: 517/353-2976
Web: www.msu.edu/user/ucrihs
E-Mail: ucrihs@msu.edu

MICHIGAN STATE
UNIVERSITY

December 22, 2000

TO: Crystal F. BRANTA
134 I.M. Sports Circle

RE: **IRB # 00-540 CATEGORY:** 2-E,F

TITLE: PILOT STUDIES: MOTOR PERFORMANCE OF CHILDREN BORN PRETERM AND FULLTERM

ANNUAL APPROVAL DATE: September 8, 2000
REVISION REQUESTED: December 20, 2000
REVISION APPROVAL DATE: **December 22, 2000**

The University Committee on Research Involving Human Subjects' (UCRIHS) review of this project is complete and I am pleased to advise that the rights and welfare of the human subjects appear to be adequately protected and methods to obtain informed consent are appropriate. Therefore, the **UCRIHS APPROVED THIS PROJECT'S REVISION.**

This letter approves the revised contact procedure (invitation letter, contact return card, letter from investigator), revised consent for pilot study two

RENEWALS: UCRIHS approval is valid for one calendar year, beginning with the approval date shown above. Projects continuing beyond one year must be renewed with the green renewal form. A maximum of four such expedited renewal are possible. Investigators wishing to continue a project beyond that time need to submit it again for a complete review.
REVISIONS: UCRIHS must review any changes in procedures involving human subjects, prior to initiation of the change. If this is done at the time of renewal, please use the green renewal form. To revise an approved protocol at any other time during the year, send your written request to the UCRIHS Chair, requesting revised approval and referencing the project's IRB# and title. Include in your request a description of the change and any revised instruments, consent forms or advertisements that are applicable.
PROBLEMS/CHANGES: Should either of the following arise during the course of the work, notify UCRIHS promptly: 1) problems (unexpected side effects, complaints, etc.) involving human subjects or 2) changes in the research environment or new information indicating greater risk to the human subjects than existed when the protocol was previously reviewed and approved.
If we can be of further assistance, please contact us at 517 355-2180 or via email: UCRIHS@pilot.msu.edu.

Sincerely,

Ashir Kumar, M.D.
Interim Chair, UCRIHS

AK: bd

cc: A-Ran Chong
PO Box 144
Okemos, MI 48805

OFFICE OF
RESEARCH AND GRADUATE STUDIES

University Committee on Research Involving Human Subjects

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E-Mail: ucrihs@msu.edu

MICHIGAN STATE
UNIVERSITY

January 12, 2001

TO: Crystal F. BRANTA
134 I.M. Sports Circle

RE: **IRB # 00-540 CATEGORY:** 2-E,FEXPEDITED

TITLE: PILOT STUDIES: MOTOR PERFORMANCE OF CHILDREN BORN PRETERM AND FULLTERM

ANNUAL APPROVAL DATE: September 8, 2000
REVISION REQUESTED: January 4, 2001
REVISION APPROVAL DATE: **January 11, 2001**

The University Committee on Research Involving Human Subjects' (UCRIHS) review of this project is complete and I am pleased to advise that the rights and welfare of the human subjects appear to be adequately protected and methods to obtain informed consent are appropriate. Therefore, the **UCRIHS APPROVED THIS PROJECT'S REVISION.**

This letter approves the revised consent.

RENEWALS: UCRIHS approval is valid for one calendar year, beginning with the approval date shown above. Projects continuing beyond one year must be renewed with the green renewal form. A maximum of four such expedited renewal are possible. Investigators wishing to continue a project beyond that time need to submit it again for a complete review.

REVISIONS: UCRIHS must review any changes in procedures involving human subjects, prior to initiation of the change. If this is done at the time of renewal, please use the green renewal form. To revise an approved protocol at any other time during the year, send your written request to the UCRIHS Chair, requesting revised approval and referencing the project's IRB# and title. Include in your request a description of the change and any revised instruments, consent forms or advertisements that are applicable.

PROBLEMS/CHANGES: Should either of the following arise during the course of the work, notify UCRIHS promptly: 1) problems (unexpected side effects, complaints, etc.) involving human subjects or 2) changes in the research environment or new information indicating greater risk to the human subjects than existed when the protocol was previously reviewed and approved.

If we can be of further assistance, please contact us at 517 355-2180 or via email: UCRIHS@pilot.msu.edu.

Sincerely,

Ashir Kumar, M.D.
Interim Chair, UCRIHS

AK: bd

cc: A-Ran Chong
PO Box 144
Okemos, MI 48805

OFFICE OF
RESEARCH AND GRADUATE STUDIES

University Committee on Research Involving Human Subjects

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APPENDIX B

Approvals from the Institutional Review Board of Sparrow Hospital

SPARROW
HEALTH SYSTEM

October 12, 2000

Dr. Crystal Branta
Department of Kinesiology
Michigan State University
134 IM Sports Circle
East Lansing MI 48824

RE: **Pilot Study: Motor Performance of Children Born Pre-Term and Full-Term (#0412)**

Dear Dr. Branta,

On behalf of the Sparrow Health System Institutional Research Review Committee, we are in receipt of the above-mentioned proposal submitted for Expedited Status. During the October 9, 2000 Committee meeting, Dr. Abela, Chairperson, informed the members that after careful review he determined the study protocol exceeded the guidelines for Expedited Status and recommended full Committee review. The IRRC members accepted his recommendation.

Therefore, this study will be placed on the agenda for full review during the November 13, 2000 IRRC meeting. As the principal investigator, you or your designee, will need to attend this meeting to give a brief presentation to the members. The meeting begins prompt at 8:00 am in the Sparrow Professional Building, Conference Room E on the 2nd floor, with new protocols first on the agenda.

Sincerely,

Collin Hennessey /sl

Collin Hennessey, PharmD, Co-Chairperson
Institutional Research Review Committee
Sparrow Health System

/sl
cc: George S. Abela, MD, IRRC Chairperson
A-Ran Chong

www.sparrow.org

1215 E Michigan
PO Box 30480
Lansing, MI 48909-7980

517.483.2700

SPARROW
HEALTH SYSTEM

November 16, 2000

Crystal Branta, PhD
Department of Kinesiology
Michigan State University
134 IM Sports Circle
East Lansing MI 48824

RE: **Pilot Study: Motor Performance of Children Born Pre-Term and Full-Term (#0412)**

Dear Dr. Branta,

On behalf of the Sparrow Health System Institutional Research Review Committee, we thank you, Dr. Karna and Ms. Chong for your presentation of the above-mentioned study to the Committee. The Committee found the study protocol and risk/benefits appropriate, but did voice strong concerns about the process for initially contacting possible subjects for the study. The members recommended that Dr. Padmani Karna, as the patients' physician, offer the initial contact in a letter to her patients with a return card that would indicate their willingness to be contacted about possible inclusion in the study. At no time prior to receiving this initial approval from possible subjects shall the investigator(s) contact the patients. Also, the members recommended that Dr. Karna present the investigator(s) with blind identities and addresses of possible subjects until such time the subject actually agrees to be contacted for this study.

Therefore, effective November 13, 2000 **approval is granted pending** the Committee's receipt and review of the revised process for contacting patients to include the letter and contact card. If the Committee finds the revisions acceptable, you will be notified in writing of their formal approval.

Sincerely,

Collin Hennessey, PharmD/sl

Collin Hennessey, PharmD, Co-Chairperson
Institutional Research Review Committee
Sparrow Health System

/sl

cc: A-Ron Chong
Padmani Karna, MD
George S. Abela, MD, IRRC Chairperson

www.sparrow.org

1215 E Michigan
PO Box 30480
Lansing, MI 48909-7980

517.483.2700

SPARROW
HEALTH SYSTEM

December 19, 2000

Crystal Branta, PhD
Department of Kinesiology
Michigan State University
134 IM Sports Circle
East Lansing MI 48824

RE: **Pilot Study: Motor Performance of Children Born Pre-Term and Full-Term (#0412)**

Dear Dr. Branta,

On behalf of the Sparrow Health System Institutional Research Review Committee, we have received and reviewed the modifications to the physicians' letter, the acceptance card, the investigator's letter as well as the consent form and find these revisions meet the IRRC recommendations from the November 13, 2000 meeting.

Therefore, effective December 18, 2000, formal approval is granted for the above-mentioned protocol. This approval is valid for one year and will expire on December 18, 2001. All copies of the consent form must have the IRRC approval stamp on the signature page.

Please be advised that you will be required to inform the Committee promptly, per Federal Regulations and Committee Policies, of any changes with this study. As principal investigator, you also agree to maintain the confidentiality of all subjects. At least one month prior to the approval expiration date, you must provide the Committee with an Application for Renewal. Forms are available upon request by calling (517) 483-2150. If no update is received, the protocol will automatically be closed at Sparrow Health System at the end of twelve months. When the protocol closes, you must submit a closure letter and a project summary to the Committee.

Sincerely,

Collin Hennessey PharmD /sl

Collin Hennessey, PharmD, Co-Chair
Institutional Research Review Committee
Sparrow Health System

/sl
cc: A-Ran Chong
Padmani Karna, MD
George S. Abela, MD, IRRC Chair

www.sparrow.org

1215 E Michigan
PO Box 30480
Lansing MI 48909-7980

517 483 2700

SPARROW
HEALTH SYSTEM

Improving the health status of the people of mid-Michigan by providing quality, compassionate, cost-effective health care.

December 28, 2000

Crystal Branta, PhD
Department of Kinesiology
Michigan State University
134 IM Sports Circle
East Lansing MI 48824

RE: **Pilot Study: Motor Performance of Children Born Pre-Term and Full-Term (#0412)**

Dear Dr. Branta,

On behalf of the Sparrow Health System Institutional Research Review Committee, we received the modified consent form which had been changed per Michigan State University UCRIHS recommendation, confirmed in a letter dated December 22, 2000. After discussion with two of the IRRC reviewers, we recommended that you add some of the wording back into the consent form. Specifically, page 4, section #14, subsection 2) should read as follows: *that you agree to the foregoing.* This change has been made, a copy of the corrected page has been sent to the IRRC office, and the reviewers now recommend accepting the modifications to the consent form.

Therefore, as IRRC Chair, I am granting formal approval to accept the modified consent form, effective December 28, 2000. All copies of the consent form must have the IRRC approval stamp on the signature page.

As usual, please continue to inform the Committee annually, or as necessary, on the status of this study. If you have any questions, please do not hesitate to contact me at 483-2150.

Sincerely,

George S. Abela MD/sl

George S. Abela, MD, Chairperson
Institutional Research Review Committee
Sparrow Health System

/sl
cc: A-Ran Chong
Padmani Karna, MD
Collin Hennessey, PharmD, IRRC Co-Chairperson
Susan Wehner, RN, IRRC Member

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517.483.2700

APPENDIX C

Contacting Potential Participants

(Neonatologist Letter, Investigator Letter, and Contact Card)

Neonatologist Letter

SPARROW REGIONAL CHILDREN'S CENTER

December 7, 2000

Dear ,

Some of you may remember me, I was one of the Neonatologist, who provided care for your infant at Sparrow Neonatal Intensive Care Unit while your infant was in the NICU. You and your child are invited to participate in a study jointly sponsored by Sparrow Hospital and Michigan State University.

Please see the enclosed details attached. If you are interested in participating, please complete the attached card and return by in the enclosed envelope. Please feel free to call me at 517-483-2670 if you have any questions.

Sincerely,

Padmani Karna, MD
Neonatologist

Investigator Letter

You and your child are invited to participate in a study jointly sponsored by Sparrow Hospital & Michigan State University

Purpose of the Study: To compare the levels of motor skill development of children born preterm and fullterm

The Child will participate in:

- Movement skills such as throwing, catching, kicking, and running
- Fine motor activities such as finger tapping, beads on a rod, and finger-nose-touches
- Measurements of height and weight
- It will take approximately 45 - 60 minutes

The Parent will participate in:

- A 10 minute telephone interview
- A 10 question survey
- Measurement of height

Benefits:

- Parents will receive a gift card worth \$ from Meijer and his/her child will receive a soft ball at the end of testing
- Families will receive a chart detailing their child's height, weight, and levels of fine and gross motor skills
- Information gathered could lead to improving special service offered to children

Help us by agreeing to be included on the list of people to be contacted. Fill out the contact card and return it by to be considered for the motor skill study.

If you have questions about this study, you may contact

Dr. Padmani Karna	A-Ran Chong	Dr. Crystal Branta
(Dissertation committee)	(Investigator)	(Dissertation director)
(Neonatologist)	P. O. Box 144, Okemos	134 IM Sport Circle
1215 East Michigan Ave	MI 48805	Michigan State University
P.O. Box 30480	Tel (517) 347-3521	East Lansing
Lansing, MI 48909	E-mail: chongara@pilot.	MI 48823
Tel (517) 483-2670	msu.edu	Tel (517) 353-9467

If you have any questions about your right or your child's right as a research participant, you may contact Sparrow's Office of Risk Management, Tel (517) 483-2343, as well as Dr. David E. Wright, Ph.D. Chair University Committee on Research Involving Human Subjects, at Michigan State University, Tel (517) 355-2180.

