PREDICTION OF ADAPTIVE MOTOR SKILL PERFORMANCE IN SCHOOL-AGED CHILDREN WITH LOW BIRTH WEIGHT WITHOUT MAJOR NEUROSENSORY IMPAIRMENT

A DISSERTATION

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BY

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To the Dean of the Graduate School:

I am submitting herewith a dissertation written by Mary S. Swiggum entitled "Prediction of Adaptive Motor Skill Performance in School-Aged Children with Low Birth Weight without Major Neurosensory Impairment." I have examined this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of doctor of philosophy with a major in Physical Therapy.

Katy Mitchell, PT, PhD

We have read this dissertation and recommend its acceptance:

Department Chair

Accepted:

Dean of the Graduate School

DEDICATION

To my family, Lars and Ally,
thank you for your continuous support and love.

To all of the children and families I have worked with,
thank you for sharing your lives with me.

To my mother, Ann Scott,
thank you for always being there.

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ABSTRACT

MARY S. SWIGGUM

PREDICTION OF ADAPTIVE MOTOR SKILL PERFORMANCE IN SCHOOL-AGED CHILDREN WITH LOW BIRTH WEIGHT WITHOUT MAJOR NEUROSENSORY IMPAIRMENT

MAY 2010

Many children with low birth weight (LBW) demonstrate significant impairments in adaptive motor functioning upon school entry. Identification of these children so that appropriate remediation can be rendered is problematic.

The purpose of this study was to identify predictors of adaptive motor difficulties at kindergarten age in LBW children without diagnosed neurosensory impairment.

Children (n=341) representing a subset of the 3,338 children enrolled in the National Early Intervention Longitudinal Study (NEILS) met the inclusion criteria.

Variables were extracted from the Enrollment Family Interview and the Kindergarten Family Interview of the NEILS. Three separate multiple regression analyses were performed to examine the predictors of caregiver reported functioning at kindergarten age in fine motor, dressing, and functional mobility skills. Variables were divided into three categories for analysis, including biological (gender, length of hospitalization, birth weight, gestational age), environmental (perceived social support, caregiver confidence in child rearing, maternal optimism for child's future, maternal

education, and income level), and behavioral (responsiveness to auditory and visual stimulation, activity level, ability to focus, ability to be soothed, and sleep disturbances). The alpha level was set at p=.01 for each test.

Maternal optimism was the strongest predictor of fine motor skills (r=.287, $p \leq .0005$) and one of two of the strongest predictors of functional mobility skills (r=.178, $p \leq .0005$). Perceived social support was the strongest predictor of dressing skills (r=-.245, $p \leq .0005$) and one of two of the strongest predictors of functional mobility skills (r=-.178, $p \leq .0005$). Gender and ability to focus emerged as relatively strong and significant biological and behavioral predictors, respectively.

As a group, environmental variables explained the greatest percentage of variance in adaptive motor skill performance. Gender, maternal optimism for child's future, ability to focus, and perceived social support emerged as the strongest individual predictors of adaptive motor skills at kindergarten age in children born with low birth weight without diagnosed neurosensory disorders.

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CHAPTER I

INTRODUCTION

Advances in prenatal and perinatal care and assistive reproductive technology have resulted in the delivery and survival of children of increasingly lower gestational ages and birth weights. In 2008, low birth weight (LBW) represented 8.3% of all births as compared to 6.8% in 1980.[1] Low birth weight is generally defined as a birth weight below 2500 grams.[1] Children born at less than 37 weeks' gestational age and with very low birth weight are 30% more likely to develop cerebral palsy and other conditions such as mental retardation, respiratory distress syndrome, bronchopulmonary dysplasia, retinopathy of prematurity, and hearing impairments.[2,3] These significant and severe neurosensory disabilities are often diagnosed in the first few years of the child's life. While some researchers are reporting a decrease in the severity of morbidity following preterm birth and LBW there is growing concern regarding the high percentages of LBW children who demonstrate "minor" impairments in cognitive, social, and motor functioning once they enter kindergarten.[4-9] Long-term studies of neonatal intensive care unit survivors have identified these subtle long-term morbidities as the "new morbidities" or the "hidden handicaps" for this group of children.

Outcome studies on premature infants have indicated significant impairments in school performance, even in children without previously identified disabilities.[10-13] The prevalence rate for perceptual motor problems in school-age children with LBW who are "healthy" or without major neuromotor impairment has been reported as high as 48%.[14] Difficulties are frequently encountered in visual-motor integration, motor performance, academic achievement, language, behavioral problems, and neurodevelopmental abnormalities. The specific motor problems often include clumsiness, impaired balance and coordination, visual-perceptual difficulties, and impaired fine motor function. In some children, the motor impairments occur in isolation and only mildly limit performance in school. However, for a majority of those children considered normal, these motor impairments occur in combination with behavioral and learning difficulties and significantly impede normal academic and social progress in school and ultimately, in adult life.

Knowledge of the variables and developmental profiles that are associated with developmental motor disturbances in children with low birth weight without major neurosensory impairments may aid with prediction, and hence, intervention and remediation. The variables that may affect the adaptive motor performance of these children can be divided into three broad categories- biological, environmental, and behavioral. While the relationship of biological risks to school age outcomes has received considerable attention, the role of environmental risks to the development of minor motor difficulties in school age children has received considerably less attention. Additionally, the manner in which researchers have operationally defined environmental risk has tended to be one dimensional and variable. Rarely considered environmental variables include the presence of social support, the caregiver's degree of confidence in relation to child rearing, and optimism. Furthermore, the mediating effects of the child's innate behavioral characteristics, such as responsivity to sensory stimulation and self regulation skills, combined with biological and environmental risks, on school age adaptive motor outcomes in children with LBW have not been studied.

The purpose of this study was to identify the variables which predict adaptive motor difficulties in school age children who were born prematurely and with LBW who are without major neurosensory impairments for the purpose of aiding early identification and intervention for this emerging population of children. Variables studied were classified as biological, environmental, and behavioral. Biological variables included gender, birth weight, days in the neonatal intensive care unit, and gestational age. Environmental variables included perceived degree of social support, caregiver confidence in caring for child's needs, caregiver degree of optimism for the child's future, maternal education, and income level measured at entry to early intervention. Behavioral variables were measured at entry to early intervention and included reported degree of responsiveness to auditory and visual stimulation, activity level, presence of sleep disturbance, and degree of attention. Adaptive motor skills at kindergarten age were divided into fine motor skills, dressing skills, and functional mobility skills. These categories were investigated individually.

The study of numerous variables that contribute to adaptive motor skill development in school age children and their potential interactions necessitated a large and varied data base and, ideally, longitudinal measures. The Office of Special Education Programs of the U.S. Department of Education commissioned SRI International to conduct the National Early Intervention Longitudinal Study (NEILS). Other organizations which participated in the design and instrumentation of NEILS included The Frank Porter Graham Child Development Institute, The Research Triangle Institute, and The American Institutes for Research. NEILS began in 1996 with a design phase. The frame work which guided the instrumentation used reflected a transactional/ecological perspective, that is, the development of young children with disabilities is influenced by many interrelated factors. Ninety-three counties in 20 states participated. Early intervention staff in each of the sampled counties reported the child's date of birth, gender, ethnicity, foster care status, public assistance status, reason for eligibility, date of referral, and date of Individualized Family Service Plan (IFSP) as children began early intervention services. This resulted in an enrollment sample of 5,668 children. There were three criteria that children and families needed to meet in order to be eligible to participate: 1. The child was less than 31 months of age at the time the IFSP was written; 2. There was an English- or Spanish- speaking adult in the house who could answer questions about the child; and 3. Only one child in the family could be recruited to participate. Of the 5,668 children in the enrollment sample, 4,867 were eligible. Of these, 3,338 children were enrolled in the study because an adult provided written consent for their participation (69%). Thirty-two percent of the sample was LBW.

Attempts were made to interview each family by telephone shortly after agreeing to participate in the study, annually thereafter up until age 3, at 32-36 months if that time frame did not coincide with an annual anniversary, and in the fall of the year when the child would typically enter kindergarten. Families without telephones were mailed a questionnaire. Interviews were conducted with the family member identified as most knowledgeable about the child and the child's early intervention services. Most respondents were the children's mothers. A rigorously trained and quality-monitored survey research unit, The Research Triangle, conducted the interviews using computer-assisted telephone interviewing (CATI), which allowed the interviewers to read questions and enter responses directly into a computer. CATI technology provided the interviewer with the next appropriate interview question based on the respondent's answers. The interview was designed by the NEILS research team and addressed characteristics of the child and family, a description of services received including both early intervention and private therapy services, and the respondents' perception of the effects of early intervention on themselves and their child. Respondents were given the option to complete the interview in English or Spanish. The enrollment interviews lasted an average of 38 minutes. Interim interviews were marginally shorter, and interviews at the third birthdays and at kindergarten age were slightly longer.

The NEILS research team developed the behavior and adaptive motor skills questions on the survey following a review of several instruments including the Bayley Scales of Infant Development, 2nd edition, the Child Development Inventories, the Battelle Developmental Inventory, the Ages and Stages Questionnaires, and the Pediatric Evaluation of Disability Inventory. Criteria used for selecting items for the telephone interview included the following: 1. having face validity as developmental markers; 2. contributing to a sequenced strand of development; 3. reflecting skills of a universal, rather than culture-specific, nature; and 4. readily observable by caregivers in the everyday settings and activities of children. Items were pilot-tested extensively as part of the interview development process to ensure they were understandable to caregivers and that caregivers could provide the requested information.

The principle investigator attended training on the NEILS database by invitation in June 2008 and received a compact disc containing the data and supporting documents. IRB approval for the use of this data for research purposes was obtained. Predictor variables were identified in the database and transformed into assigned codes for regression analysis. Appendix A includes the specific questions used on the Kindergarten Family Interview to determine adaptive motor skill performance.

The remaining five chapters of this dissertation contain the following content. The second chapter includes an extensive literature review. The third, fourth, and fifth chapters of the dissertation explore the relationships of the predictor variables to each of the dependent variables (fine motor skills, dressing skills, and functional mobility skills at kindergarten age). Each chapter concludes with a prediction model based on the predictor variables which explain the greatest variance in the dependent variables. Chapter six summarizes the pertinent results of the regression analyses, clinical significance, and suggestions for future research. See Figure 1 for a depiction of the study design.

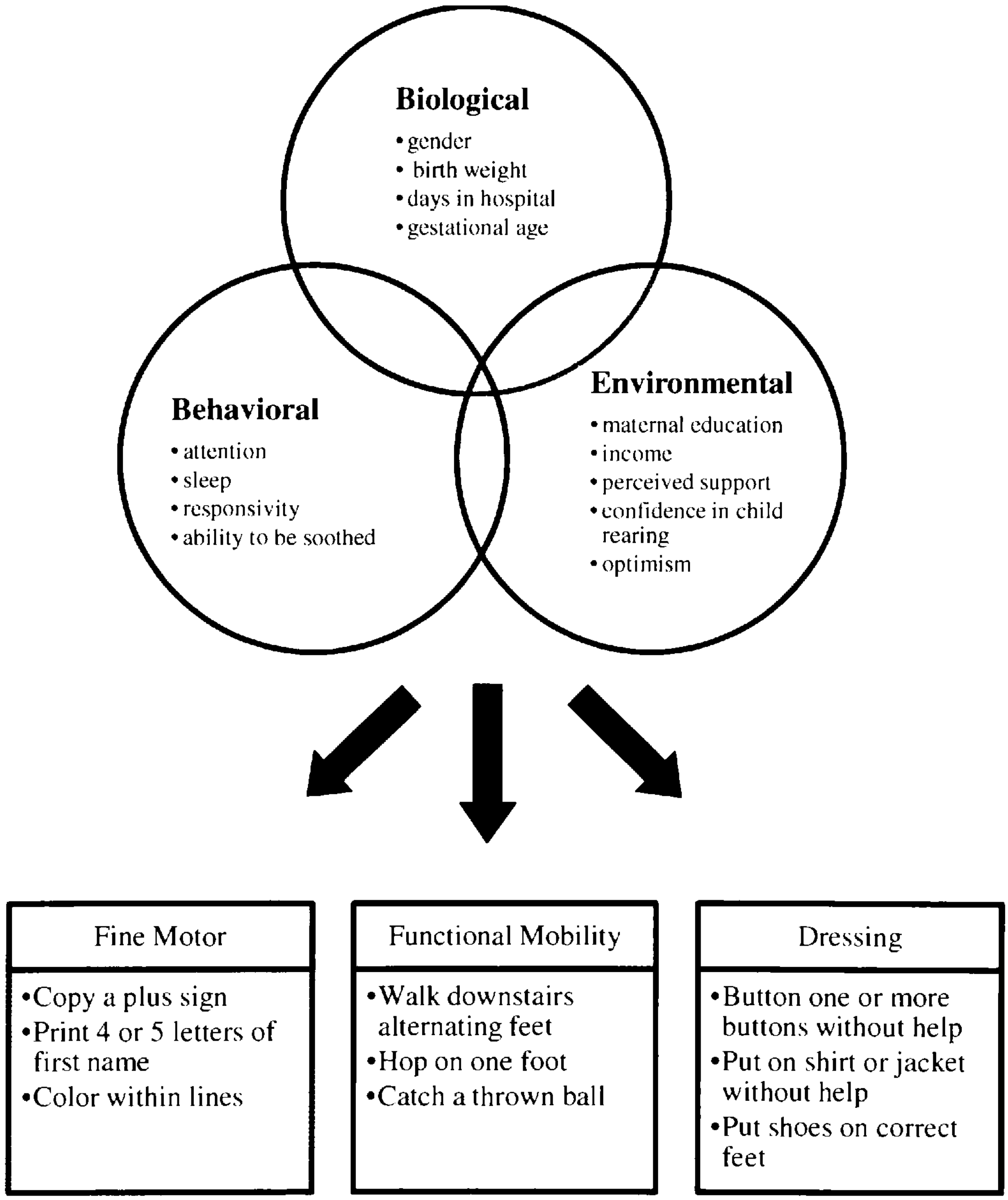

Figure 1: Biological, environmental, and behavioral predictors of fine motor, dressing, and functional mobility skills in low birth weight children without neurosensory impairments

RESEARCH QUESTIONS

1. Which ones of the targeted predictor variables in the three categories of biological, environmental, and behavioral risks, significantly correlated with delays in fine motor skills at kindergarten age in children with LBW who are without major disabling conditions?
2. Which ones of the targeted predictor variables in the three categories of biological, environmental, and behavioral risks, significantly correlated with delays in dressing skills at kindergarten age in children with LBW who are without major disabling conditions?
3. Which ones of the targeted predictor variables in the three categories of biological, environmental, and behavioral risks, significantly correlated with delays in functional mobility skills at kindergarten age in children with LBW who are without major disabling conditions?
4. What combination of the predictor variables across the three categories of biological, environmental, and behavioral risks concomitantly provided the best predictor models for outcome at kindergarten age in the areas of fine motor, dressing, and functional mobility skills in children with LBW who are without major disabling conditions?

HYPOTHESES

1. At least one variable from each category of variables, biological, environmental, and behavioral, will be a significant predictor of reported fine motor skills scores at kindergarten age in children with LBW without major neurosensory impairment.
2. At least one variable from each category of variables, biological, environmental, and behavioral, will be a significant predictor of reported dressing skills scores at kindergarten age in children with LBW without major neurosensory impairment.
3. At least one variable from each category of variables, biological, environmental, and behavioral, will be a significant predictor of reported functional mobility skills scores at kindergarten age in children with LBW without major neurosensory impairment.
4. A significant prediction model which will emerge for each of the dependent variables which will include different predictors and beta weights for the individual predictors from the three predictor categories.

