NOTICE

The quality of this microform is heavily dependent upon the quality of the original thesis submitted for microfilming. Every effort has been made to ensure the highest quality of reproduction possible.

If pages are missing, contact the university which granted the degree.

Some pages may have indistinct print especially if the original pages were typed with a poor typewriter ribbon or if the university sent us an inferior photocopy.

AVIS

La qualité de cette microforme dépend grandement de la qualité de la thèse soumise au microfilmage. Nous avons tout fait pour assurer une qualité supérieure de reproduction.

S'il manque des pages, veuillez communiquer avec l'université qui a conféré le grade.

La qualité d'impression de certaines pages peut laisser à désirer, surtout si les pages originales ont été dactylographiées à l'aide d'un ruban usé ou si l'université nous a fait parvenir une photocopie de qualité inférieure.

UNIVERSITY OF ALBERTA

VALIDITY OF MOTHERS' ASSESSMENTS OF INFANT MOTOR DEVELOPMENT

BY

DOREEN JOAN BARTLETT

A thesis submitted to the Faculty of Graduate Studies and Research in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE.

DEPARTMENT OF PHYSICAL THERAPY

EDMONTON, ALBERTA
SPRING 1992

ISBN 0-315-73149-4

UNIVERSITY OF ALBERTA

RELEASE FORM

NAME OF AUTHOR: Doreen Joan Bartlett

TITLE OF THESIS: Validity of Mothers' Assessments of Infant Motor Development

DEGREE: Master of Science

YEAR THIS DEGREE GRANTED: 1992

Doreen Bartlett

8534 106 A Street
Edmonton, AB T6E 4J9

April 13, 1992

UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled VALIDITY OF MOTHERS' ASSESSMENTS OF INFANT MOTOR DEVELOPMENT submitted by DOREEN JOAN BARTLETT in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE.

Martha Piper

Dr. Martha C. Piper

Joyce Magill-Evans

Dr. Joyce Magill-Evans

Sharon Warren

Dr. Sharon Warren

April 8, 1992

ABSTRACT

The purpose of this study was to determine the validity of mothers' assessments of infant motor development using the Alberta Infant Motor Scale (AIMS). Two groups of infants between 1 and 15 months were identified: full-term infants (n = 30) and preterm infants with birthweights of less than 1500 grams (n = 30). Mothers scored their infants using the maternal version of the AIMS; physical therapists then scored the infants "blind" to maternal scoring.

The Intracl[illegible]rrelation Coefficients between mothers' and physical therapists' assessments were [illegible] and .95 for the full-term and preterm samples respectively. Mothers in both groups over-rated their infants' motor development; however, the magnitude of over-rating was twice as great in the preterm group. Mothers' accuracy in classifying infants as being either "suspicious" or "abnormal" was evaluated by calculating predictive values. Sensitivity, specificity, and positive and negative predictive values for the full-term mothers' ratings were all 100%. Sensitivity, specificity, and positive and negative predictive values for the preterm mothers' ratings were 30%, 90%, 60%, and 72% respectively. A detailed item analysis revealed consistent discrepancies between the ratings of the physical therapists and the mothers of preterm infants on clinically important items.

Full-term mothers accurately identified infants with normal and slightly delayed motor development. Whether they are able to identify abnormality in motor development using the AIMS is not yet known. Preterm mothers are clearly insufficiently accurate in the assessments of their infants' motor development to suggest that they replace physical therapists in the early assessment of motor development. It is not clear whether this difficulty in identifying delay or abnormality in motor development is due to the stressful experience of preterm birth or the difficulty in detecting the finer details of preterm motor development.

ACKNOWLEDGEMENTS

I wish to express my appreciation to the following people and institutions for their assistance in completing this thesis.

To my advisor, Dean Martha Piper, for constantly challenging and stimulating my thoughts, for assisting me to express my ideas more clearly in writing, and for giving me the opportunity to closely observe a researcher with superb integrity, knowledge, and insight. I would especially like to thank her for suggesting the topic for this thesis, which is consistent with my interest in learning how to work better with parents of children with disabilities.

To my committee member, Dr. Joyce Magill-Evans, for asking thoughtful questions that facilitated reorganization of the literature review and for thoroughly reviewing the proposal and thesis drafts. Special thanks also for her constant encouragement through the lengthy process of data collection.

To my committee member, Dr. Sharon Warren, for helping to sort through the issues of validity and reliability and for asking questions encouraging interpretation of the results of this study from a broader perspective.

To Cheryl Vandenbroek, for assisting with the translation of the Alberta Infant Motor Scale into terms that mothers would understand.

To Ed Rodgers, Faculty Service Officer, for converting the Alberta Infant Motor Scale to the Maternal version and for always being cheerfully available to assist with technical matters.

To Dr. Paul Byrne, Director of the Division of Newborn Medicine, Department of Pediatrics at the University of Alberta Hospitals, for facilitating ethics approval at the UAH.

To Penny MacDonald, Director of Research, and the Research Review Committee of the Edmonton Board of Health, for suggesting revisions to the instructions to mothers, and to Marianne Stewart, for facilitating access to the families in various Health Centres for the pilot study and the data collection of the full-term sample.

To Johanna Darrah and Lynda Schmidt, for assisting with data collection.

To Annette Kujda, for coordinating the appointments of the families of the preterm infants and for completing the forms on the medical history of the preterm infants with thoroughness and accuracy.

To Dr. Lynn Pinnell, consultant to the Rehabilitation Research Centre, for assisting with the statistical analysis.

To Dr. Jean Wessel, Chairman of the Graduate Program, for always being available to answer many questions during the process of producing the thesis.

To all of the mothers who participated in this research, for giving so generously of their time.

To my husband, Michael, for his constant support, guidance, and encouragement throughout my graduate studies, and for his assistance in the final preparation of the thesis.

Appreciation is also extended to the Alberta Heritage Foundation for Medical Research for their financial support.

TABLE OF CONTENTS

LIST OF APPENDICES

LIST OF TABLES

TABLE PAGE

LIST OF FIGURES

FIGURE PAGE

CHAPTER 1
THE PROBLEM

Introduction

Parents' assessments of the overall development of full-term infants (Frankenburg, van Doorninck, Liddell, & Dick, 1976) and infants at-risk for developmental problems (Knobloch, Stevens, Malone, Ellison, & Risemberg, 1979) correspond closely with professional evaluation. Little information is available, however, on the validity of parental evaluation of gross motor development of full-term and preterm infants.

Undeniably, parents, particularly mothers (Miller, 1988), have the potential to describe their infants' developmental level in great detail since they have the opportunity to observe their children in a variety of situations over time, whereas a health care professional has but a small sample of an infant's abilities (Squires, Nickel, & Bricker, 1990). Wolfensberger and Kurtz (1971) suggest that parents have the best opportunity to transmit the valuable information they have about their child's development when the scale or questionnaire used is objective and follows a detailed developmental continuum. The Alberta Infant Motor Scale (AIMS) (Piper, Darrah, Pinnell, Maguire, & Byrne, 1989a), with its pictorial and detailed properties, may provide the means to enable mothers to describe their infants' motor development accurately.

Problem Statement

The ability of mothers of full-term and preterm infants to accurately rate their infants' motor development on the Alberta Infant Motor Scale is not yet known.

Significance of the Study

Developmental assessments are usually performed to meet one of two objectives: (1) identification and classification or (2) programming for intervention and remediation (King-Thomas, 1987). This study specifically investigated the ability of mothers to assist in the early identification of neuromotor disorders through the assessment of infant motor development.

Evaluation of infant gross motor development provides the earliest opportunity to diagnose neuromotor abnormality such as cerebral palsy (Scherzer & Tscharnuter, 1982). Prematurity is the most salient birth related risk factor associated with cerebral palsy

(Nelson & Ellenberg, 1986); however, 75% of children with cerebral palsy have normal, healthy neonatal histories (National Institute of Neurologic and Communicative Disorders and Stroke and National Institute of Child Health and Human Development, 1985). Early diagnosis of cerebral palsy therefore requires assessment of both preterm and full-term infants. Of the developmental domains, abnormalities in early gross motor development are of particular interest in preterm infants, because they are often associated with later problems such as speech and language disorders, learning disabilities, and attention deficits (Coolman *et al.* 1985; Piper, Mazer, Silver, & Ramsay, 1988).

In Canada, 18,000 infants at-risk for central nervous system dysfunction are assessed every year in neonatal intensive care follow-up clinics (Hanvey, 1987). Physical therapists are members of the multidisciplinary team that assesses many of these infants. Given the shortage of pediatric physical therapists and the emphasis on improving efficiency in the work place, it is of practical interest to determine whether parents can serve a more active role in the early detection of neuromotor abnormality. If mothers are found to be accurate observers of their infants' motor development, the AIMS may be completed routinely by mothers attending follow-up and well-baby clinics. As a result, health care dollars will be saved (Bricker, Squires, Kaminski, & Mounts, 1988) and parents' feelings of competence in their abilities to help their children will be enhanced (Deal, Dunst, & Trivette, 1989).

CHAPTER 2
LITERATURE REVIEW

Introduction

Determination of the extent to which parents are able to assist in infant motor assessment is important from a practical point of view. In addition to deciding whether parents' assessments are sufficiently accurate to assist in the early identification of neuromotor disorders, knowledge of the degree of correspondence between scores obtained by parents and physical therapists may also affect the nature of their working relationship in the event of a diagnosis of cerebral palsy. A physical therapist is often the first health professional to work closely with the infant and family (Kratochvil & Devereux, 1989), and as such, has the potential to shape parents' attitudes towards the medical and educational service delivery systems (Healy, Keesee, & Smith, 1989). Although the medical model of assessment and treatment is used by many physical therapists, it is considered to be inadequate in the approach to the chronic problems of children with disabilities (Healy *et al.* 1989). Decisions are frequently made unilaterally by health professionals, potentially fostering dependence and undermining a parent's sense of competence. Conversely, in a collaborative model, parents are more likely to acquire a sense of control since they participate fully in identifying and solving problems. Their confidence and ability to handle future challenges is thereby enhanced (Deal *et al.* 1989).

Full parental involvement in assessment and treatment planning is legislated in the United States. Amendments to the Education of the Handicapped Act, which mandate services for infants and children with disabilities from birth through two years of age (Public Law 99-457, Part H, 1986) require that parents and professionals function in a collaborative fashion. While legal changes have not yet been implemented in England, the British government has released initiatives advocating a parent partnership model to manage service delivery to children with special needs (Appleton & Minchom, 1991). Parental involvement is considered to increase the validity of developmental evaluations since parents have a greater opportunity to observe their children in a broader range of circumstances. The Council for Exceptional Children also advocates seeking and using parents' knowledge and expertise in planning, conducting, and evaluating services for children with disabilities (Council for Exceptional Children, 1986). Individuals working with families are encouraged to consider parents as partners and valuable sources of information. Aside from assisting in determining a diagnosis, benefits of the collaborative approach include clarification of parents' perceptions of their child's functional level

(Wolfensberger & Kurtz, 1971), more meaningful goal setting (Turnbull & Turnbull, 1986), and a greater opportunity for generalization of new skills (McConkey, 1985).

Availability of universal health care in Canada has precluded the necessity for legislation mandating services for children with disabilities. Consequently, there are no legal requirements for parental involvement. Canadian experience has determined, however, that compliance with therapeutic recommendations is greater when the parent's opinions of the child's problems are considered during assessment (Cadman, Shurvell, Davies, & Bradfield, 1984). Since compliance is considered to be a major determinant of the effectiveness of treatment programs, clinicians in this country should also be interested in collaborating with parents in assessment. It is of interest to examine the extent to which physical therapists can involve parents in early assessments.

Parents as Observers of their Children's Development

Developmental Concerns

One of the major attitudinal barriers to effective collaboration with parents is the professional's belief that parents' perceptions of their children's abilities are less accurate than the objective results of professional assessment (Brooks-Gunn & Lewis, 1981). Parents believe that they are regarded as less observant, less perceptive, and less intelligent than professionals (Sonnenschein, 1982). In a collection of statements made by professionals who are also parents of children with disabilities (Turnbull & Turnbull, 1978), the discontent expressed as a result of not being heard when reporting concerns about their children's early development to pediatricians is a recurring theme. While some practitioners consider parental concerns sufficient justification for full developmental investigation (Scherzer & Tscharnuter, 1982), it is clear that this philosophy is not held by all. Parents reportedly continue to be disturbed by the lack of value professionals place on parents' perceptions of their child's competencies or deficits (Healy *et al.* 1989). Recently, however, a moderate correlation coefficient of .72 between parental concerns in the areas of articulation, expressive and receptive language, fine motor skills, and global development and failure on a developmental screening test in children under six years of age was obtained (Glascoe, Altemeier, & MacLean, 1989). It was concluded that health care professionals should listen to parents' concerns about their children's development. Unfortunately, the screening test used did not cover social, behavioral, adaptive or gross motor domains; therefore, parental abilities to accurately report concerns in these areas have not yet been validated.

Knowledge of Development

Parents have been shown to lack knowledge of the typical ages at which infants and young children are expected to achieve various milestones (Rivara & Howard, 1982; Shea & Fowler, 1983; Vukelich & Kliman, 1985). Expectations for earlier acquisition of skills are most common.

Recall of Developmental Milestones

Parents have long been known to accurately recall details of their child's birth history such as birth weight and gestational age (Pyles, Stolz, & MacFarlane, 1935); however, the ages at which developmental milestones are acquired are not precisely remembered, with the exception being age of independent walking (Hart, Bax, & Jenkins, 1978). Accuracy of recall of most developmental milestones is known to fade with time. When mothers of one year old children were asked whether their child had been able to sit independently at 6 months, 20% could not remember, 15% reported their child was sitting earlier, and 14% reported their child was sitting later than the records indicated (Hart *et al.* 1978). It was concluded that recall of developmental milestones is likely to be inaccurate.

Reporting Present Status: Typically Developing Children

Frankenburg and associates (1976) have designed a parental questionnaire called the Denver Prescreening Questionnaire (PDQ) in an effort to enhance developmental screening efficiency. The PDQ comprises ninety seven questions derived from the complete Denver Developmental Screening Test (DDST) (Frankenburg & Dodds, 1967) covering an age range of three months to six years. In a concurrent validity study, parents answered ten questions from the PDQ selected for the age of their child. Item agreement between parental ratings on the PDQ and professionals' assessments using the DDST ranged from 68% to 100% with a mean of 93.3%. Not surprisingly, items having the highest rate of agreements were predominantly those which could be passed by report on the DDST. In the case of non-agreement, parents showed a tendency to overestimate the abilities of their children relative to the trained tester. The developmental domains preferentially overrated were not reported. The investigators concluded that overall, parents can accurately prescreen the development of their children.

The PDQ was subsequently revised: parents were asked to respond to a greater number of items, scoring was simplified, and comparison to the DDST to establish developmental age was facilitated (Frankenburg, Fandal, & Thornton, 1987). The investigators reported that parental scoring of the revised PDQ identified 84% of the non-normal DDST results and recommended its use in community mass screening programs.

A team interested in the validity of parental report of infant behavior and temperament designed a scale called the Baby Behavior Questionnaire (Hagekull, Bohlin, & Lindhagen, 1984). Objectivity of direct parental observation of infant behavior was determined by correlating ratings of parents with those of a trained observer. Correlation coefficients on six scales ranged from .52 to .93 (median = .78). They then recruited a second sample of parents and correlated both parental ratings of the Baby Behavior Questionnaire completed from their memory of the child and parental ratings of direct observations with professional evaluation and found a greater degree of correspondence in the scores in the latter condition. They concluded that parents are relatively objective observers of their own infants; however, they recommended that parents observe their children directly prior to filling out the form to increase accuracy.

Reporting Present Status: Atypically Developing Children

Early studies investigating the utility of parental ratings of children with cognitive disabilities compared parental estimates of their child's intelligence and formal IQ testing. Correlations were only moderate with coefficients of .55 (Ewert & Green, 1957), .67 (Schulman & Stern, 1959), and .49 (Heriot & Schmickel, 1967). These relatively low values may have been due to poor test administration by the psychologists, lack of parental observation of child development in the 1950s and 60s, or vague questioning of the parents (e.g., "Your child is .... years old. At what age would you estimate he is functioning?" [Schulman & Stern, 1959]).

By questioning parents specifically on the abilities of their globally delayed children across several developmental domains prior to asking them to estimate cognitive age level, improved correlations with formal intelligence testing were obtained: .85 (Coplan, 1982), and .87 (Johnson, Poteat, & Kushnick, 1986). The latter group reported that while mothers recognized that their children were functioning below the norm, they did not recognize the magnitude of the delay and tended to overestimate their children's abilities. The higher correlation coefficients obtained by these investigators may be attributed to increased rigor in psychological testing, improved observation by parents, or more detailed discussion of developmental areas prior to the assessment.

Studies determining the concurrent validity of parental rating scales and formal standardized testing of children referred for developmental evaluation or enrolled in an intervention program are listed in Table 1. Correlation coefficients are generally moderate to high, indicating that parental rating may be as valid a measure of the abilities of developmentally delayed children as formal testing. Gradel, Thompson, and Sheehan (1981) were the only investigators to report a difference based on the age of the child.

Table 1.
Concurrent Validity: Parental Ratings and Standardized Tests

Investigator	Sample	Parent	Professional	Correlation Coefficient
Gradel et al. (1981)	3-24 mth+ (n = 30)	BSID (interview)	BSID - MDI - PDI	0.69 0.67
	38-73 mth+ (n = 30)	MCSA (interview)	MSCA - GCI	0.88
Sexton et al. (1982)	7-72 mth* (n = 18)	modified LAP	LAP	0.95
Stancin et al. (1984)	1-9 years' (n = 106)	KIDS	BSID	0.89
Byrne et al. (1986)	12-30 mth* (n = 67)	MCDI - GDI	BSID - MDI	0.66
	34-79 mth* (n = 71)	MCDI - GDI	MSCA - GCI	0.52
Saylor and Brandt (1986)	8-30 mth* (n = 115)	MCDI - GDI	BSID - MDI	0.91
Sonnander (1987)	18 mth* (n = 57)	Parental Questionnaire (from GMDS)	GMDS	0.87
Sexton et al. (1990)	23-66 mth+ (n = 53)	DP II - physical	BDI - motor	0.91

Key: + attending early intervention program
* referred for developmental assessment
' severely disabled

BSID Bayley Scales of Infant Development (Bayley 1969) - MDI Mental Developmental Index - PDI Psychomotor Developmental Index
MCSA McCarthy Scales of Children's Abilities (McCarthy, 1972) - GCI General Cognitive Index
LAP Learning Accomplishment Profile (Sanford, 1974)
KIDS Kent Infant Development Scale (Katoff, 1978)
MCDI Minnesota Child Development Inventory (Ireton & Thwing, 1978) - GDI General Development Index
GMDS Griffiths Mental Development Scale (Griffiths, 1954)
BDI Batelle Developmental Inventory (Newborg et al. 1984)
DP II Developmental Profile II (Alpern, Boll, & Shearer, 1988)

They obtained greater congruency with the older children, possibly due to mothers becoming more aware of their children's developmental level through involvement in an intervention program.

Most of the investigators used, or appeared to use, the Pearson's Product Moment Correlation as a measure of association. Although this correlation provides a measure of association, it is not sensitive to the systematic differences between the raters (Hartmann, 1977); that is, correlations can be high if one group consistently rates development higher than the other. Most of the investigators also compared mean scores to determine whether there was a difference between the overall ratings of parents and professionals. Three groups found no difference between raters (Byrne, Backman, & Smith, 1986; Sexton, Kelley, & Scott, 1982; Sonnander, 1987); one reported that mothers overestimated by one month (Stancin, Reuter, Dunn, & Bickett, 1982); two others noted that mothers consistently and significantly overestimated (Gradel *et al.* 1981; Sexton, Thompson, Perez, & Rheams, 1990); and one did not discuss the issue (Saylor & Brandt, 1986). Gradel and colleagues (1981) stated that the difference in mean scores may be due to professionals underestimating the children's abilities due to lack of opportunity to adequately observe behavior.

Byrne and associates (1986) also analyzed their results based on correct categorization of delayed or normal status, recognizing that determination of overall status is more important than a single value. They found that mothers correctly identified 83 percent of the preschool sample, and only 62 percent of the infant sample, again indicating that parental scoring of infants' abilities may be less accurate than scoring the abilities of preschoolers.

Reporting Present Status: At-risk Infants

Results of investigations of parental rating of at-risk infants do not consistently support the apparent trend of infants being more difficult to rate accurately than preschoolers. Field, Hallock, Dempsey, and Shuman (1978) studied the reliability of maternal rating of infant behavior using the Mother's Assessment of the Behavior of her Infant (MABI) which was derived from Brazelton's Neonatal Behavioral Assessment Scale (NBAS) (Brazelton, 1973). Twenty full-term infants and twenty preterm infants with respiratory distress syndrome (RDS) were independently assessed near term by mothers using the MABI and by clinicians using the NBAS. No significant differences in the scoring of the dimensions of motoric processes and state control were reported between the two groups of raters, both scoring the RDS babies less optimally than the full-term babies.

It was concluded that mothers of preterm infants are objective observers of their infants' behavior.