Contact Card that was sent to the Hospital: Children who were Born Preterm Group

- Contact Card -

I wish to be considered for the motor skills study _____(please Mark)

Name: ______________________________

Address: ______________________________

____

Telephone: ______________________________

E-Mail: ______________________________

A good time to call me is ______________________________

Pease return by ________in the return envelop to be included on the list.
Thank you!

Contact Card that was sent to the Hospital: Children who were Born Fullterm Group

- Contact Card -

I wish to be considered for the motor skills study. ____________*(Please Mark)*

Name: ____

Address: ____

____

Telephone: ____

E-Mail : ____

A good time to call me is ____

Thank you!

APPENDIX D

Contact Letter, Consent Form, Family/Demographic Survey, and Verbal Consent Form

Feb 1, 2001

Dear prospective parent(s),

Hello, my name is A-Ran Chong and I am a Ph.D. student in the Department of Kinesiology at Michigan State University (MSU). I am contacting you because I received your contact card from Sparrow Hospital, indicating your interest in participating in the motor skills study. This is an expression of thanks for your willingness to have your child participate in fine and gross motor skills tests.

Please carefully read the consent form attached to this letter. You will be contacted by telephone soon for an interview. **After the interview, an interviewer will make an appointment for you and your child to come to Jenison Fieldhouse, room 309 at Michigan State University.**

Please bring the filled out survey (attached) and signed consent form (attached) with you when you arrive at the gym. Please call me or send me e-mail if you have any questions regarding this study.

I have included a map of the parking area near Jenison Fieldhouse on the campus of Michigan State University. When you come up in front of Jenison Fieldhouse, please look up to the third floor window. The orange colored sign will be attached to the window of room 309.

If for any reason you are unable to be at Jenison Fieldhouse at the appointment time and date, please call me at __________**(cellular phone #) or** ___________ so that we can arrange another time for the assessment. Thanks again for your willingness to take part in this important research project.

Sincerely,

A-Ran Chong
Ph.D. candidate
Department of Kinesiology
Michigan State University
Tel (Fax) (517) 347-3521
Cellular Phone (517) 410-5370
E-mail: chongara@pilot.msu.edu

SPARROW
HEALTH SYSTEM

PATIENT CONSENT FORM
FOR NEW PROCEDURE, STUDY OR DRUG UNDER CLINICAL INVESTIGATION

To: Participants in this study

Your Attending Physician is: ______________________ M.D./D.O.

Phone Number: ______________________

1. Sparrow Hospital permits physicians and other qualified persons to engage in research and study the nature of disease together with the study of new methods of diagnosis and treatment. Such research may subject patients participating in it to risks or complications, such as injury, or even death, due to either known/unknown or unforeseen causes. No warranty or guarantee has been or will be made as to a result or cure. Except in cases of emergency or exceptional circumstances, you may not participate in research or studies unless and until you have discussed with your physician regarding the research, risks associated with the research, and the possibility of and risks of alternative treatments, including foregoing treatment. After receiving such information from your physician, you have the right to consent or refuse participation in any project or activity studying disease and new methods of diagnosis and/or treatment. Your refusal to participate will involve no penalty or loss of benefits to which you are otherwise entitled.

2. You are invited to participate in the following research study, entitled "Pilot study: Motor performance of children born preterm and fullterm". The investigator (A-Ran Chong), who is a Ph.D. student in the department of Kinesiology at Michigan State University (MSU), is performing this study. Please call her if you have any questions or concerns regarding this study; her phone number is: 517-347-3521/517-410-5370 (cellular Phone #) or call Dr. Karna at 517-483-2670.

3. The purpose of the study is to determine test-retest and inter-rater reliabilities to use in A-Ran Chong's dissertation.

4. The procedures in this project are:

Initials __________ *Date* ______________

(a) If you decide to participate, then you are indicating your consent that Dr. Karna may look at your child's medical record from the hospital and pull out birthweight, gestational age, and diagnosis at discharge.
(b) If your child is eligible, found during the telephone interview, then an appointment will be scheduled to come to room 309 of Jenison fieldhouse at MSU ("the gym").
(c) You will be asked to complete the attached survey questions of demographic information.
(d) Your child will complete motor skills from the McCarron Assessment of Neuromuscular Development (MAND) and the Motor Performance Study (MPS), and her/his height and weight will be measured.
(e) You will be asked for permission to have your height measured and then provide the other parent's height, with verbal consent.

5. The purposes of each procedure mentioned above are:

   (a) and (b) Process of selecting participants.
   (c) Find out if there are differences in family influences for each group, which could influence children's motor skills.
   (d) Find out motor skill levels of each group, and compare if there are height and weight differences among children from each group. Further, the influence of the children's height and weight on their motor performance levels will be considered.
   (e) Your heights will be measured to see what the average differs by from group to group. In other words, if your genetic influences affect your child's height.

6. Benefits reasonably to be expected from each procedure mentioned above include:

   (a) Accuracy of analysis of data in this study.
   (b) Selecting the child who is eligible.
   (c) Finding out if there are significant differences between groups that could influence the children's motor skills.
   (d) & (e)
   - The investigator will tell you how your child's motor skill levels compare to children in the MPS at MSU and against national norms from the MAND.
   - Your child's height and weight will be provided and compared to the national norm. Therefore, you will know your child's level of motor performance, height, and weight in order to plan the development of your child's motor skills and physical growth.
   - Participation in this research will not involve any extra costs to you or your health care insurer.

Initials ___________ *Date* ________________

➢ You will receive a gift card worth $ 25.00 from Meijer and your child will receive a soft small-sized ball at the end of testing (this includes if you and your child come to the gym but decide not to participate).

7. The procedures mentioned above may involve the following risks or discomforts, which include:

(a) There is no recognizable risk or discomfort
(b) Calling your home and asking about your child's disabilities (whether your child has a disability or not) will not be harmful but you may feel uncomfortable. In order to minimize this effect, you will be told that you can request not to participate in this study and/or not answer any questions at anytime.
(c) The survey relative to demographic information will make clear that you may decline to respond to any question to which you prefer not to respond.
(d)

➢ Your child might be uncomfortable when the investigator is observing her/him performing motor skills, such as catching, running, jumping, and so on, in the open space of the gym, and when the child's height and weight are being measured. In order to minimize this effect, a test instructor, who has greater experience with children and motor skills testing, will direct your child's motor skills and measure height and weight.

➢ Your child should perform comfortably during the motor skill performances (e.g., physical activities) and should not fall down. Your child will be required to wear comfortable clothes and rubber-soled shoes to participate during testing.

(e) You might be uncomfortable when your height is measured and/or when providing the other parent's height, however you may refuse this measurement and/or refuse to provide information on the other parent's height.

8. You are hereby informed that you are free to withdraw your consent and discontinue your child's or your participation in this study at any time without penalty or loss of benefits to which you are otherwise entitled. Your doctor may stop your participation in this study at any time.

9. Your participation in this research study will last for a period not to exceed 1 hour 18 minutes unless you voluntarily withdraw from the study sooner.
   - ➢ You are indicating your voluntary agreement to complete and bring the attached survey with you when you arrive at the gym; it should take approximately 5 minutes.
   - ➢ You are indicating your voluntary verbal agreement to, after you have fully read this consent form and decided to participate, participate in a telephone interview to find out whether your child satisfies the participant criteria; the

Initials ___________ *Date* ________________ telephone interview should take approximately 5 to 10 minutes.

- You are being asked to consent to having your child participate for approximately 30 – 60 minutes in physical activities during one visit in the gym; and you consent to having your child's physical activities videotaped once during that time.
- You are being asked to consent to having your child's height and weight assessed and to agree that it should take approximately 2 minutes on three separate times during the same visit in the gym.
- You are being asked to have your height measured and give the other parent's height, with verbal consent; it is optional and should take approximately 1 minute.

10. All data for this study will be held strictly confidential, and your child's identification will not be revealed to anyone outside of the investigator (A-Ran Chong). Your privacy will be protected to the maximum extent allowable by law.

11. The data collected will be used for Ms. Chong's doctoral dissertation, and may be used for articles, presentations, and instructions. Names will not be used.

12. If you have questions about the procedures mentioned, contact your attending physician at the number on page 1 or call:

    Dr. Padmani Karna

    Day Phone: (517) 483-2670

13. If injury occurs as a direct result of the procedure(s) used in this research study, emergency medical care required to treat such injury will be provided by Michigan State University. If available, reimbursement will be sought from your insurance company for this emergency care and any other medical expenses incurred as a result of the injury. No additional compensation will be provided. If the injury is not caused by the negligence of MSU, you would be personally responsible for the expense of this emergency care and any other medical expenses incurred as a result of this injury.

    In the event of such an injury occurring as a direct result of the experimental procedure used in this research study, you may contact:

    Name: A-Ran Chong Phone: 517-347-3521 (day/night)
    Cellular Phone: 517-410-5370 (day or before 9:00 p.m.)

Initials __________ *Date* ____________

In addition, you may also contact:

Name: Dr. Crystal Branta Phone: 517-353-9467

If you have any questions regarding this research, you or your child's rights as a research participant, or any other related concerns about your participation, you may contact the following:

Sparrow Health System Office of Risk Management
Tel: (517) 483-2343

or

David E. Wright, Ph.D.
Chair University Committee on Research Involving Human Subjects
Michigan State University, Tel: (517) 355-2180.

14. Upon your authorization and consent, you may participate in the research and/or study, which will be performed by your physician and surgeon and/or other physicians or personnel participating in the investigation with your physician(s).

Your signature below constitutes your acknowledgement: (1) that the foregoing has been verbally explained to you, and that you have had the opportunity to read the foregoing; (2) that you agree to the foregoing; (3) that you desire to participate in the project or activity described and are aware of the material risks involved in such treatment; (4) that information will remain confidential except that the institutions sponsoring the study and/or government agencies (i.e., FDA, NIH) may have access to such information, and; (5) that you have received a full copy of this consent form.

If you decide to participate in this study, please sign below and bring this consent form with the survey when you and your child come to room 309 of Jenison fieldhouse (on the north side of Kalamazoo Street) on the campus of Michigan State University.

Initials ___________ *Date* _______________

Optional

Yes ______________ No ______________ You may use the videotape of my child that shows my child in presentations as long as you do not identify my child by name, and this videotape will be kept in a self- locked cabinet.

____
Child Participant

____
Signature of Participant (18 years or older) or Legally Authorized Representative

____
Witness (or parent participant)

____
Signature of Parent or Guardian (required permission of parent or guardian if participant has not attained age 18)

____
Date

Investigator's Statement

I acknowledge that the nature and purpose of the investigational device(s), drug(s), or procedure(s), possible alternative methods of treatment, the risks involved, and the possibility of complications or unintended results were fully explained to the participant or her/his representative by me before the participant consented.

____
Investigator

____
Date

Format Revised 1/20/2000
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UCRIHS APPROVAL FOR THIS project EXPIRES:

SEP - 8 2001

SUBMIT RENEWAL APPLICATION ONE MONTH PRIOR TO ABOVE DATE TO CONTINUE

SPARROW HEALTH SYSTEM INSTITUTIONAL RESEARCH REVIEW CMTE

APPROVED: DEC 28 '00

APPROVAL EXPIRES: DEC 18 '01

Submit Renewal Application One Month Prior to Expiration Date to Continue

Initials __________ *Date* __________

Family Information Survey

Family Information Survey

The following are questions concerning yourself and your child. The answers to these questions will help us understand how the family background influences the child's motor performance in general. Please make a checkmark on the correct line __v__, and in other cases provide the requested information on the blank line. However, if you do not want to answer a certain question, feel free not to answer it.

1. I am my child's
   _________ Mother
   _________ Father
   _________ Legal Guardian/Other

2. Does your child have brothers or sisters?_________Yes ______ No

   If YES: My child has
   (How many?)_____ Older brother(s) ______ Age(s) ___________
   (How many?)_____ Younger brother(s) ______ Age(s) ___________
   (How many?)_____ Older sister(s) ______ Age(s) _________
   (How many?)_____ Younger sister(s) ______ Age(s) ___________

3. Your education:
   _____ Some high school or less
   _____ High school graduate
   _____ Some college or technical school
   _____ College or technical school graduate
   _____ Professional/graduate degree

4. Your spouse/partner's education (if you have a spouse/partner):
   _____ Some high school or less
   _____ High school graduate
   _____ Some college or technical school
   _____ College or technical school graduate
   _____ Professional/graduate degree

5. Your current occupation (the major category of your own work during most of your adult life):
   ____ Corporate manager and executive, highly skilled technical job, government official, college professor
   ____ Middle manager, other professional/technical worker, independent business person

____ Public school and junior college teacher, skilled labor and trades, real estate sales
____ Factory worker, general service worker, office work, secretarial work
____ Farmer, farmhand
____ Homemaker
____ Other

6. If you have a spouse/partner: Your spouse/partner's occupation (the major category of your spouse/partner's work during most of her/his adult life):
   ____ Corporate manager and executive, highly skilled technical job, government official, college professor
   ____ Middle manager, other professional/technical worker, independent business person
   ____ Public school and junior college teacher, skilled labor and trades, real estate sales
   ____ Factory worker, general service worker, office work, secretarial work
   ____ Farmer, farmhand
   ____ Homemaker
   ____ Other

7. Estimate of your annual family income:
   _____ Less than $ 10,000
   _____ $10,000 - $30,000
   _____ $30,000 - $60,000
   _____ $60,000 - $100,000
   _____ Above $100,000

8. My child went to nursery school. ______ Yes _______ No
   If Yes, for how many months? ___ Months
   At what ages? _______Years

9. My child went to preschool. _________ Yes _______ No
   If Yes, for how many months? ___ Months
   At what ages? _____ Years

10. I would like a copy of this study's results after the testing is finished.
    _____ Yes _____ No

Thank you very much for participating!

