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Physiological responses of preterm infants in the neonatal intensive care unit to repeated stressors: moderating effect of skin-to-skin care

Catherine R. Smith

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To the Graduate Council:

I am submitting herewith a dissertation written by Catherine R. Smith entitled "Physiological responses of preterm infants in the neonatal intensive care unit to repeated stressors: moderating effect of skin-to-skin care." I have examined the final electronic copy of 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 Human Ecology.

Connie Steele, Major Professor

We have read this dissertation and recommend its acceptance:

Sharon Judge, Susan Benner

Accepted for the Council:

Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

To the Graduate Council:

I am submitting herewith a dissertation written by Catherine R. Smith entitled "Physiologic Responses of Preterm Infants in the Neonatal Intensive Care Unit: Moderating Effects of Skin-to-Skin Care." I have examined the final copy of 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 Human Ecology.

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Connie Steele, Ed.D., Major Professor

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recommend its acceptance:

Sharon Judge

Accepted for the Council:

Associate Vice Chancellor and
Dean of The Graduate School

PHYSIOLOGICAL RESPONSES OF PRETERM INFANTS IN THE NEONATAL INTENSIVE CARE UNIT TO REPEATED STRESSORS: MODERATING EFFECT OF SKIN-TO-SKIN CARE

A Dissertation
Presented for the
Doctor of Philosophy
Degree
The University of Tennessee, Knoxville

Catherine R. Smith

May, 2000

DEDICATION

This dissertation is dedicated to my husband, Ray,
and to my children, Stephen, Courtney and Kristen.
Without their help and encouragement
this project would never have come to fruition.

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As I reflect on this dissertation process, there are many individuals who deserve special recognition and thanks for their contributions and support. It has been a privilege to work with Dr. Connie Steele, Dr. Mick Nordquist, Dr. Susan Benner, and Dr. Sharon Judge as members of my dissertation committee. I am grateful for the outstanding guidance and reflective critique of Dr. Steele, the committee chair, beginning from the earliest days of my matriculation in the doctoral program and continuing through the submission of the final edited version of this dissertation. Doctors Nordquist, Benner and Judge each contributed significant content expertise in the areas of family systems and the theoretical perspectives undergirding research focusing on family-centered care practices.

I am extremely grateful to the parents who agreed to enroll their infants in the study and who were willing to participate in the Skin-to-Skin intervention sessions. Without their cooperation, this dissertation could not have been conducted. The financial support provided by the Ronald McDonald House charity and the 1999 AWHONN Johnson & Johnson Marshall Klaus Mother/Baby investigator award helped underwrite the cost of the laboratory analyses required by this research.

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ABSTRACT

Technological advances in neonatal care have resulted in a dramatic rise in the survival rate of premature infants. However, knowledge is limited regarding the preterm infant's stress reactivity and the most effective methods to reduce the stress response. This research was designed to investigate stress reactivity in preterm infants and to determine the effect of the intervention strategy of Skin-to-Skin Care (SSC) on the stress response.

Twelve preterm infants meeting eligibility criteria established by the approved guideline for SSC in a level III neonatal intensive care unit (NICU) participated in this study. The cardiopulmonary parameters of heart rate, blood pressure, and respiratory rate were monitored. Adrenocortical responses were determined by changes in levels of concentration of salivary cortisol. Stress reactivity was determined by changes in cardiopulmonary parameters and adrenocortical responses to an invasive stressor, defined in this study as a routine heelstick procedure.

Stress reactivity was evaluated under the following test conditions: baseline measures of dependent variables in bed, SSC without invasive stressor, invasive stressor in bed, and invasive stressor in SSC.

Changes in the values of the cardiopulmonary parameters and salivary cortisol concentration levels indicated that the preterm infants regulated their responses to aversive stressors differently when they were in SSC than when they were not in SSC. The differences found under these test conditions supported the research hypotheses that providing organizing postural support during SSC reduces stress reactivity in preterm infants in the NICU as reflected by changes in adrenocortical function. Significant changes in cardiopulmonary measures were not demonstrated.

The results of this study improved understanding of the mechanism undergirding the process of co-regulation. The clinical implications provide valuable information for medical professionals challenged to implement care in the NICU in a way that reduces destabilizing stress responses of premature infants to the repeated intrinsic and extrinsic stressors experienced during the hospitalization period following a premature birth.

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CHAPTER 1

INTRODUCTION

Modern technological advancements have resulted in a dramatic rise in the survival rate of premature infants. However, modern science still has much to learn to enable the normal growth and development process to continue undamaged when the prenatal course is interrupted by a premature birth. In a full term pregnancy, the interplay of intrauterine sensory information and experience function in a continuum to prepare a fetus with behavioral capacities that enable the full term newborn to integrate environmental stimuli in a stable, developmentally appropriate manner (Brazelton, 1984). Als (1986) contended that a mismatch of brain expectancy and environmental input exists when an infant is born prematurely, and this places the infant at increased risk for developmental compromise. Research has verified that optimal behavioral adaptability enhances physiological stability (Brazelton, 1984). It is therefore incumbent upon the medical professional to pay careful attention to the identification and modification of stress producing care routines if they are demonstrated to disrupt that stability. Professionals must strive to identify and implement care in a way that enhances stability and competence in this fragile population.

The premature infant is at great risk for becoming stressed by environmental inputs due to neurological immaturity and physiological instability (Glass, 1994; Gonsalves & Mercer, 1993; Gorski, 1985; Gorski Hole, Leonard & Martin, 1993; Peters, 1996). Unless modified, the caregiving practices essential to maintain life in the prematurely born infant are often stressful or painful procedures that produce adverse physiological or behavioral reactions (Catlett & Davis, 1990; Craig & Grannau, 1993; Gunnar, 1989; Johnston, Stevens, Craig & Grannau, 1993; Peters, 1998; Stevens & Johnston, 1994). This raises difficult issues regarding the efficacy of current routine caregiving practices in the neonatal intensive care unit (NICU).

In order to evaluate critically current medical caregiving practices in the NICU, there is a need to improve the current level of understanding about the moderating effects of co-regulatory intervention strategies on physiologic responses of preterm infants to repeated stressors. Research confirms that providing individualized developmental support for premature infants during the hospitalization period improves short-term and long-term medical and developmental outcomes (Als, 1988; Als, Lawhorn, Brown, Gibes, Duffy, McAnulty & Blickman, 1985; Als, Lawhorn, Duffy, McAnulty, Gibes-Grossman & Blickman, 1994; Becker, Grunwald, Morman & Stuhr, 1993). The importance of designing care plans that administer medical procedures in a manner that buffers premature infants' stress reactivity to painful stimuli is recognized (Als & Gilkerson, 1997; Gilkerson, 1990; Gilkerson, Gorski & Panitz, 1990). Carefully applied postural support has been shown to enhance the infant's ability to organize motor responses and promote autonomic stability (Anderson, 1991; Fay, 1988; Heriza & Sweeney, 1990; Stap, Overbach, Reinhart, Beaton, Knowles, Nelson & Jackson, 1991). However, the moderating effect of SSC intervention on infant stress reactivity, when parents provide co-regulatory organizing postural support for their infants, has not been examined.

Rationale for the Study

Parents are recognized as important members of the NICU caregiving team. However, providing opportunities that optimize the family's potential to help buffer the preterm infant's reactivity to repeated stressors experienced during the hospitalization period presents many challenges for the medical professional.

A current challenge in the medical arena involves effective integration of the family into the high-tech medical environment of the NICU in order to optimize the developmental support being provided for hospitalized preterm infants. The influence of the family on the process of human development is currently under renewed investigation in the bio-social sciences. The bi-directional nature of human development has been a primary focus of research in the field of child and family studies for many years. The concept of parent/infant co-regulation that has emerged in the literature from this area of investigation has been postulated as a theoretical framework undergirding the social nature of human infant/parent interaction. Many authors consider the process of parent/infant co-regulation central to the understanding and support of the relationship between the infant and family in the NICU (Als & Gilkerson, 1995; Gilkerson, 1990). Further, incorporating co-regulatory principles in caregiving practices in the NICU is postulated to effect positively both short-term and long-term medical and psychosocial outcomes for the infants (Fleisher, VandenBerg, Constantinou, Heller, Benitz, Johnson, Rosenthal & Stevenson, 1995; Field, 1978; Field, 1990; Field, Schanberg & Scafidi, 1986; Greenberg & Crnic, 1988).

Co-regulation has been described as a neurobiological process that supports the naturally occurring expectation of nurture in human infants and their parents. Increasingly, research suggests that both premature infants and their families experience a stabilizing, calming effect when co-regulatory processes are acknowledged and incorporated in caregiving procedures in the NICU (Affonso, Bosque, Wahlberg & Brady, 1993; Affonso, Wahlberg & Persson, 1989; Anderson, 1989; Harrison, Olivet, Cunningham, Bodin & Hicks, 1996; Kurihara, Chiba & Shimmizu, 1996). The reasons for these benefits, however, and the mechanisms by which co-regulatory processes occur are poorly understood. Limited research has been identified that investigates biophysiologic responses that reflect parent/infant co-regulatory mechanisms during stressful procedures. Additional research examining the physiologic effects of caregiving procedures that support co-regulation is needed to improve the understanding of the medical community about co-regulatory processes in infancy.

Multiple researchers have found that infants demonstrate stable vital signs such as heart rate (HR), respiration rate (RR), oxygen saturation (SpO_2) and thermoregulation during skin-to-skin care (Anderson, 1991; Anderson, Marks & Wahlberg, 1986; Bauer, Uhrig, Sperling, Pasel, Wieland & Versmold, 1997; Fardig, 1980; Ludington-Hoe, Hadeed & Anderson, 1991). Skin-to-skin care

(SSC) is a method of holding premature or ill infants in the NICU that potentially provides opportunity for co-regulation to occur. SSC involves parents holding their infants on their chests in a vertical position. The infant wears only a diaper, and is covered by the parent's shirt or gown. The nurturing process of holding the infant in direct skin contact has been reported to be a calming experience for parents (Affonso, Wahlberg, Persson, 1989; Drozten-Brooks, 1993; Victor & Persoon, 1994; Sagmeister, 1990). Current research suggests that SSC is an intervention that promotes co-regulation between the infant and parent. However, studies published to date have not investigated whether infants receiving co-regulatory postural support during SSC regulate their responses to painful procedures in the NICU differently from infants not receiving SSC.

Purpose of the Study

The objective of this research project was to determine whether or not a difference existed in the stress reactivity of preterm infants when they experienced an invasive stressor while being held by a parent in SSC compared with their responses when they experienced the same stressor while in bed. Heart rate (HR), pulse, respiration rate (RR), and oxygen saturation (SpO_2) were measured to evaluate cardiopulmonary responses to interventions. Salivary cortisol was the measure used to evaluate the response of the adrenocortical system to the interventions applied. The infants' responses were compared when heelsticks were performed while the infants were in their beds with their responses when identical procedures were performed while the infants were held in SSC. This research added to the current knowledge about the benefits of applying relatively simple co-regulatory interventions, such as providing organizing postural support for premature infants during SSC, as a means of reducing stress reactivity of premature infants to painful procedures in the NICU was increased. The results of the study demonstrated that SSC intervention did not increase stress reactivity, defined by this study as a significant change in salivary cortisol levels, HR, RR or SpO_2, and successfully moderated the adrenocortical response to heelstick in the infants as measured by change in salivary cortisol levels. These findings reinforced the value of incorporating co-regulatory caregiving procedures that parents can provide for their infants into NICU care plans.

Operational Definitions

Adaptive response: The physiologic mechanism whereby an organism regains internal homeostatic balance in response to an intrinsic or extrinsic stressor event .

Co-regulation: A concept based on an evolutionary, theoretical framework of a bi-directional, neurobiological basis for the social nature of human interaction that supports the naturally occurring expectation of nurture between infants and their parents.

Developmentally Supportive Care: An approach to implementing care for preterm infants in the NICU that views infants as active collaborators in their own care, determinedly striving to continue their normal developmental trajectory. In this approach, members of the caregiving team are regarded as co-regulators who seek to infer from the infant's own behavior the capacities and strategies the infant accesses to accomplish his or her developmental goals. These developmental goals are then incorporated into caregiving plans designed to facilitate the infant's overall development and neurobehavioral organization in the face of necessary medical and nursing interventions.

Gestational Age: Duration of the pregnancy, calculated from the date of the last menstrual period as determined by score at birth on the Dubowitz maturity rating scale.

Habituation: The protective mechanism by which the infant decreases responsivity to external stimuli.

Post-conceptual Age: The developmental or gestational age of the infant since conception, measured in weeks.

Post-natal Age: The chronological age of the infant since birth, measured in days.

Preonate: This term refers to the infant in-utero during the three stages of development (zygote, embryo, fetus) from conception to birth.

Stressor event: Any event that produces a nonspecific response of the body to external demands that acts to mobilize the general adaptive system of the organism.

Stress reactivity: The physiologic response of the body to stressor events.

Assumptions

This study makes the following assumptions:

1. The measurement instruments are reliable and valid means of determining changes in stress reactivity in preterm infants as reflected in the adrenocortical and cardiopulmonary systems.
2. Preterm infants demonstrate predictable adrenocortical and cardiopulmonary responses to repeated stressor events experienced during the NICU hospitalization period.
3. Changes in physiological measures of salivary cortisol, heart rate, respiration rate, and transcutaneous oxygen saturation levels accurately reflect stress reactivity in preterm infants.
4. A heelstick procedure constitutes a stressor event for preterm infants in the NICU.
5. SSC is a non-stressful intervention for preterm infants in the NICU.
6. Hospitalized preterm infants are at increased risk for exhibiting autonomic instability in response to invasive stressors in the NICU—i.e. heelstick blood draw—due to the immaturity of their body systems.
7. Human development is a bi-directional process.

Hypotheses

H_1: Preterm infants exposed to heelsticks while being held by their mothers in SSC will demonstrate less change in mean salivary cortisol levels than when exposed to heelsticks while swaddled in bed.

H_2: Preterm infants exposed to heelsticks while being held by their mothers in SSC will demonstrate less change in mean heart rate, pulse, respiratory rate, and SpO_2 than when exposed to heelsticks while swaddled in bed.

H_3 : Preterm neonates exposed to SSC holding by their mothers will demonstrate no significant change in mean salivary cortisol levels compared with baseline mean salivary cortisol levels while swaddled in bed.

H_4 : Preterm infants exposed to SSC holding by their mothers will demonstrate no significant change in mean heart rate, pulse, respiratory rate, or SpO_2 compared with baseline measures of mean heart rate, respiratory rate, or SpO_2 while swaddled in bed.

H_5 : There will be a direct relationship between salivary cortisol and HR, pulse, and RR., and an indirect relationship between salivary cortisol levels and SpO_2. As salivary cortisol levels increase, heart rate, pulse, and respiratory rate will rise, and SpO_2 values will drop.

CHAPTER II

REVIEW OF THE LITERATURE

The review of literature presents a discussion of the theoretical bases of this study, including Sameroff and Chandler's transactional theory of development (1975), Bronfenbrenner's ecological theory (1977) and family systems theory (Bowen, 1978; Minunchin, 1988). Also contained in this chapter is a comprehensive review of research studies and publications dealing with medical and behavioral outcomes of prematurity. Issues involved in applying principles of family centered care in the NICU are discussed. Critical factors influencing neonatal stress reactivity and its impact on preterm infants are examined along with medical and neurobehavioral outcomes of infants who receive developmentally supportive care in the NICU. A review of the mechanism of the function of the adrenocortical system is presented. The findings of research examining the cardiopulmonary and adrenocortical effects of skin-to-skin care and procedural stressors such as the heelstick are reviewed.

Theoretical Framework

Three major theoretical perspectives are particularly relevant when applying the family-centered-care model of intervention in the NICU setting. Family-centered early intervention embraces the theoretical framework of the transactional and the ecological models of human development, as well as the systems theory of family functioning. First, the transactional model presents the mutual effects of child and parents on one another (Sameroff & Chandler, 1975; Horowitz, 1992). Second, the family systems model stresses the importance of interconnectedness among family system units (Bowen, 1978; Minuchin, 1974; 1988). Third, Bronfenbrenner 's socio-ecological theory (1977;1986) combined with Bronfenbrenner and Ceci's (1994) bioecological perspective on human development expands the parent-infant relationship to include the larger social context of the family.

Each of these theoretical frameworks contributes a unique, yet complementary perspective on infant development that enhances the researchers' understanding of how to implement developmentally supportive care in the NICU environment. Explicit in each of these three theoretical concepts is the consensus that family functioning interacts with environment and influences child development. Taken together, they provide a more focused view of the complex system of the family and highlight the importance of taking into account the relationship between the developing human being and the setting and contexts around that individual when designing optimal developmental support programs for medically fragile infants.

Transactional Theory of Human Development

The philosophy of family-centered early intervention in the NICU is consistent with current theories of infant development and family functioning. Sameroff and Chandler (1975) proposed a transactional model as the most appropriate for understanding developmental outcome. The transactional model is, in effect, a systems perspective developed because previous linear cause and effect explanations for developmental problems were felt to be inadequate (Sameroff & Chandler, 1975). The transactional model for explaining individual differences in developmental outcomes takes into account the changing nature of the developing child and, simultaneously, the constantly altering environment in which the child grows.

Transactional theory acknowledges the constantly changing and complex nature of the reciprocal, or bi-directional, interactions of children within their environment. This explanation of developmental progression and change attempted to capture the whole system rather than focusing merely on individual parts (Sameroff & Chandler, 1975). Horowitz (1992) reexamined the concept of risk associated with prematurity using the transactional model and concluded that "much of the [*individual*] variance is tied up in transactional dynamics that result in some children overcoming the risk factors and showing good or excellent development, while others succumb to lower levels of developmental achievements" (p. 66). She contends that development is neither essentially continuous or discontinuous, but rather, becomes contingent upon the interaction between behavioral domains, developmental period, and to the matrix of organism/environment conditions that are relevant to the behavioral domain at a particular period in developmental time (Horowitz, 1992).

Transactional theory recognizes the balancing nature and self-righting principles of adaptation of all organisms within a system. Co-regulation is a central concept developed by Sameroff and Chandler (1975) to explain the self-righting principle, and it is foundational to understanding the reciprocal nature of the parent/child relationship. Co-regulation is based on an evolutionary, theoretical framework that describes a neurobiological foundation for the social nature of human development. In their seminal work describing the transactional model of development, Sameroff and Chandler (1975) suggested that a supportive parent-infant relationship may minimize the effects of early biological risk factors, while a deprived or stressed care-giving environment may exacerbate problems in development. The co-regulatory framework undergirds the current understanding and support of the relationship between the infant and family in the NICU. The concept of co-regulation is, therefore, central to developmental care in the NICU (Als, 1986; Gilkerson & Als, 1995).

Ecological Theory of Human Development

Bronfenbrenner's theory of the ecology of human development expands the parent-infant relationship to include the larger social context of the family (Bronfenbrenner, 1977). Bronfenbrenner's ecological model of human development has played a prominent role in developmental psychology for over three decades, and has transformed the way many researchers approach the study of human beings and their environments. The transdisciplinary appeal of the ecological perspective of human development has resulted in a profound dissemination of the ecological theoretical framework to social and behavioral scientists throughout the social science disciplines. It has been applied across many disciplines, and is consistently cited in the literature from the field of family-centered care research.

Bronfenbrenner's ecological perspective encompassed a lifespan approach to the study of human development. Distinctive for his focus on the formative nature of interactions between individuals and the social/physical setting of their external world, he placed a strong emphasis on the interrelationship between theory and research (Bronfenbrenner, 1979c; 1980; 1984).

Ecological theory focused on the interaction effects of numerous biological, psychological, social, cultural, and economic variables. To understand human development, Bronfenbrenner argued that researchers had to extend beyond directly observable or measurable behaviors involving one or two people in a laboratory setting to include multi-person systems of interaction. If human behavior was to be studied accurately, Bronfenbrenner contended that researchers must determine how different expectations, pressures, demands and experiences influence the individual as defined within the context of home, family, friends, neighbors, work or peer group and the community at large. Drawing heavily from the Gestalt theorists of the early 20th century, social historical evolution theory, symbolic interactionism and Piaget's work on cognitive development, Bronfenbrenner's theory supported a holistic view of behaviorism (Bronfenbrenner, 1979 b; Bronfenbrenner & Mahoney, 1975).

The conceptual model, developed to reflect the interrelated network of ecological influences, describes four major levels or systems that constitute nested dynamic structures. Presented as a hierarchical arrangement, the ecological environment is conceived as a "set of nested structures, each inside the next, like a set of Russian dolls" (Bronfenbrenner, 1979 c; 1986). Including both proximal and distal processes of interaction, the levels defined by Bronfenbrenner were: (a) microsystem of individuals with whom a person has direct contact, such as family members, friends, co-workers, and professional; (b) mesosystem of related groups of people that the person is not a member of, but that directly affect the person, such as sibling subsystems that affect parental functioning, and supervisors who influence the course of family processes without being directly involved with the child; (c) exosystem of bureaucratic structures that have an impact on groups without the knowledge of the specific individuals affected—e.g., legislative bodies that make funding decisions, administrators who affect individuals and institutions through values, traditions, and role expectations; and (d) macrosystem of ethnic and cultural belief systems that help design the social structures and activities occurring at lower, more concrete levels (Muuss, 1996).