CHAPTER II

LITERATURE REVIEW

Advances in medical care have resulted in the birth and survival of increasing numbers of premature and low birth weight (LBW) children. Low birth weight is generally defined as a birth weight of less than 2500 grams.[1] In 2008, LBW represented 8.3% of all births, the highest level reported in the past 4 decades.[1] Advances in prenatal and neonatal care, such as the use of prenatal steroids, Surfactant for respiratory distress syndrome, prophylactic Indomethacin for prevention of intraventricular hemorrhage, improved nutritional management and ventillatory techniques have resulted in the survival of increasingly lower gestational ages and birth weights.[15] Prior to the 1980s, approximately 40% of all preterm infants were expected to die from medical complications in the first year of life. An infant is considered preterm if the gestational age is less than 37 weeks and very preterm if the gestational age is less than 32 weeks. Currently, extremely low birth weight infants (ELBW- birth weight of less than 1000 grams) of at least 25 weeks' gestation have a 65-87% chance for survival whereas very low birth weight infants (VLBW- birth weight between 1001g and 1499g), and moderately low birth weight infants (MLBW- birth weight between 1500g and 2499g), infants have greater than 90% and 95% survival rates respectively.[16]

Assisted reproductive therapies (ART) to treat infertility have also contributed to increasing numbers of LBW children. The multiple pregnancy rate following ART in the

United States is 31.7% as compared to a rate of 1-2% which occurs in the general population. While multiple pregnancy increases the risk for prematurity and LBW, a Meta analysis revealed that even singleton children born after ART were at increased risk for prematurity and LBW. Underlying parental subfertility has been projected as a contributing factor.[17]

Infants with LBW are at increased risk for many long term health conditions and developmental disabilities. Preterm and VLBW children are 30% more likely to develop cerebral palsy (CP) and other conditions such as mental retardation, respiratory distress syndrome (RDS), bronchopulmonary dysplasia (BPD), retinopathy of prematurity (ROP), and hearing impairment (HI).[15,16] These significant physical and severe neurosensory disabilities are often diagnosed in the first few years of the child's life. Yet, some researchers are reporting a decrease in the severity of morbidity following premature birth and LBW.[18] Jarvenpaa et al.[19] reported a decrease in the frequency of brain lesions such as intraventricular hemorrhage (IVH) and periventricular leukomalacia (PVL) among ELBW survivors over a six year period, with the frequency of major disabilities decreasing from 28% to 8% and an increase in the number of normal neurological examinations at the age of two.

While the severity of morbidity following premature birth is decreasing, there is growing concern regarding the high percentages of LBW children who demonstrate "minor" impairments in cognitive, social, and motor functioning once they enter school. Long-term studies of neonatal intensive care unit survivors have identified these subtle long-term morbidities as the "new morbidities" or the "hidden handicap".[5-9] These include difficulties in visual-motor integration, motor performance, learning, academic achievement, and language as well as behavioral problems, and neurodevelopmental abnormalities. The specific motor problems often include clumsiness, impaired balance and coordination, visual-perceptual difficulties, and impaired fine motor function.[10,11] In some children, the motor impairments occur in isolation and only mildly limit performance in school. However, for a majority of these children, the motor impairments occur in combination with behavioral and learning difficulties and significantly impede normal academic and social progress in school and ultimately, in adult life.[12,13]

The developmental skills of children are largely expressed through school functioning. Minor developmental disturbances usually pose no problem until greater demands are placed on the child, as in the school environment. Greater independence is expected in the school environment, specifically in the area of adaptive motor functioning which includes self help skills and neurobehavioral regulation.[20] These often over looked developmental skills require the integration of visual perceptual, fine and gross motor skills, motor planning, imitation, social, behavioral, and cognitive skills.[21] Some researchers suggest that frequently used developmental motor tests may not be sensitive enough to identify children with minor impairments prior to school entry. Until more sensitive tests are developed, knowledge of the variables and developmental profiles that are associated with developmental motor disturbances in LBW children who are without major neurosensory impairments may aid with prediction, and hence, intervention and remediation.

LONG-TERM MOTOR OUTCOMES IN NONDISABLED PREMATURE CHILDREN WITH LBW

Outcome studies on premature infants have indicated significant impairments in school performance, even in children without previously identified disabilities. The prevalence rate for perceptual motor problems in school-age preterm, LBW children who are "healthy" or without major neuromotor impairment has been reported as high as 48%. Jongmans et al.[14] studied 156 PT survivors at age 6. Children with CP were excluded from the analysis. Perceptual motor competence was assessed using the Movement Assessment Battery for Children (Movement ABC) and the Developmental Test of Visual-Motor Integration (VMI). The Movement ABC requires the child to perform eight tasks which sample manual dexterity, ball skills, and balance. The VMI is a paper-and-pencil task in which a child copies a series of geometric shapes of increasing difficulty. These two tests are designed to provide an index of how well a child deals with tasks which might be encountered in everyday life, at home or at school. On the Movement ABC, 44% scored below the 15th percentile while 19% scored below the 5th percentile. On the VMI, 17% scored below the 15th percentile. Similar results were found in a study on preterm, LBW children ages 7-8 and age 4.[22,23] Sullivan et al. studied four dimensions of motor competence in preterm children at age 4 and related these findings to academic performance and use of school services at age 8. They identified mild motor delays in preterm children at age 4 across both healthy and medically ill preterm groups. These delays were significantly correlated with academic outcomes at age 8 with the effect ranging from small to moderate (r =.12 to .39).

Collin et al.[24] found a pattern of decreasing performance in all domains of development with age among preterm infants. They suggested that, as the demand for performance and environmental complexity increased, the children's capacity for function was exceeded and they began to do less and less well. This pattern of deteriorating performance was consistent with the identified pattern of preterm infant behavior as described by Als [25] and suggests that subsystem interaction (autonomic, motor, state) may limit performance of higher level skills.

INTERRELATIONSHIPS OF COGNITIVE AND MOTOR DEVELOPMENT

Several researchers have attempted to explain the relationship between motor development and academic performance as well as the apparent deterioration of developmental skills in terms of brain development and function. Functional neuroimaging studies consistently find that when a cognitive task increases activation in dorsolateral prefrontal cortex, it also increases activation in the contralateral cerebellum.[26] These two areas function as critical parts of a neural circuit when: 1. A cognitive task is difficult as opposed to easy; 2. A cognitive task is new as opposed to familiar and practiced; 3. Conditions of the cognitive task change, as opposed to when they remain stable and predictable; 4. A quick response is required; and 5. One must concentrate instead of being able to operate on "automatic pilot." These functions are examples of what is required for planning movements in new environments or under new circumstances. While early research on brain lesions associated with prematurity have focused on injuries to the cortex, advances in neuroimaging techniques have revealed that cerebellar abnormalities occur frequently in premature infants. These abnormalities are being increasingly recognized as related to long term cognitive, social, and motor deficits in this population.

The cerebellum demonstrates a period of rapid growth from 28 weeks' postconceptional age to term.[27] This rate of growth far exceeds that of the cerebral hemispheres. Thus, the first weeks of extreme prematurity coincide with a highly vulnerable phase of cerebellar development. This period is characterized by high mitotic activity, extensive changes in the cortical layering pattern, and the onset of complex interrelationships between various classes of young neurons and glial differentiation. However, not all premature infants demonstrate disruption of cerebellar development. Decreased cerebellar volume had been associated with gestational age at birth, birth weight, postnatal growth parameters, risk factors related to illness severity, such as the need for and duration of mechanical ventilation, and concomitant brain injuries such as PVL.

Peterson et al.[28] compared regional brain volumes in PT and term infants at 8 years of age and correlated these results with measures of cognitive function. At age 8, regional cortical volumes in preterm children were significantly smaller than in term controls, most prominently in the sensorimotor region but also in the premotor, midtemporal, parieto-occipital, and subgenual cortices. Preterm children's brain volumes were significantly larger in the occipital and temporal horns of the ventricles and smaller in the cerebellum, basal ganglia, amygdala, hippocampus, and corpus callosum. These findings persisted even when children with a history of IVH were excluded from the analyses. Volumes of sensorimotor and midtemporal cortices were associated positively with full-scale, verbal, and performance IQ.

DEFINITION OF RISK

While many healthy LBW premature infants demonstrate motor and learning difficulties in school, possibly due to the influence of brain abnormalities, a significant number do not. Investigation into factors that mediate poor outcomes and perhaps protect against the adverse effects of prematurity and LBW could assist future attempts at providing intervention, both in early intervention programs and in the preschool period. Additionally, identifying which healthy preterm LBW children are at greatest risk for neuromotor dysfunction at school age would assist states in allocating expensive and often scarce therapeutic and special education resources. Traditional methods to identify children who may experience developmental difficulties include analysis of risk factors. Risk has traditionally been viewed as a spectrum of biological or environmental variables.[29] Some factors are thought to carry a higher risk than others. Generally, as the number of risk factors increases, the risk for the child developing a disability increases. The interaction of biological and social risk factors in preterm LBW children, the majority of whom are born into families with low socioeconomic status (SES), has led to the term "double vulnerability." Historically, this double vulnerability has been considered to influence cognitive, language, and behavioral outcomes while motor outcomes were considered to be more a result of the biological risk factors such as IVH or bronchopulmonary dysplasia (BPD).[30] While this may be evident for major neuromotor and sensory disabilities such as cerebral palsy and visual impairment secondary to retinopathy of prematurity (ROP), such a view may not hold true for minor motor impairments that impact functional skills which are not evident until the child enters school. It is quite possible that the biological risk that may result in minor neurological abnormalities may be mediated by the effects of the child's environment. (See Figure 2 for a depiction of the traditional view of risk).

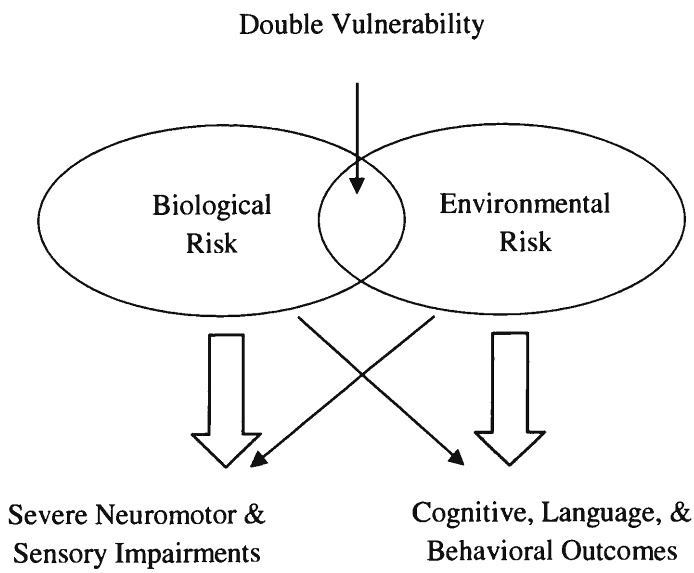

Figure 2. Traditional view: relationship of risk to outcomes in low birth weight premature children

NEW MODELS OF RISK

The transactional model of child development has influenced theories on the neurodevelopmental outcomes of high risk children. This model takes into account the biological characteristics of the child, the environmental characteristics, and the interaction of the two within a caregiving context.[31] For example, a child's characteristics influence the caregiver's actions and vice versa and both can be influenced by environmental risks. This is the premise on which early intervention programs are based. Families enrolled in early intervention programs are provided with educational materials, life skills assistance, and social supports so that they can provide an optimal environment for their child and respond in a manner which is contingent with the child's needs. Behavior management and recognition of early infant behavioral communication is a growing area of early intervention. The role of early temperament and behavioral patterns on developmental outcome has received considerable attention and dysfunction in this area is becoming increasingly recognized as a risk for adverse developmental outcomes. Conversely, the interaction of early atypical behavioral patterns with biological and environmental risk factors in the prediction of long term adaptive motor behavior outcomes for children with LBW has not received attention. (See Figure 3 for a proposed model).

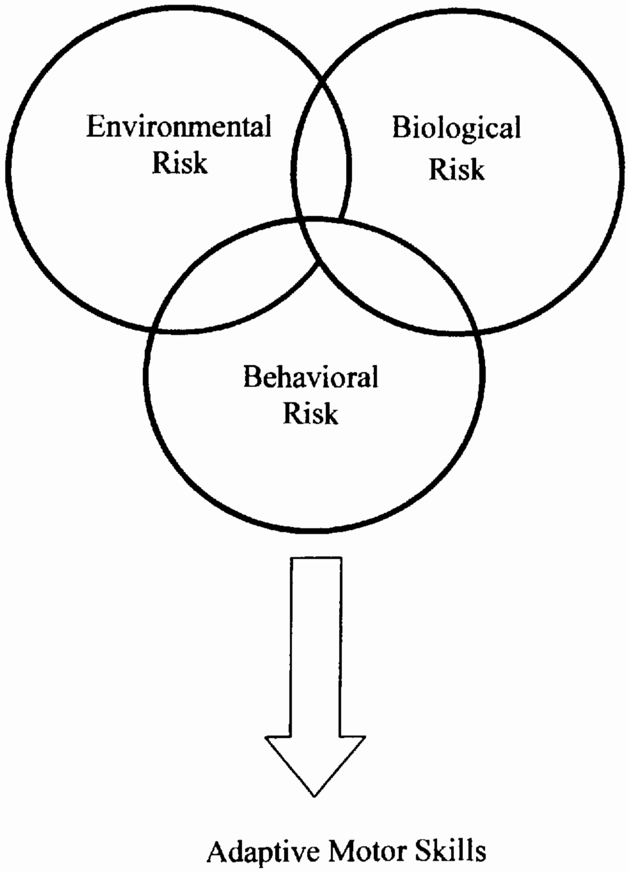

Figure 3. Proposed model: interaction of risk factors, behavioral profile, and adaptive motor outcomes at kindergarten age

VARIABLES THAT INFLUENCE MOTOR OUTCOME IN PRETERM AND LOW BIRTH WEIGHT CHILDREN

Many biological and environmental factors may affect the motor performance of prematurely born children with LBW. These variables may be divided into three broad categories: biological, environmental, and behavioral. Biological risk variables include factors such as birth weight, gestational age, gender, perinatal and postnatal medical intervention and complications. Environmental risk variables can be classified as proximal or distal variables. Distal variables include those that indirectly affect the child through its impact on such factors as the family's lifestyle, availability of resources including food, medical attention and social support. Examples of these variables include SES, neighborhood, type of residence, and immigrant status. Proximal variables, such as caregiver responsivity, availability of appropriate play materials, and opportunities for varied daily stimulation, are not consistently related to SES and have been found to be independently related to developmental function. Proximal variables are targeted through early intervention efforts. Examples of behavioral risk variables include irritability, hyperresponsivity to sensory stimulation, decreased ability to attend, and poor self regulation skills. The following literature review examines these three broad categories in terms of long term motor and self help outcomes in children with LBW without obvious neurosensory impairment. For the purposes of this review, long term motor outcomes will be defined as outcomes measured after 3 years of age.

BIOLOGICAL RISK VARIABLES

Gender

Male gender has been implicated as a negative predictor of motor outcomes in preterm children. In children ages 6 to adolescence born with LBW, male sex has been linked to poorer performance on the Bruininks-Oseretsky Test of Motor Proficiency, the Riley Motor Problems Inventory (RMPI), and the Movement ABC.[33,34] In the study by Whitaker et al., male gender was an independent predictor of poor performance on the RMPI (β =.14, p<.001) while in the study by Davis et al., male sex in combination with ELBW and very preterm status was predictive of Developmental Coordination Disorder (DCD). ELBW and very preterm children with DCD had poorer cognitive function and academic test scores than normal birth weight (NBW) children with DCD. They also had more behavioral problems. Davis et al. concluded that the lack of strong perinatal factors (such as the use of antenatal steroids or Surfactant, presence of BPD, IVH, or PVL) suggested that genetic or environmental factors may have a major role in motor development in this population.

Jongmans et al.[14] studied the relationship between the extent of perceptual-motor difficulties at age 6 and selected biological risk variables in a group of 156 children born prematurely. Overall, males performed significantly less well than females on the VMI (p<0.016) and two subsections of the Movement ABC ('rolling ball in goal' (p<0.001) and 'one-leg balance' (p<0.009)). Children with extensive perceptual-motor problems were more likely to demonstrate concomitant problems with cognition, reading, and/or behavior. Kessel-Feddema et al.[35] examined the relationship of numerous perinatal characteristics on school functioning in 5 year old preterm children who were without major disability. Male gender and being small for gestational age (SGA) were related to problematic school outcomes in children who had scored within the normal range in the domains of cognition, language, motor functioning, and behavior on developmental follow up tests.

Respiratory Impairments

Singer et al.[36] followed three groups of infants, infants with BPD, infants with VLBW without BPD, and full term infants to 3 years of age, using the Bayley Scales of Mental and Motor Development to assess outcomes. BPD was an independent predictor of poor motor outcome at age three ($b = -10.0$, $p = .02$). Meanwhile, social class, race, and neurologic risk predicted mental outcome, suggesting that the specific effects of BPD are primarily on the motor domain.

Goyen et al.[37] studied the visual-motor, visual-perceptual, and fine motor outcomes of 83 VLBW children without identified neurologic impairment at 5 years of age. Outcome measures included the VMI, the Motor Free Visual Perception Test, and the Peabody Developmental Fine Motor Scale. Seventeen percent demonstrated below average visual motor scores, 11 percent had below average visual perception scores, and 71 percent had below average fine motor scores. The fine motor scores were significantly lower in children who were born less that 28 weeks' gestation ($p = 0.039$), had hyaline membrane disease ($p = 0.043$), or had required a longer period of ventilation ($p = 0.008$).