Verbal Consent for the Parent and the Child When They Come to the Gym

HEIGHT – VERBAL CONSENT WHEN THE PARENT COMES TO THE GYM

- Would you mind if I measure your height? If you do not want to be measured, it is fine.
- How tall is your child's father/mother?

MOTOR SKILLS FOR THE MAND AND MPS FROM MSU – THE CHILD'S VERBAL CONSENT WHEN FEASIBLE:

The tester speaking to the child: "We are in the gym. Today, we will be running, catching, jumping, and others. That camera (pointing) will take pictures of you and I (tester) will tell you what to do. She (pointing to the investigator) will watch you. Now, do you want to try?

HEIGHT AND WEIGHT MEASUREMENTS WITH CHILD'S VERBAL CONSENT WHEN FEASIBLE:

Speaking to the child: "Let's see how tall you are. Is it OK if I check?"

"Let's see how much you weigh. Is it OK if I check?"

APPENDIX E

Telephone Interview with Parent Using ABILITIES Index

Formal Interview of the Parent

Verbal consent of parent during the telephone interview

This call will be made after the parent should have received the second letter from the investigator:

1. Did you get the letter, from A-Ran Chong, concerning the motor performance of children born preterm and fullterm?

1) If yes,

   Are you interested in participating in this study?
   If yes,
   Would you mind answering a few questions to determine your child's disability level and determine whether your child could participate in this study?

2) If no,

   Explain what the study is and offer to send another copy of the letter, consent form, and survey, and then ask the parent the same questions as number 1.

Questionnaire during the telephone interview

1) Does your child have an Individual Family Service Plan or an Individual Education Plan (IEP)? If yes, what is the particular reason?

2) Has your child ever been referred for special education services?
   If yes, what was the reason for the referral?

3) Has your child received special education services?
   If yes, what types of services did s/he receive? When? For how long?

4) Has your child received physical therapy treatment during the past year and/or current year?
   If yes, why? How many sessions?

   Has your child experienced some tension in a body part?
   For instance, one leg or arm or both legs or arms?

5) Has your child gone to any intervention programs (educational, social, medical, etc.)?

   For what? ____

   How long? ___________Months Which year(s)? _______

   What kinds of intervention programs?

Ratings in each area are made on a scale of 1 to 6, with 1 indicating normal ability, 2 (suspected) indicating some questions about the child's ability, and 6 indicating extreme or profound lack of ability. In making each rating, think about the child compared to other children the same age. Guidelines follow to assist you in making each rating. You may use the space on the back of this form to provide additional information about ratings.

Audition (Hearing) Think about the child's ability to hear in everyday activities. Score hearing for each ear separately. A score of 6 (Profound loss) means that the child has no hearing. Rate the child's hearing without a hearing aid. If the child uses a hearing aid, indicate this on the back of the form.	**Behavior & Social Skills** Two ratings are made in this area, one for social skills and one for inappropriate or unusual behavior. Social skills refer to the child's ability to relate to others in a meaningful manner. Inappropriate & unusual behavior may include fighting, hitting, screaming, rocking, hand flapping, biting self, etc.	**Intellectual Functions (Thinking & Reasoning)** This rating reflects the child's abilities to think and reason. Think about the way the child solves problems and plays with toys and compare this to other children of the same age.
Limbs (Use of Hands, Arms, & Legs) Think about the child's ability to use his or her hands, arms, and legs in daily activities. Score left and right limbs separately. A score of 6 (Profound difficulty) means that the child has no use of a limb.	**Intentional Communication (Understanding & Communicating with others)** Two ratings are made, one for the child's ability to understand others and one for the child's ability to communicate in ways other than talking (signs, gestures, picture boards). Think about the child's ability to understand and communicate with others and compare this to other children of the same age.	**Tonicity (Muscle Tone)** Think about the child's muscle tone. Normal means that the child's muscles are neither tight nor loose. If the child's muscle tone is not in the normal range, place an "X" in each box that indicates the degree of tightness or looseness or both. Two ratings should be made since, in some children, tightness or looseness can vary in different parts of the body or from one time to the next.
Integrity of Physical Health (Overall Health) Think about the child's general health. Normal means the usual health problems & illnesses typical for a child this age. If there is a health problem, ratings should be made indicating the degree to which health problems limit activities. Ongoing health problems may include seizures, diabetes, muscular dystrophy, cancer, etc.	**Eyes (Vision)** Think about the child's ability to see in everyday activities. Score both the left & right eye. A score of 6 (Profound loss) means that the child has no vision. Rate the child's vision without glasses. If the child uses glasses, indicate this on the back of the form.	**Structural Status (Shape, Body Form, & Structure)** This rating reflects the form and structure of the child's body. Normal means that there are no differences associated with form, shape, or structure of the body parts. Differences in form include conditions like cleft palate or clubfoot; differences in structure include conditions like curved spine and arm or leg deformity. Ratings should indicate how much these differences interfere with how the child moves, plays, or looks.

The ABILITIES Index

Rune J. Simeonsson
Donald B. Bailey

I.D. # _____

INSTRUCTIONS: In each column, place an **X** in the space that best describes the child. Please note that multiple Xs should be recorded under **A** (Audition), **B** (Behavior), **L** (Limbs), **I** (Intentional Communication), **T** (Tonicity), & **E** (Eyes).

	A	B		I	L	I	T		I	E	S
	Audition (Hearing)	Behavior & Social Skills		Intellectual Functioning	Limbs (Use of hands, arms, & legs)	Intentional Communication	Tonicity (Muscle Tone)		Integrity of Physical Health	Eyes (Vision)	Structural Status
	Left Ear / Right Ear	Social Skills	Inappropriate Behavior	Thinking & Reasoning	Left Hand / Left Arm / Left Leg / Right Hand / Right Arm / Right Leg	Under-standing others / Commu-nicating with others	Degree of tightness	Degree of looseness	Overall Health	Left Eye / Right Eye	Shape, Body Form & Structure
1	Normal	All behaviors typical & appropriate for age		Normal for age	Complete normal use	Normal for age verbal & non-verbal (includes signs, gestures or symbol systems)	Normal		General good health	Normal	Normal
2	Suspected hearing loss	Suspected disability	Suspected inappropriate behaviors	Suspected disability	Suspected difficulty	Suspected disability	Suspected		Suspected health problems	Suspected vision loss	Suspected difference or interference
3	Mild hearing loss	Mild disability	Mildly inappropriate behaviors	Mild disability	Mild difficulty	Mild disability	Mild		Minor ongoing health problems	Mild vision loss	Mild difference or interference
4	Moderate hearing loss	Moderate disability	Moderately inappropriate behaviors	Moderate disability	Moderate difficulty	Moderate disability	Moderate		Ongoing but medically-controlled health problems	Moderate vision loss	Moderate difference or interference
5	Severe hearing loss	Severe disability	Severely inappropriate behaviors	Severe disability	Severe difficulty	Severe disability	Severe		Ongoing poorly-controlled health problems	Severe vision loss	Severe difference or interference
6	Profound hearing loss	Extreme disability	Extremely inappropriate behaviors	Profound disability	Profound difficulty	Profound disability	Totally tight	Totally loose	Extreme health problems, near total restriction of activities	Profound vision loss	Extreme difference or interference

You may use this space to clarify ratings or provide additional information.

The ABILITIES INDEX

Individual interested in using the ABILITIES index for purposes of research program planning or evaluation may copy and distribute this instrument as long as the source is recognized. Address all correspondence to: The ABILITIES Project, Frank Porter Child Development Center, University of North Carolina at Chapel Hill, Campus Box #8180, Chapel Hill, NC 27599-8180

APPENDIX F

MAND

Protocol for Testing MAND

Fine Motor Tasks

Task 1: Beads in box

Two boxes, one empty and the other holding 37 beads, are placed in front of the subject. The empty box is closest to the child while the full box is the farthest away. The child is asked to use one hand to move as many beads from the far box to the near box one bead at a time, as many as possible in 30 seconds. Then the child switches hands and performs the same task.

Task 2: Beads on rod

One box full of 17 cylindrical beads is placed directly in front of the child. The child holds a rod in the non-preferred hand and uses the remaining hand to place as many beads on the rod in 30 seconds as possible. The second part of the test is performed with the eyes closed.

Task 3: Finger tapping

A difficult task, the child must move her/his index finger up and down a specified distance quickly and consistently. A rubber band wrapped around the hand helps to specify the distance. Other than the steady, consistent tapping of the finger, the observer must also look for extraneous movements beyond the finger, such as the hands or arms.

Task 4: Nut and bolt

The child uses the preferred hand to turn a bolt into a nut as fast as possible. The child will hold the nut stationary in the opposite hand during the entire task. The task is repeated with a smaller nut and bolt.

Task 5: Rod slide

The child is to move two slide beads from opposite sides of a rod toward the middle. Each bead is controlled by each hand and moved as slowly as possible toward the middle of the rod. The maximum time scored is only 30 seconds but the child is allowed to take as much time as needed.

Gross Motor Tasks

Task 6: Hand strength

The child is to alternately switch hands, squeezing the dynamometer as hard as possible. Each hand squeezes the device twice for good measure.

Task 7: Finger-Nose-Finger

With one arm extended out in front of the body, the child's only goal is to use the index finger on the opposite arm and touch first the nose, then the extended fingertip. The emphasis is on completing the task as accurately as possible. Then the child switches fingers and performs the same task. Finally, the child performs both tasks with the eyes closed.

Task 8: Jumping

The child performs a standing long jump from a line as far forward as possible. The child will wear something on the feet that promotes traction, or wear nothing. Three trials are allowed, once any pre-jump training is complete.

Task 9: Heel-Toe Walk

The child will try to walk a line on the floor, placing one foot directly in front of the other foot. The child should wear flat shoes/socks or bare feet. The heels and toes must be clearly observable to the scorer. The goal for the child is to walk the line as accurately as possible. After that portion of the task is complete, then the child will walk backwards.

Task 10: Standing on One Foot

The child is instructed to stand on one leg, without any support, for as long as possible. As soon as the unused leg touches the floor, a hand starts to lean against something, or the child begins to hop around, the timing stops. Both legs are tested for two total tests. Then the tests are repeated with the eyes closed.