Three important features contributed to this conceptual model that have influenced the development of research applications. First, the model is dynamic; all systems are adjusting all the time to both internal and external influences.

Second, it is interactive; each person not only is influenced by the systems of which he or she is a member, but also influences the systems in return. Third, the systems are highly interconnected both vertically (micro- to macrosystems), and horizontally (members of one microsystem are members of other microsystems).

Early research efforts designed to apply this model to an understanding of human development suggested that although effective intervention efforts —often construed as linear, unidirectional input that families accept or resist—are in reality far more dynamic and complex processes. Evolutionary changes occurred in the ecological framework in response to these early findings that are significant when considering the application of ecological theory to family-centered care in the NICU. Bronfenbrenner's early theoretical work focused on the developing person, the environment, and the evolving interaction between the person and the environment. His later work, published in 1986, expanded to include a family focus—specifically that external influences affect the capacity of families to foster the healthy development of their children (Bronfenbrenner, 1979 b; 1986; Bronfenbrenner & Mahoney, 1975).

Ecological theory is based on the children's interpretations of their surroundings. Bronfenbrenner described the need for every child to have a "strong and 'irrational' attachment" as a crucial component of human development; all children need someone to be "crazy" about them. This focus on the value of an individual's intrinsic strengths has been used extensively in the family-centered-care movement, as professionals in the field of early intervention sought to support families more effectively by acknowledging and enhancing inherent strengths and abilities, and has significant application in the NICU setting (Dunst, Trivette & Deal, 1994).

Acknowledging the importance of studying developmental tasks and problems as they actually operate in the lives of children reflected a paramount objective of research designed to validate Bronfenbrenner's theoretical framework. He argued that "the properties of the environmental context in which research is carried out influence the processes that take place within that context and thereby affect the interpretation and generalizability of the research findings"(Bronfenbrenner, 1977, p. 516). The implications of this concept for the NICU environment are noteworthy as environmental issues have been clearly demonstrated to impact both short-term and long-term outcome of premature survivors.

Methodological issues addressed by the ecological model are also of interest to the researchers seeking to identify the most effective research design to examine the efficacy of family-centered developmental care in the NICU. Bronfenbrenner suggested that research designed from an ecological perspective must vary simultaneously along the dimensions of external system structure and intrafamilial processes as influenced by the environment. The direct implication of these findings for the NICU setting is that research that is multidimensional in nature may more accurately reflect changes in the outcomes being measured.

Of particular interest to the family-centered researcher in the NICU is Bronfenbrenner & Ceci's modified bioecological model of human development. Proposed in 1994, the bioecological model expands our understanding of the bi-directional mechanism of interaction between intrinsic genetic factors and extrinsic environmental factors. The bioecological model reconceptualizes the nature-nurture controversy in a developmental perspective. It seeks to answer one of the most fundamental biological questions, which is to identify the mechanism whereby genetic genotypes are transformed into phenotypes. This model extends and redefines several of the key assumptions underlying the classical paradigm of behavioral genetics by incorporating explicit measures of the environment conceptualized in systems terms, while at the same time allowing for non-additive, synergistic effects in genetics-environment interaction. The model posits empirically assessable mechanisms, called proximal processes, through which genetic potentials for effective psychological functioning are actualized.

The cardinal theoretical principle undergirding the bioecological framework is the acknowledgment that genetic material does not produce finished traits, but rather interacts with environmental experience in determining developmental outcomes. The concept of presumptive neural tissue, which refers to the ability of early transplanted embryological tissue to be altered in its ultimate effect by placing it in a new location in a host embryo, reinforces the fully integrative nature of structural neural development.

The most important functional implication of bioecological theory when examining family-centered care in the NICU is the concept that all human developmental processes are bi-directional in nature. Individual neural substrate is transformed as external processes are internalized and internal processes are externalized throughout the life span (Bronfenbrenner & Ceci, 1994). In the bioecological model of development, the ultimate phenotypic complement of an individual is not caused by passive transference of genotypic potential into phenotypic expression, but results instead from an active interactive process between the organism and the environment. Bronfenbrenner and Ceci (1994) stated that "the realization of human potentials requires intervening mechanisms that connect the inner with the outer in a two-way process that occurs not instantly, but over time" (p. 572).

Three principal concepts are postulated in this model that apply when examining the efficacy of family-centered-care in the NICU. These concepts are as follows: (1) Proximal processes raise levels of effective developmental functioning, and thereby increase the proportion of individuals' differences attributable to actualized genetic potential for such outcomes such that phenotypic expression will be more likely when proximal processes are strong and less likely when proximal processes are weak; (2) Proximal processes actualize genetic potentials both for enhancing functional competence and for reducing degrees of dysfunction. (3) If persons are exposed over extended periods of time to settings that provide developmental resources and encourage engagement in proximal processes to a degree not experienced in the other settings in their lives, then the power of proximal processes to actualize genetic potentials for developmental competence will be enhanced (Bronfenbrenner & Ceci, 1994).

Operationally, the authors contended that as the level of proximal process is increased, indexes of competence will rise, those of dysfunction will fall, and the likelihood of phenotypic expression will become greater in both instances. The power of proximal processes to actualize genetic potentials for developmental competence (as assessed by an increase in phenotypic expression of genetic endowment) will be greater in advantaged and stable environments than in those that are disadvantaged and disorganized. The power of proximal processes to buffer genetic potentials for developmental dysfunction will be greater in disadvantaged and disorganized environments than in those that are advantaged and stable. Skin-to-skin interventions and heelstick procedures in the NICU would constitute examples of proximal processes for hospitalized premature infants, as defined by Bronfenbrenner and Ceci (1994). The bioecological model complements recent research in neuroplasticity, and may well become a foundational theory of neurobehavioral research in the next decade. The importance of a multidisciplinary biosocial approach to the study of human development is being validated through ongoing research efforts (Bronfenbrenner & Ceci, 1994; Horowitz, 1992; Lenn, 1991; Plomin & Neiderhiser, 1992; Troost & Filsinger, 1993).

Family Systems Theory

Family systems theory offers yet another rich framework for understanding and working with families during their stay in the NICU. Both the transactional and ecological models are consistent with the family-systems theory, which views individual and family functioning as an interactional dynamic process (Becvar & Becvar, 1988).

With its broad socio-ecological basis, family-systems theory provides the wide-angle lens needed to see the pattern and understand the rules of the family system. This theory is as much a way of thinking as it is a set of concepts or specific techniques. Briefly stated, a family-systems approach applies general systems constructs such as pattern, organization, hierarchy and function to understanding the behavior of families (Minuchin, 1988). Family systems theorists assume that all families follow the laws of social systems and that there is regularity and predictability to family behavior; they assume that the family operates as a system—that is, a set of units that interrelate (Bowen, 1978; Minunchin, 1988). The "unit" in a family system is one or more family members who have a certain role, such as the father or the daughter. Each role has a set of tasks in the family even though the set differs with stages in the family life cycle.

Rather than focusing on pathology or dysfunction, this theoretical perspective tends to highlight the positive and adaptively creative qualities of families. Problems in behavior, emotional symptoms, and dysfunctional symptoms are understood as attempts to cope (though perhaps poorly) with the changes and stresses that individual and family development bring. When this wide-angle lens brings the context of the individual into sharper focus, different meanings become possible. Knowledge about different relationships in a family permits one to understand the behavior of an individual differently. For example, the overprotection of a mother toward her child might be understood as a response to other relationships in her life, possible balancing of a painful emotional distance with her partner. This understanding of the mother's behavior opens the door for new intervention alternatives (Freedman, Kaplan & Sadock, 1975; Nochi, 1996).

In addition to offering a model for understanding families and for problem solving with families, systems theory can help professionals better identify their personal patterns and professional assumptions in context. Used in this context, the systems framework becomes a tool to assist professional team members in understanding their own interpersonal processes and how they affect the individual's work with fellow staff members and clients.

The way family systems theory has been applied in the field of special education may assist professionals working in the NICU environment to understand the responses of both the medically fragile infant and his/her family to developmental care strategies. Programs that take into account the family-systems perspective in their program design have demonstrated positive ability to reach consensus with families regarding intervention goals, and improved ability to provide intervention that is meaningful to the family (Berger & Foster, 1986;

Dillard, Auerbach & Showalter, 1980; Ladmer, 1994; Mahoney & O'Sullivan, 1990). Some of the studies suggest that during portions of the developmental family life cycle, family dynamics and functioning in families caring for children with disabilities are similar to those of families caring for children with no disabilities. Differences appear to be related to multiple factors such as: the child's responsiveness to the caregiver and caregiving environment; the family's ability to cope with needs of the child with developmental disabilities and his/her siblings; the extent to which cultural expectations and child rearing practices conflict with, or support, the child's needs and professional interaction; and the availability of support networks for the caregivers, including the parents' support of one another—as reflected in the quality of their marital relationship (Breslau & Prabucci, 1987; Clark, 1984; Goldberg & Esterbrooks, 1984; Parke & Tinsley, 1987; Sabbeth & Leventhal, 1984; Trivette, Dunst, Allen & Wall, 1993). The dynamic nature of the interaction of these factors with the caregiving environment is further demonstrated by differences that have been shown to exist within subgroup populations of families of children with specific disabilities, and even within the same family at different times of the family's life cycle (Carter & McGoldrick, 1980; Kazak, 1989; Knobloch & Pasamanick, 1980).

Infant Stressors in the NICU

The intrinsic and extrinsic risk factors associated with prematurity produce bioecological challenges that impact all domains of development. Intrinsic risk factors stem from the biophysical compromise resulting from the degree of neurological immaturity and the accompanying physiological instability associated with the infant's young gestational age. Extrinsic risk factors include bioecological challenges resulting from altered sensory and social input to the preterm infant in an extrauterine environment.

The birth process normally occurs between two periods of growth and development: the fetal developmental period and the postnatal developmental period. The healthy term infant undergoes an orderly transition between these two periods allowing the growth process to continue virtually undisturbed. But when a precipitous premature delivery interrupts the gestational period of development, an internal discrepancy is created between the readiness of the systems that are called to begin functioning and the demands placed upon them. Fetal organ systems that are structured to be protected, shielded and facilitated by the mother's body are required to act prematurely on their own (Gorski, 1985; Harrison, 1983).

The younger the infant, the less mature and fragile are the body systems that have been called on to function prematurely. The intrinsic and extrinsic risk factors associated with a premature delivery are reflected in adverse responses of the preterm infant to caregiving procedures that have been shown to be associated with increased morbidity in both medical and neurobehavioral outcomes.

Research has identified a common medical sequelae of prematurity that confirms a constellation of medical problems frequently identified in premature survivors. These include increased oxygen support demands leading to chronic lung disease, increased incidence of interventricular hemorrhage and increased incidence of iatrogenic complications such as necrotizing entercholitis and nursery acquired deformities. Approximately 70% of infants with birth weight less than 1000 grams (gms) require mechanical ventilatory assistance. Within this extremely low birth weight (ELBW) population, as many as 70% of the infants who require respiratory support develop chronic lung disease (bronchopulmonary dysplasia). In addition to pulmonary sequelae, infants requiring assisted ventilation have the highest incidence (about 45%) of neurologic deficit and developmental delay. Respiratory and developmental outcomes are among the most costly consequences of prematurity both during the course of hospitalization as well as during long-term follow up after discharge (Dusick, 1997).

The premature infant is also at great risk for becoming stressed by extrinsic factors arising from the altered sensory input created by the extrauterine environment. Unless modified, the caregiving practices essential to maintain life in preterm infants often are stressful and painful procedures that produce adverse physiological or behavioral reactions. Numerous studies confirm that diffuse sleep states, crying, supine positioning, excessive handling, ambient noise, lack of opportunity for nonnutritive sucking, and poorly timed social and caregiving interactions can greatly influence the arterial oxygen saturation of the preterm infant. These issues are especially problematic for the infant with respiratory disease (Fritzhardinge, Pape & Aistikartes, 1976; Hanson & Olken, 1979; Martin & Okken, 1979; and Teberg, 1980). Physiologic stress increases the inspired 0_2

requirement of the infant. Als (1986) contended that high levels of inspired 0_2 may contribute to the development of chronic lung disease in the preterm infant.

Gorski, Hole, Leonard & Martin (1993) used direct computer recording of changes in behavior, color, oxygen level, heart rate and respiratory rate to record the responses of preterm infants following two seemingly contrasted caregiver routines: chest percussion and close social interaction. Microanalytic data analysis technique was utilized to determine if the probability of the onset of a particular stress behavior is significantly greater following some caregiver behavior than the baseline probability that the behavior would occur whether or not preceded by the manipulation. The results showed that subtle as well as gross distress signs occurred with significant frequency within five minutes following both procedures when compared with the baseline incidence of distress episodes. Interpretation of the findings suggest that timing of interventions is as consequential as content towards safeguarding autonomic regulation in the preterm infant.

In a subsequent report on 37 days of observation of 18 preterm infants in the NICU born between 28 and 34 weeks gestation, Gorski, Huntington and Lewkowicz (1990) found apnea, bradycardia and hypoxia often followed routine caregiving procedures such as taking vital signs, diapering, feeding, and suctioning. These events have been shown to trigger associated changes in cerebral blood flow, intracranial pressure, cerebral oxygen levels and carbon dioxide tension. Changes in these physiologic parameters have been reported to increase the risk for postnatal intraventricular hemorrhage or infarction.

Pohlman and Beardslee (1988) conducted a descriptive study to determine the number of direct contacts an infant typically experiences during the day in the NICU. They found the highest number of contacts was moderately intrusive with relatively few comforting touch contacts administered. In a similar study, Catlett & Holditch-Davis (1990) observed premature infants' responses before and after caregiving events to determine the physiological effects of environmental stimulation. They found that behavioral changes precede and consistently predict rapid physiological deterioration. Frequent interventions can result in sleep deprivation, thereby intensifying the neonate's stress. Rapid decreases in oxygenation as measured by transcutaneous oxygen monitors were seen following a variety of procedures, especially suctioning, with recovery from hypoxic state prolonged if multiple procedures were performed together. Comparable results were reported by Field (1990) where suctioning was found to be the most aversive of the nursing procedures observed, requiring as much as 20 minutes recovery time to return to pre-intervention baseline. In contrast, Bada, Korones, Perry, Arheart, Pourcyrous, Ruyan, Anderson, Magill, Fitch and Somes (1990) reported no significant increased risk for grades two to four periventricular or intraventricular hemorrhage for very low birthweight hospitalized infants when comparing subjects exposed to standard and reduced manipulation protocols.

Another question impacting intrinsic risk factors addressed extensively in the literature is whether or not mild perinatal and early postnatal neurological insults produce lasting effects. One major school of thought in the neurobiological literature suggests that a person never really recovers from a perinatal insult, but rather adapts and reorganizes to compensate for the injury. The concept of a continuum of perinatal casualty is proposed whereby insults to the central nervous system occurring during the prenatal or perinatal period continue to produce significant influences on development throughout the life span of the individual (Duffy, Mower, Jensen & Als, 1994; Gunnar & Barr, 1998; Kitchen, 1986). These authors pointed to the high incidence of minor neuromotor sequelae found during follow-up exams performed at eight to nine years of age, especially of the very small preterm infants. Acknowledging that compensatory accommodation occurs, authors subscribing to the concept of continuum of perinatal casualty suggest that the original insult is maintained and reflected in more subtle processes, such as learning disabilities and sensory motor integration dysfunction (McCormick, 1989). Given the rapid development of the brain from the 26th to the 40th week of fetal life and the emergence and the differentiation especially of association cortical areas in this period, this profound impact resulting from a biologically, ontogenetically unexpected experience should not be surprising (Bellig, 1989). Pape and Wigglesworth (1979) surmised that in many ways, there are greater differences between the brain of a 28-week infant and that of a 36-week infant than there are between the brain of a three-month old baby and an adult. They contend such fragility cannot undergo severe repeated neurological stress and emerge completely unscathed.

Numerous articles were identified in the literature that examined other extrinsic factors influencing the bioecological developmental processes for the fetus prematurely extracted from the womb by precipitous birth (Becker, Grunwald, Morman & Stuhr, 1993; Beckwith & Cohen, 1984; Dusick, 1997; Glass, 1994; Gottfried, Hodgman & Brown, 1984; Gunnar, Porter, Wolf, Rigatuso & Larson, 1995; Heriza & Sweeney, 1990; Peters, 1996). Overwhelmingly, the findings demonstrated that an inappropriately stimulating, overwhelming postnatal environment retards the continuum of the developmental process. Examples of additional bioecological risk factors that were found to contribute substantially to acquired nursery dysfunction are light, noise, and inadequate positioning support of the infant. The incidence of sensorineural hearing impairment is 13% in very low birth weight infants as compared to 2% incidence among all newborns (Thomas, 1989). The American Academy of Otolaryngolgy's Committee on Conservation of Hearing designates 80 decibels [dB] as the maximum sound intensity below which no sensorineural hearing loss occurs in adults. EPA standards further lower the value to 7O dB. No such threshold was found in the literature for premature infants, though most researchers speculated that the level would be considerably lower (at least 60 dB) due to immaturity of the auditory structures. An average home nursery measures 40 dB, which is 1 / 100 the sound energy identified in the incubator (Kellmon, 1982).

Long and Phillip (1989) determined that most high amplitude deflections (70 to 75 dB) were associated with various activities of the staff such as closing doors, trash removal, laughter, and cross unit conversations. Polygraph recording of infants, including sound levels, showed a drop in transcutaneous oxygen saturation levels (SpO_2) followed by a rise in intracranial pressure, heart rate and respiratory rate following sudden loud noises. Nursery acquired positional malformations are seen all too often in NICU graduates. Orthopedic complications including soft tissue contractures and skeletal malalignment have been associated with prolonged immobilization and gravitational effects on the global hypotonia of the premature infant.

Responses of Premature Infants to NICU Procedures

Cardiopulmonary Responses to Stressors in Preterm Infants

Physiological responses to invasive stressors that have been investigated in the term neonate include heart rate, respiratory rate, blood pressure, endocrine reaction and oxygen saturation. Beaver (1987) compared the responses of eight preterm infants to touch and a painful stimulus with each participant serving as his/her own control. Methodological problems, such as reduced environmental control and inconsistent use of measures, cloud the findings of this study. When the percentage of change from the mean was reported for heart rate, oxygen saturation and blood pressure, this researcher concluded that excessive stimulation, whether it is painful or benign, could be stressful for a preterm infant.

Macintosh, VanVeen and Brameyer (1993) investigated the response of 35 premature infants to heelstick stressor by documenting variability in heart rate, respiratory rate, and oxygen and carbon dioxide concentrations in the blood. The subjects in this study were between 26 and 34 weeks gestation, and many were in critical condition, still requiring ventilatory support. Treatments consisted of a heelstick and a "dummy" treatment where the procedure was mimicked except for the actual stick. Although there were no significant differences for any mean values, variability values were all significant. Variability was measured by the standard deviation around the mean and seemed to hold some promise for analyzing physiological signs of distress.

Stevens and Johnston (1994) examined the cardiovascular responses of heart rate, intracranial pressure, and oxygen saturation of a convenience sample of 124 premature infants between 32 and 34 weeks gestation to a routine heelstick. Severity of illness and behavioral state were examined for the impact they might have on the dependent variables. The measure of severity of illness, the Physiological Stability Index, demonstrated criterion and construct validity; the kappa for inter-rater reliability was .86 when the PSI was analyzed. Their findings included significant changes in heart rate, intracranial pressure, and oxygen saturation across all four phases of the heelstick. Measurements were taken across four periods for a total of two minutes: a 60-second baseline, 15-second warming, 15-second heelstick, and 30-second squeezing. Variability of heart rate and oxygen saturation had significant differences between baseline and warming only.

An interaction effect of state by phase with $p < .0001$ on the variables, and state by severity of illness were documented. Authors concluded that heel warming alone was enough to excite the autonomic system. Intracranial pressure increased significantly between baseline and heelstick and baseline and squeeze, putting the preterm at increased risk of cerebral blood flow fluctuation and resultant intraventricular hemorrhage.

Adrenocortical Responses in Preterm Infants

The ability to adapt successfully under different levels of stress is important for maintaining homeostatic balance in response to environmental challenges. The release of cortisol from the adrenal cortex contributes to successful adaptation under different levels of stress by sustaining the higher energy levels needed for awake behavior and preventing the over-reaction of other stress sensitive systems (Gunnar, 1992; Rawlings, Miller & Engel, 1980). Premature infants in the NICU are often exposed to seemingly high and prolonged periods of stress due to medical and environmental conditions. Moreover, because of the state of their development, premature infants may be even less prepared than full-term infants to deal with such an environment. Limited research has examined the ability of the developing adrenocortical system to maintain adaptive cortisol regulation after exposure to prolonged stress during a period of prematurity.