Gestational Age and Birth Weight

Kilbride et al.[38] examined the cognitive, language, and motor outcomes of preschool children born with ELBW as compared to full term normal weight siblings, controlling for gender and socioeconomic status. Children with major motor disabilities were excluded from the study. Outcome measures included the Stanford Binet, the Preschool Language Scale, and the Peabody Developmental Motor Scales. They reported that preterm status (gestational age and birth weight) and SES variables seemed to influence cognitive and language functioning at preschool age. Motor scores were significantly related (paired t tests, p=0.004) to preterm status but not to SES. High SES seemed to mediate the impact of preterm status on cognitive and language scores but not motor scores. The authors suggest that motor dysfunction is related to biological risks, such as those associated with LBW and prematurity, with less potential for modification through environmental factors such as socioeconomic variables. It is important to note that the Peabody Developmental Motor Scales was used to assess motor skills. Some researchers have suggested that such measures may not be sensitive enough to ascertain the types of motor dysfunction which tend to occur in children with LBW without major sensorimotor impairments.

Keller et al.[39] examined the effects of VLBW and ELBW on the neuromotor ability of children at 5-7 years of age. Neuromotor ability was assessed using measures of reaction time, cycling speed, and the Koerperko-ordinationstest fuer Kinder, KTK (a whole body coordination test for children). The motor performance of the ELBW group was impaired as compared to the VLBW and NBW groups. Examination of body weight, height, lean tissue at the thigh and calf, and head circumference size in relation to neuromotor measures revealed low correlations with all variables except maximal cycling speed and fat-free body mass. The researchers concluded that the motor deficiencies observed in ELBW children do not merely reflect a small body or muscle size but may also reflect qualitative differences in the neuromuscular system.

Jongmans et al.[14] studied the relationship of neonatal variables to perceptual-motor difficulties in 6 year old children with birth weights ranging from 680g to 2500g and gestational ages ranging from 25 to 34 weeks. Children with cerebral palsy (CP), sensory impairments, genetic and metabolic disorders were excluded. Perceptual-motor skills were assessed using the Movement ABC and the VMI. On the Movement ABC, the prematurely born children scored significantly below term children (F=16.41, p<0.001). On the subsections of this test, the main effect of group was confined to ball skills (F=9.19, p<0.003) and balance (F=15.03, p<0.001). The preterm group also performed significantly poorer on the VMI (F=5.66, p<0.018).

Foulder-Hughes and Cooke[40] examined motor outcomes in premature children at 7-8 years of age and reported a weak negative correlation between degree of prematurity, birth weight, and performance on several tests of perceptual motor skills, posture and coordination. The poorest performers on these tests were distributed through the gestation and weight range, suggesting that the relationship was not a simple one.

ENVIRONMENTAL RISK VARIABLES

It has been suggested that in the absence of severe neurological impairment, environmental factors can be viewed as the best predictors of the long term outcomes for children with VLBW and that neonatal medical factors become less important as the child develops while the environmental factors begin to play a more prominent role. Investigators have suggested that biological risk factors are more likely to be associated with motor and perceptual difficulties whereas environmental factors are more closely linked to language and overall cognitive and behavioral functions.

The majority of the research on environmental variables that impact outcomes of children born with LBW have focused on learning and behavioral outcomes. In light of the emergence of a growing new morbidity of minor motor impairments, many concomitantly associated with poor academic performance, this view may change. Additionally, the link between environmental variables and adaptive motor function, as can be measured in the performance of self help and functional mobility skills, has not been adequately assessed nor have environmental attributes such as family attitudes and beliefs and degree of social support.

Three studies specifically examined the impact of family variables on motor outcome in preterm children with LBW. Goyen et al.[37] studied the motor outcomes of neurologically and intellectually normal 5 year old children of VLBW using the VMI, the Motor Free Visual Perception Test, and the Peabody Scales of Motor Development. However, the only environmental variables studied were maternal and paternal occupation. These environmental variables did not influence fine and gross motor function at age 5. Hack et al.[42] studied school age children with birth weights under 750g. They found that an index of social disadvantage including such variables as maternal race, maternal education, and marital status was not associated with motor outcomes.

Zahr[43] studied ethnicity in relation to child and environmental characteristics at 8 months of age. She found that child and environmental variables had differing effects on outcomes, dependent on the ethnicity of the families. Using multiple regression analyses, she found that motor development in African American children was dependent on maternal education and days that the infant had spent in the hospital while Hispanic children's home environment predicted motor scores. In a subsequent study on 24 month old LBW children, she found that maternal income, home environment, and maternal confidence explained 40% of the variance (p=.002) in motor development in Hispanic families.[44] It appears that environmental risk factors may affect motor outcomes in LBW children of differing ethnicities in disparate ways.

BEHAVIORAL RISK VARIABLES

In comparison to full-term infants, premature infants demonstrate less regulatory and sensory organization.[45] Consistency has been observed within neonates regarding their responses to auditory and visual stimulation and irritability levels.[46] Since these behaviors are apparent almost immediately after birth, differences cannot be attributed solely to the care giving environment. These traits may reflect innate differences in the central nervous system functioning that form the foundation for how the infant will interact with the care giving environment. Identifying infant behavioral patterns that may interfere with optimal development is an emerging theme in early intervention policy and practice.

The Neurobehavioral Assessment of the Preterm Infant (NAPI) is a tool used to assess infant regulatory and sensory organization. Constantinou et al.[47] assessed ELBW and VLBW infants using the NAPI at 36 weeks post conceptional age and correlated scores with scores on the Bayley Scales of Infant Development at 12, 18, and 30 months of age. NAPI scores were correlated with Bayley scores at 12 months (r=.35, p=.0006), 18 months (r=.35, p=.0006) and 30 months (r=.35, p=.002). ELBW children scored significantly lower on the NAPI than VLBW children on measures of alertness (duration of sustained attention) and orientation (degree of responsiveness to stimulation).

Scarborough[48] examined differences in reported patterns of behavior and the relationship with selected child, family, and poverty predictors in children under three who were receiving early intervention services. She divided 15 caregiver reported items of child temperamental and behavioral patterns into four underlying constructs: adaptability, persistence, approachability, and sensory threshold. She found that child characteristics (age, gender, milestone achievement) provided 10% of the 18% explained variance for persistence and 11% of the 16% explained variance for approachability. Poverty contributed 6% of the 17% explained variance for adaptability. Poverty and amily characteristics contributed 8% and7% respectively to the explained variance for sensory threshold.

SUMMARY

Biological risks have been associated with both major and minor neuromotor impairments in children with LBW. Biological risks associated with minor motor impairments in school aged LBW children include gender, gestational age, birth weight, and respiratory disorders. The contribution of environmental risks to the development of minor motor impairments at school age is less defined. Ethnicity appears to interact with environmental risks in younger children. This interaction has not been investigated in the adaptive motor outcomes of school age "healthy" LBW children. Early behavioral measures hold promise as predictors of motor outcomes at least up to 30 months and some measures of behavior appear to interact with environmental and biological characteristics.

GAPS IN THE LITERATURE

The relationship of biological risks to school age outcomes has received considerable attention. However, the role of environmental risks in the development of minor motor difficulties in school age LBW children has received considerably less attention. Additionally, the manner in which researchers have operationally defined environmental risk has tended to be one dimensional and variable between studies. Most frequently used measures have included maternal education and/or income which are distal variables. Many other environmental factors may potentially impact the development of high level motor skills such as the presence of social supports, the caregiver's confidence in child rearing, and the caregiver's degree of optimism regarding the child's future. Additionally, the interaction of these individual environmental risk factors with biological risk factors in the prediction of adaptive motor development has not been investigated. The possible mediating effects of innate behavioral characteristics, combined with biological and environmental risks, on school age adaptive motor outcomes in LBW children has not been studied.

PURPOSE STATEMENT

This multiple regression analysis examined the variables that were associated with reported delays in adaptive motor skills at kindergarten age in children with LBW who are without major neurosensory impairment for the purpose of aiding early identification and intervention for this emerging population of children. Variables studied were classified as biological, environmental, and behavioral. Biological variables included gender, birth weight, days in the neonatal intensive care unit, and gestational age. Environmental variables were divided into proximal and distal factors. Proximal factors included perceived degree of social support, caregiver confidence in caring for child's needs, and caregiver degree of optimism for the child's future at entry to early intervention. Distal environmental factors included maternal education and income level measured at entry to early intervention. Behavioral variables were measured at entry to early intervention and included reported degree of responsiveness to auditory and visual stimulation, ability to be soothed, presence of sleep disturbance, and degree of attention. Adaptive motor skills at kindergarten age were divided into fine motor skills, dressing skills, and functional mobility skills.

OVERVIEW OF METHODS

The study of numerous variables that contribute to adaptive motor skill development in school age children and their potential interactions necessitated a large and varied data base and, ideally, longitudinal measures. The Office of Special Education Programs of the U.S. Department of Education commissioned SRI International to conduct the National Early Intervention Longitudinal Study (NEILS). Other organizations which participated in the design and instrumentation of NEILS included The Frank Porter Graham Child Development Institute, The Research Triangle Institute, and The American Institutes for Research. NEILS began in 1996 with a design phase. The frame work which guided the instrumentation used reflected a transactional/ecological perspective, that is, the development of young children with disabilities is influenced by many interrelated factors. The study was designed to answer the following questions: 1.Who are the children and families receiving early intervention services? 2. What early intervention services do participating children and families receive, and how are they delivered? 3. What are the costs of these services? 4. What outcomes do participating children and families' experience? and 5. How do outcomes relate to variations in child and family characteristics and services provided? Ninety-three counties in 20 states participated. Early intervention staff in each of the sampled counties reported the child's date of birth, gender, ethnicity, foster care status, public assistance status, reason for eligibility, date of referral, and date of Individualized Family Service Plan (IFSP) as children began early intervention services. This resulted in an enrollment sample of 5,668 children. There were three criteria that children and families needed to meet in order to be eligible to participate: 1. The child was less than 31 months of age at the time the IFSP was written; 2. There was an English- or Spanish- speaking adult in the house who could answer questions about the child; and 3. Only one child in the family could be recruited to participate. Of the 5,668 children in the enrollment sample, 4,867 were eligible. Of these, 3,338 children were enrolled in the study because an adult provided written consent for their participation (69%). Thirty-two percent of the sample was LBW with 17% of the LBW infants being VLBW.

Attempts were made to interview each family by telephone shortly after agreeing to participate in the study, annually thereafter up until age 3, at 32-36 months if that time frame did not coincide with an annual anniversary, and in the fall of the year when the child would typically enter kindergarten. Families without telephones were mailed a questionnaire. Interviews were conducted with the family member identified as most knowledgeable about the child and the child's early intervention services. Most respondents were the children's mothers. A rigorously trained and quality-monitored survey research unit, The Research Triangle, conducted the interviews using computer-assisted telephone interviewing (CATI), which allowed the interviewers to read questions and enter responses directly into a computer. CATI technology provided the interviewer with the next appropriate interview question based on the respondent's answers. The interview was designed by the NEILS research team and addressed characteristics of the child and family, a description of services received including both early intervention and private therapy services, and the respondents' perception of the effects of early intervention on themselves and their child. Respondents were given the option to complete the interview in English or Spanish. The enrollment interviews lasted an average of 38 minutes. Interim interviews were marginally shorter, and interviews at the third birthdays and at kindergarten age were slightly longer. During the kindergarten interview, the respondent provided the name of the child's school and kindergarten teacher, in the spring of the child's kindergarten year, the kindergarten teacher was sent a two-part questionnaire that asked about the child's performance in kindergarten. The first part asked about the child's educational progress, social skills, literacy and mathematics knowledge, parent involvement, the child's transition into kindergarten, and whether the child received special education services as a preschooler. The second section was completed for children with an Individualized Education Program or 504 plan and asked about the child's disability classification and the nature of the services being provided.

The NEILS research team developed the behavior and adaptive motor skills questions on the survey following a review of several instruments including the Bayley Scales of Infant Development, 2nd edition, the Child Development Inventories, the Battelle Developmental Inventory, the Ages and Stages Questionnaires, and the Pediatric Evaluation of Disability Inventory. Criteria used for selecting items for the telephone interview included the following: 1. having face validity as developmental markers; 2. contributing to a sequenced strand of development; 3. reflecting skills of a universal, rather than culture-specific, nature; and 4. readily observable by caregivers in the everyday settings and activities of children. Items were pilot-tested extensively as part of the interview development process to ensure they were understandable to caregivers and that caregivers could provide the requested information.

Table 1 contains the environmental and biological predictor variables, definitions, and codes which were used in the regression analysis. Table 2 contains the behavioral predictor variables, definitions, descriptions and codes which were used in the regression analysis. The specific questions from the NEILS survey which correlate with measures of the dependent variables are included in Appendix A.

Table 1. Independent Variables Used as Predictors in the Regression Analysis

Variable	Definition	Code
Biologic Variables		
Gender	Male	0
	Female	1
Birth Weight	Reported birth weight in grams	n/a
Gestational Age	Reported gestational age in weeks	n/a
Days in Hospital	Reported days infant spent in NICU immediately following birth	
Environmental Variables		
<u>Proximal</u>		
Perceived Caregiving Skills	3-level ordinal index:	
	Disagree	0
	Agree	1
	Strongly agree	2
Perceived Social Support	3-level ordinal index:	
	Disagree	0
	Agree	1
	Strongly disagree	2

Table 1. (continued)

Variable	Definition	Code
Optimism	5-level ordinal index	
	Poor	0
	Fair	1
	Good	2
	Very Good	3
	Excellent	4
<u>Distal Environmental Variables</u>		
Maternal Age	Age reported to closest year	n/a
Maternal Education	Highest year or grade completed	
	7 level ordinal Index	
	Less than high school	0
	High school or GED	1
	Some college	2
	2 or 3 year college	3
	4 year degree	4
	Some graduate work	5
	Graduate degree	6

Table 1. (continued)

Variable	Definition	Code
Income Level	<15,000	0
	15,001-25,000	1
	25,001-50,000	2
	50,001-75,000	3
	<75,000	4

Table 2. Definition and Coding of Behavioral Measures

Behavioral Measure	Description	Code
Responsivity to Auditory and Visual stimulation	*Child startled by loud noises or quick movements*	
	3 level ordinal scale	
	Very much like child	0
	A little like child	1
	Not like child	2

Table 2. (continued)

Behavioral Measure	Description	Code
Self Regulation	*Ability to be soothed*	
	3 level ordinal scale	
	Often hard	0
	Sometimes hard	1
	Easy	2
Sleep Disturbances	*Trouble getting to sleep or staying asleep*	
	3 level ordinal scale	
	Often	0
	Sometimes	1
	Rarely	2
Attention	*Good at paying attention and staying focused*	
	3 level ordinal scale	
	Not like child	0
	A little like child	1
	Very much like child	2

RESEARCH QUESTIONS

1. Which ones of the targeted predictor variables in the three categories of biological, environmental, and behavioral risks, significantly correlated with delays in fine motor skills in kindergarten in children with LBW who are without major disabling conditions?
2. Which ones of the targeted predictor variables in the three categories of biological, environmental, and behavioral risks, significantly correlated with delays in dressing skills in kindergarten in children with LBW who are without major disabling conditions?
3. Which ones of the targeted predictor variables in the three categories of biological, environmental, and behavioral risks, significantly correlated with delays in functional mobility skills in kindergarten in children with LBW who are without major disabling conditions?
4. What combination of the predictor variables across the three categories of biological, environmental, and behavioral risks concomitantly provided the best predictor models for outcome at kindergarten age in the areas of fine motor, dressing, and functional mobility skills in children with LBW who are without major disabling conditions?

HYPOTHESES

1. At least one variable from each category of variables, biological, environmental, and behavioral, will be a significant predictor of reported fine motor skills scores at kindergarten age in children with LBW without major neurosensory impairment.
2. At least one variable from each category of variables, biological, environmental, and behavioral, will be a significant predictor of reported dressing skills scores at kindergarten age in children with LBW without major neurosensory impairment.
3. At least one variable from each category of variables, biological, environmental, and behavioral, will be a significant predictor of reported functional mobility skills scores at kindergarten age in children with LBW without major neurosensory impairment.
4. A significant prediction model which will emerge for each of the dependent variables which will include different predictors and beta weights for the individual predictors from the three predictor categories.

Chapters three, four, and five of the dissertation explore the relationships of the predictor variables to each of the dependent variables (fine motor skills, functional mobility skills, and dressing skills at kindergarten age). Each chapter concludes with a prediction model based on the predictor variables which explain the greatest variance in the dependent variables. Chapter six summarized the pertinent results of the regression analyses, clinical significance, and suggestions for future research.