Table F1

Conversion of Summed Scaled Scores to Factor Scores Children <11 Years of Age

Factor Score	Persistent Control	Muscle Power	Kinesthetic Integration	Bimanual Dexterity	Factor Score
155	38		38	35	155
150	37	40	36 - 37	33 - 34	150
145	35 - 36	38 -39	35	32	145
140	33 - 34	36 - 37	33 - 34	31	140
135	32	34 - 35	32	29 - 30	135
130	30 - 31	32 - 33	30 - 31	28	130
125	28 - 29	30 - 31	28 - 29	27	125
120	27	28 - 29	27	25 - 26	120
115	25 - 26	26 - 27	25 - 26	24	115
110	23 - 24	24 - 25	23 - 24	23	110
105	22	22 - 23	22	21 - 22	105
100	20 - 21	20 - 21	20 - 21	20	100
95	18 - 19	18 -19	18 - 19	19	95
90	17	16 - 17	17	17 - 18	90
85	15 - 16	14 - 15	15 - 16	16	85
80	13 - 14	12 - 13	13 - 14	15	80
75	12	10 - 11	12	13 - 14	75
70	10 - 11	8 - 9	10 - 11	12	70
65	8 - 9	6 - 7	8 - 9	11	65
60	7	4 - 5	7	9 - 10	60
55	5 - 6	2 - 3	5 - 6	8	55
50	3 - 4	0 - 1	3 - 4	7	50
45	2		2	5 - 6	45
40	0 - 1		0 - 1	4	40
35				3	35
30				0 - 2	30

Table F2

Conversion of Summed Scaled Scores to the Neuromuscular Development Index (NDI) for Children <11 Years of Age

NDI	Summed Scaled	NDI	Summed Scaled	NDI	Summed Scaled	NDI	Summed Scaled	NDI	Summed Scaled
155	160	131	134	107	108	83	78 - 79	59	45
154	159	130	133	106	107	82	77	58	43 - 44
153	158	129	132	105	106	81	76	57	42
152	157	128	131	104	105	80	74 - 75	56	40 - 41
151	156	127	130	103	103 - 104	79	73	55	39
150	155	126	129	102	102	78	71 - 72	54	37 - 38
149	154	125	128	101	101	77	70	53	36
148	153	124	127	100	100	76	69	52	34 - 35
147	152	123	126	99	99	75	68	51	32 - 33
146	151	122	124 - 125	98	97 - 98	74	66 - 67	50	31
145	150	121	123	97	96	73	65	49	29 - 30
144	148 - 149	120	122	96	95	72	64	48	27 - 28
143	147	119	121	95	94	71	62 - 63	47	26
142	146	118	120	94	92 - 93	70	61	46	24 - 25
141	145	117	119	93	91	69	60	45	22 - 23
140	144	116	118	92	90	68	58 - 59	44	21
139	143	115	117	91	89	67	57	43	19 - 20
138	142	114	116	90	87 - 88	66	55 - 56	42	17 - 18
137	140 - 141	113	115	89	86	65	54	41	16
136	139	112	114	88	85	64	52 - 53	40	14 - 15
135	138	111	113	87	84	63	51		
134	137	110	112	86	82 - 83	62	49 - 50		
133	136	109	110 - 111	85	81	61	48		
132	135	108	109	84	80	60	46 - 47		

Score Sheet for Individual MAND

MAND Individual score sheet ID # _____

PROTOCOL FOR SCORING FINGER TAPPING
(Observation for a 10 second interval with each hand)

	RIGHT	LEFT
A. Rhythm of tapping 4. Even, consistent rhythm of tapping 2. Disruption of rhythm once or twice, but regains consistent tapping 1. Erratic, nonrhythmic tapping		
B. Extraneous hand movements 4. Moves only the index finger; fist remains closed 2. Extraneous movement of thumb 1. Extraneous movement of thumb and other fingers		
C. Overflow of movement in arm 4. Wrist or forearm remains stationary while tapping 2. Occasional (once or twice) movement of wrist or forearm to "assist" the tapping 1. Frequent (three or more) movement of wrist or forearm to "assist" the tapping		
D. Complete distance 4. Index finger moves the complete distance between base and rubber band 2. Occasional (once or twice) incomplete movement between base and rubber band 1. Frequent (three or more) incomplete movements of the index finger between base and rubber band		
E. Number of complete finger taps in ten seconds Do not count incomplete movements or contacts made by movements of wrists of forearm.		
Record Right and Left Totals on Summary Sheet		

MAND Individual score sheet ID # _____

PROTOCOL FOR SCORING ROD SLIDE

(Observations during movements of the right and left hands)

The individual stands approximately one foot away from the rod slide and the height of the rod is at waist level.

	RIGHT	LEFT
A. Impulsive-jerky movements (changes in rate of speed) 4. Continuous even slide 2. Changes in slide motion; obvious deviation in speed 1. Changes in slide motion; obvious deviation in speed with erratic and impulsive movement		
B. Distractibility 4. Attended to task without distraction (eyes remained focused on bead during slide) 2. Distracted by extraneous stimuli (eyes shifted from focus once during slide) 1. Distracted by extraneous stimuli (eyes shifted from focus two or more times during slide)		
C. Head-body shifting 4. Head and body remain stationary while the eyes track the bead; the movement of the eyes parallels the movement of the bead 2. Limited tracking movement of eyes with turning of head or partial shifting of body to follow the bead 1. Simultaneous shifting of body while tracking the bead; the body or head, rather than the eyes, shifts past the midline		
D. Extraneous body movements 4. Body posture relaxed and stationary; moves only the arm performing the task 2. Extraneous movement of other arm or legs once during the task 1. Extraneous movement of other arm or legs two or more times during the task		
E. Speed of movement (up to 30 seconds) Record the time taken to move the bead the full distance across the rod. The maximum possible score for each hand is 30 seconds. When the speed of movement is 5 seconds or less, record a score of "1" for each of the behavioral observations above (A, B, C, and D).		
Record Right and Left Totals on Summary Sheet		

MAND Individual score sheet ID # _____

PROTOCOL FOR SCORING FINGER-NOSE-FINGER
(Allow a 10 second interval to observe each trial)

	EYES OPEN Right	EYES OPEN Left	EYES CLOSED Right	EYES CLOSED Left
A. Arm movement 4. Smooth, direct arm movement 2. Somewhat irregular or wavery arm movement 1. Confused and jerky arm movement				
B. Index finger on the extended hand 4. Held steady 2. Slight tremor or swaying 1. Marked tremor or swaying				
C. Contact points 4. Contact points at tip of nose and tip of extended index finger 2. Missed contact point at either tip of nose or tip of index finger 1. Missed contact points at *both* tip of nose and tip of index finger				
D. Bending of elbow (gradual movement inward 4. Holds arm fully extended 2. Slight bend at elbow (less than 30°) 1. Noted bend at elbow (more than 30°)				
E. Indenting 4. Lightly touches tip of extended index finger and end of nose 2. Noted pushing of tip of extended index finger or presses in end of nose once or twice 1. Noted pushing in of tip of extended index finger or presses in the end of nose three or more times				
Record Open and Closed Totals on Summary Sheet				

MAND Individual score sheet ID # _____

PROTOCOL FOR SCORING JUMPING

Body movements are rated according to an overall impression of typical performance as observed during all three jumps.

A. Spring
4. An even spring into the air from both feet
2. An awkward spring into the air: predominant use of one leg to spring
1. Clumsy spring: limited ability to spring off the floor

B. Use of arms
4. Arms assist with slight pull on evaluator while jumping
2. Arms move limply while jumping
1. Arms held rigidly while jumping

C. Trunk balance
4. Landing stable; center of gravity midline (remains in place)
2. Landing unstable but able to regain balance
1. Landing unstable; takes step backward or forward or uses evaluator to prevent falling

D. Landing with knees flexed
4. Smooth landing on both feet simultaneously with slight bending of knees to absorb the fall
2. Somewhat stiff landing; limited use of knee bend
1. Stiff landing with stiff knees; jars the body when landing

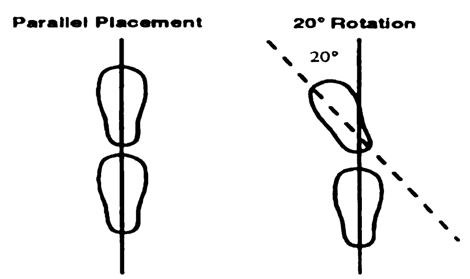
E. Distance of jump
The distance score recorded is the farthest jump of the three attempts.

Record Total Score on Summary Sheet

MAND Individual score sheet ID # ______

PROTOCOL FOR SCORING HEEL-TOE WALK
(Individual walks a distance of 10 feet)

	FORWARD	BACKWARD
A. Arms/body sway 4. Both hands remain on hips 2. Removed one hand from hip 1. Removed both hands from hips		
B. Feet 4. Retained both feet on tape line 2. Foot altered from line once or twice (when less than half the tape is covered, the foot is considered off) 1. Foot altered from line three or more times		
C. Heel to toe distance 4. Heel positioned within one inch of toe 2. Heel positioned greater than one inch from toe once or twice 1. Heel positioned greater than one inch from toe three or more times		
D. Progression 4. Smooth forward walk 2. Slight pauses in forward movement 1. Shifting of weight backward and forward while walking		
E. Parallel placement 4. Both feet kept parallel to the tape line 2. Steps correctly, but then rotates foot to an angle (20° or more) with the line 1. Steps at an angle (20° or more) with the line		
Record Total Score on Summary Sheet		



MAND SUMMARY SHEET

ID # ______

1. **Beads in Box** (# placed in 30 seconds) Right ___ + Left ___ = Score

2. **Beads on Rod** (# of cylinders placed in 30 seconds) Open ___ + Closed ___ = Score

3. **Finger tapping** (use score sheet) Right ___ +Left ___ = Score

4. **Nut and Bolt** (# of seconds to complete task)
   (Large) 100 - ___ = ___
   (Small) 100 - ___ = ___

   Total = ___ Large + Small Score

5. **Rod slide** (use score sheet) Right ___ + Left ___ = Score

Fine Motor Total

6. **Hand strength** (best of two trials with each hand) Right ___ + Left ___ = Score

7. **Finger-Nose-Finger** (use score sheet)
   Eyes Open ___
   Eyes Closed ___

   Total = ___ Open + Closed = Score

8. **Jumping** (use score sheet) Score

9. **Heel-Toe-Walk** (use score sheet) Score

10. **Standing on One Foot** (# of seconds up to 30)
    Eyes Open, Right ___ Eyes Open, Left ___
    Eyes Closed, Right ___ Eyes Closed, Left ___

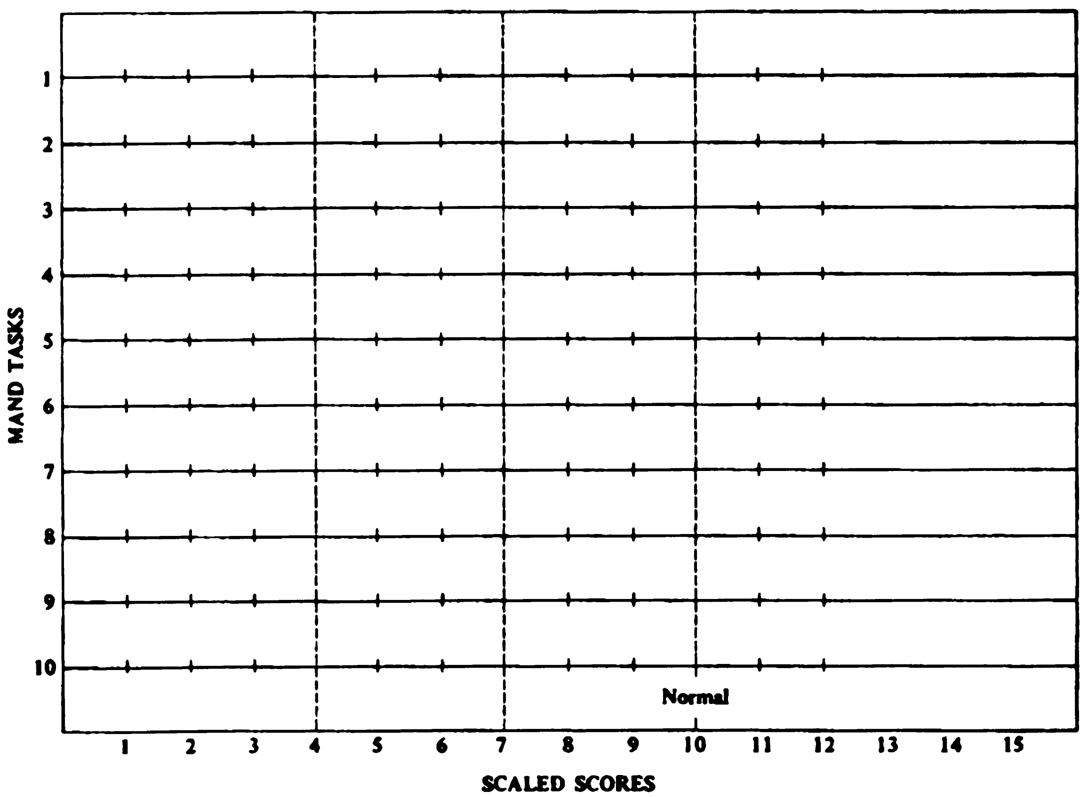
    Total ___ Score

Gross Motor Total

TOTAL

INDIVIDUAL PROFILE OF NEUROMUSCULAR DEVELOPMENT

MAND TASKS	Raw Scores	Scaled Scores	Persistent Control	Muscle Power	Kinesthetic Integration	Bimanual Dexterity
1. Beads in Box						
2. Beads on Rod						
3. Finger Tapping						
4. Nut and Bolt						
5. Rod Slide						
6. Hand Strength						
7. Finger-Nose-Finger						
8. Jumping						
9. Heel-Toe-Walk						
10. Stand One Foot						
SUM OF SCALED SCORES						
NDI AND MAND FACTOR SCORES		NDI	PC	MP	KI	BD



APPENDIX G

MPS

Table G1

Summary of Fundamental Motor Skill Stage Characteristics-Michigan State University Motor Performance Study: Total Body Approach