Knobloch and colleagues (1979) developed a parental questionnaire to evaluate the overall development of infants from four weeks to thirty six months. Following the scoring of the questionnaire, children are classified as being normal, abnormal, or questionable. In a predictive validity study, mothers of 526 high-risk infants completed the questionnaire when their baby was 28 weeks of age, adjusted for prematurity, and subsequently the family attended the clinic for a full scale professional Gesell assessment (Knobloch & Pasamanik, 1974) at 40 weeks. When the results at 40 weeks were compared to those from the 28 week assessment, mothers classified more than 80% of the infants correctly. The false negative rates were 2.6% and 10% for major and minor abnormalities, respectively, while there was a 6% false positive rate. The false negative rates may be attributed to the finding that motor developmental quotients have been found to decline with age (Barrera, Rosenbaum, & Cunningham, 1987; Largo, Molinari, Weber, Comenale Pinto, & Duc, 1985; Mazer, Piper, & Ramsay, 1988). The false positive rate may be explained by transient neurological findings which may have resolved in the interval from 28 to 40 weeks (Coolman *et al.* 1985; Piper *et al.* 1988). The authors concluded that parental report as mediated through this questionnaire is an accurate method of screening high-risk infants.

Similarly, Bricker *et al.* (1988) developed a series of questionnaires covering a broad range of domains designed to be completed by parents every 4 months from 4 to 24 months of age. In a sample of at-risk infants (n = 264), 97% agreement in categorizing a child as normal or abnormal was obtained between mothers, who used the questionnaire, and clinicians, who used the Revised Gesell Schedules (Knobloch, Stevens, & Malone, 1980) as criterion. An extension of this study (Bricker & Squires, 1989) on a similarly sized mixed sample of parents of preterm and full-term infants resulted in 89% agreement in classification of the infant between the parental questionnaires and professional scoring the Bayley Scales of Infant Developme (Bayley, 1969). Test-retest reliability of parental scoring within a two to three week interval was determined to be .91 demonstrating that parents' evaluations are consistent over time. The data from the studies were pooled to determine the questionnaires' sensitivity and specificity. Overall sensitivity was .63 ranging from a low of .43 at 4 months to a high of .94 at 12 and 16 months. Overall specificity was .91 ranging from a low of .83 at 24 months to a high of .94 at 12 and 16 months. It was concluded that parents can contribute significantly to the developmental follow-up of infants greater than 4 months of age.

Kopparthi and associates (1991) conducted a concurrent validity study investigating the extent of correspondence between the General Developmental Index of the Minnesota Child Development Inventory (MCDI) (Ireton & Thwing, 1974) and the Mental Developmental Index of the Bayley Scales of Infant Development (BSID) (Bayley, 1969) on a sample of moderately at-risk infants between 8 and 19 months. While they obtained a strong correlation of .88 between the scales, the sensitivity and positive predictive value of the MCDI in identifying infants with an MDI of greater than two standard deviations below the mean was too low for the investigators to suggest that parents are able to identify infants with delayed development.

Factors Affecting Parental Rating

Gender of Parent

Although it has been shown that mothers and fathers do not differ in estimates of their child's abilities (Coplan, 1982; Keshavan & Narayanan, 1983), mothers generally have more experience with children, both their own and others (Miller, 1988; Ninio, 1988). Mothers have demonstrated better knowledge of development (Ninio, 1988; Shea & Fowler, 1983) and less error in estimating age of acquisition of developmental milestones (Kliman & Vukelich, 1985; Ninio, 1988).

Demographic Characteristics of Mothers

The main maternal characteristic cited as being related to knowledge of development and ability to accurately rate developmental status is years of education (McCune, Richardson, & Powell, 1984; Ninio, 1988; Parush & Clark, 1988; Rivara & Howard, 1982; Shea & Fowler, 1983; Vukelich & Kliman, 1985). While socioeconomic status affects maternal rating, maternal educational level has been shown to have the greatest impact (McCune *et al.* 1984; McGillicuddy-DeLisi, 1982). Conversely, no effect of either education or socioeconomic status on knowledge of development or the ability to rate a child has also been reported (Coplan, 1982; Eisert, Spector, Shankaran, Faigenbaum, & Szego, 1980; Ely, Healey, & Smidt, 1972; Hagekull *et al.* 1984; Knobloch *et al.* 1979; Sawyer, Sarris, Baghurst, Worsley, & Kalucy, 1989).

Other potential factors include age, race, marital status, and number and spacing of children in the home. Maternal age affects knowledge of child development during the teenage years (Becker, 1987; Vukelich & Kliman, 1985), but has no impact during adulthood (Parush & Clark, 1988). While race may affect the expectations a mother has for her child's development (Hopkins & Westra, 1989), this may be attributed to the different patterns of development in the races (Capute, Shapiro, Palmer, Ross, & Wachtel, 1985), and should not affect the ability a mother has to describe her child's current development. There is no evidence that marital status affects maternal perception of development (Eisert *et al.* 1980). Finally, it has been shown that the number and spacing of children in the family do not affect the knowledge of development (McCune *et al.* 1984; Rivara & Howard, 1982; Sawyer *et al.* 1989; Vukelich & Kliman, 1985) or the ability to report on overall child development or infant behavior (Coplan, 1982; Hagekull *et al.* 1984). Whether these two variables affect mothers' abilities to rate motor development specifically is unknown.

Maternal Perceptions

Parents prepare for the birth of a normal, healthy baby with joyful anticipation. The untimely interruption of pregnancy has long been recognized to be extremely stressful for parents (Prugh, 1953), particularly mothers (Kaplan & Mason, 1960). Parents are initially shocked and frightened with the unexpected onset of premature labour. The impending delivery quickly evolves into an emergency situation necessitating rapid transfer to a regional hospital with specialized facilities for preterm infants (Shosenberg & Lennox. 1985). Following the delivery, anxiety is intensified when the tiny, fragile, and unattractive infant is first seen. Parents find the appearance of the ventilated infant in the isolette with an intravenous line, nasogastric tube, and monitors to record heart rate, oxygen level, and temperature very distressing (Goldberg & DiVitto, 1983). They report that the most stressful situations encountered in preterm birth involve the appearance and behavior of their infant, specifically when the infant turned blue or stopped breathing, acted as if in pain, or appeared weak and limp (Miles, 1989). Fear of the infant's death and helplessness are predominate early emotions (Blackburn & Lowen, 1986; Fraley, 1986; Hummel & Eastman, 1991; Pederson, Bento, Chance, Evans, & Fox, 1987). Many mothers grieve the alteration of their parental role; they are distressed at not being able to care for their infant (Miles, 1989) and are frustrated by lengthy separations (Shosenberg & Lennox, 1985). Details of the events around the time of a preterm birth remain very clear in mothers' minds for a long time, and feelings of guilt in having caused the early birth are common, even though half of the preterm births continue to be unexplained (Goldberg & Divitto, 1983; Hummel & Eastman, 1991).

Upon the infants' discharge, mothers frequently have concerns about being able to care for a baby who has previously required so much expert attention (Fraley, 1986; Goldberg & Divitto, 1983; Pederson *et al.* 1987). Mothers of preterm infants have been found to provide their infants with more care, attention, and stimulation at 4 months of age than mothers of full-term infa nard, Bee, & Hammond, 1984). Compensation for the preterm infants' reduced responsiveness is speculated as the reason for this increased effort.

While the infant is in the NICU, a mother fears for her baby's life; following hospital discharge, she is concerned about developmental outcome (Hummel & Eastman, 1991). Fear that the child may not develop normally surfaces when other infants surpass her child in attaining skills such as crawling or walking (Fraley, 1985). Mothers remain anxious for their infants to "catch-up" to the developmental milestones attained by full-term infants (Barrera *et al.* 1987). Uncertainty continues throughout the first few years of the child's life until questions about prognosis for long-term development can be answered (Goldberg & Divitto, 1983).

The experience of preterm birth is undeniably stressful. The literature contains inconsistent reports on the duration of the stressful period following preterm birth. While all studies report increased stress when the infant is in the NICU, normal emotional experiences among mothers of preterm infants were reported when the infant reached 1 (Trause & Kramer, 1983), 2 (Gennaro, 1988), 7 (Trause & Kramer, 1983), and 9 (Brooten *et al.* 1988) months of age. In contrast, other investigators have observed continued anxiety throughout the first year (Hummel & Eastman, 1991; Jeffcoate, Humphrey & Lloyd, 1979).

These early experiences may have a long term negative impact on parents' perceptions of their infant. Over the longer term the "vulnerable child syndrome" may result if parents of a previously acutely ill preterm infant perceive their child to be vulnerable to serious illness or accident, despite a good recovery. This syndrome features over-protectiveness and infantilization by the parents who have lost objectivity regarding their child's current health and developmental status (Green & Solnit, 1964). Several reports express the concern and fear that mothers of preterm infants experience when leaving their child with a baby-sitter through the first year (Hummel & Eastman, 1991; Jeffcoate *et al.* 1979). Stern and Hildebrandt (1988) have identified a phenomenon referred to as "prematurity stereotyping" which is defined as a set of biased beliefs about infants who are identified as having been born early. When mothers of preterm infants were asked to describe the characteristics of full-term infants who were labelled either full-term or preterm, the preterm labelled infant was perceived to be smaller, weaker, more passive, and slower than the infant labelled full-term (Stern & Hildebrandt, 1988).

While mothers of at-risk infants have been described as objective observers of their infants' overall development (Bricker *et al.* 1988; Field *et al.* 1978; Knobloch *et al.* 1979), they have also been influenced by prematurity stereotyping. Stern and Karraker (1990) suggest that further research is needed to describe how parents of preterm infants perceive their infants. Are mothers of preterm infants influenced by "prematurity stereotyping", consequently underestimating their infants' motor skills, or do they overestimate their preterm infants' abilities, perhaps as a result of having invested more time and effort in interacting with and caring for them (Goldberg & DiVitto, 1983)?

Sex stereotyping in infants has also been identified, such that infants labelled female are described as softer, finer and weaker, while infants labelled male are firmer, larger featured, stronger and better coordinated (Rubin, Provenzano, & Luria, 1974). In rating children with disabilities, parents of boys tend to overestimate their children's abilities more than parents of girls (Wolfensberger & Kurtz, 1971). It is important, therefore, to consider infant gender when investigating parents' perceptions of their infants.

Infant Motor Development

Definition

Motor development is defined as the sequential change in specific motor activities with age, in part reflecting the structural changes in a maturing central nervous system (McGraw, 1969). Consequently, it is often referred to as "motor maturation". Changes in motor behavior are most dramatic during the first year of life when the infant gradually gains control against gravity, ultimately achieving stable upright stance and mobility around the first birthday. McGraw (1969) was among the first to recognize that the change in the quality of movement was more important than the simple acquisition of motor milestones. Bly (1983) emphasized that components of movement such as balanced axial flexion and extension against gravity, controlled weight shift, and highly developed righting and equilibrium reactions in response to weight shift are required in order to achieve good quality in the performance of motor milestones. In order to truly measure the qualitative changes occurring during motor maturation, the developmental scale should capture these components of movement.

Differences between Preterm and Full-term Infants

Many preterm infants demonstrate motor behavior that is different from that of full-term infants. Transient dystonia, a syndrome of temporary abnormal neurological signs, has been observed in approximately 50% of preterm infants in the first year of life (Drillien, 1972). Affected infants commonly exhibit poverty of movement and poor head control in pull to sit in contrast to good head control in prone, extended and adducted lower extremities with plantarflexion, exaggerated primitive reflexes, brisk phasic reflexes, ankle clonus, and delayed motor development (Drillien, 1972). Other researchers have also observed neck hyperextension and reduced lateral head righting (Gorga, Stern, & Ross, 1985; Valvano & DeGangi, 1986), and hypertonicity of the extremities (McGrew, Caitlin, & Bridgeford, 1985; Piper, Darrah, & Byrne, 1989b), shoulder girdle (Georgieff & Bernbaum, 1986), and trunk (Georgieff, Bernbaum, Hoffmann-Williamson, & Daft, 1986; Touwen & Hadders-Algra, 1983). Qualitatively, preterm infants demonstrate less trunk rotation in transition movements, and their movement is described as being less smooth and coordinated than full-term infants (Gorga, Stern, Ross, & Nagler, 1988). Tonal abnormalities and the subsequent movement differences progressively resolve through the first year and the affected preterm infants then appear to be developing similarly to full-term infants (Drillien, 1972; Gorga *et al.* 1985). It is not known whether these differences in early motor development affect a mother's ability to accurately assess motor development.

Deficits in Existing Measures

The most popular measures of infant motor development in use today are the Revised Gesell Developmental Schedules (GDS) (Knobloch *et al.* 1980), the Motor Scale of the Bayley Scales of Infant Development (BSID) (Bayley, 1969) and the Gross Motor Scale of the Peabody Developmental Motor Scales (PDMS) (Folio & Fewell, 1983). Although they are widely used due to acceptable indices of reliability, they are inadequate tools for the pediatric physical therapist.

The GDS were originally published in 1925 after many years of careful observation of child development (Gesell, 1925). Revisions and standardization lead to the first edition of *Developmental Diagnosis* (Gesell & Amatruda, 1941). Gesell has been credited with providing the first quantitative measure of child development (Buros, 1949) and as such, the GDS form the basis for most tests of infant development currently in use (Goldberg & DiVitto, 1983). The GDS were further revised by Knobloch and Pasamanik (1974) and have recently been renormed (Knobloch *et al.* 1980). The revised GDS comprise five fields of behavioral development: adaptive, gross motor, fine motor, language, and personal social. The schedules have been criticized for not having an equal number of items at successive age levels (Bayley, 1949). In the gross motor section, the number of items appears to be adequate up to sixteen weeks, however, later in the schedules, only two items capture prone progression: pivoting at 32 weeks and creeping at 40 weeks. While there is a detailed analysis of the attainment of the ability to sit independently, transition from prone or supine to the sitting position is not measured. Throughout the schedules, focus is on the attainment of milestones, rather than an evaluation of the quality of movement.

The BSID also contain an uneven distribution and an insufficient number of items to test various motor skills at all age levels (Ramsay & Piper, 1980). To illustrate this point, there are three items at 9 months, none at 10 months and two at 11 months. An 11 month old who happens to fail those particular 11 month items will have an age equivalent score of 9 months. In addition, there are omissions in the motor developmental sequences. For example, all methods of prewalking progression are assessed by a single item at 7 months. The Motor Scale of the BSID is based on acquisition of motor milestones, rather than analysis of qualitative aspects of movement, and as such, an infant can obtain normal scores while exhibiting atypical posture and movement signs associated with transient dystonia (Valvano & DeGangi, 1986).

The PDMS, which contain a larger number of items at each age level, are also based on skill acquisition; however, the qualitative aspects of movement of interest to physical therapists are not incorporated. As noted with the BSID, some children may pass items yet demonstrate abnormal movement patterns indicative of neuromotor dysfunction (DeGangi, 1987). The PDMS have been identified as being more useful in the assessment of older infants or children than for early infant assessment since many of the early items involve placing the infant in a position and eliciting a response which may not occur spontaneously as part of the child's movement repertoire. For example, the child is placed in supine and required to grab a stable chair and pull to sit in order to obtain a toy (Palisano & Lydic, 1984). In addition, the scales credit manifestation of the walking and asymmetrical tonic neck reflexes, rather than the resolution of these primitive reflexes. Clearly the scales were developed by individuals unfamiliar with infant motor development. Few developmental tests have been normed for children between the ages of 3 to 5 years and therefore the PDMS fill a void (DeGangi, 1987; Hinderer, Richardson, & Atwater, 1989; Palisano & Lydic, 1984).

The Alberta Infant Motor Scale: Description

The AIMS (Piper *et al.* 1989a) is a qualitative assessment currently under construction at the University of Alberta. It encompasses motor developmental sequences by assessing 58 items in prone, supine, sitting, and standing from birth to the attainment of independent walking. The AIMS captures the components of weight bearing, posture, and antigravity movements (Bly, 1983) through drawings. McGraw (1969) and Bly (1983) both stress that repetition of a motor activity is fundamental to the acquisition of new skills. The items on the AIMS have been specifically chosen to reflect those activities likely to be observed if an infant has incorporated them into his movement repertoire. The pictures also address both the neurological and developmental dimensions required of an infant motor test (Touwen, 1976). As an observational scale, the AIMS is not invasive and subsequently does not elicit "stranger anxiety". Horner (1980) concluded that infants do not become anxious if they are in control of the situation and not confronted directly by strangers. Minimal handling is needed to administer the test, and may be done by the mother, if required.

The AIMS was designed to 1) identify infants whose motor performance is delayed or aberrant; 2) provide information to the clinician and the parent on the skills the infant has mastered, is currently developing, and has not yet developed; 3) monitor development over time; and 4) evaluate the efficacy of a rehabilitation program for infants with motor disorders (Piper, Pinnell, Darrah, Maguire, & Byrne, 1991).

Parental Rating of Infant Motor Development

In contrast to general developmental milestones, the ages of acquisition of gross motor milestones are more familiar to parents. Ely *et al.* (1972) asked 100 postpartum women to estimate the ages a child is expected to roll, sit, pull to stand, walk around furniture, stand alone, and walk independently. All maternal estimates were within the 90th percentile as determined on the DDST (Frankenburg & Dodds, 1967). It was concluded that mothers have sufficient knowledge of gross motor development to identify prolonged delays which may be indicative of a developmental disorder.

One study specifically examined parental rating of motor abilities of 72 one year old graduates of an intensive care nursery (Goldstein, 1985). A correlation of .86 was obtained between the parental report of motor development as measured by the Motor Scale Survey Form of the Vineland Adaptive Behavior Scales (Sparrow, Balla, & Cicchetti, 1984) and the Motor Scale of the BSID (Bayley, 1969). No significant difference in the age equivalents as determined by parents or professionals was reported, and it was concluded that parents were able to give accurate accounts of their infants' motor age.

In contrast, although Kopparthi and associates (1991) obtained a strong correlation (.92) between the gross motor scale of the MCDI (Ireton & Thwing, 1974) and the PDI of the BSID (Bayley, 1969), the positive predictive value of the MCDI in correctly identifying infants functioning more than two standard deviations below the mean on the PDI was too low (27%) for the researchers to recommend that parents' assessments are useful in identifying infants with motor delay.

The discrepancy between the conclusions of these two reports is partially due to different methods of analysis. A more significant consideration pertaining to both studies is the questionable validity of the criterion measure. The accuracy of a test result is based on the belief that the criterion measure represents a sound assessment of the phenomenon under investigation (Fletcher, Fletcher, & Wagner, 1988). The MDI of the BSID (Bayley, 1969) may measure motor milestones, however it does not differentiate between infants with normal and atypical motor development (Valvano & DeGangi, 1986). Although Goldstein (1985) found that parents are able to report on the motor milestones their infants currently exhibit, one cannot extend this by concluding that if a parent identifies age appropriate milestone acquisition, motor development is normal. This extrapolation is also confounded by the observation that the norms for the BSID may be out-dated (Campbell, Siegel, Parr, & Ramey, 1986).

Summary

Although not all parents may be able to recall developmental milestones precisely or be knowledgeable of general child development, they frequently have valid concerns regarding their children's development. Parents have the ability to reliably report on the overall development of typically developing, delayed, and at-risk infants and children. There is growing evidence that when asked the right questions in sufficient detail, they are able to provide valuable information about their children's abilities.

Mothers are believed to have better knowledge of their infants than fathers, with education level being the most important factor determining a parent's ability to accurately report about development. Preterm infants often demonstrate different motor behavior when compared with full-term infants. In addition, preterm and full-term, and male and female infants may be perceived differently. Little information is available as to how these differences may affect mothers' abilities to assess motor development.

Gross motor development is an important developmental domain in the assessment of neurological abnormality. The Alberta Infant Motor Scale is a measure of infant motor development which may be amenable to parental scoring. While mothers have been shown to be accurate in the assessment of behavior and general development, the ability of mothers of full-term and preterm infants to rate their infant's motor development on a qualitative motor developmental scale is not yet known.

CHAPTER 3
METHOD

Objectives

1. To determine the concurrent validity of infant motor assessment between mothers of full-term infants and experienced pediatric physical therapists using the Alberta Infant Motor Scale (AIMS).

2. To determine the concurrent validity of infant motor assessment between mothers of preterm infants and experienced pediatric physical therapists using the AIMS.

3. To determine whether the concurrent validity of infant motor assessment between mothers of full-term infants and experienced physical therapists differs from the concurrent validity obtained between mothers of preterm infants and experienced physical therapists.

Research Hypotheses

1. There will be a significant positive relationship between mothers' and physical therapists' assessments of motor development of full-term infants.

2. There will be a weak, non-significant positive relationship between mothers' and physical therapists' assessments of motor development of preterm infants.

3. There will be a significant difference between correlation coefficients obtained between mothers of full-term infants and physical therapists and between mothers of preterm infants and physical therapists.