CHAPTER III

PREDICTORS OF FINE MOTOR SKILL PERFORMANCE IN LOW BIRTH WEIGHT CHILDREN AT KINDERGARTEN AGE

INTRODUCTION

Advances in prenatal and perinatal care and assistive reproductive technology have resulted in the delivery and survival of children of increasingly lower gestational ages and birth weights. In 2008, low birth weight (LBW) represented 8.3% of all births as compared to 6.8% in 1980.[1] Low birth weight is generally defined as a birth weight below 2500 grams.[1] Children born at less than 37 weeks' gestational age and with very low birth weight are 30% more likely to develop cerebral palsy and other conditions such as mental retardation, respiratory distress syndrome, bronchopulmonary dysplasia, retinopathy of prematurity, and hearing impairments.[2,3] These significant and severe neurosensory disabilities are often diagnosed in the first few years of the child's life. While some researchers are reporting a decrease in the severity of morbidity following preterm birth and LBW there is growing concern regarding the high percentages of LBW children who demonstrate "minor" impairments in cognitive, social, and motor functioning once they enter kindergarten.[4-9] Long-term studies of neonatal intensive care unit survivors have identified these subtle long-term morbidities as the "new morbidities" or the "hidden handicaps" for this group of children.[5-9]

Outcome studies on premature infants have indicated significant impairments in school performance, even in children without previously identified disabilities.[10-13] The prevalence rate for perceptual motor problems in school-age children with LBW who are "healthy" or without major neuromotor impairment has been reported as high as 48%.[14] Jongmans et al.[14] studied 156 children born prematurely at age 6. Children with cerebral palsy were excluded from the analysis. On the Movement Assessment Battery for Children, 44% scored below the 15th percentile while 19% scored below the 5th percentile. On the Developmental Test of Visual Motor Integration (VMI), 17% scored below the 15th percentile. Similar results were found in a study on children born prematurely with LBW at ages 4 and 7-8.[22,23]

Minor developmental disturbances usually pose no problem until greater demands are placed on the child, as in the school environment.[23,49] Maris' observational study of fine motor skill requirements in preschool and kindergarten revealed significantly increased demands with entry to kindergarten.[49] Children in kindergarten spent 50% of the school day performing activities which required fine motor skills. Of those activities, 42% involved pencil and paper activities. Other researchers have established a link between early fine motor difficulties and later academic achievement. Sullivan et al.[23] studied four dimensions of motor competence in preterm children at age 4 and related these findings to academic performance and use of school services at age 8. They identified mild motor delays in preterm children at age 4 across both healthy and medically ill preterm groups. These delays were significantly correlated with academic outcomes at age 8 with the effect ranging from small to moderate (r=.12 to.39).

While many healthy LBW children demonstrate motor and learning difficulties in school, a significant number do not. Investigation into factors that mediate poor outcomes and perhaps protect against the adverse effects of prematurity and LBW could assist future attempts at providing intervention, both in early intervention programs and in the preschool period. Additionally, identifying which healthy preterm LBW children are at greatest risk for fine motor dysfunction at school age would assist states in allocating expensive and often scarce therapeutic and special education resources in hopes of ameliorating the academic difficulties faced by this population of children.

Methods to identify children who may experience developmental motor difficulties include analysis of risk factors which traditionally have been viewed as a spectrum of biological or social/environmental variables.[29] The transactional model of child developmental, which influences early intervention practices, suggests that other factors warrant study. The role of early temperament and behavioral patterns of the child on developmental outcome and caregiver responses has received considerable attention and dysfunction in this area is becoming increasingly recognized as a risk for adverse developmental outcomes.[47,48] Conversely, the interaction of early atypical behavioral patterns with biological and environmental risk factors in the prediction of long term adaptive motor behavior outcomes for children with LBW has not been researched.

The purpose of this study was to explore the relationships of biological, environmental, and behavioral predictor variables with fine motor skill performance at kindergarten age in LBW children who are without major neurosensory impairment and to develop a predictive model for fine motor skill performance in this population that will guide early intervention efforts.

RESEARCH QUESTIONS

1. Which ones of the targeted predictor variables in the three categories of biological, environmental, and behavioral risks, significantly correlated with delays in fine motor skills in kindergarten children with LBW who are without major disabling conditions?
2. What combination of the predictor variables across the three categories of biological, environmental, and behavioral risks concomitantly provided the best predictor models for outcome at kindergarten age in the areas of fine motor, dressing, and functional mobility skills in children with LBW who are without major disabling conditions?

HYPOTHESES

1. At least one variable from each category of variables, biological, environmental, and behavioral, will be a significant predictor of reported fine motor skills scores at kindergarten age in children with LBW without major neurosensory impairment.
2. A significant predictor model will emerge for fine motor skills which will include a combination of predictors from the three predictor categories.

METHODS

The 341 children in the sample for this study represent a subsample of the 3,338 children who were enrolled in the National Early Intervention Longitudinal Study

(NEILS). Additional information regarding the NEILS can be found at www.sri.com/neils. The Office of Special Education Programs of the U.S. Department of Education commissioned SRI International to conduct the National Early Intervention Longitudinal Study (NEILS). Other organizations which participated in the design and instrumentation of NEILS included The Frank Porter Graham Child Development Institute, The Research Triangle Institute, and The American Institutes for Research. NEILS began in 1996 with a design phase. The frame work which guided the instrumentation used reflected a transactional/ecological perspective, that is, the development of young children with disabilities is influenced by many interrelated factors. Ninety-three counties in 20 states participated. Early intervention staff in each of the sampled counties reported the child's date of birth, gender, ethnicity, foster care status, public assistance status, reason for eligibility, date of referral, and date of Individualized Family Service Plan (IFSP) as children began early intervention services. This resulted in an enrollment sample of 5,668 children. There were three criteria that children and families needed to meet in order to be eligible to participate: 1. The child was less than 31 months of age at the time the IFSP was written; 2. There was an English- or Spanish- speaking adult in the house who could answer questions about the child; and 3. Only one child in the family could be recruited to participate. Of the 5,668 children in the enrollment sample, 4,867 were eligible. Of these, 3,338 children were enrolled in the study because an adult provided written consent for their participation (69%). Thirty-two percent of the sample was LBW.

Attempts were made to interview each family by telephone shortly after agreeing to participate in the study, annually thereafter up until age 3, at 32-36 months if that time frame did not coincide with an annual anniversary, and in the fall of the year when the child would typically enter kindergarten. Families without telephones were mailed a questionnaire. Interviews were conducted with the family member identified as most knowledgeable about the child and the child's early intervention services. Most respondents were the children's mothers. A rigorously trained and quality-monitored survey research unit, The Research Triangle, conducted the interviews using computer-assisted telephone interviewing (CATI), which allowed the interviewers to read questions and enter responses directly into a computer. CATI technology provided the interviewer with the next appropriate interview question based on the respondent's answers. The interview was designed by the NEILS research team and addressed characteristics of the child and family, a description of services received including both early intervention and private therapy services, and the respondents' perception of the effects of early intervention on themselves and their child. Respondents were given the option to complete the interview in English or Spanish. The enrollment interviews lasted an average of 38 minutes. Interim interviews were marginally shorter, and interviews at the third birthdays and at kindergarten age were slightly longer.

The NEILS research team developed the behavior and adaptive motor skills questions on the survey following a review of several instruments including the Bayley Scales of Infant Development, 2nd edition, the Child Development Inventories, the Battelle Developmental Inventory, the Ages and Stages Questionnaires, and the Pediatric

Evaluation of Disability Inventory. Criteria used for selecting items for the telephone interview included the following: 1. having face validity as developmental markers; 2. contributing to a sequenced strand of development; 3. reflecting skills of a universal, rather than culture-specific, nature; and 4. readily observable by caregivers in the everyday settings and activities of children. Items were pilot-tested extensively as part of the interview development process to ensure they were understandable to caregivers and that caregivers could provide the requested information.

The principle investigator attended training on the NEILS database by invitation in June 2008 and received a compact disc containing the data and supporting documents. Permission to access the NEILS database was granted from the Institutional Review Board at Texas Woman's University, Houston Campus. Criteria for inclusion for this study's sample was extracted from the database and included the following: 1. Birth weight of less than 2500 grams; 2. Gestational age of less than 37 weeks; 3. Enrollment in early intervention by 12 months of age; 4. Absence of reported diagnoses of cerebral palsy, spina bifida, genetic disorder, and severe vision and hearing impairments.

The predictor variables used for this study were extracted from the Enrollment Family Interview of the NEILS. This study examined four variables related to the biological characteristics of the child, five variables related to the child's social environment, and four variables related to the reported behavioral characteristics of the child at entry into the study. Biological characteristics were birth weight (BW), gestational age (GA), length of hospital stay following birth (LOH), and gender. Social environment variables included reported maternal education level (MED), income (INC), caregiver confidence in child rearing (PCR), caregiver perceived degree of social support (PSS), and caregiver degree of optimism for the child's future (OPT). Reported behavioral variables included responsivity to auditory and visual stimulation (RES), ability to be soothed (STH) , sleep disturbances (SLP), and attention (ATT). Information on all variables was obtained from a telephone interview conducted with the caregiver. The population estimates on these variables were statistically weighted to represent all children in this age group entering federally funded early intervention services in the U.S.

As part of the Kindergarten Family Interview, caregivers responded to 16 questions that described their child's hand skills. Of these, 6 represented skills that would be expected of a child beyond the age of three years. Responses were rated on a three-point Likert scale. A list of the questions and the response choices can be found in Appendix A. Cronbach's alpha for these items was .905 and suggested that these items captured a single dimension of child behavior. Scores were summed to obtain a measure of fine motor skill competence (FMC). The total fine motor score was used in the statistical analysis.

All data were coded, entered into SPSS 16 for analysis, and screened. Correlations among the predictor variables and between the predictor variables and the dependent variable were performed. Bivariate scatterplots were obtained for all variable combinations. Assumptions of the regression model were tested. Once the assumptions were determined to be met, each category of predictor variables was entered into a regression equation separately. Residual analysis, collinearity, as determined by a variance inflation factor greater than 10, and influence analysis, as assessed by DFFITS, were subsequently performed. Part correlations were interpreted to determine the relative importance of the individual predictor variables. Subsequently, the variable from each of the categories, biological, environmental, and behavioral, with the largest part correlation was entered into a regression equation. The alpha level was set at p=.01 for each of the statistical tests, representing a p=.05 divided by 4, as there were four separate hypothesis tests.

RESULTS

The following screening procedures were used for each regression analysis. The results were similar for each category and can be summarized as follows. Analysis of the standardized residuals revealed a normal curve. Scatterplot analysis of the standardized predicted value and the standardized residual was reviewed to determine if the assumption of homoscedasticity was met. Collinearity, as determined by a VIF greater than 10, was not identified. Standardized DFFITS analysis revealed two participants as problematic. Review of the data set revealed that these participants were missing many data points and appeared to have a neuromuscular disorder as determined by the need for orthotics and splinting. It was decided that these children were not properly identified using the established the exclusion criteria. They were not included in the final analysis. All statistical procedures were repeated following their removal and represent what is reported in this study.

Table 3 contains selected descriptive statistics of the sample. Fifty-four percent of the population was male. Forty-nine percent were classified as extremely low birth weight (<1000g), 28% as very low birth weight (1001-1499g), and 23% as moderately low birth weight (1599-2499g). Frequency data for the remaining predictor variables are presented in Table 4 and Table 5. The mean for the outcome measure, FMC, was 15.25 with a standard deviation of 3.1 and a range of 6-18.

Table 3. Descriptive Statistics of Biological Predictor Variables

Variable	Range	Mean	Standard Deviation
Birth weight	425 – 2495g	1205g	496.7
Gestational age	21-35 wks	29.1 wks	3.36
Length of Hospitalization	5-335 days	67.37 days	46.1

Table 4. Frequency Data for Environmental Variables

Variable	Response	%	Cum %
Education	less than high school	17.9	17.9
	high school or GED	34.3	52.1
	some college	19.7	71.9
	2-3 year college	9.1	81.0
	4 year college	12.2	93.2
	some graduate school	1.9	95.1
	graduate school	4.9	100.0
Income	<15,000	34.3	34.3
	15,001-25,000	15.1	49.4
	25,001-50,000	27.6	77.0
	50,001-75,000	12.9	89.9
	>75,001	10.0	100.0
Perceived Child	disagree	.3	.3
Rearing Skills	agree	17.1	17.4
	strongly agree	82.6	100.0

Table 4. (continued)

Variable	Response	%	Cum %
Perceived Social	disagree	5.8	5.8
Support	agree	32.3	36.1
	strongly agree	61.9	100.0
Optimism	fair	2.0	2.0
	good	11.2	13.2
	very good	30.1	43.3
	excellent	56.7	100.0

Table 5. Frequency Data for Behavioral Variables

Variable	Response	%	Cum %
Responsivity	very much like child	35.3	35.3
	a little like child	34.5	69.8
	not like child	30.2	100.0
Ability to be	often hard	11.2	11.2
Soothed	sometimes hard	43.0	54.2
	easy	45.8	100.0
Sleep Disturbances	often	19.3	19.3
	sometimes	33.1	52.4
	rarely	47.6	100.0
Ability to focus	not at all	16.9	16.9
	little	43.8	60.7
	very much	39.3	100.0

Table 6

Correlations Between Predictor Variables

	Biological Variables			Environmental Variables					Behavioral Variables		
	1	2	3	4	5	6	7	8	9	10	11
Biological Variables											
1. BW											
2. GA	.747*										
3. LOH	-.584*	-.639*									
Environmental Variables											
4. MED	.010	.016**	-.042*								
5. INC	.117*	.056*	-.038*	.566*							
6. OPT	.057*	.095*	-.132*	.226*	.155*						
7. PCR	.033*	.014	.006	.112*	.122*	.101*					
8. PSS	-.035*	.016**	.017**	.058*	.131*	.118*	.422*				
Behavioral Variables											
9. RES	-.018**	.111*	-.068*	.131*	.114*	.085*	.059*	-.022**			
10. STH	-.053*	-.054*	.075*	.064*	.029*	.119*	.083*	-.048*	.126*		
11. SLP	-.094*	-.027*	.088*	.050*	-.020**	.159*	.118*	.196*	.042*	.371*	
12. ATT	.083	.062*	.010	.064*	-.035*	.049*	.051*	-.050*	.027*	.163*	.174*

*$p \leq .0005$,** The variable with the strongest part correlation in each category is in bold. LOH- length of hospitalization, GA- gestational age ,BW- birth weight, ATT- ability to focus, RES – responsivity to auditory and visual stimulation, SLP – absence of sleep disturbances, STH – ability to be soothed, OPT – maternal optimism, PSS – perceived social support, INC – income, PCR- perceived child rearing skills, MED – maternal education*

The correlation coefficients among predictor variables and between the predictor variables and the dependent variable, FMC, are represented in Table 6 and Table 7, respectively. Biological variables of GA and BW (r=.747, $p \leq .0005$), LOH and GA (r= -.639, p. ≤0005), and LOH and BW (r=-.584, $p \leq .0005$) demonstrated the strongest correlations among predictor variables followed by the environmental variables of INC and MED (r=.566, $p \leq .0005$) and PCR and PSS (r=.422, $p \leq .0005$).OPT demonstrated the strongest correlation with FMC (r=.273, $p \leq .0005$), followed by ATT (r=.238, $p \leq .0005$) and LOH (r= -.235, $p \leq .0005$).

Table 7. Pearson Correlations Between Fine Motor Performance and Predictor Variables

Variable	Correlation with Fine Motor Skills
Biological Variables	
Birth Weight	.081*
Gestational Age	.059*
Length of Hospitalization	-.235*
Environmental Variables	
Education	.172*
Income	.067*
Optimism	.273*
Perceived Child Rearing	-.029
Perceived Social Support	-.064*
Behavioral Variables	
Responsivity	.175*
Ability to be Soothed	.128*
Sleep Disturbance	.129*
Ability to Focus	.238*

*p<.0005

Biological Variables

The four biological variables, birth weight, gestational age, length of hospitalization, and gender, significantly predicted FMC at kindergarten age in LBW children with R=.318, R^2= .101, p. ≤0005. Biological variables explained 10% of the variance in fine motor skill performance. The resulting prediction equations are as follows:

Female: Y^1=20.122 + (-6.4) BW + (-.022) LOH + (-.137) GA + 1.393

Male: Y^1=20.122 + (-6.4) BW + (-.022) LOH + (-.137) GA

Behavioral Variables

The four behavioral variables, responsivity to auditory and visual stimulation, ability to be soothed, absence of sleep disturbance, and ability to focus as an infant significantly predicted FMC at kindergarten age in LBW children with R= .300, R^2= .090, p≤.0005. Behavioral variables explained 9% of the variance in fine motor skill performance. The resulting prediction equation is as follows:

Y^1= 11.747 + (.971)ATT + (.590)RES + (.184)STH + (.343)SLP

Environmental Variables

The five environmental variables, perceived child rearing skills, perceived social support, maternal education, income, and maternal optimism, significantly predicted FMC at kindergarten age with R=.397, R^2=.120, p. ≤0005. Environmental variables explained 12 % of the variance in fine motor skill performance. The resulting equation is as follows:

Y^1=11.533 +(.673)PCR + (-1.019)PSS + (1.184)OPT + (.091)INC

The standardized beta coefficients and the part correlations for the variables from each of the categories is presented in Table 8.