Fundamental Motor Skills	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5
Throw	Vertical wind-up "Chop throw" Feet stationary No spinal rotation	Horizontal wind-up "Sling throw" Block rotation Follow-through across body	High wind-up Ipsilateral step Little spinal rotation Follow-through across body	High wind-up Contralateral step Little spinal rotation Follow-through across body	Downward arc wind-up Contralateral step Segmented body rotation Arm-leg follow-through
Catch	Delayed arm action Arms straight in front until ball contact, then scooping action to chest Feet stationary	Arms encircle ball as it approaches Ball is "hugged" to chest Feet stationary on may take one step	"To-chest" catch Arms "scoop" under ball to trap it to chest Single step may be used to approach ball	Catch with hands only Feet stationary or limited to one step	Catch with hands only Whole body moves through space
Kick	Little/no leg wind-up Stationary position Foot "pushes" ball Step backward after kick (usually)	Leg wind-up to the rear Stationary position Opposition of arms and legs	Moving approach Foot travels in a low arc Arm/leg opposition Forward or sideward step on follow-through	Rapid approach Backward trunk lean during wind-up Leap before kick Hop after kick	
Punt	No leg wind-up Ball toss erratic Body stationary Push ball/step back	Leg wind-up to the rear Ball toss still erratic Body stationary Forceful kick attempt	Preparatory step(s) Some arm/leg yoking Ball toss or drop	Rapid approach Controlled drop Leap before ball contact Hop after ball contact	
Strike	"Chop" strike Feet stationary	Horizontal push/swing Block rotation Feet stationary/stepping	Ipsilateral step Diagonal downward swing	Contralateral step Segmented body rotation Wrist rollover on follow-Through	

(continued)

(Continued)

Fundamental Motor Skills	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5
Long Jump	Arms act as "brakes" Large vertical component Legs not extended	Arms act as "wings" Vertical component still great Legs near full extension	Arms move forward/elbows in front of trunk at takeoff Hands to head height Takeoff angle still above 45° Legs often fully extended	Complete arm and leg extension at takeoff Takeoff near 45° angle Thighs parallel to surface when feet contact for landing	
Run	Arms -- high guard Flat-footed contact Short Stride Wide stride, shoulder width	Arms -- middle guard Vertical component still great Legs near full extension	Arms -- low guard Arm opposition -- elbows nearly extended Heel-toe contact	Heel-toe contact (toe-heel when sprinting) Arm-leg opposition High heel recovery Elbow flexion	
Hop	Nonsupport foot in front with thigh parallel to floor Body erect Hands shoulder height	Nonsupport knee flexed with knee in front and foot behind support leg Slight body lean forward Bilateral arm action	Nonsupport thigh vertical with foot behind support leg -- knee flexed More body lean forward Bilateral arm action	Pendular action on nonsupport leg Forward body lean Arm opposition with swing leg	
Gallop	Resembles rhythmically uneven run Trail leg crosses in front of lead leg during airborne phase, remains in front at contact	Slow-moderate tempo, choppy rhythm Trail leg stiff Hips often oriented sideways Vertical component Exaggerated	Smooth, rhythmical pattern, moderate tempo Feet remain close to group Hips oriented forward		
Skip	Broken skip pattern or irregular rhythm Slow, deliberate movement Ineffective arm action	Rhythmical skip pattern Arms provide body lift Excessive vertical component	Arm action reduced/hands below shoulders Easy, rhythmical movement Support foot near surface on hop		

Source: Haubenstricker (1990). Used with permission.

MOTOR PERFORMANCE STUDY (MPS) SCORE SHEET

ID # ______

Evaluator ______________________

Date ______________

MOTOR SKILLS ITEMS	STAGES				
	1	2	3	4	5
THROW					
CATCH					
KICK					NA
PUNT					NA
STRIKE					NA
LONG JUMP					NA
RUN					NA
HOP					NA
GALLOP				NA	NA
SKIP				NA	NA

Note. Each stage can be "#" or "# +".
NA = Not Applicable

Child's height: ______________________
Child's weight: ______________________
Mother's height: ______________________
Father's height: ______________________

Table G2

How to Convert Stages to Scores

Stages	0	1	1 +	2	2+	3	3 +	4	4 +	5
5-stage skill	0.0	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
4-stage skill	0.0	1.0	1.5	2.0	2.5	3.0	3.5	4.0	NA	NA
3-stage skill	0.0	1.0	1.5	2.0	2.5	3.0	NA	NA	NA	NA

Note. NA = Not Applicable.

APPENDIX H

Pilot Study

Results of Pilot Study

A pilot study was conducted to assist in producing better administration during the data collection of this research and future studies related to the topic. Additionally, some parents were asked to recommend how the instruments (including the survey, interview questions, etc.) could be improved. This pilot study helped to decide more accurately how many children should be tested at one time, how long the process actually takes, and where to locate the video camera.

If a procedure worked well in this pilot study, it would not be changed for the actual study; but if a procedure did not work well, that procedure was modified. The investigator was acquainted with the participants in the pilot study to ascertain extent. After the parent(s) agreed to participate, the interviewer called the parent(s) on the phone for interviewing. When the criteria were satisfied, the parent(s) and his/her child made an appointment to come to the lab at the university.

After the pilot study, the investigator decided to set up non-overlapping appointments, thus testing each child individually so that s/he did not have to wait for another child to finish the testing before participating. If both children were tested at the same time, the parent(s) would have to wait longer. All children from this pilot study enjoyed being tested in the motor skills tests of MPS, regardless of being tested individually or tested with another child.

For instance, the original plan was for the first child to be tested in MAND. Then both children were tested in MPS. Finally, the second child was tested in MAND. The improved plan was for the first child to be tested in both MAND and MPS. After completion by the first child, the second child would complete the entire battery of tests, completely independent of the first child. Therefore, the time period was not dependent on another child's finishing the motor skills testing.

This researcher also found that the time of testing varied depending on the tester and how well the child followed the directions during the administration of the MAND. The amount of time spent for both MAND and MPS ranged from 45 minutes to 1 hour 10 minutes. In one instance, when this investigator tested one child, both batteries of tests took only 45 minutes, yet some other children took a much longer time. Therefore, future appointments were made in 1 hour 30 minute intervals for each individual visiting the lab; hence, if a child took longer to test than average, the next parent(s) and child did not have to wait long, if at all.

The location of the video camera was not in the center of the room, but rather was closer to the video recording room and the windows; therefore, the cameraperson moved the video camera by remote control easily (Figure 3). All of the fine motor skills and some gross motor skills, which were tested in a sitting position, were tested in the middle of the room, faced by the video camera, which only needed to zoom in and out. The children moved from one side of the lab to the other and vice versa for all of the locomotor skills as well as some of the object control skills such as throwing, kicking, punting, and striking. The long jump and heel-toe walk were tested on the near wall area where a ruler was attached to the floor and parallel to a tapeline.

When the investigator and a professor, who had a great amount of experience in data collection of motor skills, watched a video, sound was necessary for understanding what was going on during the testing of a particular motor skill; therefore, the investigator decided that the tester would carry a clothing-attached microphone.

Results of the pilot study indicated that the motor skills from the MAND should be recorded on the videotape from the front view and the side view was used for jumping and heel-toe walking. All of the locomotor skills and object control skills on the videotape were recorded from the side, except for the front view for catching. Parents did not give any suggestions on the interview questions and survey. Therefore, the same survey questions and interview questions were used in this research.

Letter to Show to the Parent for Pilot Study

PILOT STUDY: LETTER TO PARENT(S)

Dear Parent(s) or Legal Guardian(s):

My name is A-Ran Chong. I am a graduate student of motor development from the Department of Kinesiology at Michigan State University. For my dissertation, I would like to study the motor development (e.g., physical activities) of children born preterm and fullterm. I am writing to seek permission to test your child. I believe that the knowledge gathered would be valuable for me in administering the test better for my dissertation. Also, the knowledge gathered would be valuable to all preschool teachers, physical educators, adapted physical educators, and parents in understanding how children develop physically. Furthermore, I will provide the information on how well your child performed certain motor skills along with height and weight compared to Michigan children or U. S. children. I will be also pleased to freely consult with you in your child's motor development. Additionally, after completing this pilot study, you will be receiving a gift certificate worth $ from a major department store and your child will receive a soft, middle-sized ball (even if the child comes to participate but does not finish) after the end of the testing session.

The purpose of this pilot study is to determine the best way to administer the tests. I will be considering where I should stand, where should my assistant be, how adequate my test recording forms are, is it better to test one, two, or more children at a time, how much time does testing take, and are there any changes needed to my methods or informed consent forms. Therefore, I will also ask you for suggestions and any concerns about the phone interview to determine your child's disability level for participant criteria, survey of home background, and other important parts of my research. Your child will be videotaped during the motor skills performance in order to score him/her accurately through watching the video.

Your child will be measured according to her/his motor skills (e.g., running, catching a ball, skipping, etc.), height, and weight. It will take approximately 30 – 60 minutes. The privacy of all of the information collected will be protected to the maximum extent allowable by law. I would like to interview you regarding the participant criteria and ask you to fill out the home background survey. Each record of a child's information will be associated with a unique, random ID number to protect the identity of the child. All records and videotapes of the child's performance will be kept in a personally locked file cabinet to prevent access by anyone but the principal investigator. Only group data will be presented in presentations and publications. Also, your child and you are free to withdraw at anytime without penalty to your child or yourself.

There is a minor risk to participate in this study. The child might be uncomfortable during physical activities and could fall down. Because of that, please make sure that your child wears comfortable clothes and rubber-soled shoes when you and your child come to the gym at Michigan State University. Also, when you are interviewed and/or fill out the survey, you may not want to answer or participate in this study. You are free not to answer questions at anytime without giving a reason. You will find out your child's motor skills' development and physical growth after the end of the testing session. Further, this study will help preschool teachers understand better the developmental perspective of children.

If your child is injured as a result of your child's participation in this research project, Michigan State University will provide emergency medical care if necessary.

I hope that you will allow your child to participate in my study. If you want to participate, please send the card with the stamped self-addressed envelope. You will be contacted by phone. If the child satisfies the participant criteria during the phone interview, then an appointment will be scheduled to come to room 309 of Jenison Fieldhouse at Michigan State University. Please sign the attached consent form and survey after the phone interview and bring them in when you and your child come to Jenison Fieldhouse. If you do not return the card, I will contact you by phone to ask whether you would like to participate. You may refuse to participate in any part of the study. If you decide not to participate in the study, you will not be contacted again.

If you have questions about this project, you may contact A-Ran Chong, at P.O. Box 144, Okemos, MI 48805, Tel (517) 347-3521 or my dissertation supervisor, Dr. Crystal Branta, at 133 IM Sports Circle, Michigan State University, East Lansing, MI 48823, Tel (517) 353-9467. If you have any questions about your rights or your child's right as a research participant, please contact David E. Wright, Ph.D., Chair, University Committee on Research Involving Human Subjects, Tel (517) 355-2180.

Sincerely,

A-Ran Chong

Parent/Legal Consent Form for Pilot Study

PARENT/LEGAL GUARDIAN CONSENT FORM FOR PILOT STUDY

To participants in this study:

You are being asked to agree that the goal, procedures, and duration of your child's participation in the research project's first pilot study, "Pilot studies: Comparison of the motor skill development of children born preterm and fullterm", have been explained to you. You are also being asked to agree that you have had an opportunity to ask questions about the researcher measuring your child's motor skills, height, and weight.

By giving permission for your child to participate in Ms. Chong's Project, you are being asked to agree to the following:

1. You are being asked to consent to having your child participate for approximately 30 – 60 minutes in physical activities during one visit in the gym at Michigan State University; and you are being asked to consent to having your child's physical activities videotaped once during that time.

2. You are being asked to consent to having your child's height and weight assessed, and to agree that you understand that it will take about one minute during the same visit in the same gym.

3. You are indicating your voluntary agreement to complete and bring the attached survey with you when you arrive at the same gym.

4. You are indicating your voluntary agreement by completing the attached card to participate in a telephone interview with verbal consent to determine your child's disability level in order to find out whether your child satisfies the participant criteria.

5. You are hereby informed that you are free to withdraw your consent and discontinue your child's or your participation in this study at any time without penalty.

6. All data collected for this study will be held strictly confidential, and your child's identification will not be revealed to anyone outside of the principal investigator. Your privacy will be protected to the maximum extent allowable by law.

7. The data collected will be used for Ms. Chong's doctoral dissertation, and may be used for articles, presentations, and instruction. Names will not be used.

8. You are hereby informed that if your child or you are injured as a result of your child's participation in this research project, then Michigan State University will provide emergency medical care if necessary. If the injury is not caused by the negligence of MSU you are personally responsible for the expense of this emergency care and any other medical expenses incurred as a result of this injury.

9. As participants in this project, you will receive a gift certificate worth $ 25.00 from Meijer and your child will receive a soft, middle-sized ball (including if your child comes to participate and decides not to continue) after the end of testing.

If you decide to participate in this study, please sign below and bring this consent form with the survey when you and your child come to room 309 of Jenison Fieldhouse at Michigan State University.

Optional

Yes_________No__________You may use the videotape of my child that shows my child in presentations as long as you do not identify my child by name, and the videotape will be kept in a self-locked cabinet.