Production and release of cortisol occurs in the adrenal glands, located on top of the kidneys. The adrenal gland consists of an outer section, the adrenal cortex, and an inner section, the adrenal medulla. The adrenal cortex produces glucocorticoids, of which cortisol is the most predominant. Regulation of cortisol release is controlled by a negative feedback system involving the hypothalamus and pituitary gland. For resting cortisol level, the neurosecreting cells in the hypothalamus secrete corticotrophin releasing factor (CRF) into the capillaries of a vascular portal system that carries CRF to the anterior pituitary. In the anterior pituitary, CRF stimulates the release of adrenocorticotrophic hormone (ACTH) into the general circulation where it activates the adrenal cortex cells to secrete cortisol. When the cortisol level reaches a certain concentration in the blood, an inhibition of CRF production occurs in the hypothalamus, which, in turn, decreases ACTH release resulting in a decrease of cortisol release (Gunnar, 1998).

In response to a stressful event, the hypothalamus is stimulated from other brain regions and increases CRF production that then decreases the inhibitory effect of cortisol on CRF production. This breaks the negative feedback loop resulting in prolonged, elevated cortisol levels. It is believed that a separate hypothalamic pathway from the one that regulates basal cortisol levels is activated to produce the elevated cortisol levels seen during stress. Since two separate pathways are involved in the regulation of cortisol level, it is possible to detect elevations in cortisol to a specific stressful event against the circadian changes in basal corisol levels (Gunnar, 1992, 1998).

The morphology of the adrenal glands in the preonate and neonate is different from adults both in size and cell structure. However, the newborn has an additional region called the fetal zone that produces steroids that are secreted into the placenta and converted by the mother into estriol, which is necessary for maintaining pregnancy. The fetal zone grows rapidly during the second and third trimester and secretes more steroids with growth. Since the steroids from the fetal zone and adrenal cortex are dependent on the same precursors for release from the adrenals, increases in the release of steroids from the fetal zone are likely to be accompanied by an increase in cortisol release from the adrenal cortex (Peters, 1998; Merenstein & Gardner, 1993).

A cortisol surge during the end of pregnancy has been observed in almost all mammals. Although it provides a hormonal signal to end pregnancy in many mammals, it apparently does not do so in humans. Cortisol is believed to induce many of the “finishing touches” in various organs in humans as it does in other mammals. The most studied cortisol effect is the stimulation of both the synthesis of surfactant and its release into the alveolar cells in the lungs as well as the inducement of cytodifferentiation of the alveolar cells. In addition to the lungs, maturational processes in the liver, small intestine, and possibly the brain are also induced by cortisol (Merenstein & Gardner, 1993).

Unlike adults, basal (resting) cortisol levels have not been found to vary in a circadian manner in newborns (Francis, Walker, Riad-Fahmy, Hughes, Murphey & Gray, 1987; Price, Close & Fielding, 1983). This is consistent with the lack of newborn circadian rhythms observed in other systems such as the sleep/wakefulness cycle. Some observers have noted that the newborn appears to have two cortisol peaks per day. The time of the peaks, however, seems to be unrelated to diurnal, feeding or arousal patterns and varies randomly from infant to infant (Frances, et.al., 1987). It has been suggested that these peaks in cortisol release are possible precursors to the later marked circadian rhythm seen in older children. Lewis and Thomas (1990) reported the emergence of a circadian rhythm for cortisol production around three months of age, and suggested that it was firmly established by six months of age.

A cortisol response to stress has been seen in infants as young as 26 weeks gestation. Murphey(1982) and Procianoy, Cecin and Pinnheiro (1983) compared the levels of cortisol of infants born vaginally and by caesarean delivery and found that the levels were higher among the infants who experienced the more stressful vaginal delivery. Studies such as these that point to the infant's release of cortisol related to the degree of stress experienced during the birth process suggest that the term infant is born with an adrenocortical system that is sensitive to stress intensity.

In full-term neonates, a cortisol response to stress has been found for different types of stressors by measuring the amount of cortisol in the blood before and after a stressor. A measurable increase in the amount of cortisol in the blood occurs about five minutes after the event (Gunnar, 1989). The peak index of cortisol in the blood occurs approximately 30 to 90 minutes following stress and then declines, with the sharpest drop between 90 and 120 minutes after the stressor (Marchette, Main & Redick, 1989; Marchette, Main, Redick, Bagg & Leatherfield, 1991) .

Besides physical stressors, noninvasive interventions have been shown to impact cortisol levels in newborns. Gunnar (1989) compared the cortisol response of healthy, full-term infants to two neurobehavioral discharge exams conducted on separate days. She reported a rapid habituation response documented by lower cortisol levels on the second exam compared with the first.

In situations involving major stressors, such as circumcision, blood sampling, or birth, an increase in cortisol level was associated with an increase in behavioral distress (Gunnar, 1989; Gunnar, Brodersen & Krueger, 1996). However, while the amount of cortisol released seemed to be related to the amount of stress the infant was exposed to, the magnitude of the cortisol response did not predict the amount of behavioral distress shown by the infant. That is, the infants who had the highest cortisol responses to a stressor were not necessarily the infants who demonstrated the most behavioral distress to the stressor. In addition, if an infant was calmed by being given a pacifier during a stressful procedure, the decrease in behavioral distress was not always accompanied by a decrease in cortisol level. The authors concluded that the mechanism stimulated by nonnutritive sucking, which lead to behavioral calming, did not affect the release of cortisol under stress.

Milder stressors such as a discharge exam or physical restraint showed even clearer dissociation between cortisol levels and arousal. First, the responses to these stimuli were highly variable in magnitude. For example, some infants showed cortisol responses during a discharge exam as high as those measured during circumcision, although they showed much less behavioral distress. Further, when behavior was calmed with the introduction of a pacifier, a corresponding decease in cortisol level was not always seen (Gunner, 1998). Second, rather than being associated with behavioral distress, high cortisol levels were associated with more optimal performance in some infants during a discharge exam, especially on self-quieting and state regulation items. Healthy infants who had high cortisol levels demonstrated more organized behavior on the Brazelton Neonatal Behavioral Assessment exam, while slightly less healthy infants who had high cortisol levels showed more behavioral distress. Therefore, the literature suggested that although corisol level can be associated with arousal level in the newborn, the two cannot be used interchangeably for inferring how much stress the infant is experiencing. The association between cortisol and arousal level differed depending on the characteristics of the stimulus, the situation, and the infant (Gunnar, 1989, 1998; Peters, 1996,1998).

Responses of Preterm infants to Skin-to-Skin Care

In the emerging field of developmental care, new treatments are being proposed that are designed to improve the physiological status of premature infants (Becker, Grunwald, Moorman & Stuhr, 1993; Blanchard, 1991; NANN, 1993). One of the caregiving procedures often cited in developmental care protocols is skin-to-skin care. This special method of holding premature infants where parents place their infant in a vertical position between the parent's breasts so that there is direct contact between the infant's skin and the parent's skin has been the focus of much research in the last decade (Anderson, 1991; Anderson, Marks & Wahlberg, 1986). First introduced as a means of supporting thermoregulation in infants born prematurely in Bogota, Columbia as a substitute for incubator support, this method of holding premature infants has migrated to the United States and is now incorporated into the care of intermediate-care infants in numerous NICUs around the country (Ludington-Hoe, Hadeed & Anderson, 1991; Ludington-Hoe, Hashemi, Argote, Medellin & Rey, 1993).

Premature infants have reduced brown fat stores in their body. This results in poor insulator capacity that leads to increased ease of loss of body heat into the atmosphere. Thermoregulation must be carefully monitored to ensure adequate homeostatic balance is maintained at all times (Merenstein & Gardner, 1993). Bauer, Pyper, Sperling, Uhrig & Versmold (1998) examined effects of gestational and postnatal age on body temperature, oxygen and activity during early SSC of 27 infants ranging from 25 to 30 week gestation with their mothers. During the first week of life, infants 25 to27 weeks gestation lost heat during SSC contact, but the infants from 28 to30 weeks gestation gained heat despite their extreme prematurity. All infants slept more in SSC than in the incubator. These findings led the authors to conclude that SSC is a safe intervention as early as thew first postnatal week of life for infants 28 to 30 weeks gestation, but for infants 25 to 27 weeks gestation at birth, SSC should be postponed until at least the second week of life. Similar results were reported by Christensson, Bhat, Amadi, Eriksson & Hojer (1998) following a study conducted with 80 infants with birth weight of greater than 1500 grams who were diagnosed as hypothermic. When SSC was compared with incubator care as a treatment for hypothermia in these infants, SSC was found to be at least as effective as incubator care for rewarming low-risk hypothermic neonates who were clinically stable.

Synchrony of thermoregulation has been reported between the infant-parent dyad. An indirect relationship was identified by Ludington-Hoe, Anderson and Hadeed (1990) in that as the infant temperature changed, the maternal temperature changed in the opposite direction.

Cleary, Spinner, Gibson & Greenspan (1997) monitored heart rate respiratory rate, oxygen saturation, and nasal airflow during SSC and found improved breathing patterns without negative alterations in the other parameters measured. Charpak, Ruiz-Pelaez, Figueroa and Charpak (1997) compared SSC to traditional care for 746 newborn infants weighing less than 2000 grams where the infants were bedded on their mothers essentially 24 hours per day—except for brief rest periods for the mother—and found that the hospital stay was shorter for the infants who received SSC compared with the infants who did not receive SSC. The risk of dying was similar in both groups, and nosocomial infections were higher in the infants who did not receive SSC.

Anderson (1991) reviewed 28 articles published between 1983 and 1991. Varying research designs were applied to the studies reviewed, and diverse populations were included. Measures taken in these studies included heart rate, respiration rate, oxygen saturation, skin temperature, rectal temperature, behavior, average weight gain, and secondary medical complications. Overwhelmingly, the studies examined reported positive results among the SSC cohort as compared to matched infants who received conventional care.

In addition to studying the infants' responses to SSC, several researchers have investigated the mother's reactions to holding their babies in SSC. Consistently, reports from parents following SSC are positive (Gale, Franck & Lund, 1993). In a descriptive, exploratory study, Affonso, Wahlberg & Persson (1989) reported parents described an expanded sense of meaning in their relationship with their infant, a renewed sense of mastery of parenting skills that was associated with decreased levels of anxiety, and improved self-confidence in their parenting role following implementation of a developmental care program that included SSC holding. Sixty-six parent-infant dyads were enrolled in the study, with 33 infants receiving SSC and 33 receiving standard care. Qualitative measures were used to identify consistent themes from open-ended interviews with the mothers. Major themes that emerged for which differences in the SSC and standard care groups were noted included competency in parenting skills, abilities to meet the infants' needs, readiness to take the infant home from the NICU, and emotional feelings toward their infants. Overwhelmingly, the mothers who had participated in SSC expressed reduced fear of failure as a parent, stronger feelings of adequacy to meet the infants' needs, and less anxiety about taking the infant home. For the mothers who were breast-feeding, improved milk production was also documented.

Factors that Promote Resiliency in the Preterm Infant in the NICU

Both intrinsic and extrinsic factors have been identified that serve to enhance resiliency in preterm infants during NICU hospitalization period. Self-regulatory capacities afforded through the physiological, motor and interactional/state systems provide powerful intrinsic support mechanisms for these fragile infants. Current research in the area of neuroplasticity suggests the presence of a sparing concept that also helps to improve resiliency in these tiny infants (Duffy, Mower, Jensen, & Als 1994;Dusick, 1997; Lenn, 1991). The concept of neural sparing suggests that if a neurological injury occurs in an area of the brain that is not yet fully functioning in an immature infant, that the damage will not be as significant as if that same injury were to occur in an area of active brain function (Duffy, Mower, Jensen & Als, 1994).

A major issue impacting infant resiliency involves one of the most fundamental and fascinating riddles of human life: What do newborn babies know when they emerge into this world? And, how soon do they begin organizing and using that knowledge? Most authors agree that behavioral competencies of the mature neonate are more sophisticated than was previously thought (Friedrick, 1983, Bellig, 1989). It is now recognized that the full-term newborn demonstrates behavioral capabilities reflecting surprisingly sophisticated central nervous system structure, maturity, and function (Brazelton, 1984). These recent studies conflict with the classic prevailing theory that a newborn is both inactive and incompetent to interact meaningfully with the environment. For many years, the neonate was depicted as a passive recipient of environmental stimuli—an entity simply being acted on to produce learned skills rather than being an active participant in his/her own development. Peiper (1963) concluded that an understandable consciousness does not exist in a child before the end of the first year of life.

Contrary to this traditional view of the infant as a passive organism, researchers such as Als (1986), Brazelton (1984), Gorski (1985), Horowitz (1992), Sameroff and Chandler (1975), and Bronfenbrenner and Ceci (1994) have produced impressive research findings that underscore the active and interactive nature of infants with their environment. The social competencies present at birth begin very early to lay necessary sensory groundwork for later adaptation of the child to the social environment (Bronfenbrenner & Ceci, 1994). Stern (1974) found that infants interact differently with familiar persons and strangers as early as five weeks of age. Korones (1981) suggested an interactional nature/nurture model most accurately reflects an infant's response to the world. He surmised that nature plays a stronger role in establishing the behavior repertoire, and that nurture determines what stimuli are available to the child.

Prechtl's research (1984) utilizing real-time ultrasonography, in particular transducers in linear array, has generated fascinating data based on systematic and prolonged observations of the undisturbed fetus in utero. He concluded that the nervous system is an organ which enables the fetus to interact with the environment, and hence has the ability to provide specific responses to specific stimulus patterns (Prechtl, 1984). Strong support is given the theory of primacy of motor activity indicating many motor patterns are developed before they can be used by the afferent system to respond when needed to relevant sensory input (Lenn, 1991). It is the emergence of these pre-adaptive functions during the gestation period that contributes to the impressive continuity and functional proficiency displayed by the full-term neonate during transition from the intrauterine to the extrauterine environment (Prechtl, 1984).

Als (1986; 1987;1988;1993) similarly theorized that the nervous system, rather than being a function of the environment, matures as the infant reacts to external stresses based on internal competencies. Her detailed observations of premature infants have led to the development of the synactive model of infant behavioral organization in which physiological stability is seen as the foundation from which motor and behavioral organization occurs. Physiological, motor and behavioral processes act together as the infant adapts to the stresses of the environment. The infant's functioning is seen as a model of continuous intraorganism subsystem interaction. The organism, in turn, is in continuous interaction with the environment so that the infant's behavior is the channel by which thresholds of stress are communicated and degrees of functional stability are reflected (Als, 1986).

A second major school of thought in the neurobiological literature suggests that neuroplasticity may serve to enhance biophysical resiliency in preterm infants. These authors purport that in many cases, brain plasticity functions to obliterate the damage to immature neural pathways. Nelson and Ellenberg (1982) found that in a longitudinal study of 229 children diagnosed with cerebral palsy at one year of age, 188 were free of major motor handicap at seven years of age. Milder forms of neurological impairment resolved with high frequency, with higher incidence of resolution noted in black as compared to white children. Interestingly, 13% of all white children and 25% of all black children who were free of abnormal motor signs were classified mentally retarded (I.Q. below 70) by age seven. Persistent signs of other neurological problems, such as non-febrile seizures, articulation disorders, and poorer school performance scores, were noted in the 118 children who "outgrew" cerebral palsy. Citing the early dramatic recovery of function in both premature and high risk full-term infants, these investigators developed a paradigm of impermanence of developmental characteristics emphasizing brain plasticity leading to recovery and adaptability of human behavior and outcome (Nelson & Ellenberg, 1982; St. James-Roberts, 1979). Several models are described, including "vicarious functioning" wherein a separate, or dormant brain area takes over the function of the portion of brain that has suffered damage, resulting in resumption of normal behaviors. A similar theory is that of equipotentiality, where redundant pathways compensate for damaged pathways. Regeneration of damaged axons coupled with leakage of neuromotor transmitters into the damaged area has been shown in animal experimentation but remains controversial when applied to human neural processes (Brown, 1987; Lenn, 1991).

Extrinsic factors that have been shown to influence resiliency include environmental modifications that serve to reduce inappropriate sensory input and enhance the infant's potential for self-regulatory behavior. It has been hypothesized that the respiratory and functional status of the premature infant can be improved in the neonatal intensive care unit by prevention of inappropriate sensory input (Als,1988). Caregiving modifications developed in accordance with the behaviorally identifiable individual needs of the high-risk, ventilated preterm infant have been shown to decrease the level of inspired oxygen support required and, thereby, to improve both the physiological and developmental parameters for extremely low birth weight [ELBW] infants. In a landmark article published in December, 1986, Als and colleagues described the results of a study designed to test the effects of incorporating the knowledge gained from systematic neurobehavioral observations into the nursing care plan. The infants studied were at high risk for developing bronchopulmonary dysplasia. The results showed that infants with birthweight of less than 1250 gms who received individualized developmental interventions—based on Neonatal Individualized Care Assessment Plan evaluations [NIDCAP]—demonstrated the following outcomes: (1) They required ventilator support for a significantly decreased number of days, (2) They required supplemental oxygen for a decreased number of days, and (3) They were able to nipple feed completely after fewer days than infants who received the usual care. Developmental outcomes on both the Assessment of Premature Infant behavior [APIB] and the Bayley scales were also significantly improved for study infants (Als, 1986). In 1988, a replication of the study was done using a random assignment design and larger numbers in both control and intervention groups. In addition to replicating the results of the original study, this study found the following: (1) a significant reduction in the incidence of pneumothorax, (2) a reduction in the incidence and severity of intraventricular hemorrhage, and (3) reduced severity of bronchopulmonary dysplasia. Fewer days of hospitalization were required for the experimental versus the control group (Als, 1988).

Despite the improved technology leading to decreasing mortality rates in the NICU, commensurate gains are not being made in improving long term outcomes of the surviving population (McCormick,1989). Research does show some decrease in severe morbidities. However, subtle neuromotor dysfunction, learning disabilities and behavior problems are occurring at a disproportionate rate, especially in the extremely low birthweight population (Kitchen, 1986). Interestingly, this is often observed in the absence of documented intraventricular hemorrhage, severe bronchial pulmonary disease, or other significant clinical courses to which the disability could be specifically attributed. Developmental impairments, it seems, may be due to either direct or indirect insults, all of which are the result of a discrepancy between an extrauterine environment and the capacity of the central nervous system of the fetal neonate which is adapted for intrauterine existence. Normally, the interplay of intrauterine sensory information and movement experiences work in a continuum to prepare a fetus with behavioral capacities that enable the term newborn to integrate environmental stimuli in a stable, developmentally appropriate manner (Brazelton, 1984). However, a mismatch of brain expectancy and environmental input exists with every immature preterm infant (Merenstein & Gardner).

Sameroff and Chandler (1975) suggested a dynamic model of neural development that strongly supports the concept that an infant's self-regulatory capabilities can either be fostered by appropriate environmental modifications or permanently damaged by continued stressful insults. They described a "jagged progress" model where both the internal functions of the infant and the environment undergo periods of spurts and regression in their interactive attempts to achieve "normalcy." Als (1984) lent support to this model by suggesting that the interplay of sensory information can produce either mature integration on the one hand, or deleterious adaptation patterns on the other hand, as the tiny infant struggles to adapt to environmental stressors and seeks to shape a physiological social environment that is conducive to the developmental progression (Als, 1984).

Overwhelming support was found in the literature for the concept that there is a continuum of development from the womb to adulthood that is seriously jeopardized by a premature birth. Long-term outcome, irrespective of the severity of the initial insults, has been shown to be dependent on a large number of factors. These include the autoregulatory behavioral competencies of the displaced fetal neonate, the plasticity and potential for recovery and many subsequent environmental factors that influence neurological growth and developmental functions (Duffy, Mower, Jensen & Als, 1994; Horowitz, 1992).

Developmental Care for the Preterm Infant in the NICU

Research spawned from the implementation of individualized developmental care in the NICU suggests that a premature infant's own capacity for recovery at an organic and functional level, resulting in improved adaptive responses to environmental input, may be fostered through modification of his/her external experience so that the bioecological risk factors are reduced. If well-designed research examining the effects of developmental care in the NICU continues to demonstrate consistently that family-centered care is a safe and cost efficient low-tech intervention that can decrease short-term medical morbidity, decrease the hospital stay, improve long-term outcome both for the infant and the family, it will most assuredly be granted priority in the establishment of medical plan of care for premature infants.

Family-centered care is an integral component of programs designed to provide developmentally supportive care in the NICU. Most studies examining the effects of the family-centered developmental care approach in the NICU focus on short-term medical and long-term neurological outcome. Since the scope of the question examined in this study refers to the impact of parent-mediated intervention derived from a family-centered care approach on infants in the NICU, only the medical outcome data will be reported.

The developmental approach to care has been tested in multiple sites. Als, Lawhorn, Brown, Gibes, Duffy, McAnulty & Blickman (1985) conducted a highly controlled feasibility study of eight control and eight experimental singleton infants born in the hospital where the study was conducted. The participants had birth weights of less than 1251 grams, and were younger than 32 weeks gestational age at birth. The study was conducted in an initial control phase and a following experimental phase. A carefully applied individualized developmental support program was implemented that included caregiving and environmental modifications based on individualized neurobehavioral assessments. Parent education and support measures such as SSC were included in each study to promote co-regulation of the infant as needed. The experimental group infants showed significantly faster weaning from the respirator, from supplemental oxygen and from gavage feeding. The developmental outcome of the experimental group infants at 1, 3, 6, 9, 18, and 36 months post-term due date showed highly significant improvement over the control infants in standardized assessment scores, as well as improvement in behavioral organization, as assessed in an experimental play paradigm, the Kangaroo-Box Paradigm (Als, 1986).