Table 8. Regression Coefficients for the Prediction of Fine Motor Skills

Variables	Standardized Beta	Sig	Part Correlation
Biological			
gender	.22	*	.220
length of hospitalization	-.292	*	-.192
gestational age	-.149	*	-.089
birth weight	-.010	.514	-.006
Behavioral			
ability to focus	.213	*	.212
responsivity to auditory and visual stimulation	.148	*	.143
sleep disturbances	.083	*	.078
ability to be soothed	.038	*	.035

*$p \leq .0005$

Table 8 (continued)

Variables	Standardized Beta	Sig	Part Correlation
Environmental			
maternal optimism	.305	*	.287
perceived social support	-.192	*	-.176
income	.041	.001	.033
perceived child rearing skills	.081	*	.074
maternal education	.000	.983	.000

*$p \leq .0005$

Composite Prediction Equation

Gender, OPT and ATT significantly predicted FMC with $R = .408$, $R^2 = .167$, $p < .0005$. Gender, OPT, and ATT together explained 16.7% of the variance in fine motor skill performance. The resulting equations are as follows:

Female: $Y^1 = 8.524 + (1.072)\ \text{ATT} + (1.123)\ \text{OPT} + 1.081$

Male: $Y^1 = 8.524 + (1.072)\ \text{ATT} + (1.123)\ \text{OPT}$

Examination of the part correlations for the prediction equation revealed that OPT had the largest correlation ($r = .217$) followed by ATT ($r = .237$) and gender ($r = .169$) ($p \leq .0005$ for all).

DISCUSSION

This study suggests that female gender, the ability to attend as an infant (ATT), and maternal optimism at entry to early intervention (OPT) are the most significant predictors of fine motor skill performance at kindergarten age in children born prematurely with LBW without major neurosensory impairment. Female gender, high caregiver expectations for the child's future, and improved ability to attend as an infant are correlated with a higher degree of fine motor skills for this population. The role of gender is consistent with emerging literature regarding adaptive motor skills in this population of children while the role of caregiver optimism and the ability to attend as an infant are new contributions to the field.

Male gender has been linked to poor performance on the Bruinink-Oseretsky Test of Motor Proficiency, the Riley Motor Problems Inventory, and the VMI [14,32,34], developmental coordination disorder, and school performance.[35] Whitaker et al.[33]

suggest that poorer performance by males suggests that hormonal differences between the sexes may affect the acute response to brain injury as well as the recovery.

Maternal optimism is being recognized as a modifier of medical risk for a variety of pediatric disorders. Maternal optimism at initial diagnosis has been related to quality of life measures in children with acute lymphocytic leukemia two years following diagnosis, independent of initial medical status[50] and as a modifier of risk in the adjustment of mothers of children with obstetrical brachial plexus injuries.[51] Low levels of maternal optimism have been correlated with increased levels of parental perception of child vulnerability (PPCV) in premature children.[52] PPCV has been correlated with poor outcomes on adaptive motor skills in premature infants at 1 year of adjusted age, even after controlling for the presence of indicators of medical vulnerability (r=.31, p=.006). PPCV was found to be correlated with length of neonatal hospital stay independent of the need for mechanical ventilation during that time. Interestingly, PPCV was not found to be associated with birth weight or gestational age. Maternal optimism in the present study demonstrated significant ($p \leq .0005$) but low correlations with birth weight (r=.078) and gestational age (r=.095) and higher correlation with days in hospital in the neonatal period (r=-.132, $p \leq .0005$).

This study found that attention at entry to early intervention in children less than 12 months of age who were born prematurely with LBW was correlated with fine motor skill performance at kindergarten age (r=.238, $p \leq .0005$, part correlation =.237, $p \leq .0005$). Other studies report supportive findings but in older age groups of children. Sustained attention in full term, typically developing children at 9 and 24 months was found to predict 40.1% and 51.9% of the variability in goal persistence during moderately challenging problem solving tasks at 24 months of age.[53] Inattention in 30 month old children born prematurely with LBW was found to be predictive of attention deficit hyperactivity disorder and school difficulties at 8 years of age (p=.01) and of the need for special education services by age 8 years (odds ratio of 1.48).[54]

Of interest was the limited predictive ability of gestational age and birth weight on fine motor skill performance in this population. The part correlations pointed to a very weak negative predictive ability of gestational age (r=-.089) and no relationship of birth weight to fine motor skill performance. Research in this area has produced conflicting results and some researchers have suggested that the relationship of birth weight to motor performance in children without major neurosensory impairments is not a simple one. This study supports such theories. It appears that days in the hospital in the neonatal period and gender are stronger biological predictors than birth weight and gestational age. This may point to subtle brain abnormalities associated with recurrent or prolonged hypoxia secondary to autonomic instability during prolonged hospitalization in the neonatal period.

There were several limitations to this study. The dependent variable, fine motor performance score, did not demonstrate a normal distribution. While regression is robust to this assumption, the predictive ability of the variables may be underestimated under such conditions.[55] Additional limitations include the use of caregiver report to quantify several of the predictor variables and the dependent variable, limited number of items on the fine motor scale, and lack of direct observation of performance to grade quality of movement. Maternal optimism has been suggested to affect maternal ratings of child competence and this may have been an intervening factor.[52] Additionally, although all of the infants were enrolled in early intervention, the dosage was not entered into the regression equation. Given that the infants received services in 9 different states and early intervention services vary greatly among the states, it was decided that this variable could not be accounted for.

The results of this study can be used to guide early intervention and identification efforts. Interventions to improve maternal optimism should be initiated in the neonatal intensive care units. Maternal optimism should be monitored as part of high risk follow up clinics and early intervention visits. Research into effective methods to improve optimism in this population is warranted. Male children born prematurely with low birth weight should be followed closely with intensive efforts directed at improving fine motor skills performance. It would be beneficial for early interventionist to monitor closely the infant's ability to attend and to direct intervention efforts at promoting these skills. Lastly, the impact of days in the hospital in the neonatal period is likely a complex entity. A prospective study which could record and analyze the medical and physiologic events during the hospitalization period, detailed brain imaging, and the effect of prolonged hospitalization on caregiver optimism might provide more conclusive information.

CONCLUSION

Gender, maternal optimism at entry to early intervention, and ability to focus as an infant explained 16.7% of the variance in fine motor skill performance in LBW preterm children without neurosensory impairments at kindergarten age. Environmental variables as a group demonstrated stronger predictive ability than biological variables for this population. Birth weight and gestational age demonstrated low predictive ability for fine motor skill performance in this emerging population of children.

CHAPTER IV

PREDICTORS OF DRESSING SKILLS IN LOW BIRTH WEIGHT CHILDREN AT KINDERGARTEN AGE

INTRODUCTION

Advances in prenatal and perinatal care and assistive reproductive technology have resulted in the delivery and survival of children of increasingly lower gestational ages and birth weights. In 2008, low birth weight (LBW) represented 8.3% of all births as compared to 6.8% in 1980.[1] Low birth weight is generally defined as a birth weight below 2500 grams.[1] Children born at less than 37 weeks gestational age and with very low birth weight are 30% more likely to develop cerebral palsy and other conditions such as mental retardation, respiratory distress syndrome, bronchopulmonary dysplasia, retinopathy of prematurity, and hearing impairments.[2,3] These significant and severe neurosensory disabilities are often diagnosed in the first few years of the child's life. While some researchers are reporting a decrease in the severity of morbidity following preterm birth and LBW there is growing concern regarding the high percentages of LBW children who demonstrate "minor" impairments in adaptive motor functioning once they enter kindergarten.[4-9] Long-term studies of neonatal intensive care unit survivors have identified these subtle long-term morbidities as the "new morbidities" or the "hidden handicaps" for this group of children.[5-9]

While many healthy LBW children demonstrate motor and learning difficulties in school, a significant number do not. Investigation into factors that mediate poor outcomes and perhaps protect against the adverse effects of prematurity and LBW could assist future attempts at providing intervention, both in early intervention programs and in the preschool period. Additionally, identifying which healthy preterm LBW children are at greatest risk for adaptive motor dysfunction at school age would assist states in allocating expensive and often scarce therapeutic and special education resources in hopes of ameliorating the difficulties faced by this population of children.

Methods to identify children who may experience adaptive motor difficulties include analysis of risk factors which traditionally have been viewed as a spectrum of biological and/or social/environmental variables.[29] The transactional model of child development, which influences early intervention practices, suggests that other factors warrant study. The roles early temperament and behavioral patterns play in child developmental outcomes and caregiver responses have received considerable attention and dysfunction in these areas is becoming increasingly recognized as a risk for adverse developmental outcomes.[47,48] Conversely, the interaction of early atypical behavioral patterns with biological and environmental risk factors in the prediction of long term adaptive motor behavior outcomes for children with LBW has not been investigated.

Teachers identify adaptive motor skills, such as dressing, as needed for successful inclusion in kindergarten yet little research is available on the performance of this skill in at risk populations.[56] Dressing skills require the development of complex grasp and hand manipulation skills.[57] However, several studies have revealed that the relationship of fine motor skills to dressing skills is not a simple one as competency in other systems is required as well.[58,59] Significant perceptual abilities are required such as the ability to visually analyze clothing to determine front from back, top from bottom, and left from right. Form constancy, or the ability to maintain a visual picture of the clothing as it is turned upside down and sideways during donning, is also required.[60] Postural stability, the ability to cross midline and use two sides of the body together in an integrated fashion, low frustration tolerance, and concept formation are examples of other child centered components involved in dressing.[61,62] Environmental variables may also affect the development of dressing skills, such as culture, social class, and individual family factors.[63]

The purpose of this study was to explore the relationships of individual biological, environmental, and behavioral predictor variables to dressing skill performance at kindergarten age in LBW children who are without major neurosensory impairment and to develop a predictor model for dressing skill performance in this population that will guide early intervention efforts.

RESEARCH QUESTIONS

1. Which ones of the targeted predictor variables in the three categories of biological environmental, and behavioral risks, significantly correlated with delays in dressing skills in kindergarten in children with LBW who are without major disabling conditions?
2. What combination of predictor variables across the three categories of biological, environmental, and behavioral risks concomitantly provided the

best predictor models for outcome at kindergarten age in dressing skills in children with LBW who are without major disabling conditions?

HYPOTHESES

1. At least one variable form each category of variables, biological, environmental, and behavioral, will be a significant predictor of reported dressing skills scores at kindergarten age in children with LBW who are without major neurosensory impairment.
2. A significant prediction model will emerge for dressing skills which will include predictors from each of the three predictor categories.

METHODS

The 341 children in the sample for this study represent a subsample of the 3,338 children who were enrolled in the National Early Intervention Longitudinal Study (NEILS). Information on the study can be found at www.sri.com/neils. The Office of Special Education Programs of the U.S. Department of Education commissioned SRI International to conduct NEILS. Other organizations which participated in the design and instrumentation of NEILS included The Frank Porter Graham Child Development Institute, The Research Triangle Institute, and The American Institutes for Research. NEILS began in 1996 with a design phase. The frame work which guided the instrumentation used reflected a transactional/ecological perspective, that is, the development of young children with disabilities is influenced by many interrelated factors. Ninety-three counties in 20 states participated. Early intervention staff in each of the sampled counties reported the child's date of birth, gender, ethnicity, foster care status, public assistance status, reason for eligibility, date of referral, and date of Individualized Family Service Plan (IFSP) as children began early intervention services. This resulted in an enrollment sample of 5,668 children. There were three criteria that children and families needed to meet in order to be eligible to participate: 1. The child was less than 31 months of age at the time the IFSP was written; 2. There was an English- or Spanish- speaking adult in the house who could answer questions about the child; and 3. Only one child in the family could be recruited to participate. Of the 5,668 children in the enrollment sample, 4,867 were eligible. Of these, 3,338 children were enrolled in the study because an adult provided written consent for their participation (69%). Thirty-two percent of the sample was LBW.

Attempts were made to interview each family by telephone shortly after agreeing to participate in the study, annually thereafter up until age 3, at 32-36 months if that time frame did not coincide with an annual anniversary, and in the fall of the year when the child would typically enter kindergarten. Families without telephones were mailed a questionnaire. Interviews were conducted with the family member identified as most knowledgeable about the child and the child's early intervention services. Most respondents were the children's mothers. A rigorously trained and quality-monitored survey research unit, The Research Triangle, conducted the interviews using computer-assisted telephone interviewing (CATI), which allowed the interviewers to read questions and enter responses directly into a computer. CATI technology provided the interviewer with the next appropriate interview question based on the respondent's answers. The interview was designed by the NEILS research team and addressed characteristics of the child and family, a description of services received including both early intervention and private therapy services, and the respondents' perception of the effects of early intervention on them and their child. Respondents were given the option to complete the interview in English or Spanish. The enrollment interviews lasted an average of 38 minutes. Interim interviews were marginally shorter, and interviews at the third birthdays and at kindergarten age were slightly longer.

The NEILS research team developed the behavior and adaptive motor skills questions on the survey following a review of several instruments including the Bayley Scales of Infant Development, 2nd edition, the Child Development Inventories, the Battelle Developmental Inventory, the Ages and Stages Questionnaires, and the Pediatric Evaluation of Disability Inventory. Criteria used for selecting items for the telephone interview included the following: 1. having face validity as developmental markers; 2. contributing to a sequenced strand of development; 3. reflecting skills of a universal, rather than culture-specific, nature; and 4. readily observable by caregivers in the everyday settings and activities of children. Items were pilot-tested extensively as part of the interview development process to ensure they were understandable to caregivers and that caregivers could provide the requested information.

The principle investigator attended training on the NEILS database by invitation in June 2008 and received a compact disc containing the data and supporting documents. Permission to access the NEILS database was granted from the Institutional Review Board at Texas Woman's University, Houston Campus. Criteria for inclusion for this study's sample was extracted from the database and included the following: 1. Birth weight of less than 2500 grams; 2. Gestational age of less than 37 weeks; 3. Enrollment in early intervention by 12 months of age; 4. Absence of reported diagnoses of cerebral palsy, spina bifida, genetic disorder, and severe vision and hearing impairments.

The predictor variables used for this study were extracted from the Enrollment Family Interview of the NEILS. This study examined four variables related to the biological characteristics of the child, five variables related to the child's social environment, and five variables related to the reported behavioral characteristics of the child at entry into the study. Biological characteristics were gestational age (GA), birth weight (BW), length of hospital stay following birth (LOH), and gender. Social environment variables included reported income (INC), maternal education level (MED), caregiver confidence in child rearing (PCR), caregiver perceived degree of social support (PSS), and caregiver degree of optimism for the child's future (OPT). Reported behavioral variables included responsivity to auditory and visual stimulation (RES), ability to be soothed (STH), sleep disturbances (SLP), and attention (ATT). Information on all variables was obtained from a telephone interview conducted with the caregiver. The survey questions related to these variables can be found in Appendix A. The population estimates on these variables were statistically weighted to represent all children in this age group entering federally funded early intervention services in the U.S.

As part of the Kindergarten Family Interview, caregivers responded to 10 questions that described their child's dressing skills. Of these, 7 represented skills that would be expected of a child beyond the age of three years. Responses were rated on a three-point Likert scale. A list of the questions and the response choices can be found in

Appendix B. Cronbach's alpha for these items was .856 and suggested that these items captured a single dimension of child behavior. Scores were summed to obtain a measure of dressing skill competence (DSC). The total dressing skill score was used in the statistical analysis.

All data were coded, entered into SPSS 16 for analysis, and screened. Correlations among the predictor variables and between the predictor variables and the dependent variable were performed. Bivariate scatterplots were obtained for all variable combinations. Assumptions of the regression model were tested. Once the assumptions were determined to be met, each category of predictor variables was entered into a regression equation by separately. Residual analysis, collinearity, as determined by a variance inflation factor greater than 10, and influence analysis, as assessed by DFFITS, were subsequently performed. Part correlations were interpreted to determine the relative importance of the individual predictor variables. Subsequently, the variable from each of the categories, biological, environmental, and behavioral, with the largest part correlation was entered into a regression equation. The alpha level was set at $p=.01$ for each of the statistical tests, representing a $p=.05$ divided by 4, as there were four separate hypothesis tests. Separate equations for each gender were configured as appropriate.

RESULTS

The following screening procedures were used for each regression analysis. The results were similar for each category and can be summarized as follows. Analysis of the standardized residuals revealed a normal curve. Scatterplot analysis of the standardized predicted value and the standardized residual was reviewed to determine if the assumption of homoscedasticity was met. Collinearity, as determined by a VIF greater than 10, was not identified. Standardized DFFITS analysis revealed two participants as problematic. Review of the data set revealed that these participants were missing many data points and appeared to have a neuromuscular disorder as determined by the need for orthotics and splinting. It was decided that these children were not properly identified using the established the exclusion criteria. They were not included in the final analysis. All statistical procedures were repeated following their removal and represent what is reported in this study.