Please sign if you and your child participate in this study

I, ______________________________, agree to allow my child to participate as a volunteer in the study involving assessment via the McCarron Assessment of Neuromuscular Development and Motor Performance Study at Michigan State University and be videotaped, and also have my child's height and weight measured.

I, ______________________________, volunteer to participate in this study by answering a survey of demographic information and a short phone interview to determine my child's disability level and to determine if s/he satisfies the participant criteria.

Child's Name:_________________________

Parent's/Legal Guardian's Name: ___________________________

Parent's/Legal Guardian's Signature: ________________________

Date: __________________________

UCRIHS APPROVAL FOR
THIS project EXPIRES:

SEP 8 2001

SUBMIT RENEWAL APPLICATION
ONE MONTH PRIOR TO
ABOVE DATE TO CONTINUE

Survey and formal interview were the same as in this research. Therefore, the family/demographic survey is in Appendix D and the interview with the parents about the ABILITIES Index is in Appendix E.

APPENDIX I

Figures of Each Motor Skill of Motor Performance Study by Birthtype

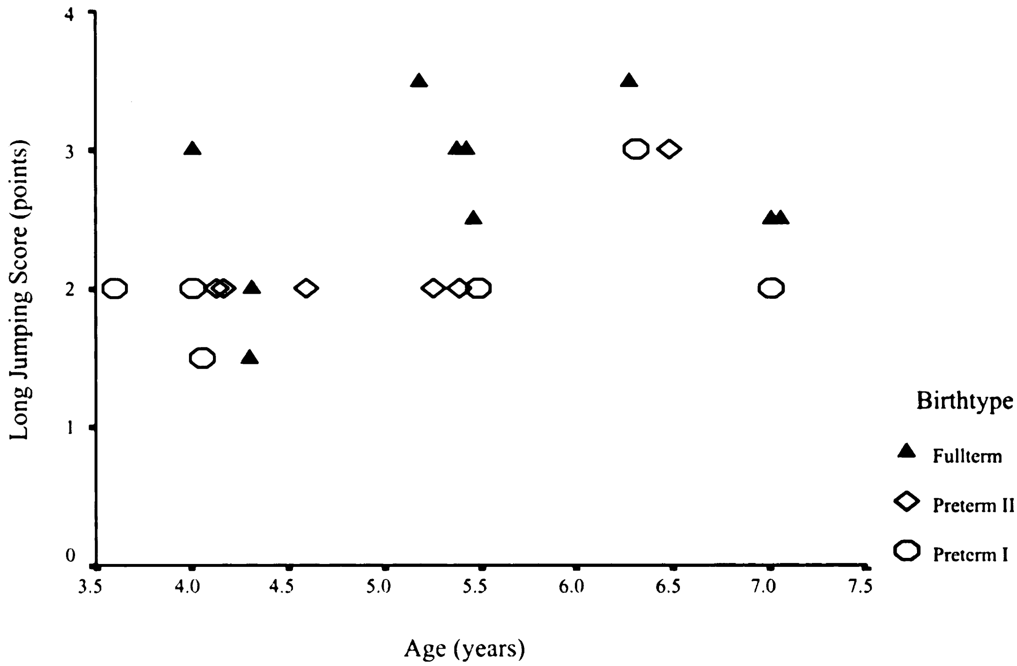


Figure I1. Long jump scores from the Motor Performance Study test as determined by the birthtype and chronological age.

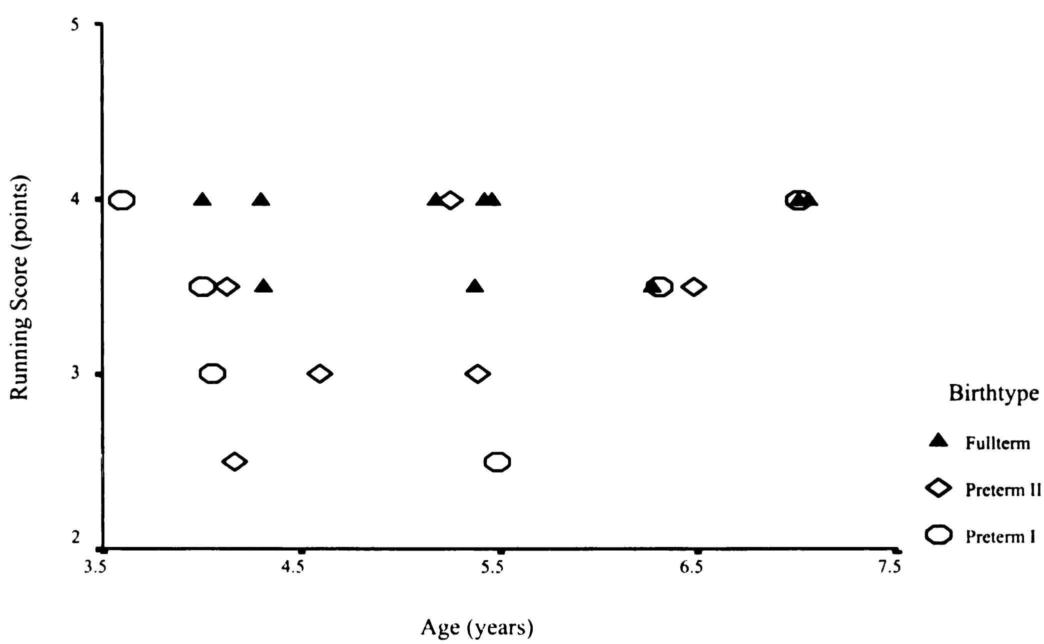


Figure I2. Running score from the Motor Performance Study test as determined by the birthtype and chronological age.

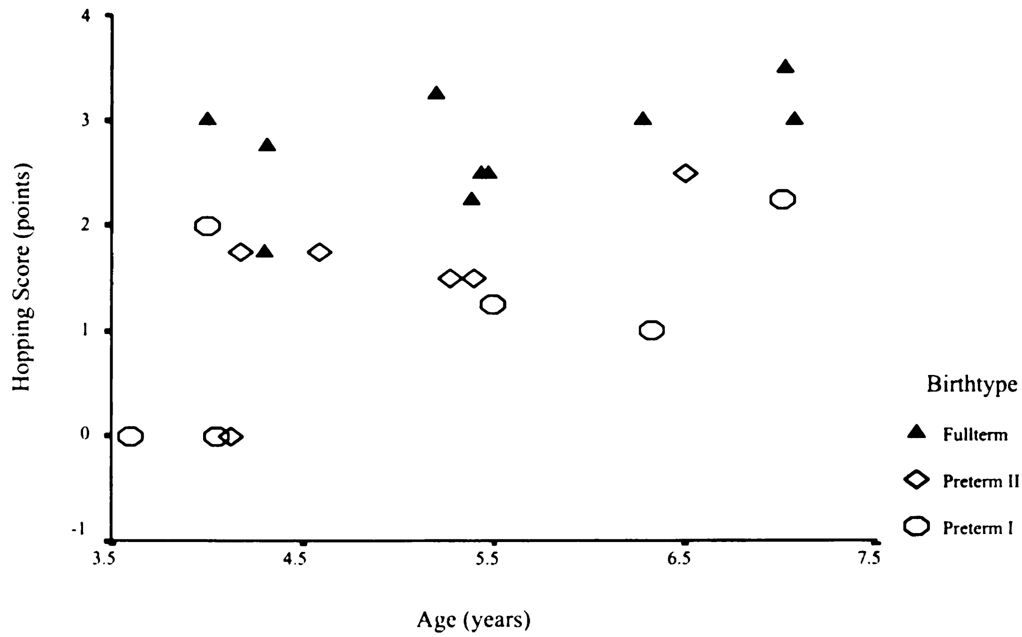


Figure I3. Hopping score from the Motor Performance Study test as determined by the birthtype and chronological age.

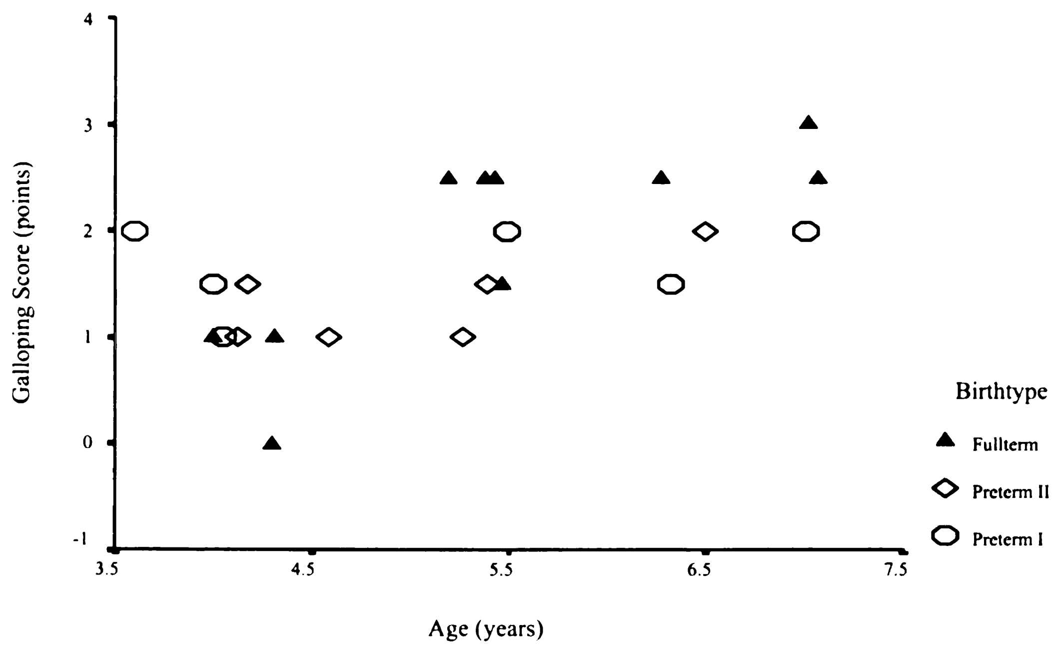


Figure I4. Galloping score from the Motor Performance Study test as determined by the birthtype and chronological age.

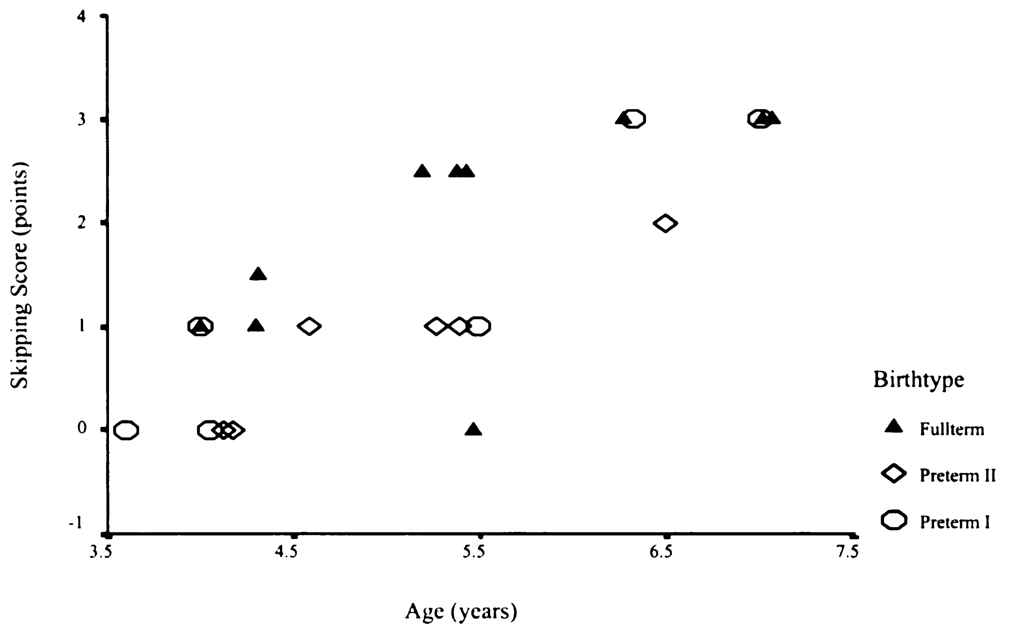


Figure I5. Skipping score from the Motor Performance Study test as determined by the birthtype and chronological age.