A modified replication study (Als, 1988; Als, Lawhorn, Duffy, McAnulty, Gibes-Grossman & Blickman, 1994) utilized random assignment of infants meeting the same inclusion criteria as in the initial study. Eighteen control and twenty experimental infants were enrolled in the study. Again, a carefully applied comprehensive developmental care plan was applied during the hospital period. At discharge the experimental group infants showed significant reduction in incidence of intraventricular hemorrhage, and severity of chronic lung disease, as well as reduced hospital cost. At two weeks post discharge, the infants showed systematic electrophysiological group differences by Brain Electrical Activity Mapping [BEAM] between the control and experimental groups, as well as improved developmental outcomes for the intervention groups. Follow up examinations demonstrated that the improved developmental outcome persisted among the experimental group to nine months post due date.

A multi-site replication project involving four NICUs and one surgical intensive care unit [SICU] was subsequently carried out to test the effectiveness impacting infant outcomes by training a small developmental leadership team to implement family-centered developmental care in the intensive care unit. Two of the sites used random assignment and two used a lag-phase design. Infant medical outcome of the two random assignment sites showed effectiveness of the developmental care model in the NICUs in terms of significant reduction in morbidity and hospital stay. Developmental outcome, as measured with the Assessment of Preterm Infant Behavior, was significantly improved on a number of variables, especially in the infants' ability to maintain state regulation and to focus their attention on items required by the examination. The experimental babies at the Stanford site demonstrated fewer days of intermittent mandatory ventilation and continuous positive airway pressure and achieved full enteral feedings sooner. Length of hospital stay was shorter and hospital charges reflected a savings in cost of $2,187,390 for the 17 survivors when compared to the cost for an equal number of control infants. This was an average reduction of charges of $128,670 per treatment patient, with the savings approximately 10 times the cost of the developmental service of the program (Fleisher, VandenBerg, Constantinou, Heller, Benitz, Johnson, Rosenthal & Stevenson, 1995). Becker, Grunwald, Morman & Stuhr (1993) conducted a study with a similar design that demonstrated that experimental infants demonstrated more optimal respiratory and feeding status, lower levels of morbidity, shorter hospital stays, and improved behavioral organization.

Taken as a whole, these studies provide consistent findings that the developmental approach to care that includes a family-centered focus holds great promise for the improvement of the medical and developmental outcome of extremely low birth weight preterm infants. Currently, accepted medical practice does not always provide adequate environmental modification to reduce infant stress created by administration of prescribed routine caregiving procedures. Studies documenting repeated stress behavior and occurrence of significant physiologic distress as measured by heart rate, respiratory rate and SpO_2 following caregiving manipulations in the NICU are prolific. Disproportionately few reports were identified where no negative effects were noted when manipulations were performed without regard for timing or methodology. In contrast, steadily increasing numbers of articles published during the last decade identify decreased incidence of stress behaviors, reduced autonomic instability and improved autoregulatory behavioral competencies in outcomes of premature infants when individualized developmental care plans that included environmental modifications were implemented. Reducing noise and light, and careful identification by caregivers of behavioral cues predicting impending physiological deterioration with appropriate application of intervention measures were consistently recognized in the literature as critical factors to be considered to optimize both the short-term and long-term outcomes of the premature infant. Summarily, these findings support the hypothesis that procedures administered in an individualized and developmentally supportive manner within the framework of currently accepted medical practice can reduce the risk factors and enhance resiliency in preterm survivors (Merenstein & Gardner, 1993; Slater, Naqvi & Andre, 1987).

Application of Principles of Family-Centered Care in the NICU

A focus on the family is the current conceptual and practice standard within the field of early intervention; however, the family has not always enjoyed its present level of acceptance as an integral part of the early intervention team (Palmer, 1997; Premji & Chapman, 1997). Although only recently introduced to the NICU setting, the development of family-centered care practices has been an evolutionary process spanning several decades that reflects changing philosophical principles guided by sound research. An appreciation for the historical perspective influencing the development of the philosophical underpinnings of family-centeredness offers valuable insights to an understanding of the literature addressing the efficacy of application of family-centered care principles in the NICU (Obrien & Dale, 1994; Rushton, 1990).

Historically, professionals in the field of early intervention have viewed families from a number of vantage points. Initially, child-centered models of treatment were employed in which families were often considered to contribute to their child's problems, and professionals were regarded as the primary change agents in the intervention process. An authoritarian model of parent/professional interaction predominated, where parents were expected to adhere to recommendations of professionals in the establishment of treatment plans for their child and were not expected to contribute to the decision making process.

The last half of this century has witnessed a major evolution in professional views of families and the role they serve in early intervention; a foundation for parent-professional partnerships has been established that reduces professional dominance and control over the lives of children with disabilities and their families (Slentz, Walker & Bricker, 1989). Supported by conceptual models such as the transactional model of the mutual effects of child and parents on one another (Sameroff & Chandler, 1975) and the family-systems model of interconnectedness of family units (Bronfenbrenner, 1977), families came to be recognized as having primary responsibility for providing nurturance and development of their members.

Research efforts during these formative years consistently reported the importance of recognizing that the family is the constant in a child's life, while the service systems and support personnel within those systems fluctuate. This resulted in a two-phase progressive shift in the focus of early intervention from a child-centered to a family-focused, and eventually, family-centered orientation. The early phase of this transition was a direct application of the finding that parent involvement in early intervention programs for disadvantaged children had a positive impact on child outcome. Compensatory education programs, such as Head Start, recognized parent involvement as being an important strategy for societal integration of poor families. These early family- focused intervention programs were based on a cultural deficit model where remediation was directed at the parents in an effort to manipulate the environment, and thereby improve the outcome of the child (Trivette, Dunst, Allen & Wall, 1993).

The parent's role in these early attempts to involve families in the intervention process was that of a learner, with professionals continuing to be the primary resources responsible for designing the structure and content of needed intervention. The parent training model was conceptually linear in that the professional imparted knowledge, skills, or support to the parent so that the parent could then use these to facilitate change in the child. The implication was that the more parents were involved in their children's treatment, the better were the outcomes for all (Foster, Berger & McClean (1981); Turnbull & Turnbull (1982). Several studies were reviewed that indicate that families place value on child-focused intervention (Able-Boone, 1993; Ladmer, 1994; McBride, Brotherson, Joanning, Whiddon & Demmitt, 1994). In all three studies, families placed priority on services for their child and expressed satisfaction with the services that they themselves were receiving. Both Able-Boone (1993) and McBride, Brotherson, Joanning, Whiddon and Demmitt (1994) noted, however, that a limitation of their findings may have been that the parents may not have fully understood that their priorities and concerns could also be addressed in intervention.

Programs designed in this tradition had many successes and contributed greatly to the knowledge base about intervention methods and strategies for young children. However, the deficit model did not adequately address the complexities and available strengths of the family system and, as the result of further philosophical refinement, eventually evolved into the currently accepted family-centered philosophy of early intervention (Ladmer, 1994).

The process toward family-centered care was enhanced by another significant historical trend that occurred concurrently with the philosophical and programmatic changes driven by the deficit model of intervention. Interventionists working during this period witnessed the emergence of family support programs that viewed socio-economically-deprived parents as disenfranchised members of society. Increased parent involvement was encouraged in these programs in order to provide opportunities to increase the decision-making power of marginalized population groups within a broader societal context. The importance of societal support systems for families during this period was reinforced by trends of social change resulting from the effects of poverty, single parenthood, teenage pregnancy, family mobility and economic factors that have resulted in reduced intrinsic family support systems for many segments of society (Zigler & Black, 1989). The family support movement is based on the family empowerment concept and has enjoyed the distinction among social services of fostering programs designed to strengthen and support families rather than to provide treatment for their deficiencies. As such, these programs have contributed significantly to the implementation of family-centered care principles in the field of early intervention in all disciplines (Weissbourd & Kagan, 1989; Zigler & Black, 1989; Van Zeben-Van, Verloove-Vanhorick & Brand, 1991).

The net result of the family-centered philosophical evolution of the past four decades is that increasingly families have come to be regarded as an essential component of an effective intervention process. Instead of being considered passive agents through which to effect change in the child, families are now appreciated as active participants in the change process (Shelton & Stepanek (1994). Based on the assumption that the functioning of the child and family are connected and interdependent, researchers in the field of family centered care have recognized that an understanding of both the family and the child is essential to good treatment (Gilkerson, Gorski & Panitz, 1990; Odom & Karnes, 1988). Numerous studies have been conducted since the early 60's that examine the effectiveness of early intervention programs based on family-centered care principles. Since 1987, an increase has been noted in the number of informal evaluations of programs attempting to operationalize the elements of family-centered care. Further, more stringently designed systematic studies reviewing the benefits of family-centered care in diverse settings, including the NICU have been published. Three important categories of outcome measures that may be examined to evaluate the efficacy of the family-centered individualized developmental care approach in the NICU include effects on infant development, effects on the parent- infant relationship, and effect on overall family functioning.

Evidence from the literature in the field of early intervention supports the need for parent participation in addition to early intervention services to optimize development. The effects of a bi-directional relationship between parents and high-risk infants have been documented (Largo, Pfister & Molinari, 1989; Als, 1987; Sigman & Parmelee, 1979; Schraeder, Rapport & Courtwright, 1987. Studies by Schraeder, et al. (1987) and Sigman and Parmelee (1979) provide evidence of environmental sensitivity of high-risk children and indicate that socioeconomic factors can either ameliorate or exacerbate developmental outcome.

Early contacts with premature infants seems to facilitate parents' adapting to the crisis of the premature birth and resolving their feelings of fear, anger, guilt and sadness (Corbiella, Mabe & Forehand, 1990; Crnic & Greenberg, 1987; Dillard, Auerbach & Showalter, 1980; Klaus & Fanaroff, 1993; Macnab, Sheckter, Hendry, Pendray & Macnab, 1985). As the intensity of these feelings recede, the mother and father can direct progressively more energy to the developing relationship with the infant. Parents who described feeling cared for by the staff and who felt the NICU had an open and warm atmosphere were more likely to visit more often. Frequent visitation patterns were positively correlated with higher levels of acceptance of their infant's behavioral characteristics and special personal and medical needs (Zeskind & Iacino, 1984). In lower socio-economic populations, infrequent visiting has been found to be associated with an increased incidence of subsequent deprivation and child abuse (Faranoff, Kennell & Klaus, 1972; Klein & Stern, 1971). An increased number of parent visitation sessions, on the other hand, was related in one study to shorter hospitalization and more realistic maternal perceptions of the infant, combined with higher expectations for the infant's eventual development (Zeskind & Iacino, 1984). Zeskind and Iacino (1984) found that scheduling a weekly visit for the mother greatly increased the number of visits she made spontaneously.

Several groups of investigators have noted that parents of premature infants are more vigorous and persistent than parents of full-term infants in attempting to gain the baby's attention and to stimulate the baby to respond (Als & Brazelton, 1981; Field, Schanberg & Scafidi, 1986; Field, 1978). Because of the fragility of the state regulation systems in preterm infants, the methods used by parents to interact with their infants were sometimes counterproductive and associated with the demonstration of stress behaviors by the infant. When provided supportive family-centered coaching, more appropriate interaction was observed, consistent with the infant's developmental goals (Widmeyer & Field, 1980; Anderson, 1991). Other studies reporting parents' perceptions of stressors in the NICU indicated that parents reported adjusting better to the demands of the infant and the nursery environment when they perceived that the infant's primary nurse, social worker, and physician were committed to care and advocate for the parents as well as for the infant. One of the most important and disturbing themes to emerge from longitudinal studies of at-risk infants is that, when brain-damaged infants are excluded, cognitive outcome is strongly predicted by the family's socioeconomic status and only slightly by birth weight (Gottfried, Hodgman & Brown, 1984; Samaroff & Chandler, 1975; Werner, 1980; Beckwith & Cohen, 1984; Seigel, 1984).

The term family-centered care has been used in various contexts for over 30 years, with family-centered philosophy influencing public policy since 1986 (Bryant & Graham, 1993; Wiedenbach, 1967). However, as is frequently the case when attempting to effect programmatic changes based on philosophical paradigm shifts, translation of the philosophical underpinnings of family-centered care into practice has not always been easy. A review of the literature in this field suggested that an implementation gap sometimes exists between family-centered policy and family-centered practice (Dunst, Johanson, Trivette & Hamby, 1991; Mahoney, O'Sullivan & Dennebaum, 1990). Many of the studies reported reflected design concerns, or incomplete findings because only a portion of the family-centered process was being addressed. Several key factors that transcend discipline boundaries have been identified that contribute to the difficulties experienced by programs attempting to transform early intervention program design through the application of the philosophy of family-centered care. Variability in the emphasis on the importance of the context of the family system has been recognized among training programs in all disciplines preparing individuals for employment in the field of early intervention (Bailey, Simeonsson, Yoder & Huntington, 1990). Additionally, the families served by early intervention programs are a heterogeneous population, and their preferences and needs regarding early intervention are variable (Upshur, 1991). Ambiguity is identified on the part of clinicians regarding what aspects of the family should be measured and what tools are appropriate. It has been postulated that a family "clock" monitoring the family life cycle and transitional periods regulates the dynamics of the family. This implies that observing the family interaction at one moment in time provides evidence or observation of only a fraction of the functional patterns used by that family in response to internal and external pressures or demands (Minuchin, 1988).

The birth of a preterm infant with subsequent hospitalization in the NICU necessitates a modification of caregiving structure. Understanding how family members interact and the family's perception of the infant's development is pivotal to understanding the behavior of infants at risk for developmental compromise. One means identified in the literature that professionals used to gain an understanding of the families and children with whom they work was through cross-sectional studies of family functioning and family interactions. An understanding of the changing nature of the traditional family structure is essential to promote optimal parent-professional collaboration (Rushton, 1990).

Many varied family structures are common in today's society. Examples of varied family units include: single adult parents rearing children alone or living with adults not related to the children; unmarried teenage parents rearing children with or without the assistance of extended family members; communal living arrangements; blended families; and married or single parents with adopted or foster children in the home. Other important family traits that need to be considered by professionals seeking to better understand and support family function in the NICU include the following: families that prefer to take care of problems within the family rather than work with professionals, schools or agencies; families that may not live in the "mainstream" of community life; and, families from a different cultural or ethnic background or with different values and social norms Shelton & Stepanek (1994). The communication style of family members, emotional state, medical status, energy level, and life view are all examples of issues that will impact strongly on parent-professional collaboration. These authors identified the following benefits of using family-centered care principles to design developmentally supportive care for medically fragile infants and their families: (1) They maintain that the integration of family-centered care into a cohesive philosophy of care has the potential to produce policies and practices in which the pivotal role of the family is recognized and respected, (2) unique family strengths are more easily identified, (3) opportunities are created for families to make informed choices for their infants which are respected by the health-care professionals, (4) family/professional partnerships are more easily developed, and (5) family living patterns become more normalized in the face of a potentially disruptive life-event (Shelton & Stepanek, 1994).

Edelman (1990) wrote that achieving family-centered care "is not a final destination, but a continual pursuit" (p. 4). The ongoing challenge for establishing "best practice" in the implementation of family-centered care in any setting is not just "doing things right," but rather, knowing "the right things to do" (Shelton & Stepanek, 1994, p. 4). Clearly more systematic research is needed in each of the three areas noted to best assess the "right things to do" in the implementation of family-centered care in the NICU.

Summary

Careful consideration of factors affecting risk and resiliency of the preterm infant raises many difficult issues regarding the efficacy of current routine caregiving practices in the NICU. A review of outcome studies examining the most commonly reported risk factors influencing premature infants in the NICU has been reported. Collectively, the findings strongly suggest some of the procedures necessary to save a tiny neonate's life that have been linked with increased morbidity in both short- and long-term outcome measures of the survivors.

Medical professionals seek to provide optimal developmental support for infants in the NICU. In order to implement care in a way that best enhances the infant's resilience against stressors created by a premature delivery, caregivers must also take into account the resources and limitations of the family as a whole. Not only does a precipitous premature delivery create unusual stressors for the infant, but it is also a stressor event for parents (Affleck, Tennen & Rowe, 1991; Speraw, 1991). Concern has been expressed that separation of parents and infants following birth may interfere with early parent-child relationships, and give rise to problems in later psychosocial development of the child (Jeffcoate, Humphrey & Lloyd, 1979). Yet our medical community has been slow to address the family support needs of families in the neonatal intensive care unit (NICU). Historically, decisions regarding the medical care of preterm infants in the NICU have been made almost exclusively by healthcare professionals. From an early intervention perspective, both medical and developmental services in the NICU have been predominately child-centered and directed by the medical professional (Brown, Pearl & Carrasco 1991; Rushton, 1990). This often leaves the parents feeling helpless and powerless during their child's hospitalization (Meck, Fowler, Claflin & Rassmussen, 1995; Speraw, 1991).

Acknowledging the centrality of the family in infant development has resulted in a philosophical shift from child-centered to family-centered care practices in the field of early intervention, and these new practice standards have application for developmental intervention practices in the NICU (Schultz-Krohn, 1997; Shelton & Stepanek, 1994). The needs and supporting contributions of the families must be acknowledged along with the strengths and vulnerabilities of the infant in order for effective developmental care approaches to be implemented. An improved understanding of how infants and parents support one another in the NICU is, therefore, an important consideration to be taken into account when designing a comprehensive developmental care plan for any infant in the NICU.

Good medical practice for preterm infants requires that both the family and the child's needs be addressed in any program of intervention. Quality care for children who require specialized health and developmental services requires more than access to services and financing strategies to pay for those services. It requires a type of synergy that is possible only when service providers and families work together to produce optimal support services for medically fragile children. Models of intervention based on the family-centered approach provide an appropriate mechanism to meet these important goals for preterm infants in the NICU.

The family constitutes a potentially powerful buffer to help reduce stressors for the preterm infant in the NICU (Crnic & Greenberg, 1987; Dunn, 1988; Schaffer, 1988; Ventura, 1982). Recognized as the principal influence shaping the health and development of the child, the family is understood to be a primary source of protective factors that mediate the effects of stress-producing events to promote resiliency in infants biologically at-risk for compromise (Patterson, 1995; Letourneau, 1997). Resilience refers to individuals' competence and successful adaptation when challenged with significant stressful life events such as a premature birth (Letourneau, 1997, Rutter, 1987). The process whereby parents and infants interact to support complex reciprocal adaptive coping responses is termed co-regulation. Co-regulation has been described as a neurobiological process that supports the naturally occurring expectation of nurturance in human infant/parent dyads (Gilkerson & Als, 1995). One example of a co-regulatory caregiving intervention available for parents in the NICU is skin-to-skin care. The modifying effect of SSC on stress reactivity of preterm infants following heelstick procedures was examined in this study.

CHAPTER III

METHODS

This research studied the adrenocortical and cardiopulmonary responses of preterm infants to SSC and heelsticks in the NICU, and examined the moderating effect of an SSC intervention on the infants' responses to the heelstick stressor event. This chapter includes a description of the research approval process, participant characteristics, data collection procedures, study design, and analysis procedures.

Research Approval Process

The research protocols used in this research study were subjected to a multi-stage approval process. First, all data collection procedures, including the saliva sampling procedure and physiologic data collection procedures, were reviewed and approved by the medical director and neonatologists who direct medical services in the NICU. Second, the research study protocols were presented to the NICU collaborative care committee to ensure they were consistent with currently approved practices in the NICU. An agreement was obtained for physicians, nurses, laboratory and respiratory staff to assist with ordering and collecting heelstick procedures to coincide with parental visits whenever possible. Third, the nursing staff and neonatal nurse clinicians agreed to monitor the data collection techniques of the principal investigator and research assistants to ensure that research protocols were stringently followed, and the staff also agreed to provide inter-rater reliability checks for the saliva sampling and cardiopulmonary data collection procedure. Finally, the Institutional Review Board of the Erlanger Medical Center and the Institutional Review Board of the University of Tennessee at Knoxville approved the study protocols for use in the NICU where this study was conducted.

Participants

Participant Enrollment Process

Infants were recruited for the study by requesting parental permission. The principal investigator reviewed the study protocol with prospective parents and thoroughly explained the purpose of the study prior to requesting parents to consider enrolling their infant in the study. The investigator paid careful attention to the protection of the rights of the participants and their families. The researcher made clear that enrollment of the infants by their parents was voluntary, and parents were advised that they were free to withdraw from the study at any time without fear that their child's care in the NICU would be compromised in any way whatsoever.

Any procedure performed with a fragile preterm infant has certain inherent risks, and each parent was advised of potential risks and benefits of participating in the study. As this study sought to examine the effect of approved routine procedures already being implemented in the NICU, the parents were assured that the risks to their infant were minimal. Parents were advised that the risk associated with transferring the infant from the bed onto the parent's chest during the SSC session would be minimized by having the bedside nurse or the principal investigator assist with the transfer for 100% of the SSC sessions. The researcher then explained why the heelstick procedure had been identified as an invasive stressor. Care was taken to ensure that parents understood that the heelstick is a routine laboratory procedure that has been scrutinized in many studies with preterm infants. While stressful because of the invasive nature of the heelstick, this procedure has been judged safe for use with premature infants. Parents were assured that the anonymity of participants would be protected at all times, and that results would be reported by case number only. Parents were given a written consent form that explained the research study in detail. Infants were not enrolled in the study until a signed parental consent form was obtained.