Table 9 contains selected descriptive statistics of the sample. Fifty-four percent of the population was male. Forty-nine percent were classified as extremely low birth weight (<1000g), 28% as very low birth weight (1001-1499g), and 23% as moderately low birth weight (1599-2499g). Frequency data for the remaining predictor variables are presented in Table 10 and Table 11. The mean for the DSC was 17.13 with a standard deviation of 3.38 and a range of 7-21.

Table 9. Descriptive Statistics of Biological Predictor Variables

Variable	Range	Mean	Standard Deviation
Birth Weight	425-2495g	1205g	496.7
Gestational Age	21-35 wks	29.1 wks	3.36
Length of Hospitalization	5-335 days	67.37 days	46.1

Table 10. Frequency Data for Environmental Variables

Variable	Response	%	Cum %
Maternal Education	less than high school	17.9	17.9
	high school or GED	34.3	52.1
	some college	19.7	71.9
	2-3 year college	9.1	81.0
	4 year college	12.2	93.2
	some graduate school	1.9	95.1
	graduate school	4.9	100.0
Income	<15,000	34.3	34.3
	15,000-25,000	15.1	49.4
	25,001-50,000	27.6	77.0
	50,000-75,000	12.9	89.9
	>75,001	10.0	100.0

Table 10 (continued)

Variable	Response	%	Cum %
Perceived Child Rearing Skills	disagree	.3	.3
	agree	17.1	17.4
	strongly agree	82.6	100.0
Perceived Social Support	disagree	5.8	5.8
	agree	32.3	36.1
	strongly agree	61.9	100.0
Optimism	fair	2.0	2.0
	good	11.2	13.2
	very good	30.1	43.3
	excellent	56.7	100.0

Table 11. Frequency Data for Behavioral Variables

Variable	Response	%	Cum %
Responsivity to Visual and Auditory Stimulation	very much like child	35.3	35.3
	a little like child	34.5	69.8
	not like child	30.2	100.0
Ability to be Soothed	often hard	11.2	11.2
	sometimes hard	43.0	54.2
	easy	45.8	100.0
Sleep Disturbances	often	19.3	19.3
	sometimes	33.1	52.4
	rarely	47.6	100.0
Ability to Focus	not at all	16.9	16.9
	little	43.8	60.7
	very much	39.3	100.0

Table 12. Pearson Correlations between Predictor Variables

	Biological Variables 1	2	3	Environmental Variables 4	5	6	7	8	Behavioral Variables 9	10	11
Biological Variables											
1. BW											
2. GA	.747*										
3. LOH	-.584*	-.639*									
Environmental Variables											
4. MED	.010	.016**	-.042*								
5. INC	.117*	.056*	-.038*	.566*							
6. OPT	.057*	.095*	-.132*	.226*	.155*						
7. PCR	.033*	.014	.006	.112*	.122*	.101*					
8. PSS	-.035*	.016**	.017**	.058*	.131*	.118*	.422*				
Behavioral Variables											
9. RES	-.018**	.111*	-.068*	.131*	.114*	.085*	.059*	-.022**			
10. STH	-.053*	-.054*	.075*	.064*	.029*	.119*	.083*	-.048*	.126*		
11. SLP	-.094*	-.027*	.088*	.050*	-.020**	.159*	.118*	.196*	.042*	.371*	
12. ATT	.083	.062*	.010	.064*	-.035*	.049*	.051*	-.050*	.027*	.163*	.174*

*$p \leq .0005$,*** The variable with the strongest part correlation in each category is in bold. LOH- length of hospitalization, GA- gestational age ,BW- birth weight, ATT- ability to focus, RES – responsivity to auditory and visual stimulation, SLP – absence of sleep disturbances, STH – ability to be soothed, OPT – maternal optimism, PSS – perceived social support, INC – income, PCR- perceived child rearing skills, MED – maternal education*

The correlation coefficients among predictor variables and between the predictor variables and the dependent variable, DSC, are represented in Table 12 and Table 13, respectively. LOH demonstrated the strongest correlation with DSC (r=-.257, p≤.0005), followed by BW (r=.227, p≤.0005) and GA (r= .214, p≤.0005). Biological variables of GA and BW (r=.778, p≤.0005), LOH and GA (r=.639, p≤.0005), and LOH and BW (r=.632, p≤.0005) demonstrated the strongest correlations among predictor variables followed by the environmental variables of INC and MED (r=.566, p≤.0005) and PCR and PSS (r=.422, p≤.0005).

Table 13. Pearson Correlations between Dressing Skill Performance and Predictor Variables

Variables	Correlation with Dressing Skill Competency
Biological Variables	
birth weight	.227*
gestational age	.214*
length of hospitalization	-.257*
Environmental Variables	
maternal education	-.045*
income	.003
optimism	.197*
perceived child rearing skills	-.013
perceived social support	-.119
Behavioral Variables	
responsivity to auditory and visual stimulation	.120*
ability to be soothed	.049*
sleep disturbances	.174*
ability to focus	.172*

*$p \leq .0005$

Biological Variables

The four biological variables, GA, BW, LOH, and gender, significantly predicted DSC at kindergarten age in LBW children with $R= .267$, $R^2 = .071$, $p \leq .0005$. The resulting prediction equations are as follows:

Female: $Y^1 = 13.983 + (.001)BW + (-.002)LOH + (.031)GA + .934$

Male: $Y^1 = 13.983 + (.001)BW + (-.002)LOH + (.031)GA$

Behavioral Variables

The four behavioral variables, RES, STH, SLP, and ATT significantly predicted DSC at kindergarten age in LBW children with $R=.206$, $R^2=.043$, $p \leq .0005$. The resulting prediction equation is as follows:

$$Y^1 = 14.846 + (.787)ATT + (.523)RES + (-.103)STH + (-.035)SLP$$

Environmental Variables

The five environmental variables, PCR, PSS, MED, INC, and OPT, significantly predicted DSC at kindergarten age in LBW children with $R = .340$, $R^2 = .116$, $p \leq .0005$. The resulting prediction equation is as follows:

$$Y^1 = 14.258 + (1.481)PCR + (-1.584)PSS + (.957)OPT + (-.489)MED + (.328)INC$$

The standardized beta coefficients and the part correlations for the variables from each of the categories is presented in Table 14.

Table 14. Regression Coefficients for the Prediction of Dressing Skills

Variables	Standardized Beta	Sig	Part Correlation
Biological			
Gender	.139	*	.137
length of hospitalization	-.024	.090	-.016
gestational age	.053	.001	.031
birth weight	.179	*	.106
Behavioral			
ability to focus	.162	*	.161
responsivity to auditory and visual stimulation	.124	*	.120
sleep disturbances	-.008	.443	-.008
ability to be soothed	-.020	.060	-.01

*$p \leq .0005$

Table 14. (continued)

Variables	Standardized Beta	Sig	Part Correlation
Environmental			
optimism	.224	*	.213
perceived social support	-.278	*	-.245
income	.133	.001	.108
perceived child rearing skills	.169	*	.149
maternal education	-.253	.983	-.199

* $p \leq .0005$

Composite Prediction Equation

Given the relative strength of the environmental variables in predicting dressing skill performance, it was decided to use all environmental variables in addition to the variable from the biological and behavioral categories with the highest part correlations for the group (ATT and gender). All environmental variables in addition to gender and ATT significantly predicted DSC with a $R = .386$, $R^2 = .149$, $p \leq .0005$. Together, these variables explained 14.9% of the variance in DSC. The resulting equations are as follows:

Female: Y^1=12.101 = (.866)OPT + (1.276)PCR +(.952)ATT + (-.486)MED + (.356)INC + (-1.379)PSS + .6

Male: Y^1=12.101 = (.866)OPT + (1.276)PCR +(.952)ATT + (-.486)MED + (.356)INC + (-1.379)PSS

Examination of part correlations for the prediction equation revealed that PSS had the largest negative correlation (r=-.209) followed by MED (r= -.110). ATT had the highest positive correlation (r=.194) followed by OPT (r=.189). Gender had the lowest part correlation (r=.084).

DISCUSSION

This study suggests that environmental variables as a group predict more of the variance in dressing skills at kindergarten age in children born prematurely with LBW without neurosensory impairment than do biological or behavioral variables. These results can partly be explained through an examination of the factors deemed responsible for the performance of independent dressing in young children.

Dressing involves the coordination and integration of complex grasp patterns, in-hand manipulation skills, cognitive skills, and visual perceptual abilities.[57,60] In addition, cultural, class, and family variables influence the timing and acquisition of independence in self care.[63,64] The opportunities afforded to the child to practice self dressing will hence be somewhat dependent on the environmental context.

In this study, environmental variables typically viewed as positive attributes, maternal education and perceived social support, predicted poor performance in dressing skills, with perceived social support the strongest negative predictor of dressing skill performance. It is possible that the presence of social support decreased the time demands on the caregiver, lessening the need for the child to become an independent dresser. As a result, the child was presented with fewer opportunities to practice dressing.

In the composite equation, ATT had the highest positive correlation. Other studies report supportive findings but in older age groups of children. Sustained attention in full term, typically developing children at 9 and 24 months was found to predict 40.1% and 51.9% of the variability in goal persistence during moderately challenging problem solving tasks at 24 months of age.[53] Inattention in 30 month old children born prematurely with LBW was found to be predictive of attention deficit hyperactivity disorder and school difficulties at 8 years of age (p=.01) and of the need for special education services by age 8 years (odds ratio of 1.48).[54]

Maternal optimism was the strongest positive predictor of independent dressing skills when only environmental variables were entered into the equation. Maternal optimism is being recognized as a modifier of medical risk for a variety of pediatric disorders. Maternal optimism at initial diagnosis has been related to quality of life measures in children with acute lymphocytic leukemia two years following diagnosis, independent of initial medical status[50] and as a modifier of risk in the adjustment of mothers of children with obstetrical brachial plexus injuries.[51] Low levels of maternal optimism have been correlated with increased levels of parental perception of child vulnerability (PPCV) in premature children.[52] PPCV has been correlated with poor outcomes on adaptive motor skills in premature infants at 1 year of adjusted age, even after controlling for the presence of indicators of medical vulnerability (r=.31, p=.006).

PPCV was found to be correlated with length of neonatal hospital stay independent of the need for mechanical ventilation during that time. Interestingly, PPCV was not found to be associated with birth weight or gestational age. Maternal optimism in the present study demonstrated significant ($p \leq .0005$) but low correlations with birth weight ($r=.078$) and gestational age ($r=.095$) and higher correlation with days in hospital in the neonatal period ($r=-.132$, $p \leq .0005$).

There were several limitations to this study. Only 14.9% of the variance in dressing skill performance was explained. Thus, many other variables not identified in this study may impact dressing skill performance. The dependent variable, dressing skill performance score, did not demonstrate a normal distribution. While regression is robust to this assumption, the predictive ability of the variables may be underestimated under such conditions.[55] Additional limitations include the use of caregiver report to quantify several of the predictor variables and the dependent variable, limited number of items on the dressing skills scale, and lack of direct observation of performance to grade quality of movement. Maternal optimism has been suggested to affect maternal ratings of child competence and this may have been an intervening factor.[52] Additionally, although all of the infants were enrolled in early intervention, the dosage was not entered into the regression equation. Given that the infants received services in 9 different states and early intervention services vary greatly among the states, it was decided that this variable could not be accounted for.

The results of this study can be used to guide early intervention and identification efforts. Families enrolled in early intervention should be provided with a list of skills recommended for all children to have by kindergarten age, including self care skills. The importance of dressing skills as part of a child's ability to function in the typical educational environment should be stressed. It would be beneficial for early interventionists to monitor closely the infant's ability to attend and to direct intervention efforts at promoting these skills. Additionally, interventions to improve maternal perception of child vulnerability should be initiated in the neonatal intensive care units. Maternal optimism should be monitored as part of high risk follow up clinics and early intervention visits. Research into effective methods to improve optimism in this population is warranted.

CONCLUSION

Environmental variables, PSS, OPT, PCR, INC, MED, in addition to ATT, and gender explained 14.9% of the variance in dressing skill performance in LBW preterm children without neurosensory impairments at kindergarten age. Environmental variables as a group demonstrated stronger predictive ability than biological or behavioral variables for this population. Efforts to improve dressing skill performance in this population should partly focus on remediation of environmental factors.

CHAPTER V

PREDICTORS OF FUNCTIONAL MOBILITY SKILLS IN LOW BIRTH WEIGHT CHILDREN AT KINDERGARTEN AGE

INTRODUCTION

Advances in prenatal and perinatal care and assistive reproductive technology have resulted in the delivery and survival of children of increasingly lower gestational ages and birth weights. In 2008, low birth weight (LBW) represented 8.3% of all births as compared to 6.8% in 1980.[1] Low birth weight is generally defined as a birth weight below 2500 grams.[1] Children born at less than 37 weeks gestational age and with very low birth weight are 30% more likely to develop cerebral palsy and other conditions such as mental retardation, respiratory distress syndrome, bronchopulmonary dysplasia, retinopathy of prematurity, and hearing impairments.[2,3] These significant and severe neurosensory disabilities are often diagnosed in the first few years of the child's life. While some researchers are reporting a decrease in the severity of morbidity following preterm birth and LBW there is growing concern regarding the high percentages of LBW children who demonstrate "minor" impairments in cognitive, social, and motor functioning once they enter kindergarten.[4-9] Long-term studies of neonatal intensive care unit survivors have identified these subtle long-term morbidities as the "new morbidities" or the "hidden handicaps" for this group of children.[5-9]

Outcome studies on premature infants have indicated significant impairments in school performance, even in children without previously identified disabilities.[10-13] The prevalence rate for perceptual motor problems in school-age children with LBW who are "healthy" or without major neuromotor impairment has been reported as high as 48%.[14] Jongmans et al.[14] studied 156 children born prematurely at age 6. Children with cerebral palsy were excluded from the analysis. On the Movement Assessment Battery for Children (Movement ABC), 44% scored below the 15th percentile while 19% scored below the 5th percentile. On the Developmental Test of Visual Motor Integration (VMI), 17% scored below the 15th percentile. Similar results were found in a study on children born prematurely with LBW at ages 4 and 7-8.[22,23] Sullivan et al. studied four dimensions of motor competence in preterm children at age 4 and related these findings to academic performance and use of school services at age 8. They identified mild motor delays in preterm children at age 4 across both healthy and medically ill preterm groups. These delays were significantly correlated with academic outcomes at age 8 with the effect ranging from small to moderate (r =.12 to .39).

While many healthy LBW children demonstrate motor and learning difficulties in school, a significant number do not. Investigation into factors that mediate poor outcomes and perhaps protect against the adverse effects of prematurity and LBW could assist future attempts at providing intervention, both in early intervention programs and in the preschool period. Additionally, identifying which healthy preterm LBW children are at greatest risk for fine motor dysfunction at school age would assist states in allocating expensive and often scarce therapeutic and special education resources in hopes of ameliorating the academic difficulties faced by this population of children.

Male gender is one variable, in combination with low birth weight and prematurity, which has been linked to coordination difficulties in childhood. In children ages 6 to adolescence born with LBW, male sex has been linked to poorer performance on the Bruinnks-Oseretsky Test of Motor Proficiency, the Riley Motor Problems Inventory (RMPI), and the Movement ABC.[33,34] In the study by Whitaker et al., male gender was an independent predictor of poor performance on the RMPI (B=.14, p<.001) while in the study by Davis et al., male sex in combination with ELBW and gestational age of less than 32 weeks was predictive of Developmental Coordination Disorder (DCD). Davis et al. concluded that the lack of strong perinatal factors (such as the use of antenatal steroids or Surfactant, presence of BPD, IVH, or PVL) suggested that genetic or environmental factors may have a major role in motor development in this population. However, few studies have examined environmental variables in relation to coordination difficulties and in those that have, environmental variables have not been associated with motor function at age 5.[37,42] Primarily distal environmental variables, which indirectly affect the child through impact on factors such as the family's lifestyle, have been studied, such as socioeconomic status, education, and occupation and outcomes have focused on gross and fine motor skill level versus adaptive motor functioning. Proximal environmental variables, such as caregiver confidence in child rearing, caregiver perception of social support, and caregiver optimism for the future, may have a more direct effect on child outcomes.

The transactional model of child development, which influences early intervention practices, suggests that other factors warrant study as well. The roles early temperament and behavioral patterns play in child developmental outcome and caregiver responses have received considerable attention and dysfunction in these areas is becoming increasingly recognized as a risk for adverse developmental outcomes.[47,48] Conversely, the interaction of early atypical behavioral patterns with biological and environmental risk factors in the prediction of long term motor outcomes for children with LBW has not been researched.

The purpose of this study was to explore the relationships of individual biological, environmental, and behavioral predictor variables to functional mobility performance at kindergarten age in LBW children who are without major neurosensory impairment and to develop a predictor model for functional mobility skill performance in this population that will guide early intervention efforts.