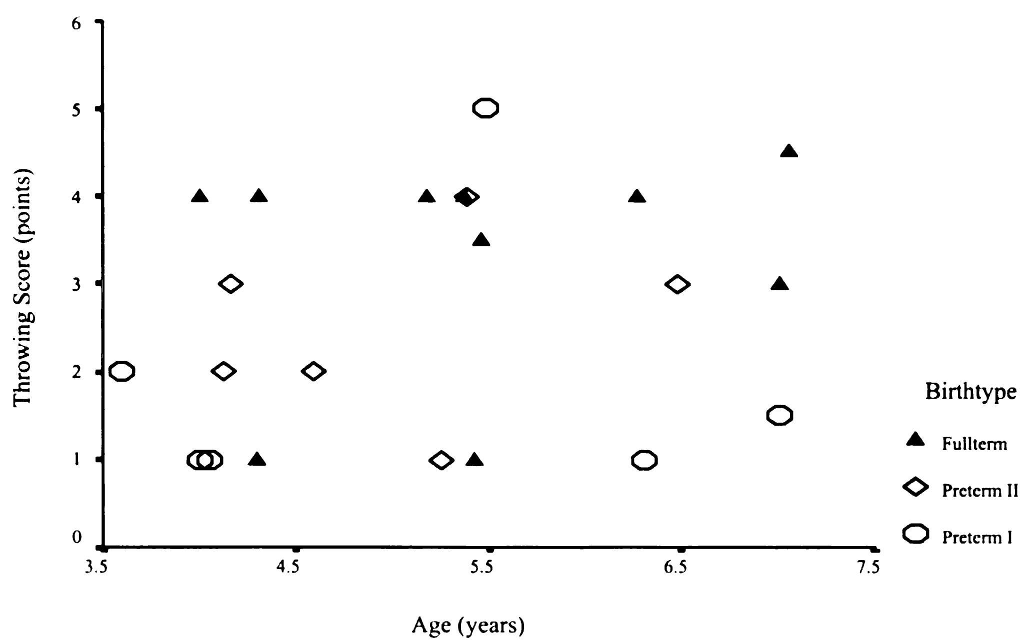


Figure I6. Throwing score from the Motor Performance Study test as determined by the birthtype and chronological age.

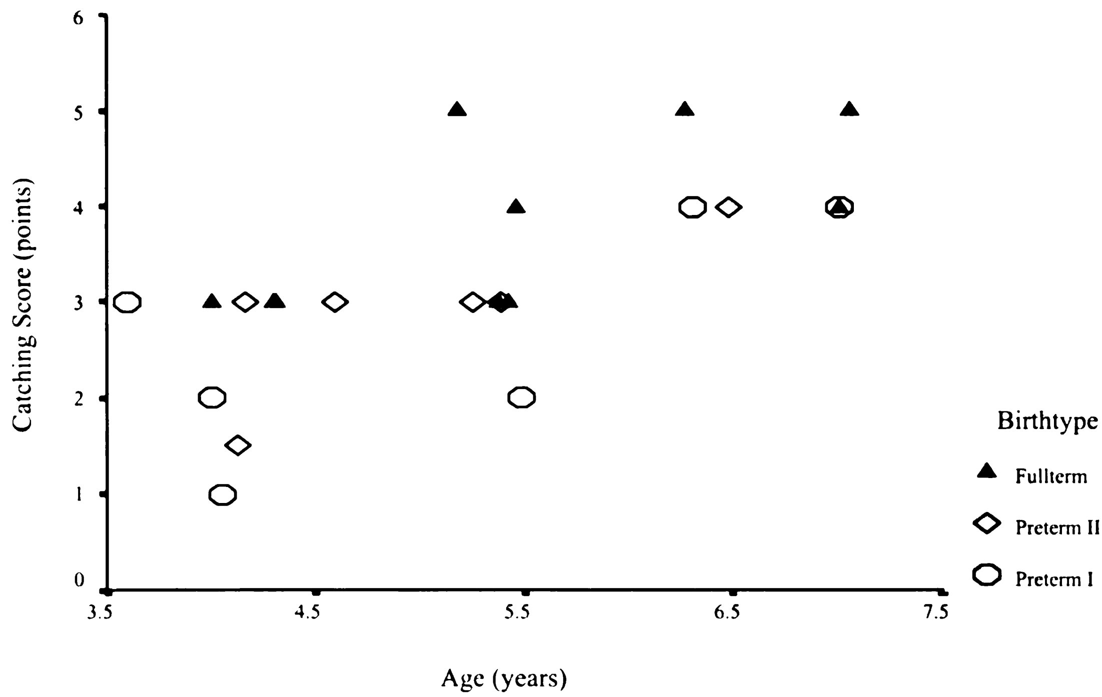


Figure 17. Catching score from the Motor Performance Study test as determined by the birthtype and chronological age.

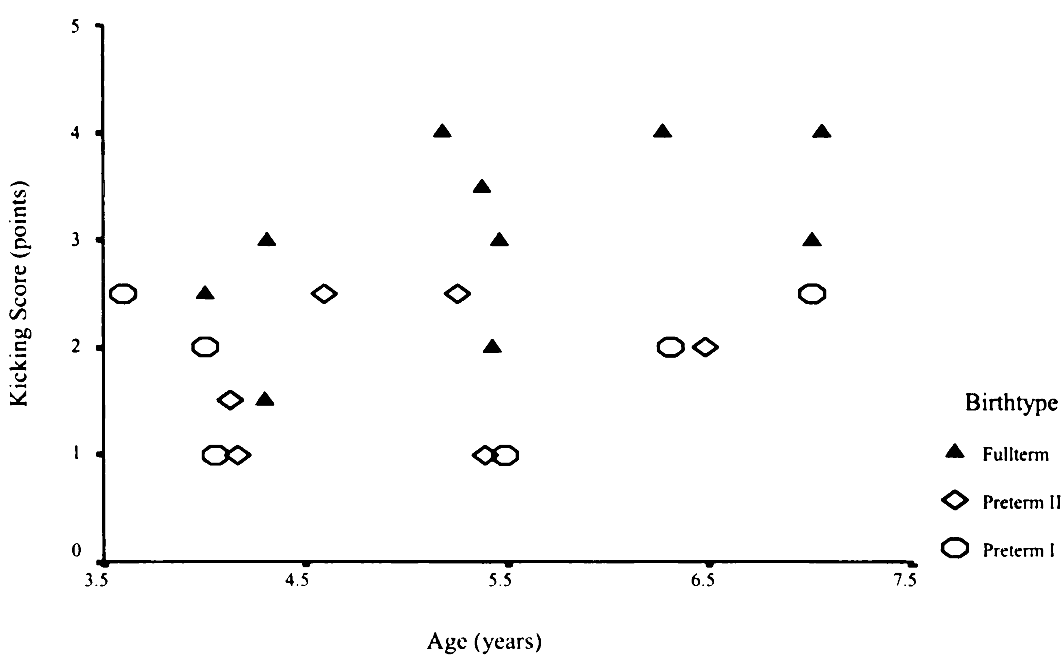


Figure 18. Kicking score from the Motor Performance Study test as determined by the birthtype and chronological age.

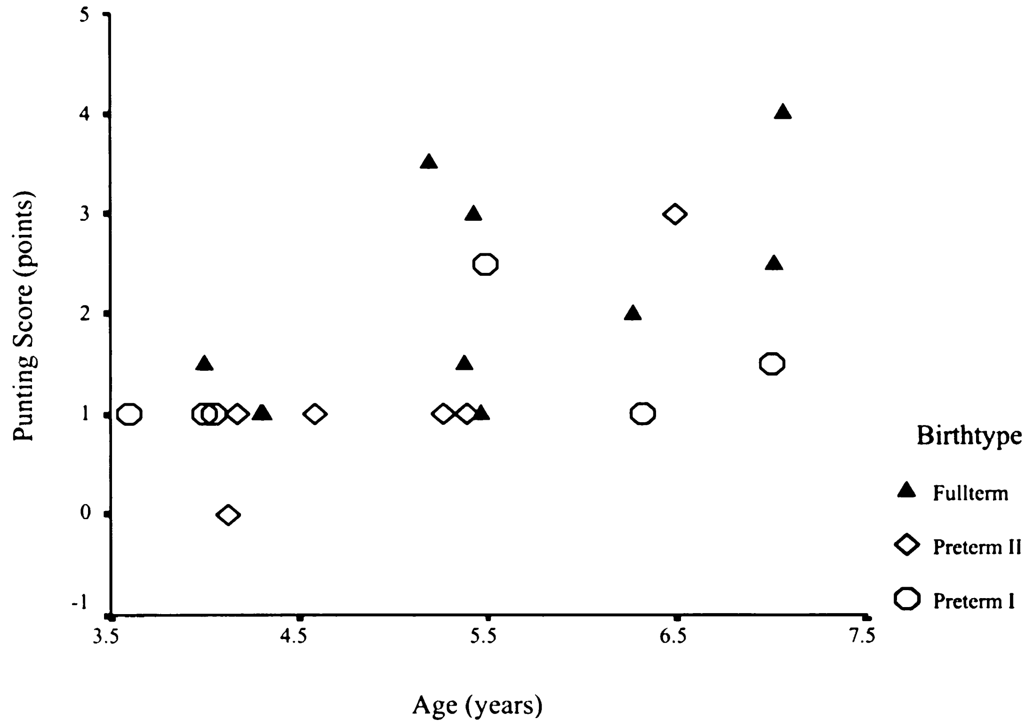


Figure I9. Punting score from the Motor Performance Study test as determined by the birthtype and chronological age.

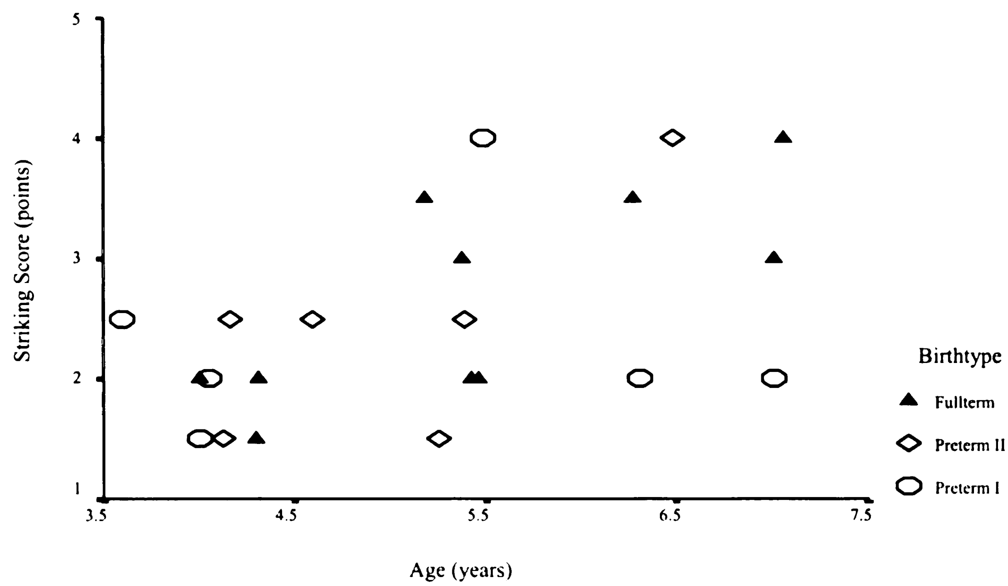


Figure I10. Striking score from the Motor Performance Study test as determined by the birthtype and chronological age.