Design

This study addresses the issue of concurrent validity of mothers' and physical therapists' assessments of infant motor development. Validity is defined as the degree to which a measurement corresponds to the true state of the phenomenon being measured (Fletcher *et al.* 1988). Concurrent validity is one type of criterion-related validity referring to the degree of correspondence between an obtained measurement and the observed standard or criterion both taken around the same time (Rothstein, 1985), which in this case are mothers' and physical therapists' scores, respectively.

Mothers of full-term and preterm infants from 1 to 15 months of age were identified. Informed consent was obtained. Mothers scored their infants using the maternal version of the AIMS from knowledge of their infants' motor performance. A physical therapist then independently completed the AIMS on the same infants, blind to maternal scoring.

Sample

Ten mothers of full-term infants and 10 mothers of preterm infants in the age ranges of 1 to 5, 6 to 10, and 11 to 15 months were recruited for a total of 30 mothers in each group, 60 overall. Recruitment was limited to mothers who spoke English. To fit into the one to five month age range, the infant was between one month zero days and five months thirty days at the time of the assessment. This guideline extended to the two remaining age ranges, and held for both samples. Stratification by age of the infant ensured representation along the developmental continuum measured by the AIMS, thereby capturing the development of axial flexion and extension, prone mobility, and ambulation.

Mothers of full-term infants were identified through the well-baby clinics of the Edmonton Board of Health. Infant criteria included gestational age from 37 to 42 weeks, birth weight greater than 2500 grams (5 pounds, 8 ounces), vaginal vertex delivery (or planned Caesarian section), Apgar score greater than or equal to 7 at 5 minutes, and age at the time of the assessment from 1 to 15 months. Infants with abnormal hospital discharge pediatric examinations were excluded (Appendix A).

Mothers of preterm infants were identified through the Neonatal Intensive Care Unit (NICU) of the University of Alberta Hospital. Preterm infants had a birth weight of less than 1500 grams. Age at the time of assessment was between 1 and 15 months, adjusted for prematurity. Infants with sensory, musculoskeletal, or major congenital abnormalities were excluded.

Data Collection: Measures

Inclusion Criteria and Descriptive Data

Data on the full-term infants' sex, date of birth, and inclusion criteria were transcribed from the Edmonton Board of Health's copy of the birth record after obtaining informed consent. Chronological age was calculated by subtracting the date of birth from the date of the assessment, and was expressed in months. For the purposes of calculation, a month is considered to have 30.4 days. See Appendix B for the Data Collection Form on the full-term infants.

Data on the preterm infants' sex, date of birth, gestational age at birth, birth weight, and details of neonatal medical status were transcribed from the health record in order to describe the sample. The corrected age was calculated by subtracting the days of prematurity from the chronological age; where days of prematurity is 40 weeks minus gestational age in weeks, all multiplied by 7 (Chandler, Andrews, & Swanson, 1980). See Appendix C for the Data Collection Form on the preterm infants.

For both infant groups, educational level was determined by asking the mother to report her highest level of achievement in formal schooling. Information on the number of additional children in the home and the dates of birth of all of the siblings was collected by questioning the mother. The interval of time between the births of the two youngest children was calculated by subtracting the older child's date of birth from the study subject's date of birth and was expressed in months.

The Alberta Infant Motor Scale: Psychometric Properties

The AIMS (Piper *et al.* 1989a), which is still under construction, was used to measure infant motor development in this study (Appendix D). Correlation coefficients reflecting concurrent validity with the motor scales of the BSID and the PDMS have been determined to be .98 and .97, respectively, on assessment of typically developing infants. Values for interrater and test-retest reliabilities on the same sample were also very high (r = .99 for both) (Piper *et al.* 1991). Concurrent validity and interrater reliability with a sample of at-risk and neurologically abnormal infants is now being determined.

To administer the AIMS, the infant is observed when in an optimal behavioral state, either fully undressed or wearing a diaper. Infants were not assessed if they were obviously fatigued, hungry, or otherwise irritable or anxious. Minimal handling is needed and may be done by the mother. No particular sequence of observation in the various positions is required. The assessment can usually be completed within 20 minutes. The infant is credited with a "pass" if the item is observed. A score of "fail" is given if the child is not capable of performing the item, is not yet performing it to the specific criteria, or if the item is not observed. A raw score is tallied from the number of items credited with "pass" plus the number of items clearly below the infant's current level of functioning.

The AIMS was "translated" to lay terms to accommodate the discrepancy in training and experience in assessing infant motor development between mothers and physical therapists (Appendix E). The maternal version was checked by the developers of the AIMS to ensure adequate representation of the items. The revised scale was piloted on four mothers who had not completed high school and three mothers who had not gone beyond high school. The pilot study led to simplified scoring instructions (Appendix F). Mothers were asked to score their infants on the maternal version by circling all of the items either "Y" (yes), if their baby was performing an activity at the present time or had done the activity in the past; or "N" (no), if their baby was not yet performing an activity. A raw score was tallied based on the number of items the mother designated "Y" plus the number either unmarked or marked "N" if they were *clearly* items much earlier in the motor sequence than represented by the infant's current repertoire.

Data Collection: Procedures

Ethics approvals were obtained from the Department of Physical Therapy, Faculty of Rehabilitation Medicine, the University of Alberta; the Edmonton Board of Health; and the University of Alberta Hospitals before data collection began.

To increase the generalizability of the results of this study, three physical therapists collected data. All three physical therapists were experienced in the motor assessment of infants and had previous experience with the AIMS. They have the ability to quickly develop rapport with families and to facilitate a comfortable atmosphere so the infant will perform optimally. The physical therapists systematically performed similar numbers of assessments for both the full-term and preterm infants in the three age ranges as outlined in the sampling guide (Appendix G).

The full-term sample came from well-baby clinics of the Edmonton Board of Health. The clinic schedule was reviewed for potential infants in the appropriate age ranges. The clerks asked mothers of selected infants if they were willing to have a physical therapist speak to them following weighing and measuring of their baby. If upon learning the details of the study the mothers agreed to participate, inclusion criteria were reviewed verbally. The mothers then read and signed the Consent Form (Appendix H) after all questions were answered. Descriptive data obtained by questioning the mother were recorded. The mother scored her infant either before or after the well-baby visit with the nurse. Following the clinic appointment, the infant was assessed by a physical therapist, who was blind to maternal scoring. The infant's health record was reviewed following all scoring to confirm that the inclusion criteria had been met.

The preterm sample was accessed through ongoing studies on preterm infants in the Faculty of Rehabilitation Medicine at the University of Alberta. Most of the subjects were part of the discriminant validity testing of the AIMS which included a mixed sample of infants: 50 infants with high risk histories, 20 infants with a diagnosed neurological abnormality, and a small number of infants with normal full-term deliveries. Therapists were blind to the history of the infants. Since interrater reliability was a component of this phase of test construction, each infant involved in the discriminant validity study was assessed by two physical therapists, who functioned as either primary or secondary rater. For the purposes of this maternal validity study, only the ratings of the primary physical therapist raters were used.

Although only the mothers of preterm infants were targeted in this phase of data collection, all mothers (that is, mothers of full-term, preterm, and neurologically abnormal infants) were asked if they wished to participate to avoid cuing the therapists as to their classification. If after further discussion the mother agreed to participate, she was asked to read and sign the Consent Form (Appendix H) after all questions are answered. Descriptive data obtained by questioning the mother were recorded. The mother then scored her infant. The infant was subsequently assessed by two physical therapists who were blind to maternal scoring. As previously mentioned, for this study, only the rating of the primary rater was used. The health record was reviewed to transcribe the additional descriptive data by an assistant not involved in scoring the infant to prevent bias due to knowledge of medical history (Ashton, Piper, Warren, Stewin, & Byrne, 1991).

Each mother was given feedback on how the physical therapist scored her infant, but was asked not to discuss how she rated her infant in order to avoid biasing the physical therapists over the course of the study. The feasibility of this strategy was assessed in the pilot study. Most mothers complied with this request, and those who did not, complied upon the first reminder. It is believed that the physical therapists were not influenced by any systematic difference in scoring by the mothers over the course of data collection.

CHAPTER 4
RESULTS

Sample Characteristics

The full-term sample comprised 30 infant-mother pairs, ten in each of the age ranges of 1 to 5, 6 to 10, and 11 to 15 months. All infants met the inclusion criteria with the exception of three infants who were delivered via emergency Caesarian section. All three infants had 5 minute Apgar scores of 9 and were judged by the physical therapists to be developing normally when assessed at 2, 6, and 14 months. One infant did not strictly meet the exclusion criteria; although a positional foot deformity was noted on the hospital discharge form, it was not evident at the time of assessment when the infant was 2 months old. Infant and familial characteristics of the full-term sample are detailed in Appendix I; summary statistics of infant characteristics are outlined in Table 2.

Table 2.
Full-term Infant Characteristics

Characteristic	Age Range (months) 1-5 (n=10)	6-10 (n=10)	11-15 (n=10)	Total (N=30)
Gender[a]				
males	5	2	8	15
females	5	8	2	15
Age at Assessment (months)[b]	3.4 (1.4)	8.1 (1.4)	12.6 (0.9)	8.0 (4.0)
Gestational Age at Birth (weeks)[b]	39.1 (1.6)	39.4 (1.5)	39.4 (1.3)	39.3 (1.4)
Birthweight (grams)[b]	3398 (362)	3525 (485)	3467 (426)	3463 (416)

[a]Frequency. [b]Mean (standard deviation in brackets).

A summary of familial characteristics of the full-term sample is recorded in Table 3. The families had an average of 0.7 additional children in the home (*SD* = 0.8). All of the study subjects were singletons. The mean birth interval between the study subject and the next oldest child was 39.4 months (*SD* = 25.7) among the sixteen families with at least one additional child.

Table 3.
Familial Characteristics of Full-term Sample

Characteristic	Age Range (months) 1-5 (n=10)	6-10 (n=10)	11-15 (n=10)	Total (N=30)
Maternal Education				
< Grade 12	1	0	0	1
Grade 12	2	3	2	7
College/Technical	4	5	7	16
University	3	2	1	6
Number of Additional Children in the Home				
0	3	4	7	14
1	5	4	3	12
2	1	2	0	3
≥ 3	1	0	0	1

Note. Number in each cell indicates frequency.

The preterm sample was made up of 30 pairs of mothers and their infants, ten in each of the age ranges of 1 to 5 and 6 to 10 months, and 11 to 15 months. All infants met the inclusion criteria and no infants had major sensory or musculoskeletal abnormalities. Infant and familial characteristics of the preterm sample are detailed in Appendix J; Table 4 contains a summary of the infant characteristics. With an average gestational age at birth of 28.4 weeks (*SD* = 2.7) and an average birthweight of 1096 grams (*SD* = 229), these infants are at-risk for neurodevelopmental disorders. In addition to the need for ventilatory assistance (73%), and presence of bronchopulmonary dysplasia (30%) and grade I or II intraventricular hemorrhage (43%), other neonatal medical complications among the preterm infants included patent ductus arteriosis (ID numbers 50,56,58,62,74 and 78),

Table 4.
Preterm Infant Characteristics

Characteristic		Age Range (months) 1-5 (n=10)	6-10 (n=10)	11-15 (n=10)	Total (N=30)
Gender[a]					
males		6	7	7	20
females		4	3	3	10
Adjusted Age at Assessment (months)[b]		4.3 (0.7)	9.1 (1.4)	12.7 (1.3)	8.7 (3.7)
Gestational Age at Birth (weeks)[b]		27.3 (2.5)	28.5 (1.4)	29.5 (3.7)	28.4 (2.7)
Birthweight (grams)[b]		1009 (293)	1152 (160)	1126 (212)	1096 (229)
Need for Ventilatory Assistance[a]	Y	7	8	7	22
	N	3	2	3	8
Days of Ventilatory Assistance[b]		26.0 (23.4)	34.0 (33.6)	30.2 (37.2)	30.1 (31.0)
Bronchopulmonary Dysplasia[a]	Y	4	2	3	9
	N	6	8	7	21
Seizure Activity[a]	Y	0	0	1	1
	N	10	10	9	29
Intraventicular Hemorrhage[a]	Y	5	5	3	13
	N	5	5	7	17
Days in NICU[b]		64.8 (25.7)	76.9 (35.3)	60.4 (33.5)	67.4 (31.5)

Note. NICU = neonatal intensive care unit.
[a]Frequency. [b]Mean (standard deviation in brackets).

necrotizing enterocolitis (ID numbers 64 and 78), seizure activity (ID number 61), chronic apneic spells and bradycardia (ID number 59), a mild hypoplastic left heart (ID number 65), and stage I retinopathy of prematurity (ID number 74). The preterm infants spent an average of 67.4 days (*SD* = 31.5) in the NICU.

Characteristics of the families of the preterm sample are recorded in Table 5. The preterm sample had an average of 1.1 additional children in the home (*SD* = 1.2), including nine subjects from multiple births. The mean birth interval between the study subject and the next oldest child among the fourteen families with at least one additional older child (excluding the siblings of multiple births) was 50.6 months (*SD* = 24.4). One family had an infant 12 months younger than the study subject.

Table 5.
Familial Characteristics of Preterm Sample

Characteristic	Age Range (months) 1-5 (n=10)	6-10 (n=10)	11-15 (n=10)	Total (N=30)
Maternal Education				
< Grade 12	1	3	1	5
Grade 12	2	3	4	9
College/Technical	5	2	1	8
University	2	2	4	8
Number of Additional Children in the Home				
0	4	1	6	11
1	4	5	4	13
2	2	0	0	2
≥ 3	0	4	0	4

Note. Number in each cell indicates frequency.

Comparison of Full-term and Preterm Samples

The full-term and preterm groups were compared on basic characteristics (gestational age at birth and birthweight) and on factors potentially affecting maternal scoring (infant gender, maternal education, age of infant at the time of assessment, and number of additional children in the home). The results are recorded in Table 6. The groups did not differ on any of the factors that may have influenced the results of the main analyses. The preterm group did include infants from multiple births, while the full-term group was made up exclusively of singletons. The range of birth interval between the subject and the next oldest child was similar for the two groups (18 to 118 months in the full-term group and 10 to 100 months in the preterm group).

Description of AIMS Scores

The distribution of AIMS section and total raw scores for the full-term and preterm samples are recorded in Appendices K and L. Scores are summarized in Tables 7 and 8. The total possible scores for the sections are 21, 9, 12, and 16 for prone, supine, sitting, and standing, respectively.

Correspondence of Physical Therapists' and Mothers' Scores

The purpose of this study is to investigate the degree of correspondence of mothers' and physical therapists' ratings of motor development as measured by activities in the infants' current repertoire. Infants scoring at the top of the scale may have developed motor skills which are more mature than those represented by the AIMS. In addition, the data points represented by subjects obtaining ceiling scores from both raters may cause an over-inflation of the value of the correlation. For these reasons, the results will be reported both with and without paired ceiling scores.

The full-term sample contained six infants who obtained ceiling scores when rated by both the physical therapist and mother. Five of the infants were in the 11 to 15 month age range and one was in the 6 to 10 month age range. With these six infants removed from the full-term sample and one preterm infant who obtained ceiling scores from both physical therapist and mother removed from the preterm sample, the groups still did not differ according to infant gender, maternal education, age at the time of assessment, or number of additional children in the home.

Table 6.
Comparison of Full-term and Preterm Samples

Variable	Full-term Sample	Preterm Sample	Value of Statistic	p
Gestational Age at Birth (weeks)				
Mean	39.3	28.4	t = 19.30	< .001
SD	(1.4)	(2.7)		
Birthweight (grams)				
Mean	3463	1096	t = 27.32	< .001
SD	(416)	(229)		
Age at Time of Assessment (months)				
Mean	8.0	8.7	t = -0.64	.52
SD	(4.0)	(3.7)		
Number of Additional Children in the Home				
Mean	0.7	1.1	t = -1.37	.18
SD	(0.8)	(1.2)		
Infant Gender[a]				
Male	15	20		
Female	15	10	Chi^2 = 1.71	.19
Maternal Education[a]				
< Grade 12	1	5		
Grade 12	7	9	M-W U = 387.0	.33
College/Technical	16	8		
University	6	8		

[a]Frequency.

Table 7.
Distribution of AIMS Scores: Full-term Sample

Section	Age Range (months) 1-5 PT	1-5 M	6-10 PT	6-10 M	11-15 PT	11-15 M	Section Score PT	Section Score M
Prone	4.5 (2.0)	5.3 (2.8)	15.6 (4.3)	17.1 (3.5)	21.0 (0.0)	20.8 (0.4)	13.7 (7.5)	14.4 (7.2)
Supine	4.5 (2.3)	5.8 (2.0)	8.7 (0.5)	8.9 (0.3)	9.0 (0.0)	9.0 (0.0)	7.4 (2.5)	7.9 (1.9)
Sitting	3.1 (2.5)	2.6 (1.8)	10.5 (1.3)	10.4 (1.5)	12.0 (0.0)	12.0 (0.0)	8.5 (4.3)	8.3 (4.4)
Stand	2.2 (0.6)	2.5 (1.1)	6.2 (4.6)	6.4 (4.6)	13.6 (2.6)	14.1 (2.4)	7.3 (5.6)	7.7 (5.7)
Total Score	14.3 (6.6)	16.2 (6.4)	41.0 (9.9)	42.8 (8.9)	55.6 (2.6)	55.9 (2.6)	37.0 (18.7)	38.3 (17.9)

Notes. PT = Physical Therapists' scores; M = Mothers' Scores.
Mean (standard deviation in brackets).

Table 8.
Distribution of AIMS Scores: Preterm Sample

Section	Age Range (months) 1-5 PT	1-5 M	6-10 PT	6-10 M	11-15 PT	11-15 M	Section Score PT	Section Score M
Prone	6.2 (1.5)	8.3 (2.4)	15.3 (4.1)	17.8 (2.9)	20.5 (0.7)	20.5 (1.0)	14.0 (6.5)	15.5 (5.8)
Supine	4.5 (1.6)	5.8 (1.5)	8.7 (0.7)	8.7 (0.5)	9.0 (0.0)	8.8 (0.4)	7.4 (2.3)	7.8 (1.7)
Sitting	2.4 (1.8)	3.4 (2.2)	10.1 (1.8)	10.4 (2.2)	11.9 (0.3)	11.8 (0.6)	8.1 (4.4)	8.5 (4.1)
Stand	2.0 (0.0)	2.3 (0.8)	6.7 (4.6)	8.3 (3.7)	11.9 (2.9)	12.2 (2.7)	6.9 (5.1)	7.6 (4.9)
Total Score	15.1 (4.4)	19.8 (5.6)	40.8 (10.5)	45.2 (7.8)	53.3 (3.4)	53.3 (3.7)	36.4 (17.5)	39.4 (15.6)

Notes. PT = Physical Therapists' scores; M = Mothers' Scores.
Mean (standard deviation in brackets).

Full-term Sample

To gain an initial impression of the degree of correspondence between the total scores obtained by mothers of full-term infants and physical therapists, the paired scores were plotted (Figure 1). The graph illustrates a very close relationship between the scores with no obvious outliers.

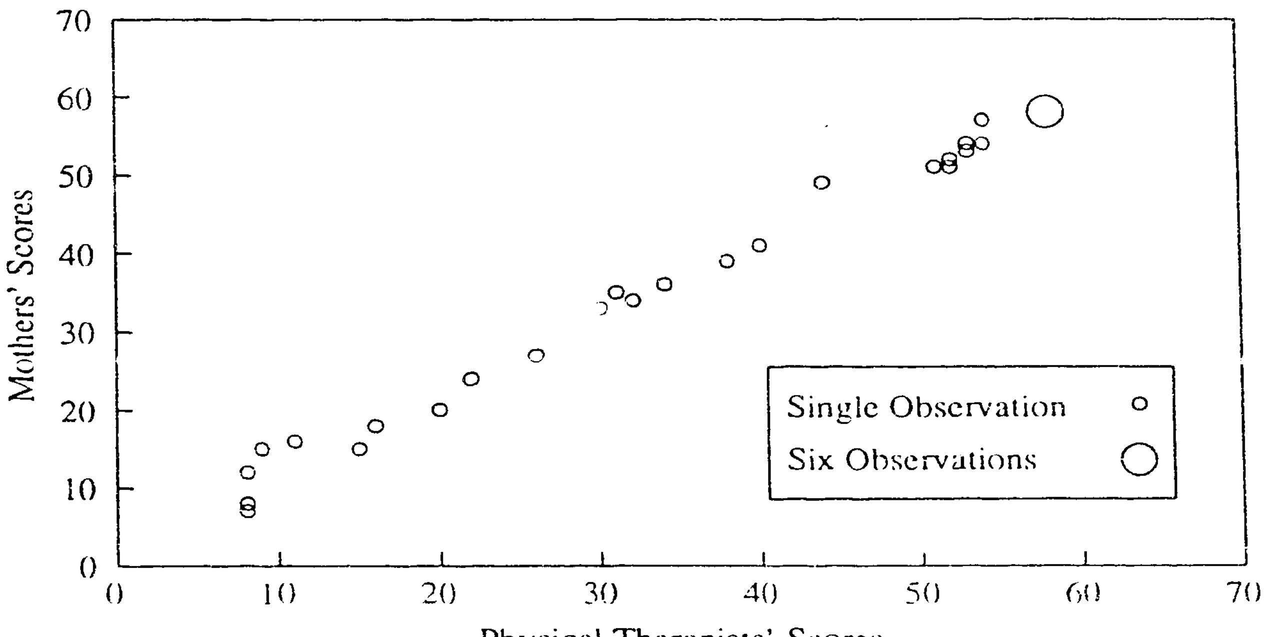


Figure 1. Correspondence of Physical Therapists' and Mothers' Total AIMS Scores: Full-term Sample

Concurrent validity was determined by calculating Pearson's correlation coefficient, yielding $r = .995$ ($p < .001$). A paired t-test indicated that the total mean scores were significantly different ($t = -3.84$, $p = .001$). The average scores were 37.0 ($SD = 18.7$) and 38.3 ($SD = 18.0$) for the physical therapists and mothers, respectively. The significant difference between the average scores, despite the strong correlation between paired scores and the high values for the standard deviations, can be explained by a systematic error between raters. In this case, mothers tended to rate the infants higher than the physical therapists. To account for the difference in mean scores, the Intraclass Correlation

Coefficient (ICC) was then calculated to be .992. The ICC is considered to be the more accurate reflection of the strength of agreement between absolute score values (Hartmann, 1977).