RESEARCH QUESTIONS

1. Which ones of the targeted predictor variables in the three categories of biological, environmental, and behavioral risks, significantly correlated with delays in functional mobility skills in kindergarten in children with LBW who are without major disabling conditions?
2. What combination of the predictor variables across the three categories of biological, environmental, and behavioral risks concomitantly provide the best predictor model for functional mobility skills in kindergarten in children with LBW who are without major disabling conditions?

HYPOTHESES

1. At least one variable from each category of variables, biological, environmental, and behavioral, will be a significant predictor of reported functional mobility skills scores at kindergarten age in children with LBW without major neurosensory impairment.
2. A significant prediction model will emerge for functional mobility skills which will include individual predictors form the three predictor categories.

METHODS

The 341 children in the sample for this study represent a subsample of the 3,338 children who were enrolled in the National Early Intervention Longitudinal Study (NEILS). Information on the study can be found at www.sri.com/neils. The Office of Special Education Programs of the U.S. Department of Education commissioned SRI International to conduct NEILS. Other organizations which participated in the design and instrumentation of NEILS included The Frank Porter Graham Child Development Institute, The Research Triangle Institute, and The American Institutes for Research. NEILS began in 1996 with a design phase. The frame work which guided the instrumentation used reflected a transactional/ecological perspective, that is, the development of young children with disabilities is influenced by many interrelated factors. Ninety-three counties in 20 states participated. Early intervention staff in each of the sampled counties reported the child's date of birth, gender, ethnicity, foster care status, public assistance status, reason for eligibility, date of referral, and date of Individualized Family Service Plan (IFSP) as children began early intervention services.

This resulted in an enrollment sample of 5,668 children. There were three criteria that children and families needed to meet in order to be eligible to participate: 1. The child was less than 31 months of age at the time the IFSP was written; 2. There was an English- or Spanish- speaking adult in the house who could answer questions about the child; and 3. Only one child in the family could be recruited to participate. Of the 5,668 children in the enrollment sample, 4,867 were eligible. Of these, 3,338 children were enrolled in the study because an adult provided written consent for their participation (69%). Thirty-two percent of the sample was LBW.

Attempts were made to interview each family by telephone shortly after agreeing to participate in the study, annually thereafter up until age 3, at 32-36 months if that time frame did not coincide with an annual anniversary, and in the fall of the year when the child would typically enter kindergarten. Families without telephones were mailed a questionnaire. Interviews were conducted with the family member identified as most knowledgeable about the child and the child's early intervention services. Most respondents were the children's mothers. A rigorously trained and quality-monitored survey research unit, The Research Triangle, conducted the interviews using computer-assisted telephone interviewing (CATI), which allowed the interviewers to read questions and enter responses directly into a computer. CATI technology provided the interviewer with the next appropriate interview question based on the respondent's answers. The interview was designed by the NEILS research team and addressed characteristics of the child and family, a description of services received including both early intervention and private therapy services, and the respondents' perception of the effects of early intervention on themselves and their child. Respondents were given the option to complete the interview in English or Spanish. The enrollment interviews lasted an average of 38 minutes. Interim interviews were marginally shorter, and interviews at the third birthdays and at kindergarten age were slightly longer.

The NEILS research team developed the behavior and adaptive motor skills questions on the survey following a review of several instruments including the Bayley Scales of Infant Development, 2nd edition, the Child Development Inventories, the Battelle Developmental Inventory, the Ages and Stages Questionnaires, and the Pediatric Evaluation of Disability Inventory. Criteria used for selecting items for the telephone interview included the following: 1. having face validity as developmental markers; 2. contributing to a sequenced strand of development; 3. reflecting skills of a universal, rather than culture-specific, nature; and 4. readily observable by caregivers in the everyday settings and activities of children. Items were pilot-tested extensively as part of the interview development process to ensure they were understandable to caregivers and that caregivers could provide the requested information.

The principle investigator attended training on the NEILS database by invitation in June 2008 and received a compact disc containing the data and supporting documents. Permission to access the NEILS database was granted from the Institutional Review Board at Texas Woman's University, Houston Campus. Criteria for inclusion for this study's sample was extracted from the database and included the following: 1. Birth weight of less than 2500 grams; 2. Gestational age of less than 37 weeks; 3. Enrollment in early intervention by 12 months of age; 4. Absence of reported diagnoses of cerebral palsy, spina bifida, genetic disorder, and vision and hearing impairments.

The predictor variables used for this study were extracted from the Enrollment Family Interview of the NEILS. This study examined four variables related to the biological characteristics of the child, five variables related to the child's social environment, and five variables related to the reported behavioral characteristics of the child at entry into the study. Biological characteristics were gestational age (GA), birth weight (BW), length of hospital stay following birth (LOH), and gender. Social environment variables included reported income (INC), maternal education level (MED), caregiver confidence in child rearing (PCR), caregiver perceived degree of social support (PSS), and caregiver degree of optimism for the child's future (OPT). Reported behavioral variables included responsivity to auditory and visual stimulation (RES), ability to be soothed (STH) , sleep disturbances (SLP), and attention (ATT). Information on all variables was obtained from a telephone interview conducted with the caregiver. The survey questions related to these variables can be found in Appendix A. The population estimates on these variables were statistically weighted to represent all children in this age group entering federally funded early intervention services in the U.S.

As part of the Kindergarten Family Interview, caregivers responded to 11 questions that described their child's functional mobility skills. Of these, 7 represented skills that would be expected of a child beyond the age of three years. Responses were rated on a three-point Likert scale. A list of the questions and the response choices can be found in Appendix B. Cronbach's alpha for these items was .873 and suggested that these items captured a single dimension of child behavior. Scores were summed to obtain a measure of functional mobility skill (FMS). The total functional mobility score was used in the statistical analysis.

All data were coded, entered into SPSS 16 for analysis, and screened. Correlations among the predictor variables and between the predictor variables and the dependent variable were performed. Bivariate scatterplots were obtained for all variable combinations. Assumptions of the regression model were tested. Once the assumptions were determined to be met, each category of predictor variables was entered into a regression equation by separately. Residual analysis, collinearity, as determined by a variance inflation factor greater than 10, and influence analysis, as assessed by DFFITS, were subsequently performed. Part correlations were interpreted to determine the relative importance of the individual predictor variables. Subsequently, the variable from each of the categories, biological, environmental, and behavioral, with the largest part correlation was entered into a regression equation. Separate regression equations for gender were configured as appropriate. The alpha level was set at p=.01 for each of the statistical tests, representing a p=.05 divided by 4, as there were four separate hypothesis tests.

RESULTS

The following screening procedures were used for each regression analysis. The results were similar for each category and can be summarized as follows. Analysis of the standardized residuals revealed a normal curve. Scatterplot analysis of the standardized predicted value and the standardized residual was reviewed to determine if the assumption of homoscedasticity was met. Collinearity, as determined by a VIF greater than 10, was not identified. Standardized DFFITS analysis revealed two participants as problematic. Review of the data set revealed that these participants were missing many data points and appeared to have a neuromuscular disorder as determined by the need for orthotics and splinting. It was decided that these children were not properly identified using the established exclusion criteria. They were not included in the final analysis. All statistical procedures were repeated following their removal and represent what is reported in this study.

Table 15 contains selected descriptive statistics of the sample. Fifty-four percent of the population was male. Forty-nine percent were classified as extremely low birth weight (<1000g), 28% as very low birth weight (1001-1499g), and 23% as moderately low birth weight (1599-2499g). Frequency data for the remaining predictor variables are presented in Table 16 and Table 17. The mean for the FMS was 18.3221 with a standard deviation of 3.36 and a range of 6-18.

Table 15. Descriptive Statistics of Biological Predictor Variables

Variable	Range	Mean	Standard Deviation
Birth Weight	425-2495g	1205g	496.7
Gestational Age	21-35 wks	29.1 wks	3.36
Length of Hospitalization	5-335 days	67.37 days	46.1

Table 16. Frequency Data for Environmental Variables

Variable	Response	%	Cum %
Maternal Education	less than high school	17.9	17.9
	high school or GED	34.3	52.1
	some college	19.7	71.9
	2-3 year college	9.1	81.0
	4 year college	12.2	93.2
	some graduate school	1.9	95.1
	graduate school	4.9	100.0
Income	<15,000	34.3	34.3
	15,000-25,000	15.1	49.4
	25,001-50,000	27.6	77.0
	50,000-75,000	12.9	89.9
	>75,001	10.0	100.0

Table 16. (continued)

Variable	Response	%	Cum %
Perceived Child Rearing Skills	disagree	.3	.3
	agree	17.1	17.4
	strongly agree	82.6	100.0
Perceived Social Support	disagree	5.8	5.8
	agree	32.3	36.1
	strongly agree	61.9	100.0
Optimism	fair	2.0	2.0
	good	11.2	13.2
	very good	30.1	43.3
	excellent	56.7	100.0

Table 17. Frequency Data for Behavioral Variables

Variable	Response	%	Cum %
Responsivity to Visual and Auditory Stimulation	very much like child	35.3	35.3
	a little like child	34.5	69.8
	not like child	30.2	100.0
Ability to be Soothed	often hard	11.2	11.2
	sometimes hard	43.0	54.2
	easy	45.8	100.0
Sleep Disturbances	often	19.3	19.3
	sometimes	33.1	52.4
	rarely	47.6	100.0
Ability to Focus	not at all	16.9	16.9
	little	43.8	60.7
	very much	39.3	100.0

Table 18. Pearson Correlations Between Predictor Variables

	Biological Variables			Environmental Variables					Behavioral Variables		
	1	2	3	4	5	6	7	8	9	10	11
Biological Variables											
1. BW											
2. GA	.747*										
3. LOH	-.584*	-.639*									
Environmental Variables											
4. MED	.010	.016**	-.042*								
5. INC	.117*	.056*	-.038*	.566*							
6. OPT	.057*	.095*	-.132*	.226*	.155*						
7. PCR	.033*	.014	.006	.112*	.122*	.101*					
8. PSS	-.035*	.016**	.017**	.058*	.131*	.118*	.422*				
Behavioral Variables											
9. RES	-.018**	.111*	-.068*	.131*	.114*	.085*	.059*	-.022**			
10. STH	-.053*	-.054*	.075*	.064*	.029*	.119*	.083*	-.048*	.126*		
11. SLP	-.094*	-.027*	.088*	.050*	-.020**	.159*	.118*	.196*	.042*	.371*	
12. ATT	.083	.062*	.010	.064*	-.035*	.049*	.051*	-.050*	.027*	.163*	.174*

*$p \leq .0005$,** *The variable with the strongest part correlation in each category is in bold. LOH- length of hospitalization, GA- gestational age ,BW- birth weight, ATT- ability to focus, RES – responsivity to auditory and visual stimulation, SLP – absence of sleep disturbances, STH – ability to be soothed, OPT – maternal optimism, PSS – perceived social support, INC – income, PCR- perceived child rearing skills, MED – maternal education*

The correlation coefficients among predictor variables and between the predictor variables and the dependent variable, FMS, are represented in Table 18 and Table 19, respectively. OPT demonstrated the strongest correlation with FMS (r=.182, $p \leq .0005$), followed by ATT (r=.168, $p \leq .0005$) and RES (r= .131, $p < .0005$). Biological variables of GA and BW (r=.778, $p \leq .0005$), LOH and GA (r=.639, $p < .0005$), and LOH and BW (r=.632, $p \leq .0005$) demonstrated the strongest correlations among predictor variables followed by the environmental variables of INC and MED (r=.566, $p \leq .0005$) and PCR and PSS (r=.422, $p \leq .0005$).

Table 19. Pearson Correlations between Functional Mobility Skills and Predictor Variables

Variables	Correlation with Functional Mobility Competency
Biological Variables	
birth weight	.080*
gestational age	.059*
length of hospitalization	-.114*
Environmental Variables	
maternal education	.017*
income	-.046*
optimism	.182*
perceived child rearing skills	-.015
perceived social support	-.061*
Behavioral Variables	
responsivity to auditory and visual stimulation	.131*
ability to be soothed	.083*
sleep disturbances	.082*
ability to focus	.168*

*$p \leq .0005$

Biological Variables

The four biological variables, BW, GA, LOH, and gender, significantly predicted FMS at kindergarten age in LBW children with R=.177, R^2= .031, $p\leq$.0005. Biological variables explained 3.1% of the variance in functional mobility skill performance. The resulting prediction equations are as follows:

Female: Y^1=15.255 + (-.322) BW + (-.006) LOH + (.127) GA + .715

Male: Y^1=15.255 + (-.322) BW + (-.006) LOH + (.127) GA

Behavioral Variables

The four behavioral variables, RES, STH, SLP, and ATT significantly predicted FMC at kindergarten age in LBW children with R= .204, R^2= .042, $p\leq$.0005. Behavioral variables explained 4.2% of the variance in functional mobility skill performance. The resulting prediction equation is as follows:

Y^1= 15.921 + (.701)ATT + (.457)RES + (.042)STH + (.205)SLP

Environmental Variables

The five environmental variables, PCR, PSS, MED, INC, and OPT, significantly predicted FMC at kindergarten age with R=.249, R^2=.062, $p\leq$.0005. Environmental variables explained 6.2 % of the variance in functional mobility skill performance. The resulting equation is as follows:

Y^1= 16.295 +(.958)PCR + (-1.087)PSS + (.764)OPT + (-.068)INC + (-.171)MED

The standardized beta coefficients and the part correlations for the variables from each of the categories is presented in Table 20.

Table 20. Regression Coefficients for the Prediction of Functional Mobility Skills

Variables	Standardized Beta	Sig	Part Correlation
<u>Biological</u>			
gender	.106	*	.106
length of hospitalization	-.081	*	-.058
gestational age	.131	*	.082
birth weight	-.079	*	-.051
<u>Behavioral</u>			
ability to focus	.144	*	.141
responsivity to auditory and visual stimulation	.108	*	.105
sleep disturbances	.046	*	.043
ability to be soothed	.030	.451	.008

*$p \leq .0005$

Table 20. (continued)

Variables	Standardized Beta	Sig	Part Correlation
Environmental			
optimism	.109	*	.178
perceived social support	-.201	*	-.178
income	-.029	.027	-.024
perceived child rearing skills	.109	*	.096
maternal education	-.093	.983	-.074

*$p \leq .0005$

Composite Prediction Equation

OPT, PSS, ATT and gender significantly predicted FMS with $R = .243$, $R^2 = .059$, $p \leq .0005$. OPT, PSS, ATT, and gender together explained 5.9% of the variance in functional mobility skill performance. The resulting equations are as follows:

Female: $Y^1 = 14.929 + (-.416)PSS + (.619)OPT + (.755)\ ATT + .491$

Male: $Y^1 = 14.929 + (-.416)PSS + (.619)OPT + (.755)\ ATT$

Examination of the part correlations for the prediction equation revealed that ATT had the largest correlation (r=.155) followed by OPT (r=.140) and gender (r=.072) and PSS (r=-.072) ($p\leq.0005$ for all).

DISCUSSION

This study suggests that the ability to attend as an infant (ATT), maternal optimism at entry to early intervention (OPT), and female gender are the most significant positive predictors of functional mobility skill performance at kindergarten age in children born prematurely with LBW without major neurosensory impairment while perceived social support (PSS) was the most significant negative predictor of these skills. The role of gender is consistent with emerging literature regarding adaptive motor skills in this population of children while the role of caregiver optimism, perceived social support, and the ability to attend as an infant are new contributions to the field.

This study found that attention at entry to early intervention in children less than 12 months of age who were born prematurely with LBW was correlated with functional mobility skill performance at kindergarten age (r=.168, $p\leq.0005$, part correlation =.155, $p\leq.0005$). Other studies report supportive findings but in older age groups of children for motor skills that involve goal persistence and school performance.[53,54] Sustained attention in full term, typically developing children at 9 and 24 months was found to predict 40.1% and 51.9% of the variability in goal persistence during moderately challenging problem solving tasks at 24 months of age.[53] Inattention in 30 month old children born prematurely with LBW was found to be predictive of attention deficit hyperactivity disorder and school difficulties at 8 years of age (p=.01) and of the need for special education services by age 8 years (odds ratio of 1.48).[54]

The deficits in the functional mobility skills measured in this study, such as hopping and ball catching, have been identified as early indicators of developmental coordination disorder, language and reading difficulties.[65,66] Difficulty with ball catching in children with DCD suggests a disturbance in visual perception or visuospatial anticipation and information processing. [65] This may explain the link to early difficulty in attention as an infant and functional mobility skills observed in this study.