Inclusion Criteria

The SSC Guidelines for intermediate-care infants approved March, 1998 for implementation by the medical staff of the NICU, defined the inclusion criteria for the study. Medical records were reviewed daily to track admissions to the NICU. The researcher approached the parents of infants who met the inclusion criteria to ask them to consider enrolling their infant in the study. They were advised that their child was expected to require two heelstick procedures prior to discharge.

All infants enrolled in the study met the following eligibility criteria:

1. Weight ≥ 1200 gms
2. Post natal age ≥ 24 hours
3. Clinical stability evidenced by:
    a) having had no apnea, bradycardia or desaturation requiring vigorous stimulation within the previous 24 hours
    b) having had axillary temperature > 97° F for the previous 24 hours
    c) having a typical apical heart rate < 200 beats per minute
    d) having a typical respiratory rate < 80 breaths per minute
    e) having oxygen requirements < 4 L without ventilatory pressures ordered
    f) having no arterial or umbilical catheter in place.
4. Participants were permitted to have a peripheral intravenous line or heparin-lock line in place.

Infants were excluded from the study who did not meet the above inclusion criteria or who were diagnosed with a medical condition that might alter the infant's responses to stressful procedures in the NICU. Events such as grade III or IV intraventricular hemorrhage documented by cranial ultrasound or a congenital anomaly such as neural tube defect or cardiopulmonary condition warranted exclusion.

A decision made by the medical service of the NICU in mid-April, 1999, to use midline catheter ports to draw blood for laboratory analyses with selected infants meant that the number of heelsticks ordered for routine laboratory blood analysis was significantly reduced for the second half of the enrollment phase of the study. This procedural change reduced the pool of eligible participants, since infants who were medically eligible for the study were not approached for enrollment if the physicians determined that there was a high probability that the infants' medical course would not require two heelsticks prior to discharge (see Researcher's Note).

Sample

Participants for this study were selected from the infants meeting inclusion criteria admitted to the Level III NICU at T.C. Thompson Children's Hospital in Chattanooga, Tennessee, during the enrollment phase of the study from February to June, 1999. The NICU at T.C. Thompson Children's Hospital is the only regional perinatal center located in southeast Tennessee. This facility receives patients from a 75-mile radius of Chattanooga. The medical complex has an associated high-risk labor and delivery department prepared to treat extreme medically acute infants.

The NICU at T.C. Thompson Children's Hospital is a 40 bed unit. Among the infants admitted to the unit during the enrollment period, seventeen infants and their parents were selected and enrolled in the study. Five of the infants enrolled in the study were deselected prior to data analysis for the following reasons: did not have a SSC session prior to discharge (n=2); had chronological ages greater than four standard deviations above the mean of the study sample at the time of enrollment (n=2); had an admitting medical diagnosis of coarctation of the aorta, a condition that compromised his cardiovascular system and potentially significantly altered his physiological stress reactivity (n=1).

The remaining sample (N = 12) represented all eligible infants admitted to the NICU at T.C. Thompson Children's Hospital during the enrollment period for whom parental consent for enrollment could be obtained. Several factors influenced the small sample size. The parents of six infants who were approached to enroll their infants in the study chose not to participate. Additionally. a number of infants who met the eligiblity criteria were not approached for enrollment because it they were determined unlikely to require two heelsticks prior to discharge

Medical records of the infants were examined for medical diagnoses. The principal morbidity of preterm infants admitted to the NICU is respiratory compromise, and this was reflected in the sample. Neurologic or metabolic pathologies commonly seen in this population that, if present, might influence the infant's stress reactivity and, therefore, disqualify the infant from the study were examined. None of the conditions established as exclusion criteria was present among the 12 participants reported in this study. Table A-1 summarizes the medical conditions of the infants enrolled in the study and their mothers. All tables and figures in this dissertation are located in the appendices.

In addition to medical diagnoses, the medical charts of the participants were reviewed to identify relevant information that might impact their responses to procedural stressors experienced in the NICU. The cohort of infants who provided the data that were analyzed in this study (N=12) ranged from 26 to 34 weeks gestational age at birth. The mean (M) gestational age at birth was 29.5 weeks, with a standard deviation (SD) of 2.06 weeks. The mean birth weight of the sample was 1062.4 grams (gms) (SD 318.24, range 680 – 1,600 gms). The mean post-conceptual age (PCA) at enrollment was 32.9 weeks (SD 1.9; range 29.5-35.4 weeks), and mean post-natal age (PNA) at enrollment was 23.5 days (SD 14.5, range 6-49 days). The gender distribution was 42% male (n = 5) and 58% female (n =7). Two of the participants were products of twin gestations, and the remaining ten were single births. All participants were born at the hospital where the study was conducted. Mean Apgar scores at birth at one minute of age were 5 (SD 2.08, range 2-9) and 7.5 (SD .9, range 6-9) at five minutes of age. The mean length of stay from admission to discharge was 50 days (SD 22.76, range 16-95 days). Ethnic distribution was 67 % Caucasian American and 33% African American. None of the families enrolled was from Hispanic or Asian origin. Seventeen percent (n = 2) of the infants were delivered vaginally, while 83% (n = 10) were delivered by cesarean section. Sixty-seven percent (n = 8) of the infants were of an appropriate size for their gestational age, while 33% (n = 4) were small for gestation age. Two of the infants who were small for gestational age at birth had been diagnosed prenatally as having intrauterine growth retardation. (See Table A-2).

In order to explore the research questions posed by this study, it was necessary to examine the characteristics of the mothers of the infants enrolled. Maternal characteristics were examined for the birth mothers of each of the infants enrolled in the study. The mean maternal age was 27.75 years (SD 9.09, range 16 - 42 years). Sixty-seven percent (n = 8) of the mothers were married, and 33% (n = 4) were single. The infant enrolled in this study was the product of the first pregnancy for 33% (n = 4) of the mothers, the second pregnancy for 33% (n = 4), the third pregnancy for 17% (n = 2), and the fifth pregnancy for 17% (n = 2). Forty-two percent (n = 5) of the mothers had experienced either spontaneous miscarriages or voluntary interruption of pregnancies. None of the mothers reported prenatal alcohol or drug use. Three of the mothers (25%) reported smoking one pack of cigarettes per day. Maternal characteristics are summarized in Table A-3.

Focus of the Research Project

This research focused on the adrenocortical and cardiopulmonary responses of preterm infants to invasive stressors in the NICU. In order for a stressor to be considered invasive, tissue damage must occur (Merenstein. & Gardner, 1993). A heelstick was chosen as the invasive stressor event to be examined because it is a routine procedure performed on a regular basis in the NICU. The mild degree of tissue damage that results from a heelstick produces a nociceptive stimulus that is perceived by the brain as equally painful each time a new heelstick occurs. Although pain responses in preterm infants vary, it is postulated that the infant cannot habituate to the nociceptive stimulus of the heelstick because of the tissue disruption that occurs. Lack of habituation of response means that in the absence of intervening variables, an infant would be expected to demonstrate similar autonomic responses each time a heelstick is performed.

Research supports that SSC does not increase autonomic instability in premature infants (Ludington-Hoe, Hadeed & Anderson, 1991; Anderson, 1991; Anderson, Marks & Wahlberg, 1986). Therefore, SSC was presumed to be a non-stressful intervention for the infants enrolled in this study. However, a review of relevant literature revealed that any caregiving procedure potentially could be a stressful event for a premature infant (Gorski, 1985; Gorski, Hole, Leonard & Martin, 1993; Gorski, Huntington & Lewkowicz, 1990). To ensure that the intervention of SSC holding was not a stressful event for the infants enrolled in the study, SSC was examined as an independent intervention, prior to being studied as a moderating variable for the heelstick performed in the SSC condition. Each infant enrolled in the study received a heelstick in both the bed and SSC treatment conditions. For 75% of the infants (n = 9), the SSC condition reported in this study was the first SSC session the infant had ever experienced. Two of the infants (16 %) had received one SSC session prior to the SSC session examined in this study, and one infant (8 %) had received two SSC sessions prior to the SSC session examined in this study (see Researcher's Note for further explanation of sessions not reported in the data analyses).

Study Design

Two treatment conditions were created to examine the responses of the participants to skin-to-skin care and heelsticks, and to determine whether or not skin-to-skin care had a moderating effect on the infants' responses to the heelstick stressor event. The first treatment condition, hereafter referred to as the bed condition, was comprised of two observation periods and one intervention period—i.e., heelstick in bed. The second condition, hereafter referred to as the SSC condition, was comprised of two observation periods and two intervention periods—i.e., SSC and heelstick. The treatment conditions were conceptualized as: Bed Condition: $O_1 X_1 O_2$; SSC Condition: $O_3 X_2 X_3 O_4$

where O_1 = premanipulation baseline period in the bed condition

O_2 = postmanipulation observation period in the bed condition

O_3 = premanipulation observation period in the SSC condition

O_4 = postmanipulation observation period in the SSC condition

X_1 = heelstick in bed

X_2 = SSC intervention

X_3 = heelstick in SSC

Figure B-1 is a graphical representation of the research model developed for this study.

The bed condition contained one invasive intervention (X_1). The SSC condition contained one non-stressful intervention (X_2) and one stressful, invasive intervention (X_3). The bed treatment condition consisted of three 30-minute periods: a) premanipulation observation period (O_1); (b) invasive heelstick intervention period (X_1) administered while the infant was swaddled in bed; and (c) postmanipulation observation period (O_2). The SSC treatment condition consisted of four 30-minute periods: (a) premanipulation observation period (O_3); (b) non-stressful intervention consisting of 30 minutes of SSC holding without any painful procedure being administered (X_2); (c) invasive heelstick stressor (X_3) administered while the infant remained in SSC; and (d) postmanipulation observation period (O_4). Each infant was studied under both treatment conditions resulting in a paired sample of one bed and one SSC session being obtained from each participant.

The premanipulation (O_1, O_2) and postmanipulation (O_3, O_4) baseline observation periods were added to both the bed and SSC treatment conditions to control extraneous variables. The premanipulation observation periods (O_1 and O_3) were conducted during separate sessions, but under similar conditions, as were the postmanipulation periods (O_2 and O_4). The same invasive stressor—i.e., heelstick—was administered using identical procedures during both the X_1 and X_3 periods; however, two different environmental conditions were created. The heelstick in treatment X_1 was administered while the infant was swaddled in bed;

the heelstick in treatment X_3 was administered while the infant was held in SSC by his/her mother.

Skin-to-skin care is an approved intervention that may be provided by parents for all infants admitted to the NICU, who meet the medically approved guidelines. Therefore, the SSC intervention could not ethically be withheld from any infants in order to create a randomly assigned, non-treatment control cohort. This constraint prevented the use of a true experimental design for the study and disallowed the determination of causation by this research. A repeated measures design in which the infants served as their own controls was employed to permit the researcher to explore relationships between the data collected for each of the variables.

To strengthen the validity of the data, the researcher reversed the order in which the bed and SSC sessions was received for half the sample. Scheduling constraints precluded the use of random assignment to determine if an infant would receive the bed condition or SSC condition first. Ethical constraints prevented any additional procedures being ordered for an infant because he/she was enrolled in the study. All heelstick procedures examined for this study were ordered as a routine part of the infant's medical care in the NICU. Laboratory orders were monitored each day to determine when procedures were ordered for the infants in the study. If a heelstick was scheduled to coincide with the mother's visit, then the SSC treatment condition was applied. If the physician ordered the heelstick to be performed with 6:00 a.m. laboratory work, then the bed treatment condition was applied.

Even though convenience, rather than random assignment, dictated the order in which the bed or SSC condition was administered for each infant, a counterbalanced design emerged when the data were analyzed. Six (50%) of the infants had the bed condition administered first followed by the SSC condition, and six (50%) infants had the SSC condition administered first followed by the bed condition. The use of a reversed treatment design, having each infant serve as his/her own control, and having each participant assigned to both the bed and SSC treatment conditions served to reduce error variance by reducing within subject error. These quasi-experimental design measures were applied to reduce threats to internal validity when the number of eligible subjects was limited (Munro, 1993).

Measures

The literature questions the reliability of any single physiological measure as a predictor of autonomic function (Merenstein & Gardner, 1993; Kenner, Brueggemeyer & Gunderson, 1993). This concern was addressed in this study by using multiple physiological measures, including premanipulation and postmanipulation observation periods, and having infants serve as their own controls. Comparable measures were taken on five dependent variables during each observation and treatment period as part of the repeated measures design (Cook & Campbell, 1979). Four of the variables—i.e. HR, pulse, RR, and $Sp0_2$—

measured the infants' cardiopulmonary responses to the procedures examined. Salivary cortisol measured the infants' adrenocortical responses. The cardiopulmonary data were collected in 15 two-minute, time-sampling increments; a saliva sample was collected at the conclusion of each 30-minute period to provide the adrenocortical measure.

Adrenocortical Measure

The use of saliva samples has been found comparable to blood plasma samples in neonates for analysis of cortisol concentrations in the body (Frances, Walker, Riad-Fahmy, Hughes, Murphey & Grey, 1987; Laudat, Cerdas, Fournier, Guiban, Guilhaume & Luption, 1988). The saliva sample from which the salivary cortisol concentration was determined for this study was drawn approximately 30 minutes after each observation or treatment period began. An enzymatic immunoassay procedure was chosen as the method of cortisol assay to be used for this study because it permitted assay of the small saliva sample sizes available from the preterm population. To reduce within-subject variance due to difference between assays, all cortisol samples collected for each infant were analyzed in the same assay batch. All samples were analyzed in duplicate with the dilution factor recorded. Salivary cortisol has been reported unstable at $pH < 4$; therefore, pH analysis was reported on all laboratory analyses (Schwartz, Granger, Susman, Gunnar & Laird, 1998).

Salimetrics, LLC (2000) was the biomedical laboratory chosen to perform the analyses on the saliva samples to assess cortisol concentration levels. Salimetrics was founded with the mission of providing research and testing labs with the highest quality non-isotopic immunoassays for salivary biomarkers. The lab has specialized expertise in salivary assays. All Salimetrics assays are subject to rigorous quality control criteria. All assays used must demonstrate linearity, antibody specificity, accuracy and precision. The HS Cortisol method of cortisol analysis was preferred for this study for several reasons: (1) It is an enzyme immunoassay developed specifically for research use with saliva, (2) it required only 25 μL of saliva per test, and (3) this assay system is designed to be very robust to the effects of interference caused by collection techniques that affect pH. Using the HS Cortisol enzymatic immunoassay, a concentration of .007pg/mL of cortisol could be distinguished from zero.

A review of the salivary cortisol enzyme immunoassay performance characteristics revealed that recovery of cortisol in a saliva sample that contained known quantities of cortisol ranged from 99% - 120% of the spiked amount of cortisol. The intra-assay precision determined from the mean of 16 replicates had standard deviation (measured in ug/dL) ranging from .087 to .731 (SD .005 - .030). The linearity of dilution as high as 1:16 calculated from three diluted saliva samples reflected minimal variation among expected, observed and recovered values (pg/mL)

(Salimetrics, 2000).

Cortisol HS enzymatic immunoassay correlates highly with radioimmunoassay procedures ($r = .956, p < .0001$)(Francis, et.al, 1987). Analysis of matched saliva and serum samples showed high correlation ($r = .942, p < .0001$). To ensure accuracy of results, all samples were tested in duplicate. The correlation between the duplicate scores was very high ($r = .997$) and the intra-assay between duplicates was well within the acceptable range.

Preterm infants who have been asleep have minimal free flowing saliva. Therefore, the smaller sample size requirement for this enzymatic immunoassay procedure was important. Further, the saliva sample stimulant required was less likely to be affected by the enzyme immunoassay than radioimmunoassay techniques. The laboratory reported that despite the modest use of the oral stimulant, the pH of some of the samples was low. The samples for which this was true were repeat tested at different dilutions using phosphate buffered saline. After the pH was corrected in this manner, the pH values were not correlated with the cortisol scores ($r = -.071$), indicating that the cortisol results were not altered by the pH readings (E. Schwartz, personal communication, May,1999).

Cardiopulmonary Measures

Each bed space in the NICU is equipped with a Hewlett Packard (HP) Merlin monitor that permits continuous recording of physiologic data, retrievable for up to 24 hours (Hewlet Packard, 1993). The cardiorespiratory monitor, using three-way leads manufactured by the 3-M company, was attached to participants as part of routine care in the NICU. Monitor readings of heart rate, pulse and respiration rate were downloaded to a centralized Hewlett Packard 9000 workstation and recorded for analysis in two-minute increment readings. Heart rate was reported as beats per minute (bpm). Respiratory rate was collected similarly and reported as inspiratory-expiratory cycles per minute. Measures of apnea and bradycardia were recorded from the computer summary analysis by the time and number of events that occurred during the treatment conditions.

The level of oxygen saturation in the blood was recorded from the bedside pulse oximeter monitor. The pulse oximeter registers a transcutaneous measure of the relative saturation levels of oxygen with hemoglobin in the blood (SpO_2). The SpO_2 value is dependent upon and reflects tissue perfusion and has been shown to correlate highly with arterial blood gas saturation values (Pierce & Turner, 1989). This measure provides an easy, non-invasive measure of oxygen saturation that can be used to identify stimuli that cause hypoxemia (Pugh & DeKeyser, 1995). In most instances, this measure was obtained from the SpO_2 module of the HP bedside monitor. An alternative machine used in the NICU to measure SpO_2 values is the Nellcor 200 pulse oximeter. The self-calibrating transcutaneous oxisensor transducer of the pulse oximeter or HP monitor was secured either to the dorsum of the hand, plantar or dorsal surface of the foot, or plantar surface of the great toe by an elastic adhesive tape. Oxygen saturation values may range from 0 to 100%, and they are displayed on an LED screen on the front of the unit.

All monitoring equipment used in the NICU in which this study was conducted has undergone rigorous testing to establish the validity of the measures. Equipment manufacturer specifications describe pulse oximetry as accurate to ± three digits. However, mild degrees of muscle activity or peripheral circulatory compromise can alter SpO_2 values as measured by the pulse oximeter. To ensure accuracy of readings and reduce false positive alarms, the oxisensor transducer also detects heart rate. In order for the SpO_2 value to be accepted for this study, the pulse value on the oximeter had to be within 5 bpm of the HR measure recorded by the cardiorespiratory monitor. If the pulse value at the two-minute time interval mark measured greater than or less than five bpm of the HR measure, the serial values registered each second were examined for 15 seconds. If a correlating value failed to occur within 15 seconds following the minute mark, the measures were examined in reverse order for 15 seconds before the minute mark. The first pulse value and associated SpO_2 that measured within five bpm of the HR was recorded on the data chart. If no value was found within this range (± 15 seconds of the minute mark), the SpO_2 was recorded as a missing value for that time-sampling interval.

Parental Stressor Scale: NICU

The Parental Stressor Scale: NICU (PSS:NICU), developed by Miles (1987), measured parental perception of stressors encountered during the NICU hospitalization period. Four domains were used to evaluate the physical and psychosocial environment of the NICU: (a) Sights and Sounds of the Unit; (b) Infant Behavior and Appearance; (c) Staff Relationships; and (d) Parental Role Alteration. The PSS:NICU is a five-point Likert scale ranging from "1", not at all stressful, to "5", extremely stressful. The process for development of this instrument included observations in the NICU, interviews with parents, consultation with a parent self-help group, and an extensive search of the literature. The psychometric properties of the instrument were evaluated using data from 122 parents hospitalized in one of three NICUs in the United States—i.e. two hospitals in the midwest and one in the southeast—and 84 parents of infants hospitalized in one of two hospitals in Canada (Miles, 1987; Miles, Funk & Carlson, 1993)).

Reliability and validity of the instrument were reported to be high. Reliability coefficients (Cronbach's Alpha) were calculated for each of the dimensions to assess internal consistency and modify the final instrument format. The alpha coefficients were >.70 for all scales. The internal consistencies for the entire scale ranged from .94 to .89 (Miles, 1987).

Descriptive statistics for the PSS:NICU scales reflected that scores were distributed throughout the majority of the range, and means varied closely about the midpoint of the scale, ranging from 2.44 to 3.62. Standard deviations were modest, and kurtosis and skew were also relatively modest (Miles, 1987).

Inter-scale correlations were calculated among the three subscales and between these subscales and the total stress score. The subscales demonstrated moderate inter-scale correlations, sharing from 12% to 40% of their variance in common. The subscales strongly correlated with the total stress scale on the instrument, sharing from 49% to 82% of their variance (Miles, 1987).

Construct validity was assessed by comparing the PSS:NICU with responses on the State-Trait Anxiety Inventory. Pearson correlation coefficients were computed between each of the NICU Parental Stressor Scale scores and State Anxiety scores. All correlations were significant at the .001 level, except for the Sights and Sounds Scale, which was significant at the .05 level (Miles, 1987; Miles, Funk & Carlson, 1993).