With the six paired ceiling scores removed, the value for Pearson's correlation coefficient was virtually unchanged (r = .994, p < .001) and the mean scores remained significantly different (t = -4.10, p < .001). The average scores were now 31.7 (SD = 17.2) and 33.4 (SD = 16.7) for the physical therapists and mothers. To account for the difference in mean scores, the ICC was calculated to be .989.

Preterm Sample

The relationship between the scores obtained by mothers of preterm infants and physical therapists is plotted in Figure 2. While the paired scores are more variable, there again are no obvious outliers.

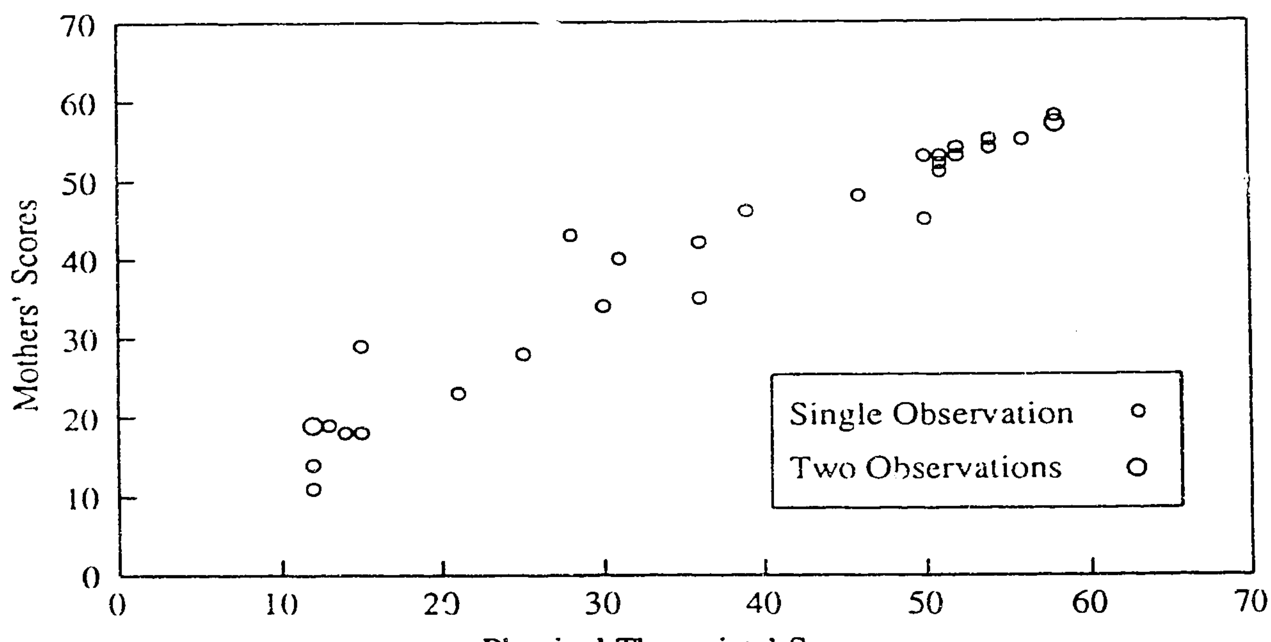


Figure 2. Correspondence of Physical Therapists' and Mothers' Total AIMS Scores: Preterm Sample

In this sample, Pearson's r was found to be .971, (p < .001); the paired t-test indicated that the mean scores were significantly different (t = -3.79, p = .001). The average scores for the physical therapists and the mothers were 36.4 (*SD* = 17.5) and 39.4 (*SD* = 15.6). The ICC was then calculated to be .950, and will be considered the more accurate reflection of the strength of correspondence between the scores. With the one infant who obtained ceiling scores by both raters removed, Pearson's r was .970, and the scores continued to be significantly different (t = -3.82, p = .001). The ICC was .947.

Sources of Discrepant Scores

The mean total AIMS scores obtained by physical therapists and mothers were previously described to be statistically significantly different for both the full-term and preterm samples. Multiple paired t-tests were done to determine whether section (prone, supine, sitting, or standing) or age range (1 to 5, 6 to 10, or 11 to 15 months) could explain the differences in mean scores.

As the probability of a Type 1 error increases when multiple comparisons are made, the Bonferroni procedure was used to set adjusted alpha levels to test for statistically significant differences between the four sections and the three age ranges (Duncan, Knapp, & Miller, 1977). This procedure involves dividing the previously set alpha level (.05) by the number of comparisons, yielding new alpha levels of .013 and .017 for the sections and age ranges.

Multiple comparisons were done between physical therapists' and mothers' section scores for the full-term sample, both with and without paired ceiling scores; the results are recorded in Tables 9 and 10. The difference in total scores between physical therapists and mothers of full-term infants is mostly attributed to the supine section for the total sample, and to the prone and supine sections when ceiling scores are removed. For the preterm sample, multiple comparisons are recorded in Table 11; the most significant difference between raters is found in scoring of the prone section. The p values were identical when the infant obtaining paired ceiling scores was removed from the sample.

Tables 12 and 13 document the results of multiple comparisons between physical therapists' and mothers' scores according to age range for the full-term and preterm samples. Significant discrepancies in scoring in the full-term sample occur in the 6 to 10 month range. The preterm sample demonstrated a significant difference between 1 to 5 months.

Table 9.
T-tests Between Physical Therapists' and Mothers' Section Scores: Full-term Sample

Section		Physical Therapist	Mother	t Value (df = 29)	p
Prone					
	Mean	13.7	14.4	-2.62	.014
	SD	(7.5)	(7.2)		
Supine					
	Mean	7.4	7.9	-3.34	.002 *
	SD	(2.5)	(1.9)		
Sitting					
	Mean	8.5	8.3	1.06	.029
	SD	(4.3)	(4.3)		
Standing					
	Mean	7.3	7.7	-2.28	.030
	SD	(5.6)	(5.7)		

* $p \leq .013$

Table 10.
T-tests Between Physical Therapists' and Mothers' Section Scores: Full-term Sample (ceiling scores removed)

Section		Physical Therapist	Mother	t Value (df = 23)	p
Prone					
	Mean	11.9	12.8	-2.68	.013 *
	SD	(7.3)	(7.1)		
Supine					
	Mean	7.0	7.6	-3.50	.002 *
	SD	(2.6)	(2.0)		
Sitting					
	Mean	7.7	7.4	1.06	.299
	SD	(4.4)	(4.4)		
Standing					
	Mean	5.2	5.6	-2.32	.030
	SD	(3.9)	(4.3)		

* $p \leq .013$

Table 11.
T-tests Between Physical Therapists' and Mothers' Section Scores: Preterm Sample

Section		Physical Therapist	Mother	t Value (df = 29)	p
Prone					
	Mean	14.0	15.5	-3.45	.002 *
	SD	(6.5)	(5.8)		
Supine					
	Mean	7.4	7.8	-2.01	.054
	SD	(2.3)	(1.7)		
Sitting					
	Mean	8.1	8.5	-1.62	.117
	SD	(4.4)	(4.1)		
Standing					
	Mean	6.9	7.6	-2.33	.027
	SD	(5.1)	(4.9)		

* $p \leq .013$

Table 12.
T-tests Between Physical Therapists' and Mothers' Total Scores by Age Range: Full-term Sample

Age Range		Physical Therapist	Mother	t Value (df = 9)	p
1-5 Months					
	Mean	14.3	16.2	-2.53	.032
	SD	(6.6)	(6.4)		
6-10 Months					
	Mean	41.0	42.8	-3.25	.010 *
	SD	(9.9)	(8.9)		
11-15 Months					
	Mean	55.6	55.9	-0.90	.394
	SD	(2.6)	(2.6)		

* $p \leq .017$

Table 13.
T-tests Between Physical Therapists' and Mothers' Total Scores by Age Range: Preterm Sample

Age Range		Physical Therapist	Mother	t Value (df = 9)	p
1-5 Months					
	Mean	15.1	19.8	-3.62	.006 *
	SD	(4.4)	(5.6)		
6-10 Months					
	Mean	40.8	45.2	-2.79	.021
	SD	(10.5)	(7.8)		
11-15 Months					
	Mean	53.3	53.3	0.00	1.000
	SD	(3.4)	(3.8)		

* $p \leq .017$

Comparison of the Intraclass Correlation Coefficients between the Preterm and Full-term Samples

The ICCs obtained in the preterm and full-term samples (with the paired ceiling scores removed) were compared by first converting the correlation coefficients to Fisher's z scores and then performing a z test between the scores. This analysis indicated that the strength of the relationship between the scores of mothers of full-term infants and physical therapists was significantly different from that of mothers of preterm infants and physical therapists ($p = .007$) (Appendix M).

Sources of Discrepant Correlations

Further exploration was done to determine whether the difference in the strength of the correlation coefficients between the full-term and preterm samples may primarily be due to the rater (physical therapist versus mother) or to the subject (full-term versus preterm infant). It is believed that by holding the degree of correspondence between the scores obtained by two physical therapists as the "gold standard", one can judge the strength of the correlations of the assessments of infant motor development between physical therapists and mothers. If the main source of error is with the raters (that is, mothers), the strength of the correlation would be weaker between mothers and physical therapists than between two physical therapists. Conversely, if the main source of error is due to inherent variability within the subjects, the strength of agreement would be similar for both sets of raters.

While testing for this source of discrepancy was not in the original study design, existing data on interrater reliability was examined to explore the issue. The ICC for interrater reliability obtained between physical therapists on a large sample of full-term infants during test development of the AIMS was .99 (Piper *et al.* 1991). This value is similar to the ICCs obtained between mothers of full-term infants and a physical therapist, calculated both with and without the infants scoring at the top of the scale.

Since the preterm sample for this study was obtained largely by accessing the discriminant validity testing of the AIMS, 26 out of 30 of the preterm infants had scores by primary and secondary physical therapist raters (Appendix N). The Pearson's correlation coefficient between the paired ratings by physical therapists was .991 ($p < .001$). The correlations between ratings of preterm infants by mothers and physical therapists and two physical therapists were compared by converting them to Fisher's z scores and performing a z test between the scores. The strength of the association of paired scores was significantly different (z(observed) = 3.07; $p = .002$; calculations similar to those in Appendix M).

An item analysis was done to identify those items showing the greatest disagreement, thereby contributing to discrepant correlations. Since the correlation between the scores of mothers of full-term infants and physical therapists was very high (ICC = .99), the level of agreement on individual items between raters obtained in the full-term sample was used as the criterion from which to judge item agreement in the preterm sample. The full-term sample obtained a range of 87 to 100 percent agreement on all items (mean = 94.4%). Percentage agreement on the items scored by raters in the preterm sample ranged from 77 to 100 percent (mean = 91.3%). All items achieving less than 87% agreement in the preterm sample were identified and are listed in Table 14.

Table 14.
Items in Preterm Sample Identified to Have < 87% Agreement

Item Label (AIMS Code)	Percentage Agreement	Nature of Disagreement[a] Yes	No
Forearm Support II (P13)	77	7	0
Extended Arm Support (P20)	77	6	1
Swimming (P16)	80	4	2
Pivoting (P5)	83	4	1
Propped Sidelying (P27)	77	7	0
Reciprocal Creeping with Rotation (P21)	83	5	0
Active Extension (Sup2)	80	6	0
Rolling Supine to Prone with Rotation (Sup6)	83	2	3
Supported Standing III (St27)	83	5	0

[a]of the paired scores demonstrating disagreement, these figures are the number of occasions mothers scored yes or no on each item (reverse frequency = number of times physical therapists scored yes or no).

Upon assessing the nature of the disagreement (Table 14), the following two items exhibit no consistent pattern of error between mothers and physical therapists: *swimming* and *rolling supine to prone with rotation*. The remaining items demonstrate either consistent or almost consistent errors. Table 15 lists the items by section and age range.

Table 15.
Categorization of Items Demonstrating Consistent Disagreement Between Physical Therapists and Mothers

Age	Section: Prone	Section: Other
1 - 5 months	Forearm Support II Extended Arm Support	Active Extension Supported Standing III
6 - 10 months	Pivoting Propped Sidelying Reciprocal Creeping with Rotation	

Clinical Significance

The American Psychological Association (Committee to Develop Standards for Educational and Psychological Testing, 1985) refers to validity as the appropriateness of inferences made from test scores. One of the purposes of the AIMS is to identify infan whose motor performance is delayed or aberrant relative to a normative group (Piper *et al.* 1991). On completion of the test development of the AIMS, clinicians will be able to interpret each individual test score by converting the raw score to a percentile score using the normative data collected for each monthly age range from 1 to 15 months.

In this study, the clinical significance of the difference in scores between physical therapists and mothers can be evaluated by examining whether the scores obtained by both raters lead to the same inferences. To do this, the raw scores of physical therapists and mothers were converted to z scores using the preliminary normative data for the AIMS collected from September to November, 1991 (Appendix O). The z scores were then read as percentiles from a Unit-Normal Distribution Table (Glass & Hopkins, 1984). Infants obtaining scores more than two standard deviations below the mean (less than the 3rd percentile) were recorded as "abnormal". Infants obtaining scores between one and two standard deviations below the mean (less than the 16th percentile) were recorded as "suspicious".

The transformed scores for the full-term and preterm samples are listed in Appendices P and Q. Physical therapists' and mothers' categorization of the scores to "normal", "suspicious", and "abnormal" groups are recorded in Tables 16 and 17 for the full-term and preterm samples, respectively.

Table 16.
Categorization of Full-term Infants

Mothers	Physical Therapists		
	Normal	Suspicious	Abnormal
Normal	27	0	0
Suspicious	0	2	0
Abnormal	0	0	0

Notes. Number in each cell indicates frequency.
One subject's score is not included due to lack of current normative data for 1 month.

Table 17.
Categorization of Preterm Infants

Mothers	Physical Therapists		
	Normal	Suspicious	Abnormal
Normal	18	6	1
Suspicious	1	1	0
Abnormal	1	0	2

Note. Number in each cell indicates frequency.

To obtain a clearer picture of whether mothers can be relied upon to identify "suspicious" or "abnormal" infant motor development, the accuracy of maternal scoring, using the physical therapists' score as the "gold standard", was determined for both the full-term and preterm samples by calculating the sensitivity, specificity, and positive and negative predictive values. Sensitivity refers to the proportion of infants identified by the physical therapists as suspicious or abnormal who were similarly identified by the mother. Specificity is the proportion of infants identified by the physical therapists as normal who were rated by their mothers as being normal. Positive predictive value is the proportion of infants identified by the mother as either suspicious or abnormal who are also identified as such by the physical therapists. Negative predictive value refers to the proportion of infants identified by the mother as normal who are also identified as being normal by the physical therapists (adapted from Fletcher *et al.* 1988).

Infants demonstrating "suspicious" early motor behavior have one of two developmental sequelae: normal neuromotor status or continued subtle neuromotor abnormality (Piper *et al.* 1988). The accuracy of mothers' scores was therefore determined in two ways to account for the different outcomes. The accuracy of mothers' assessments in identifying infants as "suspicious/abnormal" versus "normal" is calculated and listed in Table 18. The accuracy of mothers' assessments in identifying infants as "abnormal" versus "suspicious/normal" is calculated and recorded in Table 19. No infants in the full-term group were identified as abnormal, therefore Table 19 lists only the results from the preterm sample.

Table 18.
Accuracy of Mothers' Assessments
(normal versus abnormal/suspicious)

	Full-term Infants	Preterm Infants
Sensitivity	$\frac{2}{2}$ = 100 %	$\frac{3}{10}$ = 30 %
Specificity	$\frac{27}{27}$ = 100 %	$\frac{18}{20}$ = 90 %
Positive Predictive Value	$\frac{2}{2}$ = 100 %	$\frac{3}{5}$ = 80 %
Negative Predictive Value	$\frac{28}{28}$ = 100 %	$\frac{18}{25}$ = 72 %

Table 19.
Accuracy of Mothers' Assessments of Preterm Infants
(normal/suspicious versus abnormal)

	Preterm Infants
Sensitivity	$\frac{2}{3}$ = 66.7 %
Specificity	$\frac{26}{27}$ = 96.3 %
Positive Predictive Value	$\frac{2}{3}$ = 66.7 %
Negative Predictive Value	$\frac{26}{27}$ = 96.3 %

CHAPTER 5
DISCUSSION

Introduction

The purpose of this study was to determine the ability of mothers of full-term and preterm infants to accurately rate their infants' motor development using the maternal version of the Alberta Infant Motor Scale. While all mothers tended to rate their infants higher than the physical therapists, mothers of full-term infants were found to be more accurate in the assessment of their infants' motor development than mothers of preterm infants. Although the scores of mothers of full-term and preterm infants were significantly correlated with the physical therapists' scores, the two sets of ratings did differ statistically and clinically. In particular, mothers of preterm infants were less accurate in their ratings of motor development early in the first year (1 to 5 months) and in the scoring of prone items, and tended to over-rate their infants to a greater extent than mothers of full-term infants.

These results suggest that mothers of preterm infants are not accurate in the early identification of neuromotor delay or abnormality when scoring their infants with the maternal version of the AIMS. Mothers of full-term infants are able to identify normally developing infants and those exhibiting minor delays; however, their ability to accurately identify abnormalities in early motor development is not yet known.

Full-term Infants

The results of this study suggest that mothers of full-term infants may be accurate observers of their infants' motor development. While the ICC between mothers' and physical therapists' scores was .99, full-term mothers did over-rate their infants marginally. This finding may be the result of mothers having a greater opportunity to observe the complete repertoire of their infants' abilities than physical therapists. Although the AIMS has been designed to measure those activities likely to be observed if an infant has incorporated them into his repertoire, items *just* having emerged are be less likely to be observed during the brief assessment by a physical therapist.

Item agreement between full-term mothers' and physical therapists' rating of the AIMS was as high as that reported by previous investigators using versions of a general developmental scale (Frankenburg *et al.* 1976), suggesting that mothers of infants with unremarkable neonatal histories may be useful in the screening of both general and motor development.

Preterm Infants

Mothers of preterm infants were found to be less accurate in assessments of motor development than mothers of full-term infants. While the correlation between mothers' and physical therapists' assessments of preterm infants' motor development was strong, it was significantly different from the correspondence of scores between mothers of full-term infants and physical therapists.

The mothers in this study were clearly not influenced by a negative prematurity stereotyping (Stern & Hildebrandt, 1988); they consistently *over-rated* their infants relative to the scoring by the physical therapists. The magnitude of over-rating was twice as great in this sample when compared with the full-term group, indicating factors other than the advantage afforded to mothers by simply having greater opportunity to observe the complete repertoire of their infants' motor abilities. Factors explaining the difference found in this sample may be related to characteristics inherent to the mothers or the infants.

Mothers of preterm infants experience greater stress (Brooten *et al.* 1988; Hummel & Eastman, 1991) and demonstrate greater effort in caring for their infants in the first year of life (Barnard *et al.* 1984) than do mothers of full-term infants. Increased maternal stress and compensation for reduced infant responsiveness may partially explain why mothers over-rated their infants. In this study, the significant discrepancy in scores between mothers and physical therapists occurred when the infants were between 1 and 5 months, and approached significance at 6 to 10 months. At seven months of age, however, Knobloch *et al.* (1979) found parents' ratings of the overall development of their high-risk infants to be accurate. The potential adverse effects of having experienced preterm birth do not appear to affect parental scoring of general development after this age, suggesting that factors relating specifically to the *motor* development of preterm infants may have a more significant impact on the mothers' abilities to rate their infants accurately.

Mothers had difficulty accurately rating preterm infants early in the first year (1 to 5 months) and on prone items. Inspection of the items demonstrating a consistent pattern of disagreement provides some explanations for this finding. Approximately half of preterm infants have been observed to exhibit transient dystonia by six to twelve weeks of age (Drillien, 1972); most of the affected infants demonstrate typical patterns of motor development by the first birthday (Gorga *et al.* 1985). In the first six months, the normally developing infant gradually develops balanced control of flexion and extension against gravity (Bly, 1983). Transient dystonia may interfere with the development of this balance in preterm infants. Accordingly, mothers may have difficulty recognizing the effects of transient dystonia on early motor development.