APPENDIX J

Physical Growth Charts

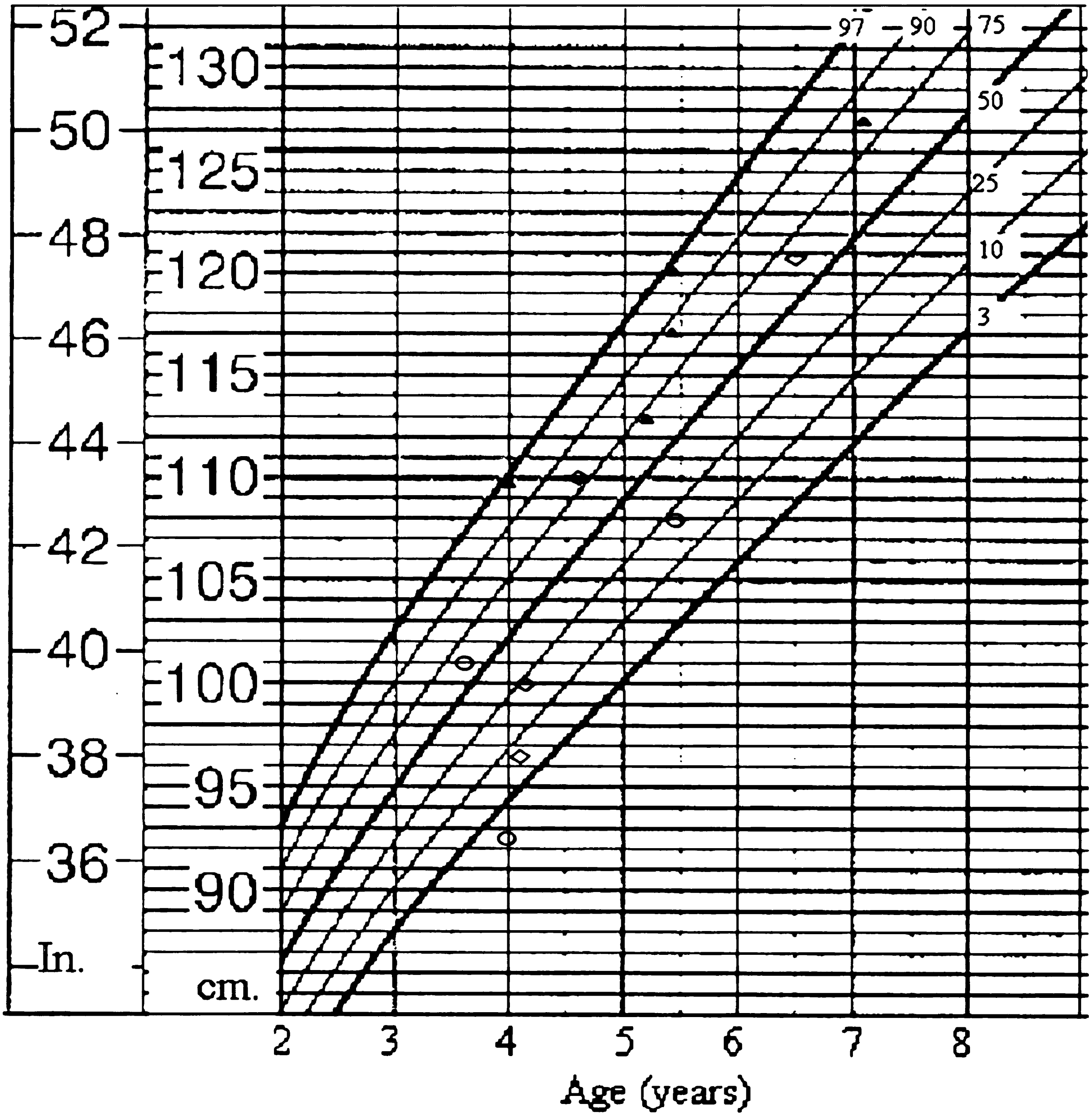


Figure J1. The heights of boys from the Preterm I (open circles), Preterm II (open diamonds), and Fullterm (filled triangles) groups, measured in inches and centimeters with percentile curves indicating national ranks. National Center for Health Statistics, & National Center for Chronic Disease Prevention and Health Promotion (2001, March 1). 2 to 20 years: Boys, Stature-for-age and Weight-for-age percentiles. Retrieved, from the World Wide Web: http://www.cdc.gov/growthcharts

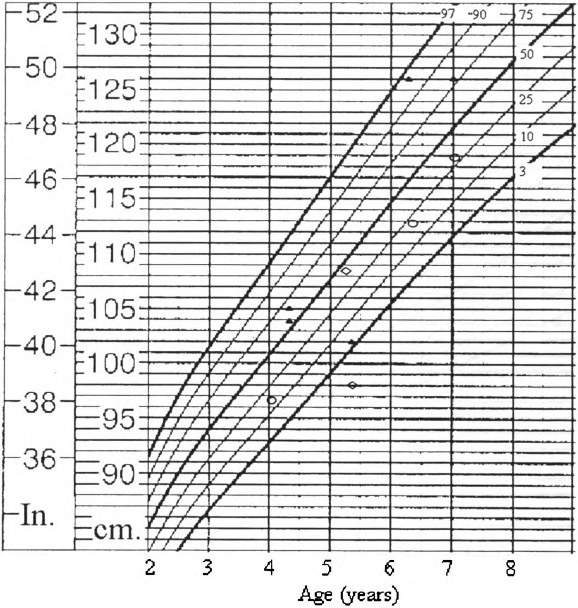


Figure J2. The heights of girls from the Preterm I (open circles), Preterm II (open diamonds), and Fullterm (filled triangles) groups, measured in inches and centimeters with percentile curves indicating national ranks. National Center for Health Statistics, & National Center for Chronic Disease Prevention and Health Promotion (2001, March 1). 2 to 20 years: Girls, Stature-for-age and Weight-for-age percentiles. Retrieved, from the World Wide Web: http://www.cdc.gov/growthcharts

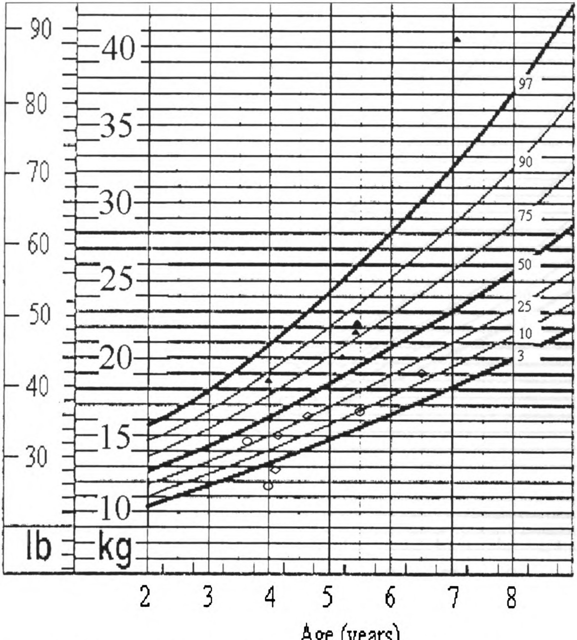


Figure J3. The weights of boys from the Preterm I (open circles), Preterm II (open diamonds), and Fullterm (filled triangles) groups, measured in pounds and kilometers with percentile curves indicating national ranks. National Center for Health Statistics, & National Center for Chronic Disease Prevention and Health Promotion (2001, March 1). 2 to 20 years: Boys, Stature-for-age and Weight-for-age percentiles. Retrieved, from the World Wide Web: http://www.cdc.gov/growthcharts

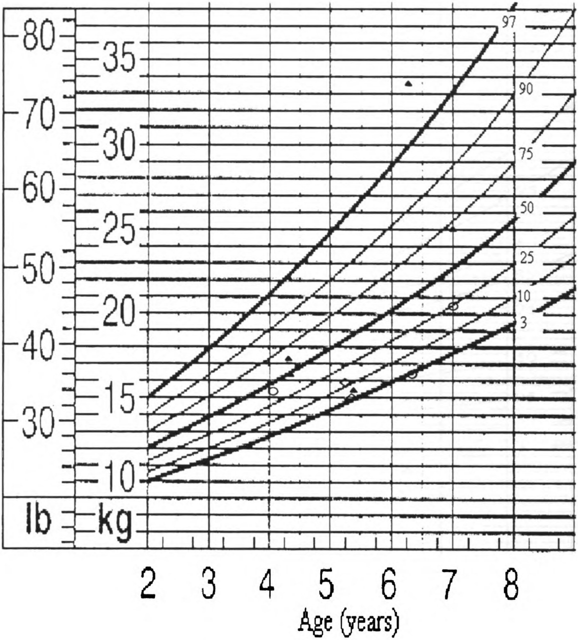


Figure J4. The weights of girls from the Preterm I (open circles), Preterm II (open diamonds), and Fullterm (filled triangles) groups, measured in pounds and kilometers with percentile curves indicating national ranks. National Center for Health Statistics, & National Center for Chronic Disease Prevention and Health Promotion (2001, March 1). 2 to 20 years: Girls, Stature-for-age and Weight-for-age percentiles. Retrieved, from the World Wide Web: http://www.cdc.gov/growthcharts

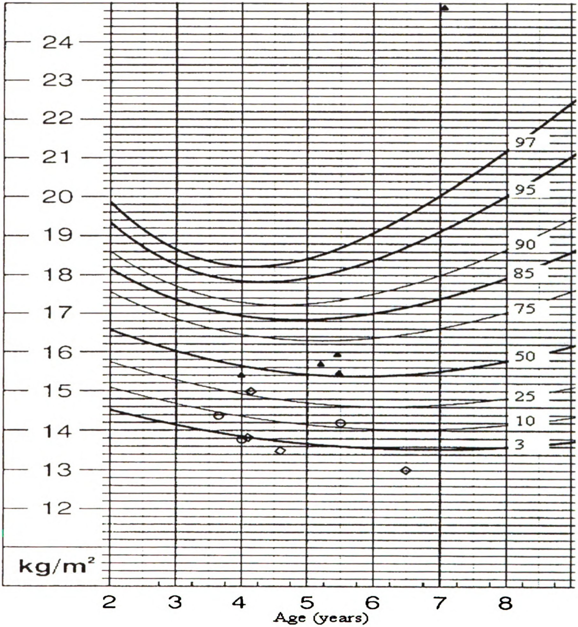


Figure J5. The Body Mass Indexes (BMIs) of boys from the Preterm I (open circles), Preterm II (open diamonds), and Fullterm (filled triangles) groups, with percentile curves indicating national ranks. National Center for Health Statistics, & National Center for Chronic Disease Prevention and Health Promotion (2000). Weight-for-stature percentiles: Boys. Retrieved, from the World Wide Web: http://www.cdc.gov/growthcharts

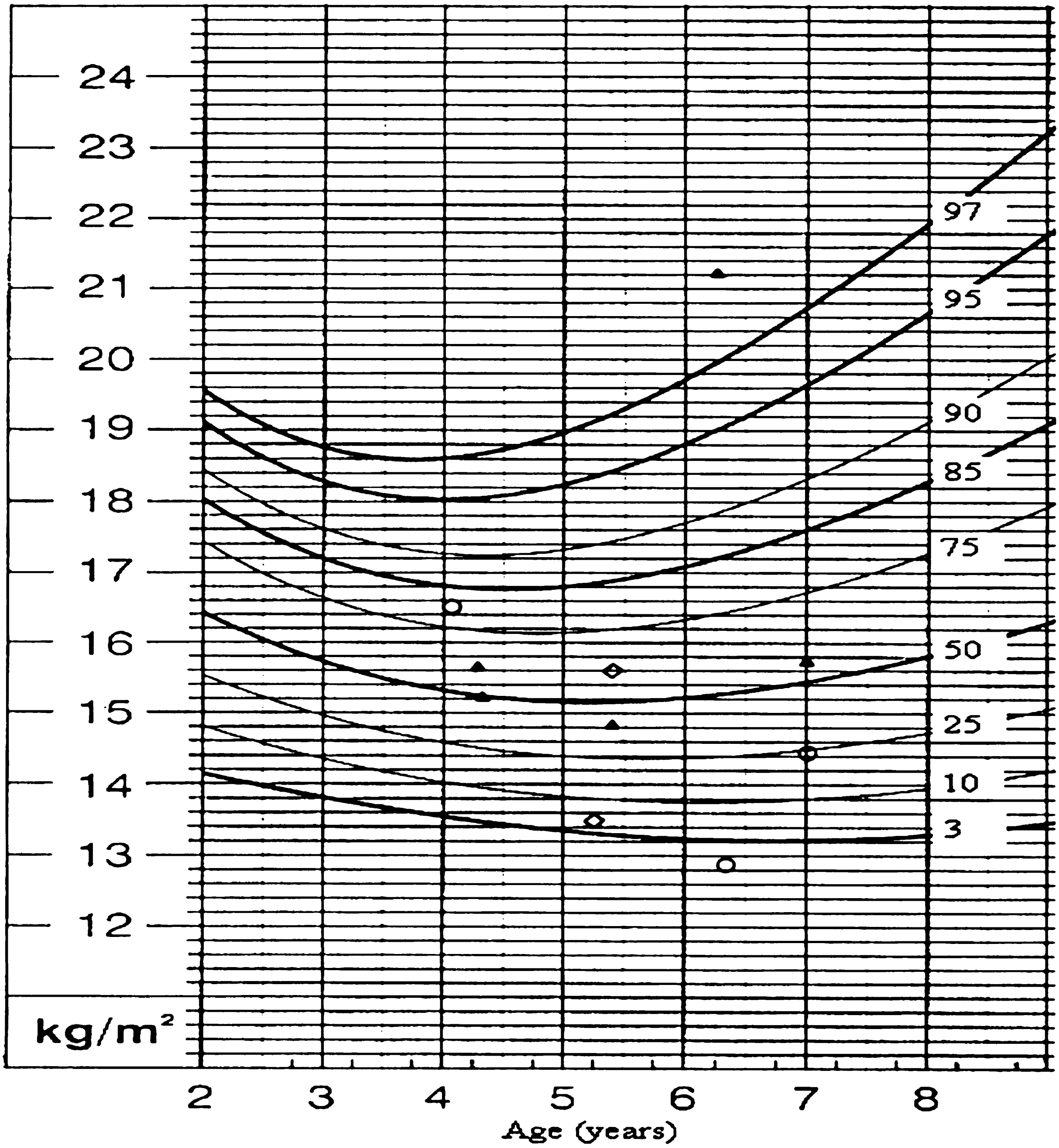


Figure J6. The Body Mass Indexes (BMIs) of girls from the Preterm I (open circles), Preterm II (open diamonds), and Fullterm (filled triangles) groups, with percentile curves indicating national ranks. National Center for Health Statistics, & National Center for Chronic Disease Prevention and Health Promotion (2000). Weight-for-stature percentiles: Girls. Retrieved, from the World Wide Web: http://www.cdc.gov/growthcharts