Procedures

Data were collected to measure the infants' responses to an SSC intervention and two heelstick procedures performed during the bed and SSC treatment conditions. Measures were taken during premanipulation and postmanipulation periods for both the bed and SSC conditions as part of the repeated measures design. During the premanipulation and postmanipulation observation periods of both conditions, the participants in open bassinets were securely swaddled with dense receiving blankets and positioned either in the prone or sidelying position. The infants in isolettes were supported with snug blanket rolls secured to form containment supports for the extremities to support flexed posturing of the extremities.

Skin-to-Skin Care Procedure

In this study, the SSC intervention was defined as a mother or father holding their preterm infant, who was clothed only in a diaper, and was lying in direct skin-to-skin contact with the parent in a prone, upright position between the parent's breasts.The infant and parent were covered with a heavy cotton blanket. The procedure for implementation of SSC intervention followed the SSC guideline approved for use in the NICU where this study was conducted in March, 1998. After obtaining signed parental consent to enroll the infant in the study, the principal investigator instructed the parents in the proper technique for administering SSC care.

Techniques for providing organizing postural support for the infant to enhance co-regulatory efforts were demonstrated. The instruction session lasted approximately 20 minutes and included information about how to identify the infant's stress signals as well as signs of regulation and stability. A 25-minute instructional video that explained SSC holding and demonstrated how the procedure was to be carried out was offered for parents to view following the instructional session with the researcher if they desired additional information about SSC (SSC, NICU video library).

All SSC sessions were performed at the infant's bedside. Mothers of the participants provided 100% of the SSC holding during the study. During the premanipulation period of the SSC condition, if infants were in open bassinets, they were dressed in a T-shirt, head cap, and swaddled in a dense cotton blanket.

If they were in isolettes during the premanipulation period they were securely supported with positioning rolls. At the beginning of the SSC period, the principal investigator gently removed all clothing except a diaper and blankets from the infant. The infant was then slowly transitioned from horizontal to upright position and moved from the bed to the parent's chest for SSC holding. The infant was positioned securely in an upright tucked position between the mother's breasts and covered with two or three layers of receiving blankets as needed to maintain stable infant thermoregulation.

Privacy screens were provided during the transition into SSC and were available throughout the session as needed. The infant's vital signs were monitored carefully while being held in SSC. Axillary temperature was checked five minutes after the infant was transitioned into SSC, and in 15-minute increments thereafter throughout the session. Constant recording of cardiopulmonary data was available from the bedside monitor, and vital signs were recorded in 15-minute increments on the SSC Flow Sheet that was kept at each infant's bedside to report the infant's tolerance and the parent's response to the SSC session. Heat lamps were readily available; however, none of the infants in the study cohort required assistance to maintain stable body temperature. The principal investigator and bedside nurse remained available throughout each SSC session to assist the parent as needed to ensure her comfort and carefully to monitor the infant's responses to SSC holding.

To ensure optimal protection for the infant against unnecessary stressors, protocols were clearly established for terminating the SSC session if signs of medical instability developed. The research study protocol dictated that SSC holding would be stopped if the infant showed any of the following signs of distress: irritability or restlessness, drop in temperature of less than 96.8° F; the occurrence of more than two episodes of apnea, bradycardia—that required stimulation to reverse—or oxygen desaturation within 30 minutes. This was done to reduce the potential autonomic response that SSC holding might elicit from the infant. To ensure adequate thermoregulation was maintained, an external heat source was utilized to assist the infant in maintaining his/her temperature >97 °F. Parents were carefully instructed to notify the bedside nurse or the researcher immediately if their infant displayed any signs of distress during the SSC session. Any exceptions to the approved SSC guidelines were approved by the attending neonatologist, neonatal nurse practitioner or pediatric resident assigned to manage each infant's care.

Heelstick Procedure

The heelsticks were performed by one of five medical technicians trained to administer the procedure in accordance with approved hospital policy. When the heelstick was performed during the bed session, only the foot was uncovered while the rest of the body remained swaddled to assist the infant with self-regulatory autonomic control, thereby reducing the overall stress of the procedure. The heel was cleaned with an alcohol soaked sponge, and then firmly squeezed two or three times prior to being lanced with a sterile lancet. The heelstick procedure consisted of a double puncture of the aspect of the heel least bruised from previous punctures. The heel was squeezed two or three times after the puncture to express adequate blood flow to fill the collection chamber of the vacupipette. After the blood was drawn, direct pressure was applied over the puncture site by the laboratory technician until blood flow stopped. The procedure was identical when the heelstick was performed during the SSC session except the mother provided dynamic positioning supports for the infant during and after the procedure.

Data Collection Protocols

Saliva Sampling Protcol

The principal investigator collected 100% of the saliva samples reported in this study. All saliva samples were taken 30 minutes after each manipulation period began. Saliva samples were collected by drawing approximately 100μL from the infant's mouth into a 200 cc vaccutainer placed inside a DeLee suction catheter attached to a wall vacuum unit (Lutkus, 1991). A 5-6 French catheter was used for the suction tubing. The timing of the collection of the sample was designed to coincide with the infant's peak index response to the manipulation of the period (Gunnar, 1989). For the premanipulation and postmanipulation periods the saliva sample was drawn after 30 minutes during which the infant had been quietly resting, with the trunk and extremities supported in natural flexed posturing by blanket rolls or swaddle wraps, with no procedures performed. For the periods following the stressor events—i.e., SSC holding or a heelstick—the saliva sample was collected 30 minutes after the infant was transitioned into SSC, or 30 minutes after the heelstick was completed.

A challenge faced in the saliva collection procedures what the fact that the preterm infant has limited saliva after being asleep for several hours. Consequently, several grains of Crystal Light lemon crystals were used, if needed, to stimulate adequate saliva flow (Gunnar, 1989). The saliva collection period was limited to 10 minutes. Once collected, the samples were stored at –20° C in the vaccutainer collection vials until shipped on dry ice to Salimetrics, LLC laboratory to be assayed.

Cardiopulmonary Data Collection Protocol

The principal investigator recorded 96% of the data on the cadiopulmonary variables for all participants in this study. Two-minute time sampling measures of HR, pulse, RR, SpO_2 values and noted episodes of apnea or bradycardia were recorded to assess physiological stress reactivity of the infants to the treatment conditions. Each cardiopulmonary measure was recorded on the data collection form at two-minute time intervals throughout the treatment condition from computerized data downloaded from each infant's bedside monitor equipment. These data were later transferred to a Microsoft Excel spreadsheet for analysis.

Neonatal nurse clinicians informed of the data recording protocol provided random accuracy checks of data being recorded. The principal investigator recorded 95% of the cardiopulmonary data from the central computer monitor. Reliability of the researcher's recording technique was determined by having a nurse who had been instructed in the data recording protocol record a 30-minute session of cardiopulmonary data from the central computer monitor screen. Although aware of the research study protocols, the nurse was unaware if the data she was recording was from a bed or SSC session. The data recordings of the nurse were then compared with the recordings made by the principal investigator for the same 30-minute period. Agreement was registered between raters on 55 of the 60 data points recorded for an inter-rater reliability score of 91%. The principal investigator recorded the cardiopulmonary data from all but one two-hour SSC session. The data from this session were recorded by a research assistant who had been trained in the research study protocols. The researcher checked the assistant's accuracy and found agreement on all except eight data points out of the 240 points recorded for the session (inter-rater reliability = 96%).

Parental Stress Scale Questionnaire Administration Protocol

After enrollment, the parents were requested to fill out the Parental Stress Scale: NICU. All parents filled out the questionnaire before they provided the

SSC intervention session reported in these data. The purpose of the questionnaire was explained, and the investigator assured parents all responses would be kept confidential. The parents were informed that their identity was registered to enable the researcher to combine the parent responses on the PSS:NICU with selected responses of their infant for analysis. However, parents were assured all results would be reported as a group or by case number only.

The questionnaires were given to the parents with a cover letter explaining the purpose of the questionnaire and describing how the results would be used. An envelope was provided in which to seal their responses. To ensure confidentiality was maintained, a sealed collection box, for parents to use to return the PSS form when completed, was provided at the central nurses station in the NICU. Once completed, the questionnaires were tabulated and analyzed to explore relationships between parental stress levels and selected demographic variables of the participants.

Data Analysis Procedures

Statistical analyses of all data were performed using Microsoft Excel and SPSS 7.0 statistical program (SPSS Base 7.0). Analysis of the recorded measures were performed in three interrelated stages. First, data files were examined to ensure all scores had been accurately transferred from the data collection form to the Excel spreadsheet. Heart rate and pulse measures were checked to see that they were within the five beats per minute correlation limit established by the study protocol. Pulse measures and the corresponding SpO_2 measures not found to correlate within five beats per minute were expunged from the data set.

In the second stage of data analysis, measures of central tendency were calculated to provide a descriptive analysis of the data. Stem-and-leaf displays were constructed to compare the chronological (PCA) and developmental (PNA) ages for the infants at birth and on the dates of both bed and SSC treatment sessions. Individual box plots were also constructed for the mean values of each dependent variable during each observation and treatment period. This was done to enable visual comparison of changes in mean, range and standard deviation across periods and to identify outlier data values. Line graphs were constructed for each variable by time period to visualize trends and variability of data for individual participants and the sample as a whole across time periods. Histograms permitted a simplistic way to examine distributions and to evaluate the equivalencies of the groups in selected split file groupings.

The descriptive analyses were used to determine what statistical tests would be most valid to use to explore relationships between the variables, and to make comparisons between the treatment conditions. Non-normalcy of data distribution and lack of homogeneity of variance as reflected by descriptive analysis of the respective variables, coupled with the small sample size, resulted in a decision by the principal investigator to use non-parametric measures for the balance of the data analysis (Linton, 1975; Seigel & Castellan, 1988). The less restrictive assumptions of these distribution-free analyses made them the methods of choice to test the hypotheses of this study (Pett, 1997). While the data did not adequately meet the assumptions required to use parametric measures, the assumptions of all of the nonparametric tests selected for use were satisfactorily met.

The third stage of data analysis was to subject the research hypotheses to statistical testing to determine if the hypotheses should be accepted as true or rejected. In order to understand the results of the hypothesis tests, relationships between dependent variables and key demographic and design variables were examined to rule out the presence of any statistical effect related to these factors. Because the absolute salivary cortisol values obtained during the premanipulation baseline periods were higher on average for the SSC sessions compared with the bed sessions, variables were created to reflect the change between mean values between periods within each treatment session. These variables were computed by subtracting the mean value of a variable for one period from the mean value of the same variable in another period within the same treatment session. These difference variables were then compared with the absolute values for each computation performed. However, because rank ordering was used in the nonparametric tests employed for data analysis, the results of tests run with the absolute values and tests run with the difference values yielded similar results (Pett, 1997; West, 1991).

The effects of key demographic and design variables were examined by creating dichotomous variables that grouped the participants by these factors to enable a comparison of independent samples using the Mann Whitney U test. For measures of relationship, the Kendall'sTau b coefficient (T) was calculated to examine the correlation between comparable variables. The Wilcoxon sign test was used to examine the measure of association of related samples between sessions, and the Friedman test followed by a post hoc Neymenyi's test was used to examine differences among variables within the two treatment conditions (Linton, 1975; Pett, 1997).

CHAPTER IV

RESULTS

Introduction

The purpose of this study was to examine the physiological responses of infants born prematurely, to a non-invasive intervention—i.e., SSC holding—and an invasive stressor—i.e., heelstick—and to determine whether or not SSC had a moderating effect on participant responses to the invasive heelstick stressor. Two treatment conditions were created—i.e., a bed condition and a SSC condition—to examine the research questions. Data were collected over a four-month period from March to June, 1999. The results of the study are presented in three major sections: (1) descriptive analysis of the participants, (2) overview of data analysis, and (3) hypothesis testing.

Nonparametric tests were employed to test the five hypotheses posited in this study. Correlations were examined using Kendall's Tau b (T) coefficient. Strength of association for related samples within conditions was calculated by the Friedman test and Nemenyi's post hoc sign test. The strength of correlation coefficients was interpreted by guidelines presented in Levin and Fox (1994): ±0.6=strong; ±0.3=moderate; ±0.1=weak. Differences between conditions for two related measures were calculated using the Wilcoxon sign test. The Mann Whitney U test was used to calculate differences between the means of independent samples when the sample cohort was split to examine the effect of key demographic and design variables on the responses of the infants.

Additionally, bivariate descriptives and line and bar graphs were examined by variable. Statistical differences were tested at the .05 significance level.

Descriptive Analysis of the Participants

The data reported in these summaries represent paired samples from 12 infants. Descriptive analyses of the demographic characteristics of the study cohort were performed to visualize the data display and to determine overt trends or patterns (Velleman & Hoaglin, 1981). A preliminary assessment of both the uniformity and variability of the data was conducted using frequency tabulation, histograms and bivariate distributions analysis for key demographic and design variables. The potential autonomic volatility of preterm infants reflected by the range of measures rendered an important statistic as it measures extreme scores that may be associated with autonomic system compromise. However, the standard deviation may be a better index of variance because it is based on all scores and not just extreme scores (Huck & Cormier, 1996). Therefore, to ensure that the variability of the data is accurately reflected in the results reported, the mean (M), standard deviation (SD) and range are consistently reported.

Maturity at Birth

In the premature population, maturational changes dramatically affect infant reactivity. Developmental age and chronological age often vary markedly in the premature population; both influence maturation of the autonomic nervous system. Therefore, two age variables were reported in these analyses. Postconceptual age (PCA) referred to the age of the infant in weeks since conception, as measured by the Dubowitz examination (Dubowitz & Dubowitz, 1981), and reflected the developmental or maturational age of the infant. The postnatal age (PNA) recorded the infant's chronological age in days of life since birth.

Weight at birth and gestational age are closely related to stability of the autonomic nervous system; infants who are lighter and younger consistently demonstrate greater autonomic volatility than heavier, older infants. Hence, studies examining outcomes of intervention strategies with premature infants frequently group subjects according to weight at birth (in gms). The classification system most frequently reported in the literature (Horowitz, 1992) classifies birth weight according to three major categories: low birth weight (1501 – 2,500 gms), very low birth weight (1001 – 1500 gms), and extremely low birth weight (< 1,000 gms). In this study, one participant (8%) had a low birth weight, six participants (50%) had very low birth weights, and five participants (42%) had extremely low birth weights. The following calculations were determined on birth weights: M = 1062.4 gms, SD = ±318.24 gms, and range = 618-1600 gms. There was a significant and strong positive relationship between birth weight and gestational age at birth (T = .75, p = .001). Further descriptive analyses of maturational factors were conducted due to the large SD and range of birth weights and due to differences in degree of fragility of the autonomic nervous system between babies of 26 and 34 weeks PCA. Table A-2 presents a summary of the descriptive characteristics of the infants enrolled in the study.

Maturity at Enrollment

Mean PCA at enrollment was 32.9 weeks (SD 1.9; range 29.5-35.4), and mean PNA at enrollment was 23.5 days (SD14.5, range 6-49). An analysis was conducted on differences in PCA and PNA of the infants on the dates that the bed conditions and SSC conditions were administered. On the date the bed condition was administered, the mean PCA was 34.07 weeks (SD = 2.3, range = 29 -36), and the mean PNA was 32.5 days (SD=17.6, range=10 - 64). On the date the SSC session was administered, the mean PCA was 34.25 weeks (SD 1.8, range 30 – 36; the mean PNA was 33.8 days (SD =16.2023, range 8 – 68). There was no significant difference in PCA between bed and SSC conditions (Z =. 533, p = .594) nor in PNA between bed and skin conditions (Z = -.511, p = .610). The absence of significant difference between both developmental and chronological ages of the groups confirmed that although the standard deviation of the gestational age of the cohort at birth seemed large, the infants were similar in maturation at the time the treatment conditions were administered. Figure B-2.1 through B-2.7 compares the maturity of the study cohort (N =12) at enrollment, at the bed session, and at the SSC session.

Preliminary Analysis of Data

With each participant serving as his or her own control, measures of central tendency were calculated for salivary cortisol concentration levels, HR, pulse, respiratory rate (RR), and transcutaneous oxygen saturation levels (SpO_2) for each period in each treatment condition. Descriptive comparisons were constructed among values for each of the three periods that comprised the bed treatment condition, as well as the four periods that made up the SSC treatment condition. The periods that comprised each condition were as follows: (1) Bed treatment condition: premanipulation baseline (O_1), heelstick in bed treatment (X_1), postmanipulation period (O_2); (2) SSC treatment condition: premanipulation baseline (O_3), SSC treatment (X_2), heelstick in SSC treatment (X_3), post manipulation baseline (O_4). The data recorded for each 30-minute period consisted of an average of 15 two-minute, time-sampling data points for HR, pulse, RR, and SpO_2, and one salivary cortisol level taken from a saliva sample collected at the end of the period. For each outcome variable, the M, SD and range at baseline were compared to the M, SD and range within periods for the bed treatment condition (Table A-4) and the SSC treatment condition (Table A-5).

Cortisol values were examined for outliers. No outlier values were found beyond the cut off value for this study which was three standard deviations from the mean. Elevated cortisol values may potentially be due to saliva sampling occurring close to a pulse of adrenocortical activity (Gunnar, 1989). A pulse release of cortisol into an infant's circulatory system results in a sudden, temporary rise in free, unbound cortisol levels. As the ratio of unbound to bound cortisol is much higher in saliva compared to blood (Vining, McGinley, Maksvytis & Ho, 1983), the rise in salivary cortisol level can be temporarily quite high after a pulse of adrenocortical activity and could confound the infant's normal cortisol level in that condition.

Varying cut off points are used in salivary cortisol research to expunge outlier values from data analysis. Some researchers exclude data that vary greater than two standard deviations from the mean, while others include data up to three standard deviations from the mean (Gunnar, 1989; 1992). In this study, outliers were defined as those cortisol values greater than three SD above M, as determined separately for each period (O_1, O_2, O_3, O_4, X_1, X_2, X_3). Five outlier values beyond two standard deviations from the mean were identified among the dependent variables. The researcher could not confirm that cortisol values greater than two standard deviations from the mean did not reflect a valid stress response of the infant to the treatment condition. Therefore, three standard deviations above or below the mean was established as the critical value that must be exceeded in order for the case to be excluded from data analysis.

The cortisol levels obtained during all periods of the SSC session for Baby 2 and the heelstick period and postmanipulation periods for Baby 6, although considerably higher than the others in the sample, were not greater than three standard deviations above the mean; therefore, these scores were not eliminated from the data set.

In 9 of the 12 cases (75%), the mean absolute cortisol values for the SSC premanipulation baseline period were higher than the absolute cortisol values during the premanipulation baseline period of the bed session. However, no significant difference was identified between the mean premanipulation absolute salivary cortisol values for the bed condition and SSC condition ($Z = -1.569$, $p=.117$). The finding of no difference confirmed that the conditions between baseline measures were not significantly different and, therefore, could be considered comparable baseline measures by which to determine changes in the infants' responses to the test conditions.

Measures of central tendency were calculated and box plots were evaluated to examine the normalcy of distribution of cardiopulmonary dependent variables (HR, pulse, RR and SpO_2) and to identify outliers. No values greater than three SD from the M were identified for HR, RR and SpO_2.

In order to account for influence of time of day and environmental condition variances between the bed and SSC conditions, a change score variable was computed as the difference in mean value of cortisol, HR, pulse, RR and SpO_2 between all periods within each session. These change score variables were then examined concurrent with the absolute value variables in subsequent analyses.

Hypotheses Testing

The research hypotheses posited for this study were tested by exploring the relationships and differences within and between the three periods of the bed treatment condition and the four periods of the SSC treatment condition. See Figure B-3 for a representation of the analyses. The lines above the period boxes represent analyses conducted between the two treatment conditions, and the lines below the period boxes represent the analyses conducted within each treatment condition. The mean values of the dependent variables by period within the bed condition is reported in Table A-4, and for the SSC condition in Table A-5.

Hypothesis One

H_1: **Preterm infants exposed to heelstick while being held by their mothers in Skin-to-Skin Care will demonstrate less change in mean salivary cortisol levels than when exposed to heelstick while swaddled in bed.**

To observe the degree of change in basal and stressor cortisol levels during the heelstick period of the bed and SSC conditions, directions of change among periods within the two treatment conditions were examined. Visual observation of the trend lines across periods and within conditions indicted variable cortisol response patterns among participants.

The researcher noted that between the premanipulative and postmanipulative observation periods of both treatment conditions, 58% of the infants exhibited an increase in cortisol levels, while 42% experienced a decrease in cortisol levels. When the premanipulation (O_3) and postmanipulation (O_4) cortisol values were compared by case for the SSC condition, five infants (42%) experienced a net increase in cortisol levels, while seven infants (58%) experienced a net decrease in cortisol levels. When the premanipulation (O_1) and postmanipulation (O_2) periods were compared for the bed condition, eight infants (67%) experienced a net increase in cortisol levels, and four infants (33%) experienced a net decrease in cortisol levels. Patterns of change were also examined between the other periods. Nine infants (75%) demonstrated a net increase in cortisol levels from bed premanipulation (O_1) to bed heelstick (X_1). One infant (8%) demonstrated increased cortisol values between the bed heelstick (X_1) and bed postmanipulation period(O_2). Four infants (33%) demonstrated a net increase during the SSC treatment condition between SSC premanipulation (O_3) and SSC baseline (X_2) , SSC baseline (X_2) and SSC heelstick (X_3), SSC heelstick (X_3) and SSC postmanipulation (O_4).