An active chin tuck, which is characterized by cervical extension and capital flexion, represents the ultimate in development of axial flexion and extension (Bly, 1983). Two of the AIMS items with the antigravity movement criterion of "active chin tuck" were scored higher by mothers: *forearm support II*, and *extended arm support*. Many high-risk preterm infants have been observed to have a predominance of neck extension activity with little active counterbalancing flexion (Gorga *et al.* 1985; Valvano & DeGangi, 1986). Preterm infants with transient dystonia may not have a well-developed chin tuck, a limitation in early motor development that was apparently not observed by preterm mothers.

A balance of flexion and extension is also demonstrated by the ability to flex the upper extremity forward while the trunk is in extension. Tonal abnormality in the shoulder girdle as manifested by scapular retraction (that is, the tendency to be extended in both the trunk and shoulder girdle) has been observed in almost half of preterm infants in their first year (Georgieff & Bernbaum, 1986). The presence of scapular retraction during *active extension* may not have prevented mothers from crediting their infant with the item. Physical therapists, on the other hand, specifically look for protraction of the upper extremities to signify some degree of balance between flexion and extension.

The last item in the 1 to 5 month age range may also be explained by the tonal abnormalities associated with transient dystonia. Hypertonia is more prevalent than hypotonia, and has been found to be most common in the lower extremities, affecting more than half of preterm infants in the first 6 months (Georgieff *et al.* 1986). *Supported standing III* may have been passed consistently by mothers who failed to recognize the stiff quality of weight bearing, resulting in lack of variable movement in the legs. In addition, increased tone in the lower extremities may have inhibited full hip extension (Bly, 1983), another of the criteria which may not have been noted by preterm mothers.

In addition to having difficulty scoring infants in the 1 to 5 month age range, mothers had difficulty scoring prone items. Two of these items are typically developed early and include the criterion of an active chin tuck: *forearm support II*, and *extended arm support*. Two of the remaining prone items that mothers had difficulty rating accurately are activities reflecting early attempts at mobility: *pivoting* and *propped sidelying*. Development of the balanced control of flexion and extension is viewed as providing the prerequisite stability for subsequent motor development (Bly, 1983). In the infant who has developed balanced flexion and extension, lateral weight shift results in lateral head and trunk righting and dissociation of the lower extremities, providing the basis for the development of prone mobility. The infant with transient dystonia may not have developed the prerequisite stability, thereby interfering with the development of lateral control. Consistent with previous findings on preterm infants, some of the infants in our study may have demonstrated reduced lateral head righting (Gorga *et al.* 1985), thereby affecting the performance of *propped sidelying* and partially explaining the therapists' hesitancy in crediting the infants with this item.

Hypertonia in the legs of preterm infants (Georgieff *et al.* 1986) may have restricted the amount of lower extremity dissociation to the point where physical therapists did not credit the older infant with *pivoting*, or *propped sidelying*. Mothers may not have noticed this subtle difference from the item criteria. Preterm infants have also been observed to exhibit less trunk rotation during movements (Gorga *et al.* 1988). This may explain the physical therapists' more critical rating of *reciprocal creeping*.

In addition to the effects of transient dystonia, mothers may have had particular difficulties accurately rating early and prone items because these items are most affected by preterm infants' altered body composition and anthropometric characteristics. Disruption of the nutritional supply caused by preterm birth clearly affects somatic growth, particularly early in the first year of life, resulting in reduced fat and muscle bulk (Prechtl & Nolte, 1984). An infant with a disproportionately heavy head relative to the weight of the trunk and lower extremities is at a biomechanical disadvantage in activities requiring extension or lateral flexion of the neck against gravity. Mothers may not have recognized subtle deviations from typical patterns of antigravity movement and joint alignment that their infants exhibited.

While mothers of at-risk infants have been considered to be accurate observers of their infants' general development (Knobloch *et al.*, 1979; Bricker *et al.* 1988; Bricker & Squires, 1989), the results of this study suggest that mothers of preterm infants are not accurate observers of their infants' motor development. Mothers were able to correctly identify two of the three infants with marked delay, but did not appear to be able to recognize more subtle motor aberrations.

The results of this study do not support the belief that the early experiences of preterm birth have a *negative* impact on parents' perceptions of their infants (Green & Solnit, 1964; Stern & Hildebrandt, 1988). Mothers were found to significantly *over-rate* the motor development of their infants. Whether this finding is due to the greater investment of time and effort in caring for the preterm infant resulting in higher expectations, or the inability to identify the finer details of preterm infant motor development associated with transient dystonia and alteration of body composition is not known. To clarify whether the difficulty mothers have in rating preterm infant motor development is due to the effects of preterm birth on the mothers' emotional experiences or the infants' variable motor behavior, further research could be done comparing the motor assessments of preterm mothers and physical therapists using both the Bayley Scales of Infant Development and the AIMS. If the over-rating is due to the emotional experience, maternal scores would be higher than those of the physical therapists on both scales. Alternatively, if over-rating is due to the inability to detect variations in the finer details of motor development, mothers may over-rate their infants on the AIMS, but not the BSID. Secondly, one could compare the ratings of other individuals not specifically trained in early motor assessment (for example, public health nurses) with those of physical therapists using the AIMS. If the untrained raters consistently over-rate the infants, the most plausible explanation would be their difficulty in observing the detailed criteria depicted by the AIMS.

Clinical Implications

In this study, when full-term infants were assessed using the AIMS, the inferences made from mothers' scores were identical to those made from physical therapists' scores; full-term mothers were able to accurately identify those infants with minor delays in motor development. There may be no true difference, however, in the observational abilities of mothers of preterm infants and mothers of full-term infants. Because full-term infants exhibit "typical" motor development, their mothers do not have to be able to [illegible] the finer details of movement that are often absent in preterm infants. This study is limited by not having any "abnormal" infants in the full-term group. Whether mothers of full-term infants are able to accurately identify abnormal motor development is not yet known.

Mothers of preterm infants are clearly not accurate in the assessment of their infants' motor development using the AIMS. They tend to significantly over-rate their infants. Inferences made from the assessment of motor development of preterm infants by mothers and physical therapists are not the same; mothers of preterm infants are not sufficiently accurate in the identification of infants demonstrating suspicious or abnormal motor development to make their assessments useful.

Deciding what constitutes "sufficiently accurate" is determined in context of the reason for the assessment. High sensitivity is desirable for assessment of motor development in order to rule out the probability of abnormality (Fletcher *et al.* 1988). A negative test result is useful given the concern that parents have about their preterm infants' developmental outcome (Amiel-Tison & Grenier, 1986). In order to reassure parents on the normalcy of those infants who are doing well, a high degree of certainty for the correct identification of both "normal" and "abnormal or suspicious" motor development is essential. In this case, neither the sensitivity nor positive predictive values of preterm mothers' scores are high enough to recommend that they be used as the sole assessment.

The rationale for undertaking this study was to determine the extent to which physical therapists can involve parents in early motor assessment. It is clear that mothers of preterm infants are not sufficiently accurate to suggest that they replace physical therapists in the assessments of infant motor development by completing the maternal version of the AIMS from memory of their infants' abilities when attending NICU follow-up clinics. As found by previous investigators studying the accuracy of parental assessment of infant behavior (Hagekull *et al.* 1984), mothers may be more accurate in detecting the finer points of motor development when they have the opportunity to directly observe their infants while scoring. In addition, the AIMS may be useful in other capacities when working with parents.

Parents have reported that knowledge of their infants' current developmental status, particularly as it relates to the wide range of behaviors exhibited by many preterm infants, is beneficial in reducing the stressful effects associated with preterm birth (Fraley, 1986). Given that the variability of early preterm infant development is largely manifested in motor behavior, and that mothers have difficulty identifying and interpreting alternate patterns of motor development, physical therapists have a very significant role in working with parents of preterm infants. One of the purposes of the AIMS is to provide information to the clinician and to parents about the motor activities the infant has mastered, those currently developing, and those not in the infant's repertoire (Piper *et al.* 1991). Physical therapists may be able to reduce the anxiety associated with preterm birth by using the AIMS as a tool to transmit information about an infant's current developmental status to parents.

Mothers' assessments of their infants' motor development may be useful if the family is referred for therapeutic intervention, not as an alternative to assessment by a physical therapist, but rather to determine a common point of reference from which to begin to work together. Review of a mother's scoring of her infant will clarify her perceptions of her infant's motor development (Wolfensberger & Kurtz, 1971). After discussing differences in scoring, mothers and therapists will be able to reach a consensus on the infant's motor abilities, and can develop goals and expectations of intervention more realistically (Turnbull & Turnbull, 1986). In addition, scoring of an infants' development has been found to increase a parent's ability to observe small developmental changes which represent improvement (Squires & Bricker, 1991). Appreciating these small changes may enhance compliance with recommendations for intervention and therefore may influence the effectiveness of the rehabilitation program.

Limitations

Mothers who were approached and subsequently agreed to participate in this study examining mothers' accuracy of scoring may not be representative of all mothers attending either a well-baby clinic or NICU follow-up clinic. Mothers seldom refused to participate in the study. The therapists had the impression that the reason for refusing was most often related to the mother's ability to make the time commitment.

Conclusions

Mothers of full-term infants were able to identify infants exhibiting normal and slightly delayed motor development. While the effects of preterm birth associated with transient dystonia and altered body composition appeared to interfere with preterm mothers' abilities to recognize subtle alterations in the motor development of their infants, little is known about full-term mothers' ability to detect neuromotor disorders among infants having experienced normal pregnancies and deliveries.

Reliance on mothers' scores from the memory of their preterm infants' motor development using the AIMS is not recommended for the purpose of identifying those infants who have suspicious motor development. Future research might investigate the usefulness of mothers scoring their preterm infants following *direct* observation of their motor performance. In addition, the AIMS could be evaluated as a tool to inform parents about the motor development of their preterm infants, thereby reducing their anxiety about developmental outcome. Finally, the effectiveness of the AIMS in facilitating shared goal-setting and appreciation of small developmental changes could be investigated.

REFERENCES

Alpern, G., Boll, T., & Shearer, M. (1988). *Developmental Profile II manual.* Los Angeles: Western Psychological Services.

Amiel-Tison, C., & Grenier, A. (1986). Complementary neuromotor examination: Early affirmation of normalcy. In *Neurological assessment during the first year of life* (pp. 96-145). New York: Oxford University Press.

Appleton, P. L., & Minchom, P. E. (1991). Models of parent partnership and child development centres. *Child: Care, Health, and Development, 17,* 27-38.

Ashton, B., Piper, M. C., Warren, S., Stewin, L., & Byrne P. (1991). Influence of medical history on assessment of at-risk infants. *Developmental Medicine and Child Neurology, 33,* 412-418.

Barnard, K. E., Bee, H. L., & Hammond, M. A. (1984). Developmental changes in maternal interactions with term and preterm infants. *Infant Behavior and Development, 7,* 101-113.

Barrera, M. E., Rosenbaum, P. L., & Cunningham, C. E. (1987). Corrected and uncorrected Bayley scores: Longitudinal developmental patterns in low and high birth weight preterm infants. *Infant Behavior and Development, 10,* 337-346.

Bayley, N. (1949). Review of the Gesell Developmental Schedules. In O. K. Buros (Ed.), *The third mental measurements yearbook* (pp. 357-358). Highland Park, NJ: Gryphon Press.

Bayley, N. (1969). *Manual for the Bayley Scales of Infant Development.* New York: Psychological Corporation.

Becker, P. T. (1987). Sensitivity to infant development and behavior: A comparison of adolescent and adult single mothers. *Research in Nursing and Health, 10,* 119-127.

Blackburn, S. & Lowen, L. (1986). Impact of an infant's premature birth on the grandparents and parents. *Journal of Obstetric, Gynecologic, and Neonatal Nursing, 15,* 173-178.

Bly, L. (1983). *Components of normal movement during the first year of life and abnormal motor development.* Birmingham, AL: Pathway Press.

Brazelton, T. B. (1973). *Neonatal Behavioral Assessment Scale.* London: Heinemann.

Bricker, D., & Squires, J. (1989). The effectiveness of parental screening of at-risk infants: The infant monitoring questionnaires. *Topics in Early Childhood Special Education, 9,* 67-85.

Bricker, D., Squires, J., Kaminski, R., & Mounts, L. (1988). The validity, reliability, and cost of a parent completed questionnaire system to evaluate at-risk infants. *Journal of Pediatric Psychology, 13,* 55-68.

Brooks-Gunn, J., & Lewis, M. (1981). Assessing young handicapped children: Issues and solutions. *Journal of the Division for Early Childhood, 3*, 84-95.

Brooten, D., Gennaro, S., Brown, L. P., Butts, P., Gibbons, A. L., Bakewell-Sachs, S., & Kumar, S. P. (1988). Anxiety, depression, and hostility in mothers of preterm infants. *Nursing Research, 37*, 213-216.

Buros, O. K. (Ed.). (1949). *The third mental measurements yearbook* (pp. 360). Highland Park, NJ: Gryphon Press.

Byrne, J. M., Backman, J. E., & Smith, I. M. (1986). Developmental assessment: The clinical use and validity of parental report. *Journal of Pediatric Psychology, 11*, 549-559.

Cadman, D., Shurvell, B., Davies, P., & Bradfield, S. (1984). Compliance in the community with consultants' recommendations for developmentally handicapped children. *Developmental Medicine and Child Neurology, 26*, 40-46.

Campbell, S. K., Siegel, E., Parr, C. A., & Ramey, C. T. (1986). Evidence for the need to renorm the Bayley Scales of Infant Development based on the performance of a population-based sample of 12-month-old infants. *Topics in Early Childhood Special Education, 6*, 83-96.

Capute, A. J., Shapiro, B. K., Palmer, F. B., Ross, A., & Wachtel, R. C. (1985). Normal gross motor development: The influence of race, sex, and socioeconomic status. *Developmental Medicine and Child Neurology, 27*, 635-643.

Chandler, L., Andrews, M., & Swanson, M. (1980). *Movement Assessment of Infants*. Rolling Bay, WA: Infant Movement Research.

Committee to Develop Standards for Educational and Psychological Testing of the AERA, APA, and NCME. (1985). *Standards for educational and psychological tests*. Washington, D.C.: American Psychological Association.

Coolman, R. B., Bennett, F. C., Sells, C. J., Swanson, M. W., Andrews, M. S., & Robinson, N. M. (1985). Neuromotor development of graduates of the neonatal intensive care unit: Patterns encountered in the first 2 years of life. *Journal of Developmental and Behavioral Pediatrics, 6*, 327-333.

Coplan, J. (1982). Parental estimate of child's developmental level in a high-risk population. *American Journal of Diseases in Childhood, 136*, 101-104.

Council for Exceptional Children (1986). Code of Ethics and Standards for Professional Practice. In A. P. Turnbull, & H. R. Turnbull (Eds.), *Families, professional, and exceptionality: A special partnership* (pp. 374-380). Columbus, OH: Merrill.

Deal, A. G., Dunst, C. J., & Trivette, C. M. (1989). A flexible and functional appr[illegible] to developing Individualized Family Support Plans. *Infants and Young Children, [illegible]*, 32-43.

DeGangi, G. A. (1987). Sensorimotor tests: Peabody Developmental Motor Scales. In L. King-Thomas, & B. J. Hacker (Eds.), *A therapist's guide to pediatric assessment* (pp. 185-190). Boston: Little & Brown.

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

Duncan, R. C., Knapp, R. G., & Miller, M. C. (1977). *Introductory biostatistics for health sciences*. (2nd ed.). New York: John Wiley & Sons.

Eisert, D. C., Spector, S., Shankaran, S., Faigenbaum, D., & Szego, E. (1980). Mothers' reports of their low birth weight infants' subsequent development on the Minnesota Child Development Inventory. *Journal of Pediatric Psychology, 5*, 353-364.

Ely, K. P., Healy, A., & Smidt, G. L. (1972). Mothers' expectations of their child's accomplishment of certain gross motor skills. *Developmental Medicine and Child Neurology, 14*, 621-625.

Ewart, J. C., & Green, M. W. (1957). Conditions associated with the mother's estimate of the ability of her retarded child. *American Journal of Mental Deficiency, 62*, 521-533.

Field, T. M., Hallock, N. F., Dempsey, J. R., & Shuman, H. H. (1978). Mothers' assessments of term and pre-term infants with respiratory distress syndrome: Reliability and predictive validity. *Child Psychiatry and Human Development, 9*, 75-85.

Fletcher, R. H., Fletcher, S. W., & Wagner, E. H. (1988). *Clinical epidemiology: The essentials*. Baltimore MD: Williams & Wilkins.

Folio, M. R., & Fewell, R. R. (1983). *Peabody Developmental Motor Scales and Activity Cards*. Allen, TX: DLM Teaching Resources.

Fraley, A. M. (1986). Chronic sorrow in parents of premature children. *Children's Health Care, 15*, 114-118.

Frankenburg, W. K., & Dodds, J. B. (1967). The Denver Developmental Screening Test. *Journal of Pediatrics, 71*, 181-191.

Frankenburg, W. W., Fandal, A. W., & Thornton, S. M. (1987). Revision of Denver Prescreening Developmental Questionnaire. *Journal of Pediatrics, 110*, 653-657.

Frankenburg, W. K., van Doorninck, W. J., Liddell, T. N., & Dick, N. P. (1976). The Denver Prescreening Developmental Questionnaire (PDQ). *Pediatrics, 57*, 744-753.

Gennaro, S. (1988). Postpartal anxiety and depression in mothers of term and preterm infants. *Nursing Research, 37,* 82-85.

Georgieff, M. K., & Bernbaum, J. C. (1986). Abnormal shoulder girdle muscle tone in premature infants during their first 18 months of life. *Pediatrics, 77,* 664-669.

Georgieff, M. K., Bernbaum, J. C., Hoffmann-Williamson, M., & Daft, A. (1986). Abnormal truncal tone as a useful early marker for developmental delay in low birth weight infants. *Pediatrics, 77,* 659-663.

Gesell, A. (1925). *The mental growth of the preschool child: A psychological outline of normal development from birth to the sixth year, including a system of developmental diagnosis.* New York: Macmillan.

Gesell, A., & Amatruda, C. S. (1941). *Developmental diagnosis: Normal and abnormal child development: Clinical methods and practical applications.* New York: Paul B. Hoeber.

Glascoe, F. P., Altemeier, W. A., & MacLean, W. E. (1989). The importance of parents' concerns about their child's development. *American Journal of Diseases in Childhood, 143,* 955-958.

Glass, G. V., & Hopkins, K. D. (1984). *Statistical methods in education and psychology.* (2nd ed.). Englewood Cliffs, NJ: Prentice-Hall.

Goldberg, S., & DiVitto, B. A. (1983). *Born too soon: Preterm birth and early development.* New York: W. H. Freeman.

Goldstein, D. J. (1985). Accuracy of parental report of infants' motor development. *Perceptual and Motor Skills, 61,* 378.

Gorga, D., Stern, F. M., & Ross, G. (1985). Trends in neuromotor behavior of preterm and fullterm infants in the first year of life: A preliminary report. *Developmental Medicine and Child Neurology, 27,* 756-766.

Gorga D., Stern, F. M., Ross, G., & Nagler, W. (1988). Neuromotor development of preterm and full-term infants. *Early Human Development, 18,* 137-149.

Gradel, K., Thompson, M. S., & Sheehan, R. (1981). Parental and professional agreement in early childhood assessment. *Topics in Early Childhood Special Education, 1,* 31-39.

Green, M., & Solnit, A. J. (1964). Reactions to the threatened loss of a child: A vulnerable child syndrome. *Pediatrics, 34,* 58-66.

Griffiths, R. (1954). *The abilities of babies.* London: University of London Press.

Hagekull, B., Bohlin, F., & Lindhagen, K. (1984). Validity of parental reports. *Infant Behavior and Development, 7,* 77-92.

Hanvey, L. (1987). *Neonatal follow-up programs in Canada.* Paper presented at the Seventh Canadian Ross Conference in Pediatrics, Val David, PQ.

Hart, H., Bax, M., & Jenkins, S. (1978). The value of a developmental history. *Developmental Medicine and Child Neurology, 20,* 442-452.

Hartmann, D. P. (1977). Considerations in the choice of interobserver reliability estimates. *Journal of Applied Behavioral Analysis, 10,* 103-116.

Healy, A., Keesee, P., & Smith, B. (1989). Parent-professional interactions. In A. Healy, P. Keesee, & B. Smith (Eds.), *Early services of children with special needs: Transactions for family support* (pp. 41-64). Philadelphia, PA: Paul H. Brookes.

Heriot, J. T., & Schmickel, C. A. (1967). Maternal estimate of IQ in children evaluated for learning potential. *American Journal of Mental Deficiency, 71,* 920-924.

Hinderer, K. A., Richardson, P. K., & Atwater, S. W. (1989). Clinical implications of the Peabody Developmental Motor Scales: A constructive review. *Physical and Occupational Therapy in Pediatrics, 9(2),* 81-106.

Hopkins, B., & Westra, T. (1989). Maternal expectations of their infants' development: Some cultural differences. *Developmental Medicine and Child Neurology, 31,* 384-390.