Maternal optimism is being recognized as a modifier of medical risk for a variety of pediatric disorders. Maternal optimism at initial diagnosis has been related to quality of life measures in children with acute lymphocytic leukemia two years following diagnosis, independent of initial medical status[50] and as a modifier of risk in the adjustment of mothers of children with obstetrical brachial plexus injuries.[51] Low levels of maternal optimism have been correlated with increased levels of parental perception of child vulnerability (PPCV) in premature children.[52] PPCV has been correlated with poor outcomes on adaptive motor skills in premature infants at 1 year of adjusted age, even after controlling for the presence of indicators of medical vulnerability (r=.31, p=.006). PPCV was found to be correlated with length of neonatal hospital stay independent of the need for mechanical ventilation during that time. Interestingly, PPCV was not found to be associated with birth weight or gestational age. Maternal optimism in the present study demonstrated significant ($p \leq .0005$) but low correlations with birth weight (r=.078) and gestational age (r=.095) and higher correlation with days in hospital in the neonatal period (r=-.132, $p \leq .0005$).

Perceived social support (PSS) was a significant negative predictor of functional mobility skill performance for the children in this study. While this finding is not directly supported by the literature on the role of social support and infant development, it can be explained upon further examination. Social support has been implicated as an important factor influencing maternal role development and maternal coping.[67-68] Yet, some researchers have argued that the type of support provided must meet the needs if the assistance is to mediate developmental problems.[69,70] Additionally, Badr[71] demonstrated that subjective reports of perceived social support did not correlate with quantitative evaluation of support as measured by the Arizona Social Support Interview Schedule (t(113)=.16, p=.22)). Thus, it is possible that either the social support reported by the mothers in this study was not an accurate measure of support or the support they received did not match their needs.

Conversely, Emmanuel et al.[67] found that mothers who were in relationships of short duration and with low social support scores had the highest "centrality" scores ($p \leq .05$). They focused more on their babies as the central point in their lives. This could suggest that these women may be less able to move past preoccupation with their infants or it could mean that they had fewer competing demands for their attention. Perhaps greater maternal attention translated into more opportunities for motor play and hence, better functional mobility skills for the children in this study.

Of interest was the limited predictive ability of gestational age and birth weight on functional mobility skill performance in this population. The part correlations pointed to a very weak predictive ability of gestational age (r=.082) and a negative predictive ability of birth weight to functional mobility skill performance (r=-.051). Research in this area has produced conflicting results and some researchers have suggested that the relationship of birth weight to motor performance in children without major neurosensory impairments is not a simple one. This study supports such theories.

There were several limitations to this study. The dependent variable, functional mobility skill performance, did not demonstrate a normal distribution. While regression is robust to this assumption, the predictive ability of the variables may be underestimated under such conditions.[55] Additional limitations include the use of caregiver report to quantify several of the predictor variables and the dependent variable, limited number of items on the functional mobility scale, and lack of direct observation of performance to grade quality of movement. Maternal optimism has been suggested to affect maternal ratings of child competence and this may have been an intervening factor.[52] Additionally, although all of the infants were enrolled in early intervention, the dosage was not entered into the regression equation. Given that the infants received services in 9 different states and early intervention services vary greatly among the states, it was decided that this variable could not be accounted for.

The results of this study can be used to guide early intervention and identification efforts. Interventions to monitor and improve infant attention should be emphasized during early intervention sessions. Perception of infant vulnerability should be monitored and addressed with educational efforts as part of high risk follow up clinics and early intervention visits. Research into effective methods to improve optimism in this population is warranted. Male children born prematurely with low birth weight should be followed closely with intensive efforts directed at improving functional mobility skills, specifically those that require repetition, rhythm, bilateral coordination, and sequencing. Caregiver-child interactions that challenge such motor skills should be promoted.

CONCLUSION

The ability to focus as an infant, maternal optimism at entry to early intervention, perceived social support, and gender explained 5.9% of the variance in functional mobility skill performance in LBW preterm children without neurosensory impairments at kindergarten age. Environmental variables demonstrated stronger predictive ability than biological variables, explaining 6.2% of the variance as compared to 3.1% for this population. Birth weight and gestational age demonstrated low predictive ability for functional mobility skill performance in this emerging population of children.

CHAPTER VI

CONCLUSION

The purpose of this study was to identify the variables which predict adaptive motor difficulties in school age children who were born prematurely and with LBW who are without major neurosensory impairments for the purpose of aiding early identification and intervention for this emerging population of children. Variables studied were classified as biological, environmental, and behavioral. Biological variables included gender, birth weight, length of neonatal hospitalization, and gestational age. Environmental variables studied included perceived degree of social support, caregiver confidence in caring for child's needs, caregiver degree of optimism for the child's future, maternal education, and income level. Behavioral variables studied included reported degree of responsiveness to auditory and visual stimulation, presence of sleep disturbance, ability to be soothed, and ability to focus as an infant. The dependent variable, adaptive motor skills at kindergarten age, was divided into fine motor, dressing, and functional mobility skills.

RESEARCH QUESTIONS

1. Which ones of the targeted predictor variables in the three categories of biological, environmental, and behavioral risks, significantly correlated with

2. delays in fine motor skills in kindergarten in children with LBW who are without major disabling conditions?
3. Which ones of the targeted predictor variables in the three categories of biological, environmental, and behavioral risks, significantly correlated with delays in dressing skills in kindergarten in children with LBW who are without major disabling conditions?
4. Which ones of the targeted predictor variables in the three categories of biological, environmental, and behavioral risks, significantly correlated with delays in functional mobility skills in kindergarten in children with LBW who are without major disabling conditions?
5. What combination of the predictor variables across the three categories of biological, environmental, and behavioral risks concomitantly provided the best predictor models for outcome at kindergarten age in the areas of fine motor, dressing, and functional mobility skills in children with LBW who are without major disabling conditions?

HYPOTHESES

1. At least one variable from each category of variables, biological, environmental, and behavioral, will be a significant predictor of reported fine motor skills scores at kindergarten age in children with LBW without major neurosensory impairment.

2. At least one variable from each category of variables, biological, environmental, and behavioral, will be a significant predictor of reported dressing skills scores at kindergarten age in children with LBW without major neurosensory impairment.
3. At least one variable from each category of variables, biological, environmental, and behavioral, will be a significant predictor of reported functional mobility skills scores at kindergarten age in children with LBW without major neurosensory impairment.
4. A significant prediction model which will emerge for each of the dependent variables which will include different predictors and beta weights for the individual predictors from the three predictor categories.

The hypotheses were tested using multiple regression analysis and were supported. At least one variable from each category of variables, biological, environmental, and behavioral, were significant predictors of each of the dependent variables (fine motor skills, dressing skills, and functional mobility skills). The prediction models which emerged for each of the dependent variables included different beta weights for the individual predictors. However, several individual predictors emerged which predicted skill performance across the three categories of the dependent variables. Gender, maternal optimism at entry to early intervention, and ability to focus as an infant emerged as the strongest significant predictors of adaptive motor skills in children with LBW at kindergarten age while caregiver perceived degree of social support emerged as the strongest negative predictor of these skills in this population. Table 21 compares part correlations of the individual predictors across categories of the dependent variable.

ENVIRONMENTAL VARIABLES

As a group, environmental variables predicted the greatest percentage of variance in adaptive motor skills. Table 22 compares the percentage of variance explained in fine motor skills, dressing skills, and functional mobility skills by the three categories of independent variables. This finding is in contrast to previous studies which have suggested that biological risk factors are more likely to be associated with motor and perceptual difficulties whereas environmental factors are more closely linked to language and overall cognitive and behavioral functions. Previous research on environmental variables has focused on maternal education and income, distal variables which had low predictive values in this study. The proximal environmental variables examined in this study, such as maternal optimism and caregiver perception of social support, may have had a more direct and intense association on the development of motor skills. Another explanation is that this study examined motor skills that had functional meaning to the families versus fine and gross motor skills typically assessed by standardized developmental tests. Additionally, adaptive motor skill competence was reported by the caregiver.

The two environmental variables that emerged as the strongest predictors of adaptive motor skills were maternal optimism at entry to early intervention and caregiver perception of social support. Maternal optimism was the strongest predictor of fine motor skill performance (r=.287, $p \leq .0005$) and one of two of the strongest predictors of functional mobility skills (r=.178, $p \leq .0005$). Maternal optimism is being recognized as a modifier of medical risk for a variety of pediatric disorders. Maternal optimism at initial diagnosis has been related to quality of life measures in children with acute lymphocytic leukemia two years following diagnosis, independent of initial medical status[50] and as a modifier of risk in the adjustment of mothers of children with obstetrical brachial plexus injuries.[51] Low levels of maternal optimism have been correlated with increased levels of parental perception of child vulnerability (PPCV) in premature children.[52] Higher PPCV has been correlated with poor outcomes on adaptive motor skills in premature infants at 1 year of adjusted age, even after controlling for the presence of indicators of medical vulnerability (r=.31, p=.006).

Perceived social support (PSS) was the strongest negative predictor of dressing skill performance (r=-.245, $p \leq .0005$) and one of two of the strongest predictors, although negative, of functional mobility skills (r=-.178, $p \leq .0005$). While this finding is not directly supported by the literature on the role of social support and infant development, it can be explained upon further examination. Social support has been implicated as an important factor influencing maternal role development and maternal coping.[67-68] Yet, some researchers have argued that the type of support provided must meet the needs if the assistance is to mediate developmental problems.[69,70] Additionally, Badr[71] demonstrated that subjective reports of perceived social support did not correlate with quantitative evaluation of support as measured by the Arizona Social Support Interview Schedule (t(113)=.16, p=.22). Thus, it is possible that either the social support reported by the mothers in this study was not an accurate measure of support or the support they received did not match their needs.

Conversely, Emmanuel et al.[67] found that mothers who were in relationships of short duration and with low social support scores had the highest "centrality" scores (p<.05). They focused more on their babies as the central point in their lives. This could suggest that these women may be less able to move past preoccupation with their infants or it could mean that they had fewer competing demands for their attention. Perhaps greater maternal-infant interaction, secondary to decreased opportunities for other social relationships translated into better adaptive motor skills for the children in this study.

Table 21. Relationship of Individual Predictors to Fine Motor, Dressing, and Functional Mobility Skill Performance

Category	Variable	Part Correlations		
		Fine Motor Skills	Dressing Skills	Functional Mobility Skills
Biological	Gender	.220*	.137*	.106*
	LOH	-.192*	-.016	-.058*
	GA	-.089*	.031**	.082*
	BW	-.006	.106*	-.051*
Behavioral	ATT	.212*	.161*	.141*
	RES	.143*	.120*	.105*
	SLP	.078*	-.008	.043*
	STH	.035*	-.018	.008
Environmental	OPT	.287*	.213*	.178*
	PSS	-.176*	-.245*	-.178*
	INC	.033**	.108**	-.024
	PCR	.074*	.149*	.096*
	MED	.000	-.199	-.074

*$p<.0005$, **$p=.001$. *The variable with the strongest part correlation in each category is underlined. LOH- length of hospitalization, GA- gestational age .BW- birth weight, ATT- ability to focus, RES – responsivity to auditory and visual stimulation, SLP – absence of sleep disturbances, STH – ability to be soothed, OPT – maternal optimism, PSS – perceived social support, INC – income, PCR- perceived child rearing skills, MED – maternal education*

Table 22. Explained Variance in Adaptive Motor Skills by Biological, Environmental, and Behavioral Variables

Category of Variable	Fine Motor	Dressing	Functional Mobility
Biological	10%	7.1%	3.1%
Environmental	12%	11.6%	6.2%
Behavioral	9%	4.3%	4.2%

BIOLOGICAL VARIABLES

Gender emerged as the biological variable that most strongly predicted each category of the dependent variable, with part correlations as follows: fine motor skill performance (r=.220, $p \leq .0005$), dressing skill performance (r=.137, $p \leq .0005$), and functional mobility skills (r=.106, $p \leq .0005$). This finding is consistent with previous research on populations of children similar to the sample in this study. Male gender has been linked to poor performance on the Bruinink-Oseretsky Test of Motor Proficiency, the Riley Motor Problems Inventory, and the VMI[14,32,34], developmental coordination disorder, and school performance[35] for children with LBW. Whitaker et al.[33] report that poorer performance by males suggests that hormonal differences between the sexes may affect the acute response to brain injury as well as the recovery.

Of interest was the limited predictive ability of gestational age and birth weight on adaptive motor skill performance in this population. The part correlations pointed to a very weak negative correlation of gestational age to fine motor skill performance (r=-.089, $p \leq < .0005$), and weak positive correlations to dressing skill performance (r=.031, p =.001) and functional mobility skills (r=.083, $p \leq .0005$). Birth weight was not significantly correlated with fine motor skill performance and demonstrated a weak negative correlation with functional mobility skills (r=-.051, $p \leq .0005$). Research in this area has produced conflicting results and some researchers have suggested that the relationship of birth weight to motor performance in children without major neurosensory impairments is not a simple one. This study supports this theory.

BEHAVIORAL VARIABLES

The ability to focus as an infant emerged as the strongest predictor of adaptive motor skills. The part correlations were as follows: fine motor skill performance (r =.212, $p \leq .0005$), dressing skills (r =.161, $p \leq .0005$) and functional mobility skills (r =.141, $p \leq .0005$). Other studies report supportive findings but in older age groups of children. Sustained attention in full term, typically developing children at 9 and 24 months was found to predict 40.1% and 51.9% of the variability in goal persistence during moderately challenging problem solving tasks at 24 months of age.[53] Inattention in 30 month old children born prematurely with LBW was found to be predictive of attention deficit hyperactivity disorder and school difficulties at 8 years of age (p=.01) and of the need for special education services by age 8 years (odds ratio of 1.48).[54]

FUTURE RESEARCH

The results of this study can be used to guide early intervention and identification efforts and future research. Maternal optimism may have influenced the caregiver's report of adaptive motor skills for this population of children, suggesting that levels of maternal optimism should be considered when interpreting developmental assessment tools that rely on caregiver report. If on the other hand, maternal optimism did not influence reporting, then interventions to improve maternal optimism should be initiated in the neonatal intensive care units. Maternal optimism should be monitored as part of high risk follow up clinics and early intervention visits. Research into effective methods to improve optimism in this population is warranted as well.

Other areas of research include investigating efficacious interventions to improve infant attention and perhaps more discrete methods to evaluate infant attention in the natural environment. The role of social support on maternal-infant interaction and contact time might also warrant investigation. Male children with LBW warrant close monitoring with intensive efforts to improve adaptive motor skill performance in this population. Perhaps different criterion for risk identification and intervention should be considered for male children born prematurely with LBW.

In conclusion, female gender, maternal optimism at entry to early intervention, and the ability to focus as an infant emerged as the strongest positive predictors while caregiver perception of social support emerged as the strongest negative predictor of adaptive motor skills at kindergarten age in LBW children without neurosensory impairment. Environmental variables as a group explained more of the variance in fine motor, dressing, and functional mobility skills at kindergarten age than either biological or behavioral variables.

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APPENDIX A

ADAPTIVE MOTOR SKILL PERFORMANCE

APPENDIX A

Adaptive Motor Skill Performance

Fine Motor Skills

How well does (he/she): (choices include "doesn't do it at all", "does it but not well", "does it well", "don't know", "refused"

a. Copy a plus sign?
b. Copy a circle?
c. Hold a pencil properly?
d. Copy a square?
e. Print 4 or 5 letters of first name, even if some letters are backwards?
f. Color within the lines of a coloring book?

Dressing Skills

How well does (he/she): (choices include "doesn't do it at all", "does it but not well", "does it well", "don't know", "refused"

a. Pull pants up and down?
b. Button one or more buttons without help?
c. Put on (his/her) shirt or jacket without help?
d. Dress (him/herself) completely without help, except shoelaces?
e. Put shoes on correct feet?
f. Hook and separate zippers?
g. Tie (his/her) shoelaces?

Functional Mobility Skills

How well does (he/she): (choices include “doesn’t do it at all”, “does it but not well”, “does it well”, “don’t know”, “refused”

a. Walk on tiptoes?
b. Walk downstairs alternating feet?
c. Walk upstairs alternating feet?
d. Throw a ball to an adult five feet away?
e. Catch a ball thrown?
f. Hop on one foot?
g. Skip on alternating feet?

APPENDIX B

IRB APPROVAL LETTER

TWU
TEXAS WOMAN'S UNIVERSITY
DENTON DALLAS HOUSTON

Office of Research
6700 Fannin Street
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713-794-2480 Fax 713-794-2488

October 6, 2009

Ms. Mary Swiggum
School of Physical Therapy-K. Mitchell Faculty Adv
6700 Fannin Street
Houston, TX 77030

Dear Ms. Swiggum:

Re: "Predictors of Adaptive Motor Dysfunction in Children with Low Birth Weight at School age"

The above referenced study has been reviewed by the TWU Institutional Review Board (IRB) and was determined to be exempt from further review.

Any changes in the study must receive review and approval prior to implementation unless the change is necessary for the safety of subjects. In addition, you must inform the IRB of adverse events encountered during the study or of any new and significant information that may impact a research participant's safety or willingness to continue in your study.

Sincerely,

John D. Radcliffe

Dr. John Radcliffe, Chair
Institutional Review Board - Houston