When the responses of the participants were individually examined for variability between treatment conditions, eight of the infants (67%) varied in the direction of change between premanipulation and postmanipulation observation periods for each condition. Two infants (17%) experienced a drop in cortisol values during both conditions; and two infants (17%) exhibited an increase in cortisol levels in both conditions. Of the eight participants that varied in the direction of change between premanipulation and postmanipulation observation periods for each condition, five infants demonstrated increased cortisol levels during the bed session and decreased cortisol levels during the SSC session, and three infants demonstrated decreased cortisol levels during the bed condition and increased cortisol levels during the SSC condition.

Although the initial absolute cortisol values were generally higher during the SSC condition compared with the cortisol values during the matched periods of the bed condition, the difference was not significant. This finding was interpreted to mean that if subsequent analyses revealed differences within and between periods of the two conditions, then these differences would be a reflection of the effect of the treatment on the participants.

The Friedman's test was used to identify differences among periods within each condition. Results indicated a significant difference among periods in the bed treatment condition ($X^2 = 8.000$, df = 2, p = .018), yet no significant difference among periods in the SSC condition ($X^2 = 1.6$, df = 3, p = .659). Linton (1975) stated that if an inspection of the sums of ranks calculated by the Friedman clearly reflects where the differences in measurement lie, then a post hoc analysis is not necessary. Upon inspecting the data, the researcher discovered that there was a difference between both the bed baseline periods (O_1 and O_2) and the bed peak heelstick period (X_1) [O_1 mean rank = 1.67; X_1 mean rank = 2.67; O_2 mean rank = 1.67]. To confirm accurate interpretation of the findings, a post hoc Nemenyi's test was calculated to examine the rank sums values for statistical significance.

Nemenyi's test uses the formula: $\sqrt{[Xr^2\alpha][a(a+1)/6n)]}$ where:

$Xr^2\alpha$ = the critical value for Xr^2 required for significance in the overall analysis of the Friedman test;

a = the number of levels, and

n = the number of subjects to calculate the value of the critical difference against which the mean sum of ranks will be compared to determine whether or not a significant difference is present.

When this formula was applied, a critical value of .9993 was obtained for significance <.05. According to Linton (1975), "any difference between mean sum of ranks that exceeds the critical difference indicates a significant difference between groups" (p. 311). The differences in the mean sum of ranks for the bed heelstick (X_1) to both the bed premanipulation period (O_1) and the bed postmanipulation period (O_2) exceeded the calculated critical value. Despite the variability of cortisol responses identified for individual participants between conditions, the difference of the mean scores of the cortisol levels among the three periods of the bed condition reached significance at the .05 level, whereas a significant difference was not demonstrated among the cortisol values for the periods of the SSC condition. Therefore, Hypothesis One was accepted as written.

Hypothesis Two

H_2: **Preterm infants exposed to heelstick while being held by their mothers in SSC will demonstrate less change between periods in heart rate, pulse, respiratory rate, and SpO_2 than when exposed to heelstick while swaddled in bed.**

To test Hypothesis Two, identical procedures were applied to the cardiopulmonary variables as were described in Hypothesis One to examine the differences in cortisol concentration levels among periods in the two treatment conditions. A line graph depicting each two-minute, time-sampling data entry was constructed to demonstrate the variability of each of the cardiopulmonary variables across periods during the two treatment conditions. Trend lines were applied to visualize the slope and direction of change across periods. These individual charts were combined by variable to create line graphs demonstrating trends in HR, pulse and RR across the bed and SSC treatment conditions for all participants. Bar graphs depicting the mean values of HR, pulse, RR and SpO_2 for each period were constructed to compare trends among and between variables across time for both treatment conditions. Within-subject variability was pronounced across both treatment conditions; however, the variability of patterns demonstrated by the cardiopulmonary measures was not as dramatic as the degree of variability of the salivary cortisol measures demonstrated between and within test conditions.

Differences among periods were examined for the two treatment conditions using the Friedman's test for HR, pulse, RR and SpO_2. A significant difference was noted between periods for the SSC condition for both HR ($Xr^2 = 11.3$, df = 3, p = .010) and pulse ($Xr^2 = 8.3$, df = 3, p = .040), but not for RR ($X^2 = 1.300$, df = 3, p = .729) or SpO_2 ($Xr^2 = 1.200$, df = 3, p = .753). Visual inspection of the sum of ranks did not conclusively reveal where the differences occurred in the HR and pulse data; therefore, a post hoc analysis was conducted using Nemenyi's test as described previously. The critical value calculated by the Nemenyi's formula for the SSC condition was 1.47288. The post hoc analysis performed by comparing the differences of all possible combinations of the mean rank sums to this critical value did not confirm that the difference between periods within the SSC conditions reached significance at the .05 level for measures of either HR or pulse. A Friedman's test calculated on each of the cardiopulmonary variables to examine the difference between periods of the bed condition revealed no significant differences for HR ($Xr^2 = 3.167$, df = 2, p = .205), pulse ($Xr^2 = 2.851$, df = 2, p = .240), RR ($Xr^2 = 2.167$, df = 2, p = .338) or SpO_2 ($Xr^2 = .500$, df = 2, p = .779).

The degree of association between periods for each condition was further examined for each cardiopulmonary variable by the Wilcoxon sign test. The change value between the mean premanipulative baseline value and the mean heelstick value for the bed condition (O_1-X_1) and for the SSC condition (O_3-X_3) for each variable was examined. The results indicated no significant difference in HR (Z = -.706, p= .480) RR (Z = -.706, p = .480), and SpO_2 (Z = -.706, p = .480).

Results indicated no significant difference among any of the physiologic variables. The negative ranks associated with the Wilcoxon sign test indicated that the difference between periods in the bed session was less than the difference between the periods in the SSC session; the positive ranks indicated that the difference between periods in the bed session was greater than the difference between the periods in the SSC condition. The heart rate measures had seven negative ranks ranging from –25.73 to –3.94 and five positive ranks ranging from 3.81 to 21.31. The respiration rate measures had six negative ranks ranging from –12.16 to –5.22 and six positive ranks ranging from 2.32 to 24.43. The SpO_2 values had five negative ranks ranging from – 4.21 to -.10 and seven positive ranks ranging from .06 to 6.86.

The difference between the bed condition and SSC condition for mean HR, pulse, RR, or SpO_2 values did not reach significance at < .05; therefore, Hypothesis Two was not supported as written.

Hypothesis Three

H_3 : **Preterm infants exposed to SSC holding by their mothers will demonstrate no significant change from SSC premanipulation baseline to SSC intervention in mean salivary cortisol levels compared with baseline mean salivary cortisol levels while swaddled in bed.**

Several procedures were used to test this hypothesis. Initially, a Friedman test and follow up Nemenyi post hoc test was conducted to examine differences among mean cortisol values between periods in the SSC condition. As reported in the analysis for Hypothesis One, no significant difference was identified among the periods of the SSC condition for mean salivary cortisol values ($Xr^2 = 1.6$, $df = 3$, $p = .659$). Hypothesis Three examined the change in cortisol values between the SSC premanipulation period (O_3) and the SSC treatment period (X_2). A Wilcoxon sign test was calculated to compare differences between the following: (a) SSC premanipulation (O_3) and SSC treatment period (X_2) ($Z = -1.255$, $p = .209$), (b) bed premanipulation baseline (O_1) and SSC premanipulation period (O_3) ($Z = -1.569$, $p = .117$); and (c) bed premanipulation period (O_1) and SSC treatment period (X_2) ($Z = -1.177$, $p = .239$). The change variables created to examine the differences between periods could not be used to test Hypothesis Three because only the premanipulation period of the bed condition could be used for comparison. Hypothesis Three was supported as written.

Hypothesis Four

H_4: **Preterm infants exposed to SSC holding by their mothers will not demonstrate a significant change in mean heart rate, pulse, respiratory rate, or SpO_2 compared with baseline measures of mean heart rate, respiratory rate, or SpO_2 while swaddled in bed.**

To test this hypothesis, the Wilcoxon sign test was used to examine the differences between the following: (a) SSC premanipulation period (O_3) and SSC treatment period (X_2); (b) bed premanipulation period (O_1) and SSC premanipulation period (O_3); and (c) bed premanipulation period (O_1) and SSC treatment period (X_2). The following results were obtained:

HR: $O_3 - X_2$: Z= -.314, p = .754; $O_1 - O_3$: Z = -.157, p = .875;
$O_1 - X_2$: Z = -.863, p =.388

Pulse: $O_3 - X_2$: Z = -.392, p = .695; $O_1 - O_3$: Z = -.549, p = .583;
$O_1 - X_2$: Z = -1.334, p = .182

RR: $O_3 - X_2$: Z = -.706, p = .480; $O_1 - O_3$: Z = -.314, p = .754;
$O_1 - X_2$: Z = -.784, p = .433

Sp02: $O_3 - X_2$: Z= -1.255, p = .209; $O_1 - O_3$: Z = - 1.020, p = .308;
$O_1 - X_2$: Z = - 1.961, p = .050

For these calculations, significance at the .05 level was demonstrated only for SpO_2 between the bed premanipulation period (O_1) and the SSC treatment period (X_2). Therefore, this hypothesis was supported as written for HR, pulse and RR, but not for SpO_2.

Hypothesis Five

H_5: **There will be a direct relationship between salivary cortisol and HR, pulse, and RR and an indirect relationship between salivary cortisol levels and SpO_2 so that as salivary cortisol levels increase, HR, pulse, and RR will rise, and SpO_2 values will drop.**

This hypothesis was tested initially by constructing clustered bar graphs by case for each treatment condition to identify patterns of data presentations and trends of change across periods. Analyses previously described to identify outliers revealed that there were none. The Kendall's Tau b (T) correlation coefficients were calculated on the mean absolute values between all dependent variables. The period correlations that were explored on the dependent variables between conditions (bed and SSC) are represented by the lines above the boxes in Figure B-3. The correlations that were explored on the dependent variables within conditions are represented by the lines below the boxes in Figure B-3.

The correlation coefficients were not significant on a consistent basis in analysis both within and between the periods that comprised the two test conditions. Within the periods of both the bed condition and the SSC condition, only the HR and pulse values were correlated. The high degree of correlation demonstrated between HR and pulse was expected because of constraints applied by the study design. The research design required the pulse value to be within five bpm of the HR value in order for that pulse value and its corresponding SpO_2 value to be retained in the data set; measures that registered outside the five bpm limit were expunged from the data set. The correlation coefficient calculated by comparing the HR and pulse values was used by the researcher to confirm the validity of the SpO_2 measure for each period; if the HR/pulse correlation coefficient was high, the SpO_2 measure was assumed to be an accurate transcutaneous measure of oxygen saturation values in the blood during the period being examined.

During the SSC condition, cortisol was correlated with SpO_2, pulse was correlated with RR, and HR was correlated with pulse, RR and SpO_2. Within the SSC heelstick period, cortisol correlated with HR, pulse, and SpO_2. The significant correlations that were identified by variable within periods of the two treatment conditions are included in Table A-6. The significant correlations that occurred by variable between each period across treatment conditions are reported in Table A-7. Interestingly, there were more significant correlations between periods than within periods.

Many correlations reached significance between the dependent variables in this study, with numerous additional trends toward significance noted. However, with the exception of HR and pulse, remarkable variability was reflected in the response patterns of the variables both within and between periods of both treatment conditions. Hypothesis Five was supported as written only for the HR and pulse variables; it was not supported for the RR and SpO_2 variables.

Analysis of the Data Related to Participant Demographics and Study Design

A repeated measure research design involving premature infants in the NICU is susceptible to threats of validity by gender differences, maturational changes—both developmental and chronological—order effect, and effect of time of day that the treatment condition was administered. To explore effects of these factors on the dependent variables, dichotomous variables were created that grouped the sample according to each infant's score compared to the collective mean score for the entire sample. By using a Mann Whitney U test to compare two independent means, the responses of males/females, younger/older, more immature/less immature, bed first/SSC first, and sessions conducted before evening-day shift change—i.e, before 7:00 a.m./ sessions conducted later in the day—could be compared for effect of the respective factor on the infant's responses for each of the dependent variables. Figure B-3 graphically represents the variables that were created to examine the potential intervening effects of gender, maturation, order of treatments and time of day of sessions. The maturational variables were created by grouping the participants according to their relationship to the mean age (PCA and PNA) of the entire cohort at the time the infants were enrolled in the study.

The mean PCA of participants at the time they were enrolled in the study was 32.9 weeks. The mean PNA in days at the time the infants were enrolled was 32.5 days. For the analyses reported in this section, all infants with a PCA of < 32 weeks at enrollment were assigned to the more immature group, and all infants with a PCA of > 32 weeks at enrollment were assigned to the less immature group. All infants with a PNA of < 23 days at enrollment were assigned to the younger age group, and all infants with a PNA of > 23 days at enrollment were assigned to the older group. Figure B-4 represents the groupings created to examine these demographic and design variables.

Maturity

Maturation has been described as a principal threat to internal validity in research examining physiological variables in infants born prematurely. To examine the influence of maturation on the dependent variables, the infants were sorted by PCA into less mature (n = 6) and more mature (n = 6) groups based on mean PCA at time of enrollment. A further maturation consideration was whether or not infants responded differently based on differences in PNA at time of enrollment in the study. To examine this potential confounding factor, a variable was created to group infants into younger (n = 6) and older (n = 6) sets based on mean PNA at time of enrollment. Dependent variables were examined for differences in measures between chronological order groups using the Mann Whitney U test to compare two independent means. The difference in the amount of change between the SSC premanipulation (O_3) and SSC heelstick periods (X_3) was significant when the more immature infants (PCA < 32 wks at enrollment) and less immature (PCA > 32 wks at enrollment) groups were compared. None of the other cardiopulmonary variables demonstrated significant differences when these two groups were compared. When chronological age differences were compared (PNA < > 23 days), significance was noted for differences in salivary cortisol values for the SSC premanipulation period (O_3) ($z = -2.082$, $p = .037$) and the SSC treatment period (X_2) ($z = -2.082$, $p = .037$). Although statistical significance at the .05 level did not occur, cortisol levels during the premanipulation observation period (O_3) exhibited differences ($Z = -1.761$, $p = .078$), as did cortisol ($Z = -1.761$, $p = .078$) and respiration ($Z = -1.922$, $p = .055$) during the SSC post manipulation period (O_4). Figures B – 5.1 – B-5.24 represent the amount of change between periods for the treatment conditions using bar graphs. These figures illustrate the difference in patterns observed among all variables when the developmental and chronological maturity groups were compared across treatment conditions. Marked variability in overall response pattern occurred between the PCA groups among cortisol level, respiratory rate, and oxygen which pointed to greater physiologic volatility among the younger, more developmentally immature infants, and improved capacity to benefit from moderating SSC support among the older, more mature infants.

Gender

The gender distribution of the sample population was 42% male ($n = 5$) and 58% female ($n = 7$). The literature suggests that male infants react more strongly to noxious stimuli than female infants (Davis & Emory, 1998). To examine the potential effect of gender on the infants' stress reactivity measures, responses of males and females were compared for key variables in each treatment condition using the Mann Whitney U test. Eighty percent (4 out of 5) of the males in the study fell in the extremely low birth weight category at birth, with a -.507 correlation coefficient (p = .093) produced when a Kendall's Tau b was calculated for gender and birth weight. The mean gestational age at birth was 28.8 weeks for the males and 30 weeks for the female. At the time the infants were enrolled in the study, however, males comprised 66% (4 out of 6) of the older (by PNA) group, and 50% (3 out of 6) of the more mature (by PCA) group. The mean age of the male (M) and female (F) cohort was closely matched on PCA in weeks at enrollment (M = 33, F = 32.75) and on the date the bed session was administered (M = 34.2, F = 33.94), with the males 1.43 PCA weeks older than the females on the date the bed session was administered (M= 35.08, F= 33.65). Males were chronologically older (PNA in days) than females at enrollment (M= 29.4 days, F= 19.2 days), on the date of the bed session (M = 39.6, F= 27.57), and on the date of the SSC session (M= 45.5, F= 25.57). Thus, even though the male infants were lighter and younger at birth, at the time of enrollment males represented the less immature and chronologically older members of the sample.

The chronological and developmental age differences between the gender cohorts were also examined by comparing scores by gender on demographic and dependent variables. When the demographic variables were examined for differences in scores by gender, males and females differed significantly only on post conceptual age in weeks at the time the SSC condition was administered ($Z = -2.034$, $p = .042$).

When the responses of males and females were compared for the physiologic variables, statistical significance was reached when SpO_2 values for the bed premanipulation period ($Z = -2.030$, $p = .042$) and RR measures during bed heelstick period were compared ($Z = -2.030$, $p = .042$).

Clinically relevant trends toward significance were demonstrated in the salivary cortisol difference scores between SSC treatment period and SSC heelstick period (X_2-X_3) ($Z = -1.647$, $p = .09$), and in the difference in mean heart rate scores between SSC treatment period (X_2) and post manipulation baseline (O_4) ($Z = -1.868$, $p = .062$) and respiration rates during the heelstick treatment period (X_1) of the bed session ($Z = -2.034$, $p = .048$). While salivary cortisol levels were consistently lower among the females than males, the variability among individual females was greater than among the male infants enrolled in the study. The respiratory rates and SpO_2 values were higher for females than males. Bar graphs reflecting the differences among the male and female infants' responses both individually and collectively are presented in Figure B5.25- B5.34.

Order of Administration of Treatment Conditions

To enhance internal validity by ruling out potential order effect, a reversed order design was implemented; 50% of the subjects had the bed condition administered first and the SSC condition second, and 50% of the subjects had the

SSC condition administered first and the bed condition administered second. To examine whether or not the infants responded differently according to the order in which the treatment conditions were administered, all dependent variables were examined for differences between order groups using the Mann Whitney U test for independent samples. A significant difference was noted for order in the following: (a) mean HR when difference in scores of the SSC premanipulation baseline (O_3) was compared with SSC treatment (X_2) ($Z = -2.082$, $p = .037$); (b) SpO_2 scores during the SSC heelstick treatment period (X_3) compared with the SSC premanipulation baseline period (O_3) ($Z = -1.922$, $p = .05$); and (c) the SSC heelstick treatment period (X_3) compared with the post manipulation period (O_4) ($Z = -2.242$, $p = .025$). A trend toward significance was demonstrated in the difference scores of the mean respiration rate between the bed heelstick period (X_1) and bed post- manipulation baseline (O_3) ($Z = -1.761$, $p = .078$). In each case the group that received the bed session first experienced greater change between periods than the group that received the SSC session first. Overall, the cortisol and heart rate values were higher in the bed 1st group, and the respiratory rates and SpO_2 values were generally lower in the bed 1st group.(See Figures B5.35- B5.46)

Time of Day of Bed Session

In young children, diurnal circadian rhythms are present that influence salivary cortisol levels by time of day. Although these rhythms have not been demonstrated in infants younger than three months of age, in 75% (9 out of 12) of the cases, the absolute value of the SSC premanipulation baseline salivary cortisol values exceeded the premanipulation cortisol values of the bed condition. While 100% of the SSC sessions occurred during the day shift when the environment is much busier than during the evening shift, only 4 out of 12 (33%) of the bed sessions occurred during the day shift. To examine the effect of time of day on heart rate, pulse, respiration rate, SpO_2 and salivary cortisol levels, a variable was created to group the cases according to whether the bed treatment condition occurred before the 7:00 a.m. shift change ($n = 8$) or after shift change ($n = 4$). The Mann Whitney U test revealed a significant difference for gender ($Z = -1.982$, $p = .047$) as all four of the bed conditions that occurred late in the day were administered to females. Trends toward greater differences were present when the mean heart rate of the SSC baseline period was compared with the SSC heelstick period (X_2-X_3) ($Z = -1.698$, $p = .089$), and when the difference score of the SSC heelstick and SSC post manipulation observation period (X_3-O_4) ($z = -1.868$, $p = .062$) were examined. These values, however, did not attain the critical .05 level. Bar graphs were constructed comparing the infants by time of day that the bed condition was administered. Infants receiving the bed session before 7 a.m. demonstrated higher HR and cortisol values and lower RR and SpO_2 values than those receiving the bed session after 7 a.m. (See Figures B5.47 – 5.70)

Parental Stress Scale: NICU

Parents of the infants enrolled in the study completed the Parental Stress Scale:NICU (PPS:NICU) (Miles, 1987). These surveys were analyzed in two ways: (1) total number of responses for each of the four dimensions (infant appearance, parental role alteration, sights and sounds, and staff behaviors) and, (2) average number of responses to 4 (very stressful) and 5 (extremely stressful) from the PSS:NICU as related to participant demographics.