Horner, T. M. (1980). Two methods of studying stranger reactivity in infants: A Review. *Journal of Child Psychology and Psychiatry, 21,* 203-219.

Hummel, P. A., & Eastman, D. L. (1991). Do parents of preterm infants suffer chronic sorrow? *Neonatal Network, 10,* 59-65.

Ireton, H., & Thwing, E. (1974). *Manual for the Minnesota Child Development Inventory.* Minneapolis, MN: Behavior Science Systems.

Jeffcoate, J. A., Humphrey, M. E., & Lloyd, J. K. (1979). Disturbance in parent-child relationship following preterm delivery. *Developmental Medicine and Child Neurology, 21,* 344-352.

Johnson, D., Poteat, G. M., & Kushnick, T. (1986). Comparison of mental age estimates made by pediatricians and mothers of preschool children. *Journal of Pediatric Psychology, 11,* 385-392.

Kaplan, D. M., & Mason, E. A. (1960). Maternal reactions to premature birth viewed as an acute emotional disorder. *American Journal of Orthopsychiatry, 30,* 539-552.

Katoff, L. S. (1978). The development and evaluation of the KID Scale. *Dissertation Abstracts International, 39,* 984.

Keshavan, M. S., & Narayanan, H. S. (1983). Parental estimation of developmental level. *American Journal of Diseases of Childhood, 137,* 87-88.

King-Thomas, L. (1987). Responsibilities of the examiner. In L. King-Thomas & B. J. Hacker (Eds.), *A therapists' guide to pediatric assessment* (pp. 11-18). Boston: Little, Brown and Company.

Kliman, D. S., & Vukelich, C. (1985). Mothers and fathers: Expectations for infants. *Family Relations, 34*, 305-313.

Knobloch, H., & Pasamanick, B. (Eds.). (1974). *Gesell and Amatruda's developmental diagnosis* (3rd ed.). Hagerstown, MD: Harper & Row.

Knobloch, H., Stevens, F., & Malone, A. (1980). *Manual of developmental diagnosis*. Hagerstown, MD: Harper & Row.

Knobloch, H., Stevens, F., Malone, A., Ellison, P., & Risemberg, H. (1979). The validity of parental reporting of infant development. *Pediatrics, 63*, 872-878.

Kopparthi, R., McDermott, C., Sheftel, D., Lenke, M. C., Getz, M., & Frey, M. (1991). The Minnesota Child Development Inventory: Validity and reliability for assessing development in infancy. *Developmental and Behavioral Pediatrics, 12*, 217-222.

Kratochvil, M., & Devereux, S. (1989, June). *Do we treat children or families?* Paper presented at the Pediatric Division Scientific Program of the Canadian Physiotherapy Association Congress, Edmonton, AB.

Largo, R. H., Molinari, L., Weber, M., Comenale Pinto, L., & Duc, G. (1985). Early development of locomotion: Significance of prematurity, cerebral palsy and sex. *Developmental Medicine and Child Neurology, 27*, 183-191.

Mazer, B., Piper, M., & Ramsay, M. (1988). Developmental outcome in very low birth weight infants 6 to 36 months old. *Journal of Developmental and Behavioral Pediatrics, 9*, 293-297.

McCarthy, D. (1972). *Manual for the McCarthy Scales of Children's Abilities*. New York: The Psychological Corporation.

McConkey, R. (1985). *Working with parents: A practical guide for teachers and therapists*. Cambridge, MA: Brookline Books.

McCune, Y. D., Richardson, M. M., & Powell, J. A. (1984). Psychosocial health issues in pediatric practices: Parents' knowledge and concerns. *Pediatrics, 74*, 183-190.

McGillicuddy-DeLisi, A. V. (1982). The relationship between parents' beliefs about development and family constellation, socioeconomic status, and parents' teaching strategies. In L. M. Laosa, & I. E. Sigel, (Eds.), *Families as learning environments for children* (pp. 261-299). New York: Plenum Press.

McGraw, M. B. (1969). *The neuromuscular maturation of the human infant*. New York: Hafner.

McGrew, L., Catlin, P. A., & Bridgeford, J. (1985). The Landau reaction of full-term and preterm infants at four months of age. *Developmental Medicine and Child Neurology, 27*, 161-169.

Miles, M. S. (1989). Parents of critically ill premature infants: Sources of stress. *Critical Care Nursing Quarterly, 12*, 69-74.

Miller, S. A. (1988). Parents' beliefs about children's cognitive development. *Child Development, 59*, 259-285.

National Institute of Neurologic and Communicative Disorders and Stroke and National Institute of Child Health and Human Development (1985). National Institutes' of Health Report on causes of mental retardation and cerebral palsy. *Pediatrics, 76*, 457-458.

Nelson, K. B., & Ellenberg, J. H. (1986). Antecedents of cerebral palsy: Multivariate analysis of risk. *The New England Journal of Medicine, 315*, 81-86.

Newborg, J., Stock, J., Wnek, L., Guidubaldi, J., & Svinicki, J. (1984). *Batelle Developmental Inventory: Examiner's manual.* Dallas, TX: DLM Teaching Resources.

Ninio, A. (1988). The effects of cultural background, sex, and parenthood on beliefs about the timetable of cognitive development in infancy. *Merrill-Palmer Quarterly, 34*, 369-388.

Palisano, R. J., & Lydic, J. S. (1984). The Peabody Developmental Motor Scales: An analysis. *Physical and Occupational Therapy in Pediatrics, 4(1)*, 69-75.

Parush, S., & Clark, F. (1988). The reliability and validity of a sensory developmental expectation questionnaire for mothers of newborns. *American Journal of Occupational Therapy, 42*, 11-16.

Pederson, D. R., Bento, S., Chance, G. W., Evans, B., & Fox, A. M. (1987). Maternal emotional responses to preterm birth. *American Journal of Orthopsychiatry, 57*, 15-21.

Piper, M. C., Darrah, J., Pinnell, L., Maguire, T., & Byrne, P. (1989a). *Alberta Infant Motor Scale Manual.* Edmonton, Alberta: Faculty of Rehabilitation, University of Alberta.

Piper, M. C., Darrah, J., & Byrne P. (1989b). Impact of gestational age on preterm motor development at 4 months chronological and adjusted ages. *Child Care, Health, and Development, 15*, 105-115.

Piper, M. C., Mazer, B., Silver, K. M., & Ramsay, M. (1988). Resolution of neurological symptoms in high-risk infants during the first two years of life. *Developmental Medicine and Child Neurology, 30*, 26-35.

Piper, M., Finnell, L., Darrah, J., Maguire, T., & Byrne, P. (1991, October). *Construction and validation of the Alberta Infant Motor Scale (AIMS)*. Paper presented at the Rehabilitation Outcome Measures Conference, University of Alberta, Edmonton, AB.

Prechtl, H. F. R., & Nolte, R. (1984). Motor behavior of preterm infants. In H. F. R. Prechtl (Ed.), *Continuity of neural functions from prenatal to postnatal life* (pp. 79-92). London: Spastics International Medical Publications.

Prugh, D. G. (1953). Emotional problems of the premature infant's parents. *Nursing Outlook, 1*, 461-464.

Public Law 99-457: The Education of the Handicapped Amendments of 1986, Part H. Washington, D.C.: Federal Register.

Pyles, M. K., Stolz, H. R., & MacFarlane, J. W. (1935). The accuracy of mothers' reports on birth and developmental data. *Child Development, 6*, 165-176.

Ramsay, M., & Piper, M. C. (1980). A comparison of two developmental scales in evaluating infants with Down Syndrome. *Early Human Development, 4*, 89-95.

Rivara, F. P., & Howard, D. (1982). Parental knowledge of child development and injury risks. *Journal of Developmental and Behavioral Pediatrics, 3*, 103-105.

Rothstein, J. M. (1985). Measurement and clinical practice: Theory and application. In J. M. Rothstein (Ed.), *Measurement in physical therapy* (pp. 1-46). New York: Churchill Livingstone.

Rubin, J. Z., Provenzano, F. J., & Luria, Z. (1974). The eye of the beholder: Parents' views on sex of newborns. *American Journal of Orthopsychiatry, 44*, 512-519.

Sanford, A. R. (1974). *Learning Accomplishment Profile*. Winston-Salem: Kaplan.

Sawyer, M. G., Sarris, A., Baghurst, P. A., Worsley, A., & Kalucy, R. S. (1989). Early childhood development: A comparative study of beliefs held by adolescents, medical students, and mothers. *Australian Paediatric Journal, 25*, 226-229.

Saylor, C. F., & Brandt, B. J. (1986). The Minnesota Child Development Inventory: A valid maternal-report form for assessing development in infancy. *Journal of Developmental and Behavioral Pediatrics, 7*, 308-311.

Scherzer, A. L., & Tscharnuter, I. (1982). *Early diagnosis and therapy in cerebral palsy: A primer on infant developmental problems*. New York: Marcel Dekker.

Schulman, J. L., & Stern, S. (1959). Parents' estimate of the intelligence of retarded children. *American Journal of Mental Deficiency, 63*, 696-698.

Sexton, D., Kelley, M. F., & Scott, R. (1982). Comparison of maternal estimates and performance-based assessment scores for young handicapped children. *Diagnostique, 7*, 168-173.

Sexton, D., Thompson, B., Perez, J., & Rheams, T. (1990). Maternal versus professional estimates of developmental status for young children with handicaps: An ecological approach. *Topics in Early Childhood Special Education, 10,* 80-95.

Shea, V., & Fowler, M. G. (1983). Parental and pediatric trainee knowledge for development. *Journal of Developmental and Behavioral Pediatrics, 4,* 21-25.

Shosenberg, N., & Lennox, K. (1985). *Dear parents of premature babies: Family experiences with premature birth.* Ottawa: Canadian Institute of Child Health.

Sonnander, K. (1987). Parental developmental assessment of 18 month old children: Reliability and predictive value. *Developmental Medicine and Child Neurology, 29,* 351-362.

Sonnenschein, P. (1982). Parents and professionals: An uneasy relationship. In M. L. Henniger, & E. M. Nesselroad (Eds.), *Working with parents of handicapped children: A book of readings for school personnel* (pp. 129-139). Lanham, MD: University Press of America.

Sparrow, S. S., Balla, D. A., & Cicchetti, D. V. (1984). *Vineland Adaptive Behavior Scales.* Circle Pines, MN: American Guidance Service.

Squires, J., & Bricker, D. (1991). Impact of completing infant developmental questionnaires on at-risk mothers. *Journal of Early Intervention, 15,* 162-172.

Squires, J. K., Nickel, R., & Bricker, D. (1990). Use of parent-completed developmental questionnaires for child-find and screening. *Infants and Young Children, 3,* 46-57.

Stancin, T., Reuter, J., Dunn, V., & Bickett, L. (1984). Validity of caregiver information on the developmental status of severely brain-damaged young children. *American Journal of Mental Deficiency, 88,* 388-395.

Stern, M., & Hildebrandt, K. K. (1988). Prematurity stereotyping by mothers of premature infants. *Journal of Pediatric Psychology, 13,* 255-263.

Stern, M., & Karraker, K. H. (1990). The prematurity stereotype: Empirical evidence and implications for practice. *Infant Mental Health Journal, 11,* 3-11.

Touwen, B. C. L. (1976). *The neurological development of the infant. Clinics in Developmental Medicine No. 58.* London: Heinemann.

Touwen, B. C. L., & Hadders-Algra, M. (1983). Hyperextension of neck and trunk and shoulder retraction in infancy: A prognostic study. *Neuropaediatrics, 14,* 202-205.

Trause, M. A., & Kramer, L. I. (1983). The effects of premature birth on parents and their relationship. *Developmental Medicine and Child Neurology, 25,* 459-465.

Turnbull, A. P., & Turnbull, H. R. (Eds.). (1978). *Parents speak out: Views from the other side of the two way mirror.* Columbus, OH: Merrill.

Turnbull, A. P., & Turnbull, H. R. (1986). *Families, professionals, and exceptionality: A special partnership*. Columbus, OH: Merrill.

Valvano, J., & DeGangi, G. A. (1986). Atypical posture and movement findings in high risk preterm infants. *Physical and Occupational Therapy in Pediatrics, 6(2)*, 71-81.

Vukelich, C., & Kliman, D. S. (1985). Mature and teenage mothers' infant growth expectations and use of child development information sources. *Family Relations, 34*, 189-196.

Wolfensberger, W., & Kurtz, R. A. (1971). Measurement of parents' perceptions of their children's development. *Genetic Psychology Monographs, 83*, 3-92.

APPENDIX A

Hospital Discharge Pediatric Examination

Pediatric Examination Performed Prior to Hospital Discharge of Newborns

All infants born in the city of Edmonton are required to have an examination performed by a pediatrician prior to discharge. A copy of the results of this examination is forwarded to the Health Units of the Edmonton Board of Health. Guidelines for this assessment are outlined below.

	Normal	Abnormal
General Appearance	[ ]	[ ]
Weight for Gestational Age	[ ]	[ ]
Head and Neck	[ ]	[ ]
Respiratory	[ ]	[ ]
Cardiac	[ ]	[ ]
Abdomen	[ ]	[ ]
Locomotor	[ ]	[ ]
GU and Anus	[ ]	[ ]
Neurologic	[ ]	[ ]
Moro	[ ]	[ ]
Grasp	[ ]	[ ]
Suck	[ ]	[ ]
Tone	[ ]	[ ]
Skin	[ ]	[ ]

In addition, any medical complications, medications, feeding difficulties, etc. are recorded. The infant is given an overall hospital discharge rating of normal or abnormal.

APPENDIX B

Data Collection Form:

Full-term Infants

Alberta Infant Motor Scale
Validity of Maternal Scoring

Infant's Name: ______________________________

Number: ____________________ Raw Score: ____________________

Place of Assessment: ______________________________

Primary Rater: ______________________________

	Year	Month	Day
Date of Assessment:			
Date of Birth:			
Chronological Age:			

Sex:		Male [ ]	Female [ ]
Gestational Age at Birth:		________	(weeks)
Birth Weight:		________	(grams)
Apgar score:		________	(5 minutes)
Presentation:	Vertex [ ]	Breech [ ]	Other [ ]
Delivery:	Vaginal [ ]	Elective C/S [ ]	Emergency C/S [ ]
Discharge Pediatric Exam:		Normal [ ]	Abnormal [ ]

Number of additional children living in the home: ________

Dates of birth of siblings (oldest to youngest):

1. ________________ Interval between 1 and 2 _____ months
2. ________________ Interval between 2 and 3 _____ months
3. ________________ Interval between 3 and 4 _____ months
4. ________________ Interval between 4 and 5 _____ months
5. ________________

Maternal Education:	Did not complete High School	[ ]
	Completed High School	[ ]
	Partial/Completed College or Technical School	[ ]
	Partial or Completed University	[ ]

APPENDIX C

Data Collection Form:

Preterm Infants

Alberta Infant Motor Scale
Validity of Maternal Scoring

Infant's Name: ______________________________

Number: ______________ Raw Score: ______________

Place of Assessment: ______________________________

Primary Rater: ______________________________

	Year	Month	Day
Date of Assessment:			
Date of Birth:			
Chronological Age:			
Days of Prematurity:			
Corrected Age:			

Sex: Male [ ] Female [ ]

Gestational Age at Birth: _____(wks) Birth Weight ______(gr)

Neonatal History:

Respiratory History: Vent. assist.: yes [ ] no [ ]
Duration: ______________
BPD: yes [ ] no [ ]

Seizure Activity: yes [ ] no [ ]

IVH: yes [ ] no [ ]

Grade: I [ ] II [ ] III [ ] IV [ ]

Other Medical Problems: ______________________________

____

Days in NICU: ______________________________

Discharge Pediatric Examination:

Sensory abnormality:	Yes [ ]	No [ ]
Musculoskeletal abnormality:	Yes [ ]	No [ ]
Congenital abnormality:	Yes [ ]	No [ ]

Number of additional children living in the home: __________

Dates of birth of siblings (oldest to youngest):

1. ______________ Interval between 1 and 2: _____ months
2. ______________ Interval between 2 and 3: _____ months
3. ______________ Interval between 3 and 4: _____ months
4. ______________ Interval between 4 and 5: _____ months
5. ______________

Maternal Education:

Did not complete High School	[ ]
Completed High School	[ ]
Partial/Complete College or Technical School	[ ]
Partial or Complete University	[ ]

APPENDIX D

Alberta Infant Motor Scale

For Use By

Pediatric Physical Therapists

SCORE SHEETS: AIMS RELIABILITY AND VALIDITY STUDY

STUDY #

PRONE

Prone Lying

Physiological flexion
Turns head to clear nose from surface

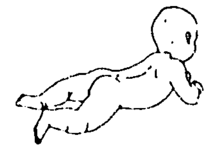
Prone Lying

Lifts head asymmetrically to 45°
Cannot maintain head in midline

Prone Prop

Elbows behind shoulders
Unsustained head raising to 45°

Forearm Support



Lifts and maintains head past 45°
Elbows in line with shoulders
Chest elevated

Prone Mobility

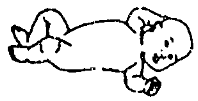
Head up to 90°
Uncontrolled weight shift

SUPINE

Supine Lying

Physiological flexion
Head rotation; mouth to hand
Random arm and leg movements

Supine Lying



Head rotation towards midline
Non-obligatory ATNR

Supine Lying

Head in midline
Moves arms but unable to bring hands to midline

Supine Lying

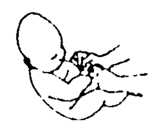
Neck flexors active - chin tuck
Brings hands to midline

SITTING

Sitting with Support

Lifts and maintains head in midline briefly

Pull to Sit



Chin tuck, head in line or in front of body

STANDING

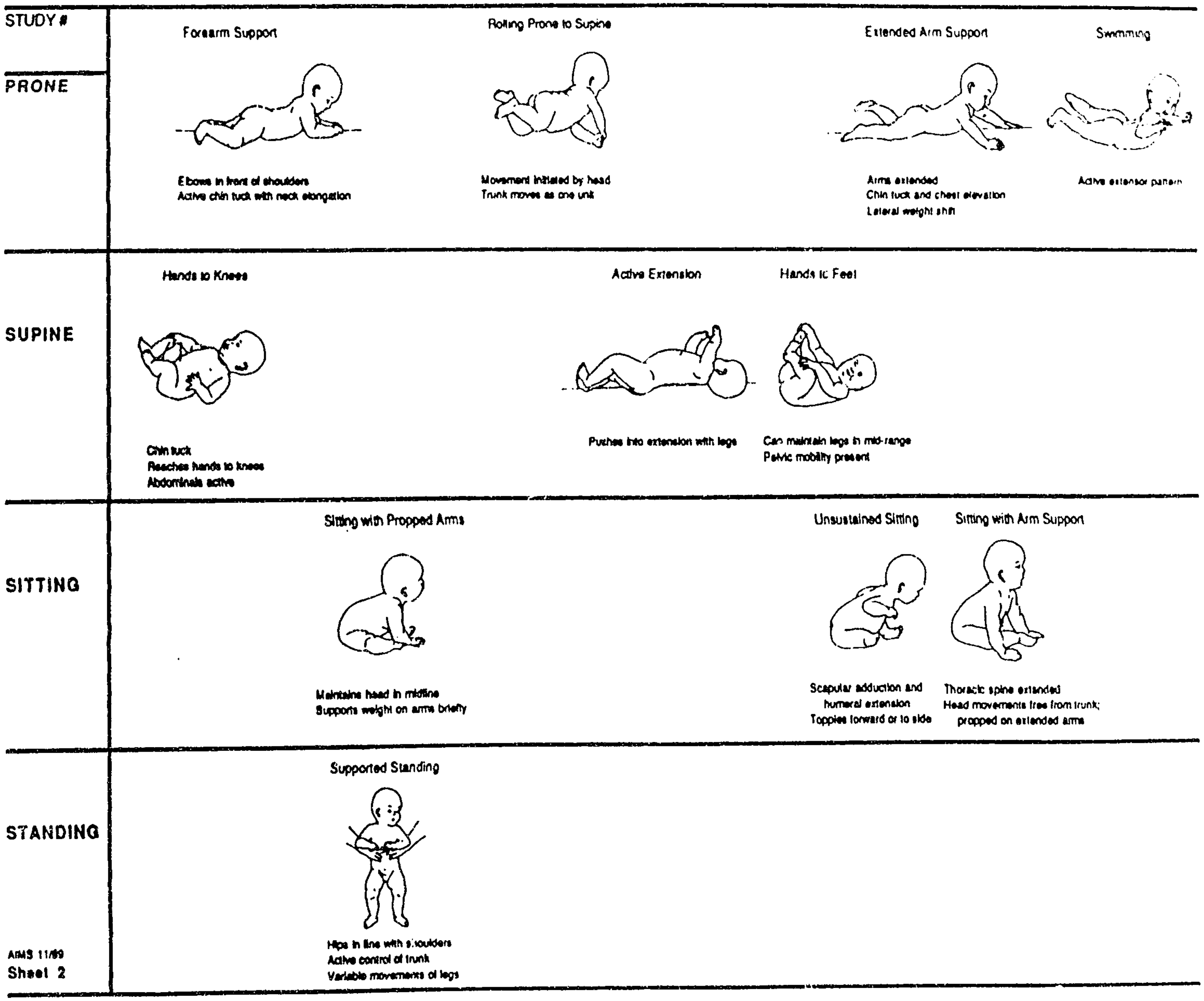
Supported Standing

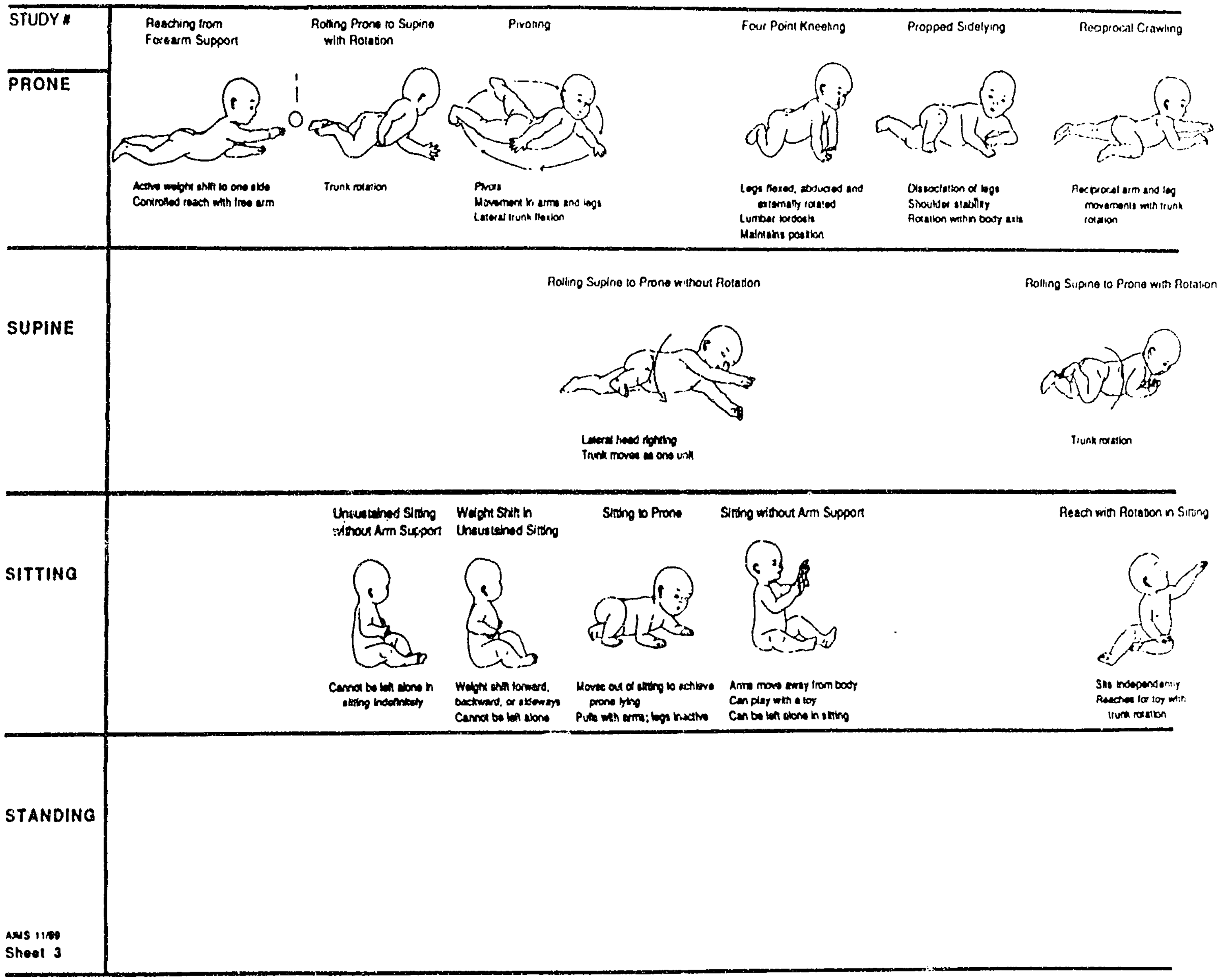
May have intermittent hip and knee flexion

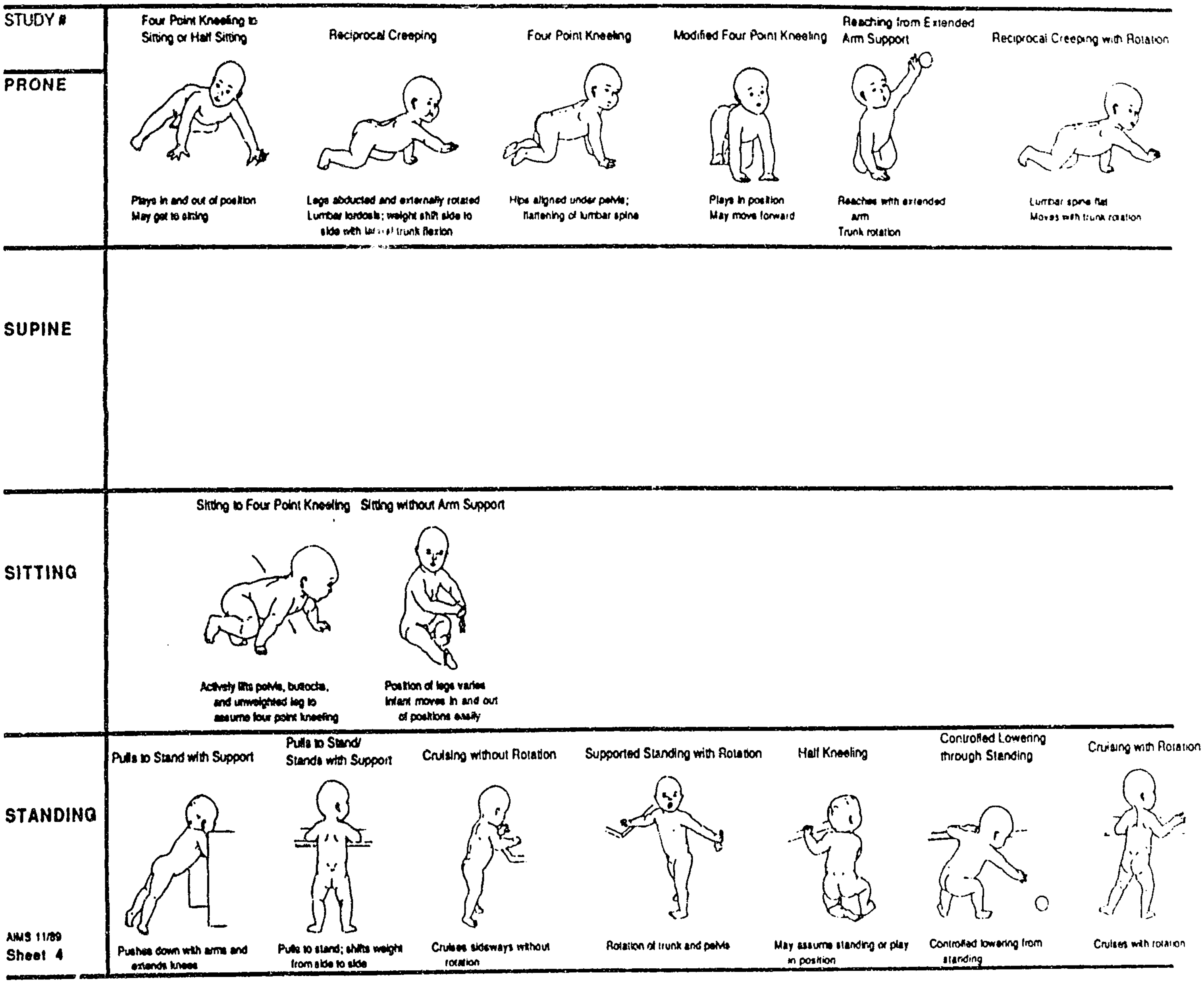
Supported Standing

Head in line with body
Hips behind shoulders
Variable movement of legs

AIMS 11/89
Sheet 1


STUDY #
PRONE
Forearm Support
Elbows in front of shoulders
Active chin tuck with neck elongation
Rolling Prone to Supine
Movement initiated by head
Trunk moves as one unit
Extended Arm Support
Arms extended
Chin tuck and chest elevation
Lateral weight shift
Swimming
Active extensor pattern
SUPINE
Hands to Knees
Chin tuck
Reaches hands to knees
Abdominals active
Active Extension
Pushes into extension with legs
Hands to Feet
Can maintain legs in mid-range
Pelvic mobility present
SITTING
Sitting with Propped Arms
Maintains head in midline
Supports weight on arms briefly
Unsustained Sitting
Scapular adduction and
humeral extension
Topples forward or to side
Sitting with Arm Support
Thoracic spine extended
Head movements free from trunk;
propped on extended arms
STANDING
Supported Standing
Hips in line with shoulders
Active control of trunk
Variable movements of legs
AIMS 11/89
Sheet 2


STUDY #
PRONE
Reaching from Forearm Support
Active weight shift to one side
Controlled reach with free arm
Rolling Prone to Supine with Rotation
Trunk rotation
Pivoting
Pivots
Movement in arms and legs
Lateral trunk flexion
Four Point Kneeling
Legs flexed, abducted and externally rotated
Lumbar lordosis
Maintains position
Propped Sidelying
Dissociation of legs
Shoulder stability
Rotation within body axis
Reciprocal Crawling
Reciprocal arm and leg movements with trunk rotation
SUPINE
Rolling Supine to Prone without Rotation
Lateral head righting
Trunk moves as one unit
Rolling Supine to Prone with Rotation
Trunk rotation
SITTING
Unsustained Sitting without Arm Support
Cannot be left alone in sitting indefinitely
Weight Shift in Unsustained Sitting
Weight shift forward, backward, or sideways
Cannot be left alone
Sitting to Prone
Moves out of sitting to achieve prone lying
Pulls with arms; legs inactive
Sitting without Arm Support
Arms move away from body
Can play with a toy
Can be left alone in sitting
Reach with Rotation in Sitting
Sits independently
Reaches for toy with trunk rotation
STANDING
AIMS 11/89
Sheet 3


STUDY #
PRONE
Four Point Kneeling to Sitting or Half Sitting
Plays in and out of position
May get to sitting
Reciprocal Creeping
Legs abducted and externally rotated
Lumbar lordosis; weight shift side to side with lateral trunk flexion
Four Point Kneeling
Hips aligned under pelvis; flattening of lumbar spine
Modified Four Point Kneeling
Plays in position
May move forward
Reaching from Extended Arm Support
Reaches with extended arm
Trunk rotation
Reciprocal Creeping with Rotation
Lumbar spine flat
Moves with trunk rotation
SUPINE
SITTING
Sitting to Four Point Kneeling
Actively lifts pelvis, buttocks, and unweighted leg to assume four point kneeling
Sitting without Arm Support
Position of legs varies
Infant moves in and out of positions easily
STANDING
Pulls to Stand with Support
Pushes down with arms and extends knees
Pulls to Stand/ Stands with Support
Pulls to stand; shifts weight from side to side
Cruising without Rotation
Cruises sideways without rotation
Supported Standing with Rotation
Rotation of trunk and pelvis
Half Kneeling
May assume standing or play in position
Controlled Lowering through Standing
Controlled lowering from standing
Cruising with Rotation
Cruises with rotation
AIMS 11/89
Sheet 4

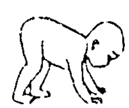
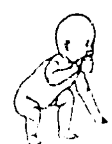
STUDY #

PRONE

SUPINE

SITTING

STANDING

Stands Alone	Early Stepping	Standing from Quadruped Position	Standing from Modified Squat	Walks Alone	Squat
					
Stands alone momentarily Balance reactions in feet	Walks independently; moves quickly with short steps; lateral flexion of trunk	Pushes quickly with hands to get to standing	Moves from squat to standing with controlled flexion and extension of hips and knees	Walks independently	Maintains position by balance reactions in feet and in position of trunk

AIMS 11/89
Sheet 5

APPENDIX E

Alberta Infant Motor Scale

For Use By Mothers

SCORE SHEETS: AIMS MATERNAL VALIDITY STUDY

STUDY #

LYING ON STOMACH

Lying on Stomach

Y N

Arms and legs tucked in
Turns head side to side

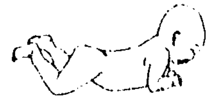
Lying on Stomach

Y N

Lifts head half way up
Cannot hold head in middle

Prop on Elbows

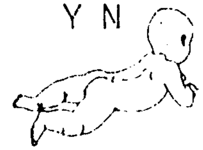
Y N



Elbows behind shoulders
Lifts head up half way in middle
"Bobs"

Forearm Support

Y N



Lifts and holds head past half way
Elbows in line with shoulders
Chest up

Movement on Stomach

Y N

Head all the way up
Wiggles around

LYING ON BACK

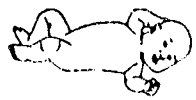
Lying on Back

Y N

Arms and hips tucked
Head to one side
Mouth to hand

Lying on Back

Y N



Able to turn head towards middle

Lying on Back

Y N

Able to keep head in middle
Moves arms but cannot bring hands together

Lying on Back

Y N

Tucks chin
Brings hands together

SITTING

Sitting with Help

Y N

Lifts and holds head
in middle for short time

Pull to Sit

Y N

Chin tuck, head in line
or in front of body

STANDING

Standing with Help

Y N

May bend and straighten
hips and knees

Standing with Help

Y N

Head in line with body
Hips behind shoulders
Movement of legs

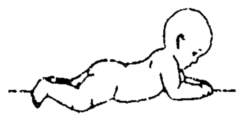
Y = yes, is doing now
N = not yet doing

AIMS 11/89
Sheet 1

STUDY #

LYING ON STOMACH

Forearm Support Y N

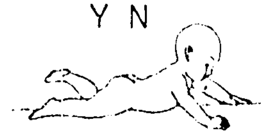


Elbows in front of shoulders
Able to tuck chin to look down

Rolling Stomach to Back Y N

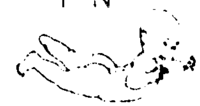
Movement started by head
Body moves as one unit
(no separation of movement between shoulders and hips)

Straight Arm Support Y N



Arms straight
Chest up, able to look down,
shifts weight side to side

"Swimming" Y N



or "Airplane", may rock on stomach

LYING ON BACK

Hands to Knees Y N

Chin tuck
Reaches hands to knees
Stomach muscles working

Stretching Back Y N

Arches, pushes back with legs and head

Hands to Feet Y N

Lifts legs and [illegible] to play with [illegible]

SITTING

Sitting with Propped Arms Y N

Holds head in middle
Takes weight on arms for short time

Unsustained Sitting Y N

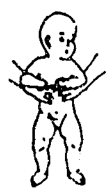
Pulls arms back trying to stay up, but falls forward or to side

Sitting with Arm Support Y N

Upper back straight, moves head freely, propped on straight arms

STANDING

Standing with Help Y N



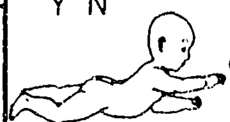
Hips in line with shoulders
Able to control upper body
Movement of legs

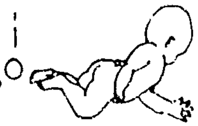
Y = yes, is doing now
N = not yet doing

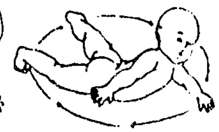
AIMS 11/99
Sheet 2

STUDY #

LYING ON STOMACH

Reaching from Forearm Support Y N

Able to reach for toy without "falling" over

Rolling Stomach to Back II Y N

"Twisting" at waist (movement between hips and shoulders)

Pivoting Y N

Pivots
Movement in arms and legs
Sends body sideways

Kneeling Y N

Legs tucked up but knees stiff out to side
"Sway back", holds position

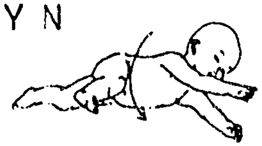
Propped on Side Y N

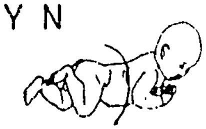
Legs in different positions
Shoulder stable for taking weight

Creeping on Stomach Y N

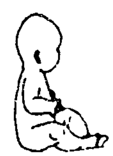
Moves opposite arm and leg together

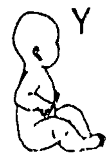
LYING ON BACK

Rolling Back to Stomach I Y N

Lifts head to side
Moves body as one unit (no movement between shoulders and hips)

Rolling Back to Stomach II Y N

"Twisting" between shoulders and hips (may be very fast)

SITTING

Sitting without Arm Support Y N

But cannot be left alone in sitting for long

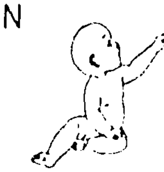
Practices Balance in Sitting Y N

But cannot be left alone

Sitting to Lying Y N

Moves to stomach on purpose
Pulls with arms; legs not active

Sitting without Arm Support Y N

Arms move away from body
Can play with a toy
Can be left alone in sitting

Reaches in Sitting Y N

Sits without help
Can reach around

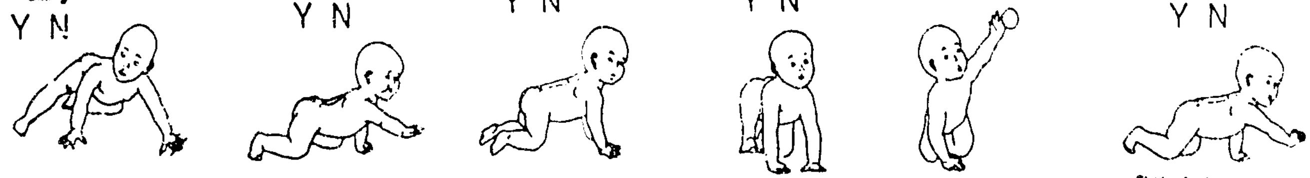
STANDING

Y = yes, is doing now
N = not yet doing

AMS 11/88
Sheet 3

STUDY #

LYING ON STOMACH

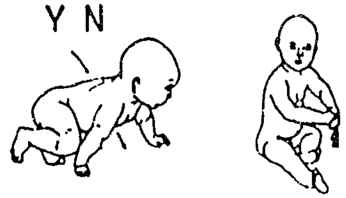


Kneeling to Sitting or Half Sitting	Crawling I	Kneeling	Modified Kneeling	Reaching	Crawling II
Y N	Y N	Y N	Y N	Y N	Y N
Plays in and out of position May get to sitting	Legs out to sides, "sway back" Hips wiggle side to side	Knees under hips Flattening of low back	Plays in position May move forward	Reaches with straight arm	Flat low back No longer "wiggles" bottom side to side

LYING ON BACK

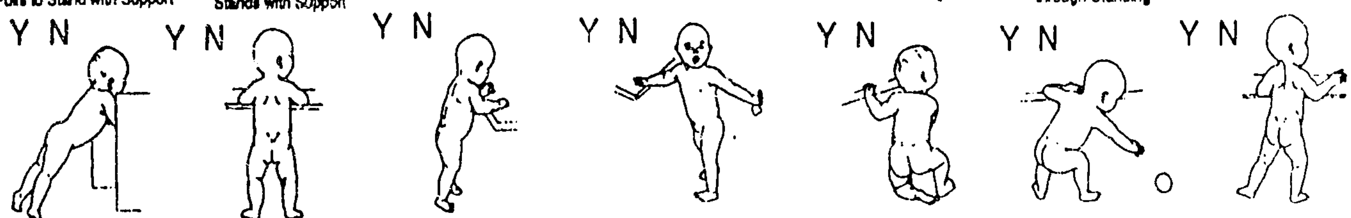
Y = yes, is doing now
N = not yet doing

SITTING



Sitting to Kneeling	Sitting without Arm Support
Y N	Y N
Lifts bottom to move to kneeling	Position of legs keeps changing Moves in and out of positions easily

STANDING



Pulls to Stand with Support	Pulls to Stand/ Stands with Support	Cruising I	Supported Standing	Half Kneeling	Controlled Lowering through Standing	Cruising II
Y N	Y N	Y N	Y N	Y N	Y N	Y N
Pushes down with arms and straightens knees	Pulls to stand; shifts from side to side	Walks sideways without turning body (body faces forward)	Able to turn body	May play or pull to stand through position	Controlled lowering from standing (no longer "falls")	Walks with body turned toward direction travelled

AMS 11/89
Sheet 4

* To score "Y" on any of the standing items, the child must move to standing without help.

STUDY #

Y = yes, is doing now
N = not yet doing

LYING ON STOMACH

LYING ON BACK

SITTING

STANDING

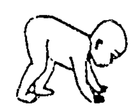
Stands Alone — Y N

Stands alone and balances for a few seconds

Early Stepping — Y N

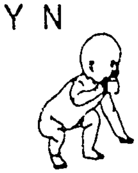
Able to take 6 or more steps on own; moves quickly with short steps; waddles from side to side

Standing from Hands and Feet — Y N



Pushes quickly with hands to get to standing

Standing from Squat — Y N



Moves from squat to standing with control of hips and knees

Walks Alone — Y N

Walks rather than crawls now

Squat — Y N

Plays in position

AIMS 11/89
Sheet 5

* To score "Y" on <u>any</u> of the last 4 standing items, the child must be able to move to standing <u>completely</u> on own (not using furniture).

APPENDIX F

Instructions for Mothers

Alberta Infant Motor Scale
Validity of Maternal Scoring

Infant's Name: ______________________

Number: ______________ Raw Score: __________

Date of Assessment: ______________________

INSTRUCTIONS FOR SCORING:

From your knowledge of your baby's abilities, please circle the appropriate letter above all of the pictures on the form:

Y (yes) if your baby is now doing or has done the activity,
N (no) if your baby is not yet doing the activity.

Your baby must be doing the item as described by the words as well as the picture.

APPENDIX G

Sampling Guide

Alberta Infant Motor Scale
Validity of Maternal Scoring
Sampling Guide

RATER	GROUP	AGE RANGE (months)	
1	full-term	1-5	X X X
	preterm	1-5	X X X
	full-term	6-10	X X X X
	preterm	6-10	X X X X
	full-term	11-15	X X X
	preterm	11-15	X X X
2	full-term	1-5	X X X X
	preterm	1-5	X X X X
	full-term	6-10	X X X
	preterm	6-10	X X X
	full-term	11-15	X X X
	preterm	11-15	X X X
3	fu[illegible]	1-5	X X X
	preterm	1-5	X X X
	full-term	6-10	X X X
	preterm	6-10	X X X
	full-term	11-15	X X X X
	preterm	11-15	X X X X

APPENDIX H

Consent Form

CONSENT FORM

TITLE: MOTHERS' ASSESSMENTS OF INFANT MOTOR DEVELOPMENT

INVESTIGATOR: Doreen Bartlett, B.Sc.P.T.
Phone: 432-7962 (home - evenings)
SUPERVISOR: Dr. M.C. Piper, Rehabilitation Medicine,
University of Alberta Phone: 492-4939

PURPOSE: The purpose of this project is to learn how closely mothers and physical therapists agree on ratings of babies' movement. This information will be useful in helping physical therapists and parents to work better together.

You will be asked to answer a few questions and then to mark the activities your baby is now doing on the Alberta Infant Motor Scale (AIMS). The AIMS is being developed through the University of Alberta with the help of the Edmonton Board of Health. It is made up of pictures of babies doing different activities while lying on the tummy and back, sitting, and standing. After you finish filling out the form, a physical therapist will also score your baby using the AIMS. This will take about 45 minutes in all. Information on your child's delivery and early medical care will be recorded from the chart.

CONSENT: I, ____________________, (please print) agree to take part in the above project which has been completely described to me. I understand that I may withdraw from the study at any [illegible] without affecting the care my baby receives. I understand that this study will not [illegible] baby and that I will be given information about my baby's motor development, as [illegible] y the physical therapist.

I understand that all records will be given a code number. No information identifying me or my baby will be released or printed, without my consent.

It has been explained to me that all babies develop differently, and that my baby may not do all of the activities shown on the scale. I understand that the physical therapist will review her scoring with me, and that I am requested <u>not</u> to inform her of my scoring.

I have read and understood the information stated above. I sign this consent form willingly and I have received a copy.

All questions that I had about the project have been answered. I understand that I may call either Doreen Bartlett or Dr. Piper, at the phone numbers above if I have more questions.

______________________________ ______________
(Signature of Parent/Guardian) (Date)

______________________________ ______________
(Signature of Witness) (Date)

______________________________ ______________
(Signature of Investigator) (Date)

FUNDING: Financial support from the Alberta Heritage Foundation for Medical Research has been received to conduct this study.

APPENDIX I

Infant and Familial Characteristics of Full-term Sample

Raw Data

Infant and Familial Characteristics
Full-term Sample

ID	Age	Sex	Mat Ed	[illegible]	BI	GA	BW
21	1.6	M	4	1	36	38	3085
13[a]	2.0	M	1	0	--	37	3030
35	2.0	F	4	1	35	40	3295
24	2.5	F	[illegible]	2	76	40	3745
22[b]	2.6	M	2	0	--	39	3382
31	4.0	F	2	0	--	42	3586
39	4.0	M	3	1	34	38	3365
26	4.1	F	4	1	23	40	4118
11	5.1	M	3	3	28	37	3480
12	5.8	F	3	1	26	40	2895
32	6.1	F	4	0	--	37	2800
23	6.4	F	4	1	54	41	4264
28[b]	6.8	F	2	1	32	40	3655
33	7.3	F	2	1	52	38	3355
14	7.9	F	3	2	118	39	3280
19	8.4	F	3	0	--	40	3270
10	8.6	M	2	0	--	38	3420
29	9.5	F	3	2	24	42	4377
34	9.6	M	3	0	--	40	3648
18	10.2	F	3	1	26	39	3180
17	11.4	M	4	1	18	41	4080
15	12.0	M	3	0	--	39	3080
25	12.1	M	3	0	--	37	2927
16	12.2	F	3	0	--	41	3825
37	12.3	M	3	0	--	40	2950
38	12.4	M	3	1	22	39	3745
20	12.8	F	3	0	--	38	3020
36	13.0	M	2	0	--	39	3735
27	13.5	M	2	1	26	40	3610
30[b]	14.6	M	3	0	--	40	3700

Notes.
ID = identification number;
Age = age in months at time of assessment;
Sex: M = male, F = female;
Mat Ed = maternal education where 1 = did not complete high school; 2 = completed high school; 3 = partial or completed college or technical school; 4 = partial or completed university;
# Add Child = number of additional children in the home;
BI = birth interval between study subject and next oldest child in months;
GA = gestational age in weeks at birth;
BW = birthweight in grams.
[a] = positional foot deformity at birth.
[b] = delivered via emergency Caesarian section.

APPENDIX J

Infant and Familial Characteristics of Preterm Sample

Raw Data

Infant and Familial Characteristics: Preterm Sample

ID	Age	Sex	Mat Ed	# Add Child	BI	GA	BW	Vent Asst	Dur	BPD	Seiz	IVH	Days NICU
68	3.8	F	4	0	--	29	1085	0	0	0	0	0	45
58	3.8	M	4	0	--	27	1060	1	35	1	0	0	44
71	3.8	M	3	2	23[a]	30	1500	1	27	0	0	1	44
56	3.9	M	1	2	48	24	690	1	65	1	0	1	108
66	4.0	F	3	1	--[a]	30	1135	0	0	0	0	0	42
67	4.0	M	3	1	--[a]	30	1390	0	0	0	0	0	42
63	4.1	M	3	1	71	28	870	1	37	0	0	1	66
64	4.1	F	2	0	--	24	636	1	50	1	0	0	100
50	5.[illegible]	M	3	0	--	26	1035	1	6	0	0	1	69
72	5.7	F	2	1	100	25	690	1	40	1	0	1	88
70	6.7	F	3	3	35[b]	30	1365	0	0	0	0	1	47
59	7.3	F	2	0	--	26	840	1	100	0	0	0	151
57	7.8	M	4	1	24	28	1220	1	61	1	0	1	74
52	8.0	M	4	1	10	28	1180	1	5	0	0	1	56
62	9.7	M	3	1	--[a]	27	1235	1	30	0	0	0	64
54	10.1	M	1	4	50[b]	29	1220	1	41	1	0	1	55
55	10.1	M	1	4	50[b]	29	1215	1	1	0	0	1	55
53	10.1	M	1	4	50[b]	29	1155	0	0	0	0	0	55
65	10.3	M	2	1	73	28	1190	1	61	0	0	0	129
60	10.5	F	2	1	81	31	895	1	41	0	0	0	83
73	11.4	M	4	0	--	33	1165	1	9	0	0	0	101
77	11.9	M	2	1	43	31	1265	0	0	0	0	0	36
79	11.9	F	3	0	--	31	1325	1	7	0	0	0	32
76	12.0	F	4	1	--[a]	36	1150	0	0	0	0	0	28
78	12.0	M	1	0	--	27	995	1	80	1	0	1	89
51	12.1	F	4	0	--	25	795	1	104	1	0	1	104
69	12.2	M	2	1	-12	30	1415	0	0	0	0	0	43
61	13.4	M	4	0	--	26	870	1	33	0	1	0	90
74	14.3	M	2	0	--	25	990	1	54	1	0	1	66
75	15.4	M	2	1	51	31	1350	1	15	0	0	0	15

Notes. [a]twin; [b]triplet.
ID = identification number; Age = adjusted age in months at time of assessment;
Sex: M = male, F = female;
Mat Ed = maternal education where 1 = did not complete high school; 2 = completed high school; 3 = partial or completed college or technical school; 4 = partial or completed university;
# Add Child = number of additional children in the home;
BI = birth interval between subject and child of closest age in months;
GA = gestational age in weeks at birth; BW = birthweight in grams;
Vent Asst = ventilatory assistance; BPD = bronchopulmonary dysplasia; Seiz = seizures; IVH = intraventricular hemorrhage (0 = no, 1 = yes);
Dur = duration of ventilatory assistance in days;
Days NICU = days in NICU before discharge.

APPENDIX K

AIMS Section and Total Scores

Full-term Sample

AIMS Section and Total Scores
Full-term Sample

ID	Age	PT Pr	PT Sup	PT Sit	PT St	PT Tot	M Pr	M Sup	M Sit	M St	M Tot
21	1.6	3	2	1	2	8	3	3	1	0	7
13	2.0	3	2	1	2	8	4	4	2	2	12
35	2.0	4	2	1	1	8	2	3	1	2	8
24	2.5	3	3	1	2	9	6	5	2	2	15
22	2.6	5	3	1	2	11	5	6	2	3	16
31	4.0	3	7	4	2	16	6	7	2	3	18
39	4.0	3	7	3	2	15	3	7	2	3	15
26	4.1	6	6	7	3	22	7	7	7	3	24
11	5.1	6	6	5	3	20	5	7	4	4	20
12	5.8	9	7	7	3	26	12	9	3	3	27
32	6.1	10	8	9	3	30	11	9	10	3	33
23	6.4	11	8	9	3	31	15	9	8	3	35
28	6.8	17	9	11	3	40	18	9	10	4	41
33	7.3	12	8	9	3	32	13	8	10	3	34
14	7.9	12	9	10	3	34	15	9	9	3	36
19	8.4	15	9	11	9	44	18	9	12	10	49
10	8.6	16	9	10	3	38	18	9	9	3	39
29	9.5	21	9	12	10	52	21	9	12	10	52
34	9.6	21	9	12	9	51	21	9	12	9	51
18	10.2	21	9	12	16	58	21	9	12	16	58
17	11.4	21	9	12	11	53	21	9	12	12	54
15	12.0	21	9	12	11	53	21	9	12	11	53
25	12.1	21	9	12	10	52	20	9	12	10	51
16	12.2	21	9	12	16	58	21	9	12	16	58
37	12.3	21	9	12	16	58	21	9	12	16	58
38	12.4	21	9	12	12	54	21	9	12	15	57
20	12.8	21	9	12	16	58	21	9	12	16	58
36	13.0	21	9	12	16	58	21	9	12	16	58
27	13.5	21	9	12	12	54	20	9	12	13	54
30	14.6	21	9	12	16	58	21	9	12	16	58

Notes.
ID = identification number;
PT = physical therapist;
M = mother;
Pr = prone raw score;
Sup = supine raw score;
Sit = sitting raw score;
St = standing raw score;
Tot = total raw score.

APPENDIX L

AIMS Section and Total Scores

Preterm Sample

AIMS Section and Total Scores
Preterm Sample

ID	Age	PT Pr	PT Sup	PT Sit	PT St	PT Tot	M Pr	M Sup	M Sit	M St	M Tot
68	3.8	6	5	2	2	15	8	6	2	2	18
58	3.8	6	3	1	2	12	9	6	2	2	19
71	3.8	6	3	1	2	12	8	5	4	2	19
56	3.9	5	3	2	2	12	6	4	2	2	14
66	4.0	6	3	1	2	12	4	3	2	2	11
67	4.0	5	4	3	2	14	7	5	3	3	18
63	4.1	5	5	1	2	13	10	7	1	1	19
64	4.1	9	7	3	2	21	9	8	4	2	23
50	5.6	9	7	7	2	25	9	7	8	4	28
72	5.7	5	5	3	2	15	13	7	6	3	29
70	6.7	11	8	9	2	30	14	8	9	3	34
59	7.3	18	9	11	8	46	20	9	12	7	48
57	7.8	14	9	10	3	36	14	8	10	10	42
52	8.0	11	7	7	3	28	19	9	10	5	43
62	9.7	15	9	11	4	39	17	9	11	9	46
54	10.1	21	9	12	12	54	21	9	12	13	55
55	10.1	20	9	12	15	56	21	9	12	13	55
53	10.1	20	9	12	11	52	21	9	12	12	54
65	10.3	12	9	9	6	36	15	8	5	7	35
60	10.5	11	9	8	3	31	16	9	11	4	40
73	11.4	20	9	11	10	50	18	8	10	9	45
77	11.9	20	9	12	10	51	20	9	12	10	51
79	11.9	20	9	12	10	51	21	9	12	10	52
76	12.0	21	9	12	10	52	21	9	12	11	53
78	12.0	19	9	12	10	50	21	9	12	11	53
51	12.1	21	9	12	9	51	21	9	12	11	53
69	12.2	21	9	12	16	58	20	9	12	16	57
61	13.4	21	9	12	12	54	21	9	12	12	54
74	14.3	21	9	12	16	58	21	9	12	16	58
75	15.4	21	9	12	16	58	21	8	12	16	57

Notes.
ID = identification number;
PT = physical therapist;
M = mother;
Pr = prone raw score;
Sup = supine raw score;
Sit = sitting raw score;
St = standing raw score;
Tot = total raw score.

APPENDIX M

Calculation of Comparison of ICCs

A: Convert Correlation Coefficients to Fisher's Z Values

ICC Full-term Group = .989

$$\text{Fisher's Z} = \frac{1}{2}\ln\left(\frac{1+r}{1-r}\right) = 2.599$$

ICC Preterm Group = .947

$$\text{Fisher's Z} = \frac{1}{2}\ln\left(\frac{1+r}{1-r}\right) = 1.802$$

B: Use Formula to Test the Difference Between Independent Correlation Coefficients
(Glass & Hopkins, 1984)

$$Z\text{ (observed)} = \frac{Z_{\text{full-term}} - Z_{\text{preterm}}}{\sqrt{\frac{1}{n_{ft} - 3} + \frac{1}{n_{pt} - 3}}}$$

$$Z\text{ (observed)} = \frac{2.599 - 1.802}{\sqrt{\frac{1}{21} + \frac{1}{26}}} = \frac{0.797}{0.293} = 2.720$$

$p = 0.007$

APPENDIX N

AIMS Total Scores: Preterm Sample

Primary and Secondary Physical Therapist Raters

AIMS Total Scores: Preterm Sample
Primary and Secondary Physical Therapist Raters

ID	Age	Primary Rater[a]	AIMS Tot	Secondary Rater[a]	AIMS Tot
58	3.8	1	12	2	12
56	3.9	2	12	3	14
66	4.0	1	12	3	11
67	4.0	3	14	1	13
63	4.1	3	13	1	15
64	4.1	1	21	3	18
50	5.6	3	25	2	25
72	5.7	2	15	1	16
70	6.7	2	30	1	29
59	7.3	1	46	3	42
57	7.8	2	36	3	39
52	8.0	2	28	1	32
62	9.7	3	39	2	43
54	10.1	3	54	1	54
55	10.1	3	56	1	55
53	10.1	1	52	3	53
65	10.3	1	36	2	34
60	10.5	1	31	3	26
73[b]	11.4	2	45	3	44
77	11.9	3	51	1	51
79	11.9	3	51	2	50
76	12.0	2	52	3	52
78	12.0	3	50	1	51
51	12.1	1	51	2	51
69	12.2	1	58	2	58
61	13.4	3	54	1	52

Notes.
ID = identification number;
AIMS Tot = AIMS total raw score.
[a]raters are simply identified by number.
[b]subject 73 seen by rater 1 for maternal validity study and by raters 2 and 3 for discriminant validity study.

APPENDIX O

Preliminary Normative Data for the AIMS

Alberta Infant Motor Scale
Preliminary Normative Data
Collected September to November, 1991

Age (months)	n	Mean	Standard Deviation
1	--	--	--
2	27	10.074	2.615
3	24	12.500	3.270
4	37	18.730	4.937
5	61	22.934	5.183
6	48	29.938	5.909
7	53	34.868	7.312
8	27	40.593	9.901
9	26	46.346	7.076
10	40	51.100	4.355
11	29	52.793	7.306
12	24	55.917	2.992
13	33	56.970	1.992
14	15	57.333	1.589
15	14	57.929	0.267

<u>Note</u>. Normative data not yet available for 1 month.

APPENDIX P

Percentile Scores of Full-term Infants

Percentile Scores of Full-term Infants

ID	Age (months)	Physical Therapist Total Score	z Score	Percentile	Mother Total Score	z Score	Percentile
21	1.6	8	--	--	7	--	--
13	2.0	8	-0.7931	21	12	0.7365	77
35	2.0	8	-0.7931	21	8	-0.7931	21
24	2.5	9	-0.4107	34	15	1.8837	97
22	2.6	11	0.3541	64	16	2.2660	99
31	4.0	16	-0.5530	29	18	-0.1479	44
39	4.0	15	-0.7555	22	15	-0.7555	22
26	4.1	22	0.6623	75	24	1.0674	86
11	5.1	20	-0.5661	28	20	-0.5661	28
12	5.8	26	0.5915	72	27	0.7845	78
32	6.1	30	0.0105	50	33	0.5182	70
23	6.4	31	0.1797	57	35	0.8567	81
28	6.8	40	1.7028	96	41	1.8720	97
33	7.3	32	-0.3922	35	34	-0.1187	45
14	7.9	34	-0.1187	45	36	0.1548	56
19	8.4	44	0.3441	63	49	0.8491	80
10	8.6	38	-0.2619	40	39	-0.1609	44
29	9.5	52	0.7990	79	52	0.7990	79
34	9.6	51	0.6577	75	51	0.6577	75
18	10.2	58	1.5840	94	58	1.5840	94
17	11.4	53	0.0283	51	54	0.1652	57
15	12.0	53	-0.9749	17'	53	-0.9749	17'
25	12.1	52	-1.3091	10+	51	-1.6430	5+
16	12.2	58	0.6962	76	58	0.6962	76
37	12.3	58	0.6962	76	58	0.6962	76
38	12.4	54	-0.6407	26	57	0.3619	64
20	12.8	58	0.6962	76	58	0.6962	76
36	13.0	58	0.5170	70	58	0.5170	70
27	13.5	54	-1.4910	7+	54	-1.4910	7+
30	14.6	58	0.4198	66	58	0.4198	66

Note. Normative data not yet available for 1 month.

+ Suspicious (less than 16th percentile);

' Borderline.

APPENDIX Q

Percentile Scores of Preterm Infants

Percentile Scores of Preterm Infants

ID	Age (months)	Physical Therapist Total Score	z Score	Percentile	Mother Total Score	z Score	Percentile
68	3.8	15	0.7645	78	18	1.6820	95
58	3.8	12	-0.1529	44	19	1.9878	98
71	3.8	12	-0.1529	44	19	1.9878	98
56	3.9	12	-0.1529	44	14	0.4587	68
66	4.0	12	-1.3632	9+	11	-1.5657	6+
67	4.0	14	-0.9581	17'	18	-0.1479	44
63	4.1	13	-1.1606	12+	19	0.0547	52
64	4.1	21	0.4598	68	23	0.8649	81
50	5.6	25	0.3986	66	28	0.9774	84
72	5.7	15	-1.5308	6+	29	1.1704	88
70	6.7	30	0.0105	50	34	0.6874	75
59	7.3	46	1.5224	94	48	1.7960	96
57	7.8	36	0.1548	56	42	0.9754	64
52	8.0	28	-1.2719	10+	43	0.2451	59
62	9.7	39	-1.0382	15+	46	-0.0489	48
54	10.1	54	0.6659	75	55	0.8955	82
55	10.1	56	1.1251	87	55	0.8955	82
53	10.1	52	0.2067	58	54	0.6659	75
65	10.3	36	-3.4672	0.03*	35	-3.6969	0.01*
60	10.5	31	-4.6154	0.0003*	40	-2.5488	0.5*
73	11.0	50	-0.3823	35	45	-1.0667	4+
77	11.9	51	-0.2454	41	51	-0.2454	41
79	11.9	51	-0.2454	41	52	-0.1085	46
76	12.0	52	-1.3092	9.5+	53	-0.9749	17'
78	12.0	50	-1.9776	2.4*	53	-0.9749	17'
51	12.1	51	-1.6434	5+	53	-0.9749	17'
69	12.2	58	0.6962	76	57	0.3620	64
61	13.4	54	-0.6407	26	54	-0.6407	26
74	14.3	58	0.4198	66	58	0.4198	66
75	15.4	58	0.2659	60	57	-3.479	0.03*

* Abnormal (less than 3rd percentile);

+ Suspicious (less than 16th percentile);

' Borderline.