Analysis of Dimensions of the PSS:NICU Survey Instrument

The analyses of the dimensions of this survey instrument were examined to gain anecdotal information about similarities between infant/mother dyadic relationships in stress reactivity. The mean score of the Parental Stress Scale dimensions for the total cohort, measured on a Likert scale of 1(low) to 5(high) was as follows: (a) *Infant Appearance/Sights and Sounds*, 2.68 (SD .616); (b) *Parental Role Alteration*, 3.22 (SD 1.07); (c) *Staff Behaviors*, 1.925 (SD .853). When parents were asked to rate their "general experience" during their stay in the NICU in a single score, the majority of responses were moderately to extremely stressful. When this rating indicating how stressful in general the NICU experience had been for the parent was compared with the averages of the three subscales for each participant, 75% of the parents (n= 9) registered a higher overall measure of perceived stress than was indicated by the average of the combined subscales.

A further analysis of the total number of responses for each of the four dimensions was conducted. In the category of *Infant Appearance*, the only scenario experienced by all for infant appearance was seeing tubes and equipment on or near the baby. The most stressful situation was seeing the baby in pain, seeing bruises, cuts or incisions on the baby, and noticing altered breathing patterns. The least stressful infant appearances were the color and wrinkled appearance of the baby.

In the second dimension, *Parental Role Alteration*, the following situations were most stressful for the mothers: being separated from the baby, not being able to hold or care for the baby, especially feeding, and feeling helpless/unable to help the baby. Forgetting what the baby looked like was the least stressful and least applicable circumstance for the mothers.

In the category of *Sights and Sounds*, the most common response to stress was the sudden noise of alarms; however, it was only ranked at a moderate level stress. The large amount of people in the NICU was the least stressful response reported.

The final dimension, *Staff Behavior*, had a greater percentage of responses in the not at all or mildly stressful category and fewer very stressful and extremely stressful ratings than the other dimensions. The *staff behavior* reported to cause the greatest stress for parents was uncertainty that the parent would be called about changes in their infant's condition. The staff behaviors that were perceived as mildly stressful by the majority of the parents were the following: staff using words the parents did not understand, not being talked to enough, or being talked to by too many different professionals—doctors, nurses, other medical personnel—and concerns that too many people were allowed in the unit. The least stressful aspect concerned not being able to get information or help when they visit or telephone the unit, and the least applicable was staff looking worried about their baby.

At the completion of the PSS:NICU questionnaire, an open-ended question provided an opportunity for parents to express additional impressions or concerns experienced during their infants' hospitalization period that had not been addressed on the questionnaire. Nine parents responded with one or more comments; three parents chose not to comment further. Overwhelmingly, the comments were positive in nature, and identified *staff behaviors* as supportive of their families' needs and concerns.

Statements made by the parents on the PSS:NICU form included the following comments:

- One of the older mothers who had 2 teenage children wrote the following:

  "I feel one of the most stressful things about the NICU is there are so many nurses caring for your baby. It's so nice and comforting when your baby has the same nurses. It's very hard to leave your baby in the hands of someone you don't know. It seems just as you get comfortable with a rotation of nurses your child has had there pops up a nurse you have never seen and has never had your baby. I feel as if I want to tell them the way my baby normally eats, the medicine and feedings my baby is getting. I realize the nurses have all the info. But it feels as if I am dropping my baby off at a baby sitters for a long period of time and know nothing of the babysitter nor the babysitter of me. This stress ranks a high 5 for me."

- One of the youngest mothers wrote:

  " Staff should check ID for all parents coming to visit their child."

- The mother of the infant who was the most medically fragile wrote:

  " My main stress is when I leave my baby."

- A mother who's three year old son was also born prematurely wrote:

  " The whole ordeal is stressful for anyone. In general everything went or is going well.

- A mother who lives about 65 miles from the medical center noted:

  " It is more stressful trying to pay bills and being away from our regular routine than anything else.

- The mother of one of the sets of twins enrolled in the study wrote:

  "Moving both our twins in the NICU was very stressful, as it would be for any parent. However, we felt very good about them being cared for by Children's NICU. Your staff was extremely comforting towards us, were very honest and open with information regaarding the babies' conditions, and we felt <u>very</u> confident in the care they were receiving. We would like to specifically commend *[five nurses named]* for taking such great care of [*twins names]* and for being so kind to us.

- Other comments from the mothers included:

  " Our baby has progressed tremendously, we think, in her short stay, and we are very proud of the way your staff has cared and watched over her while she is there. We feel confident in leaving at night because the staff takes really good care of her. Her doctors [*names of two physicians*] are excellent doctors. We appreciate everything everyone has done, and the way we have been treated.

  " Everything was basically great here. Everyone did a very good job and really seems to care about the babies. The only stress I had was knowing that he was too early and wondering about complications and not being able to room with him all the time. Thank you all!!"

  "All the people that helped take care of my baby done a great job. I couldn't ask for better care they all done such a good job. Thanks NICU."

Analysis of Specific Responses on the PSS:NICU

The second type of analysis conducted on the PSS:NICU questionnaire considered the average number of responses to four and five on the Likert scale with respect to patient demographics. Six categories were extrapolated from patient charts and are as follows: birth weight, post-natal age of the infant when the survey was taken, mother's age, marital status, number of previous pregnancies, and drug/alcohol use.

To examine the effect of birth weight, the infants were grouped into lighter (< 1062 gms at birth, n = 6) and heavier (> 1062 gms at birth, n = 6). The parents of the lighter infants had higher numbers of extremely stressful and very stressful responses in the dimension of *Infant Appearance*. For the categories of *Parental Role Alteration* and *Sights and Sounds*, the trends seemed relatively equally distributed across both birth weight groups.

The relationship of infant maturity and maternal stress was explored by analyzing the mothers' responses according to the post-natal age (PNA) of the infant at the time the mother responded to the survey. The cases were divided into two groups: (a) younger (< 21 days PNA, n = 6) and (b) older (> 21 days PNA, n = 6). The postnatal age of the younger infants ranged from 6 to 17 days, and the postnatal age of the older infants ranged from 24 to 49 days. The mean birth weight of the younger infants was 1203 gms (SD 392.9, range 680-1600gms) compared with a mean birth weight of 921 gms (SD 144.94, range 694 – 1100 gms) for the older group. On average the mothers of the younger group of infants were older (M = 29.8) than the mothers of the older group (M = 25.7). The mothers of the infants in the younger group had lower average stress scores (M = 2.5) and lower total stress scores (M = 3.3) than the mothers of the older group (M = 3.5, 2.7). *Overall stress scale* scores were significantly correlated with maternal age (T = .606, p = .006), post conceptual age of the infants at enrollment (T = .545, p = .014), *Staff Behavior* scores

(T = .812, p = .001), and *Infant Appearance* scores (T = .646, p = .004). In general, the parents of infants whose length of stay was less than 21 days demonstrated a greater number of stressful responses for the items in the *Sights and Sounds* and *Infant Appearance* (M = 2.8) dimensions than the parents of the infants who had been in the NICU for longer than 21 days (M = 2.4). The parents of the older infants (> 21 days) reported higher levels of stress related to *Staff Behaviors* (M = 2.07) and *Parental Role Alteration* (M = 3.4) compared with the responses of the parents of the younger group (M =1.8 & 2.9).

To examine the effect of maternal age on parental stress in the NICU, the mothers were grouped into four age categories: 16 – 20 (n = 3), 21-25 (n = 3), 26-35 (n = 3), 36-42 (n = 3). *Very stressful* and *extremely stressful* responses were more frequent in the *Sights and Sounds* responses of the mothers in the younger (16-20) and older (36-42) age groups. *Parental Role Alteration* and *Infant Appearance* items were evident in all age groups, but occurred more frequently in the responses of mothers over 21 years of age, particularly those who had previous parenting experience. An inverse relationship was present between total stress scale (TSS) and maternal age in that the younger the age of the mother, the higher the measure of her overall perceived stress.

None of the mothers reported prenatal drug or alcohol abuse; however, three mothers reported they smoked one pack of cigarettes per day. Two of the three infants born to mothers who smoked were small for gestational age at birth. The maximum total stress score (TSS) that can be registered on the PSS:NICU is

200. The mean total stress scale for the cohort of parents who completed the survey was 68.75 out of a possible 200. The total stress scores of the mothers who smoked were compared with the scores from the rest of the sample. Two of the mothers who smoked had total stress scores in the top 25% of the cohort (TSS =124, 91) while the third mother who smoked scored in the lowest 25% (TSS = 50). One of the mothers who smoked was the youngest member of the cohort (16 years), and one was next to the oldest participant in the study (41yrs). More items from the *Infant Appearance* dimensions were rated as very stressful for the 16-year-old mother, and more items from the *Parental Role Alteration* were rated as stressful for the 41-year-old mother than for the majority of the other mothers.

Marital status was divided into two categories: married (n = 8) and single (n = 4). Two of the single mothers had other children; this was the first child for two of the mothers who reported single marital status. Two of the single mothers were the two youngest mothers in the study cohort (16 & 18 years) and this was their first child. These mothers reported that they were receiving support from their extended family and intended to reside with the maternal family of origin after discharge. One single mother was 41 years old and was in the oldest group of parents. She reported she was separated from her husband and lived alone with her eight-year-old daughter. The fourth single mother was 25 years of age, and although she designated her marital status as "single," she reported that the father was actively involved with parenting the child. She indicated she lived with the infant's father, and that they were mutually responsible for the parenting roles in their family, both for this infant and their four-year-ld son. For the dimension of *Infant Appearance*, both married and single parents averaged similar scores on stress responses. In *Parental Role Alteration*, previous parenting experiences seemed to have a stronger influence on the parents' responses than marital status. The mothers who were married and had other children registered higher stress scores on this dimension than the single parents for whom this was the first pregnancy. The two single mothers who had another child rated *Parental Role Alteration* more stressful than the single mothers who did not have other children. The responses to items in the *Sights and Sounds* dimension were not noticeably different between marital status groups.

The infant enrolled in this study was the first live birth for six of the mothers responding to the Parental Stress Scale questionnaire. The four highest total stress scale scores (135, 124, 112, 99 out of a possible 200) were from this group, as was the lowest total score (28). The "first-time" mother with the lowest stress scale score was 42 years old and had an 8-year-old adopted daughter; in addition, she was comfortable in a medical environment as her husband worked as a medical professional in an acute care medical setting.

Summary of Results

General Conclusions

1. The infants enrolled in this study were similar in maturation at the time the two treatment conditions were administered. This was evidenced by the following:
    - There was no significant difference between the developmental ages (post-conceptual age measured in weeks) of the participants on the dates that the bed treatment condition and the SSC treatment condition were administered.
    - There was no significant difference between the chronological ages (post-natal age measured in days) of the participants on the dates that the bed treatment condition and the SSC treatment condition were administered.
2. Although the mean absolute cortisol values for the premanipulation period of the SSC condition were higher than the mean absolute cortisol values of the premanipulation period for the bed condition, the baseline values were not significantly different and represented comparable measures for the statistical analyses.
3. Greater individual variability was demonstrated in cortisol responses than in cardiopulmonary responses when responses to the two treatment conditions were compared; however, trends of all variables across treatment conditions demonstrated reduced stress reactivity when heelsticks were performed during

SSC holding compared to when the heelsticks were performed while the infant was in bed.

4. The participants demonstrated greater variability of oxygen saturation responses during SSC holding than HR, pulse or RR responses.
5. In general, cortisol, HR, RR and SpO_2 responses within 30 minutes following a stressful event did not highly correlate with one another.
6. Cortisol levels tended to be directly related to HR, pulse and RR and inversely related to SpO_2 in that as cortisol levels increased, HR, pulse and RR tended to increase, and SpO_2 values tended to decrease.
7. Heart rate tended to be more often inversely related to respiration rate and SpO_2, so that as heart rate increased, respiration rate and SpO_2 values decreased.
8. Changes in salivary cortisol level were highly correlated across all treatment periods except bed premanipulation to bed heelstick. A significant relationship ($p<.01$) was evidenced in cortisol measures between the bed heelstick and bed postmanipulation periods (X_2-O_2), SSC premanipulation and SSC holding (O_3-X_2), SSC holding and SSC heelstick (X_2-X_3), and SSC heelstick and SSC postmanipulation period (X_3-$O_{4,}$). A significant correlation ($p<.05$) was also registered between the SSC premanipulation period (O_2) and the SSC postmanipulation period (O_4).
9. Heart rate measures were consistently highly correlated both within and between treatment conditions.

10. In general, RR values were directly related, but did not tend to be highly correlated within and between test conditions. Significant correlation was noted only 22% of the time.
11. SpO_2 measures reflected a direct relationship, and were significantly correlated ($p<.05$) with other SpO_2 measures 33% of the time.
12. Maternal scores on the four dimensions of the PSS:NICU were highly correlated.
13. Maternal stress scores on the *staff behavior* dimension of the PSS:NICU and post conceptual age of the infant at the time of enrollment were highly correlated.
14. Maternal overall stress scale ratings were highly correlated with scores on the *Infant Appearance* and *Staff Behavior* dimensions of the PSS:NICU, and with the post conceptual age of the infant at enrollment.
15. The most stressful situations for parents as identified by the PSS:NICU vary most dramatically according to age, previous parenting experiences, family support measures, maturity of the infant, and length of stay in the NICU.

Conclusions of Hypotheses Testing

1. Preterm infants exposed to heelstick while being held by their mothers in skin-to-skin care demonstrate significantly less change in mean salivary cortisol levels than when exposed to heelstick while swaddled in bed.

2. Preterm infants exposed to heelstick while being held by their mothers in skin-to-skin care do not demonstrate significantly less change in mean heart rate, pulse, respiratory rate, and SpO_2 than when exposed to heelstick while swaddled in bed.
3. Preterm infants exposed to skin-to-skin care holding by their mothers do not demonstrate a significant change in mean salivary cortisol levels compared with baseline mean salivary cortisol levels while swaddled in bed.
4. Preterm infants exposed to skin-to-skin care holding by their mothers do not demonstrate a significant change in mean heart rate, pulse, respiratory rate, or SpO_2 compared with baseline measures of mean heart rate, respiratory rate, or SpO_2 while swaddled in bed.
5. In intermediate care preterm infants, there is a not a significant direct relationship between salivary cortisol and HR, pulse, and RR nor is there an indirect relationship between salivary cortisol and SpO_2, heart rate and pulse so that as salivary cortisol levels increase, HR, pulse, and RR also rise, and SpO_2 values drop.

CHAPTER V

DISCUSSION

Introduction

This study focused on a description of the physiologic responses of preterm infants to an invasive and non-invasive stressor as measured by changes in adrenocortical and cardiopulmonary measures. The researcher examined the moderating effect of skin-to-skin care on the infants' responses to heelstick blood draw procedures by creating two treatment conditions—i.e., bed condition and SSC condition. Changes in the concentration level of cortisol in the saliva measured the adrenocortical response of the participants. The cardiopulmonary outcome variables included heart rate, pulse, respiratory rate, and transcutaneous oxygen saturation (SpO_2) levels.

In review, the methodology was appropriate for the type of study being conducted. Inter-rater reliability and consistency of data collection and reporting was achieved at a high level. Construct validity was supported through discrimination of adrenocortical and cardiopulmonary response in the nonintervention—i.e., premanipulation and postmanipulation—and intervention—i.e., bed heelstick and SSC heelstick—periods (Newman, 1997). Because of the many controls within the design, external validity was enhanced and the generalizability of the findings, although limited, was strengthened. Internal validity, the degree to which the independent variable (in this case, the heelstick and SSC interventions) influenced the response of the dependent variables, can be inferred. Because response over time was a factor, the treatment conditions were given in reverse order to 50% of the study cohort. Systematic error was reduced by employing a repeated measures, counterbalanced study design. Statistical conclusion validity, as seen in the statistical evidence, attended to random error (Cook & Campbell, 1979; Neuman, 1997; Pett, 1994).

This research confirmed that skin-to-skin care (SSC) intervention had a significant moderating effect on the adaptive physiologic responses of the adrenocortical system of hospitalized preterm infants after they experienced heelstick procedures. The infants did demonstrate significantly less change in the mean salivary cortisol levels following heelsticks when they were being held by their mothers in skin-to-skin care as compared with the responses of the infants when the heelstick occurred in bed. The benefit of parent-mediated consoling interventions to dampen adrenocortical reactivity was greater among the older, more mature members of the cohort, and had a stronger moderating effect on females than males.

Of note was the fact that skin-to-skin care did not produce a significant moderating effect (α .05) on the cardiopulmonary variables examined in this study when the changes in the infants' HR, pulse, RR, and SpO_2 following heelsticks performed during the bed sessions were compared with their responses following heelsticks during the SSC session. Four possible explanations are proposed to account for the variability of findings between the adrenocortical and cardiopulmonary systems in the preterm infant. First, differential maturational processes may be present between the systems. Second, the small sample size of this exploratory study may have contributed to this finding. Third, the physiologic data collection procedure designed for this study may have obscured the transient cardiopulmonary changes needed to reflect significance in the examination of the moderating effect of SSC. Since a two-minute, time sampling method was employed for recording the cardiopulmonary measures, transient events that occurred between these sampling points could have been missed. Fourth, the explanation may reside, in part, with pitfalls that have been identified in the literature relative to accurate monitoring of preterm infants' respiratory and cardiac responses. Despite the sophistication of the monitoring equipment currently available in the NICU, Sontheimer, Fischer, Scheffer, Kaempf and Linderkamp (1994) identified inconsistencies in repiratory monitoring of preterm infants during skin-to-skin care. In a study of 12 infants participating in SSC, apenic episodes were not registered in 3 out of 4 infants because parental respiration was recorded as infant breathing when the electrodes were placed on the infant's chests. Wharburton, Stark and Taeusch (1977) found that respiratory monitoring can sometimes fail to detect apneic episodes resulting from upper airway obstruction. The "trending mode" available in the monitors currently in use in the NICU in which this research was conducted provides a useful overall impression of how the infant has responded during the length of time being examined in this study, but the specific data is rendered inaccessible to statistical analysis unless manually retrieved (Hewlett Packard, 1993). In addition, the clinical monitor used for this study employs an averaging technique rather than reporting each and every value of the measured cardiopulmonary output. For example, the pulse oximeter provided an average of the oxygen saturation over 2 to 15-second intervals, depending on the averaging mode selected. Real time oxygen saturation values were not possible to obtain with the monitoring equipment available. As a result, the averaging technique may have masked the magnitude and duration of changes that may signal compromise of cardiopulmonary function. Promising real time monitoring techniques have been reported, however, by Ludington-Hoe and Kasper (1995) that may help eliminate these pitfalls to cardiopulmonary monitoring of preterm infants and enhance the researcher's ability to more accurately evaluate their cardiorespiratory responses to repeated stressor events.

Dissertation Results Related to Previous Literature

These findings are consistent with the results reported by Gunnar and associates in multiple studies (Gunnar, 1989, 1992; Gunnar, Brodersen & Krueger, 1996). Their work examined the effect of consoling interventions on male neonates' adrenocortical responses to circumcision. Gunnar's research posited an age-related change in stress reactivity among neonates. She found that the strength and sustainability of both physiologic and behavioral responses increased as the infants approached 40 weeks gestational age. Similarly, adaptive stress responses are compromised by a precipitous premature delivery or by significant health complications.

The moderating effect of SSC on cardiopulmonary responses did not reach statistical significance in this study. However, some clinically relevant findings were disclosed. Distinct differences in patterns of response were present when the mean values of the participants were examined collectively. Studies of this type are beneficial for improved understanding of the capacities of premature infants to withstand the aberrant sensory onslaughts of the extrauterine environment, and for determining optimal intervention methods to enhance resiliency among members of this fragile population.

The results demonstrated that the heelstick intervention was a stressful event for the participants. The SSC intervention, on the other hand, did not increase measures of stress reactivity. Heelsticks have been studied in pain management research because they consistently produce an increase in adrenocortical and cardiopulmonary measures when performed on healthy neonates and young infants (Anand, 1998; Gunnar &Barr,1998; Lutkus, 1991; McIntosh, Van Veen & Brameyer, 1993). The SSC intervention did not produce significant physiologic changes in either adrenocortical or cardiopulmonary responses when the salivary cortisol, heart rate, respiration rate and SpO_2 measures from the SSC intervention period were compared with the same measures taken during the baseline period of the SSC treatment condition. However, clinically identifiable patterns of differences between test conditions were present. These findings were consistent with the work of Anderson (1991), Gunner (1989), Gunnar & Barr, (1998), Ludington-Hoe, Hadeed & Anderson (1991), Ludington-Hoe, Hashemi, Argote, Medellin & Rey (1993) and Peters (1997). These authors reported distinct patterns of physiologic and behavioral responses of preterm infants to heelstick, circumcision, and SSC interventions.

The infants enrolled in the study presented remarkable individual variability when the responses of each infant were examined for all variables across periods between treatment conditions. The individual variability of the participants' responses echoed the findings of multiple authors who have reported differential response to tissue damage versus handling stressors in premature infants (Johnston, Stevens & Horton,1993; Stevens, & Johnston, 1994; Stevens, Johnston & Horton, 1994). The following key factors related to the inconsistency of behavioral responses of preterm neonates were identified by Johnston, Stevens, Franck, Jack, Stemler & Platt (1999): (a) postconceptual age at birth, (b) time since last painful procedure, and (c) wake/sleep state. They found that newborns who were younger, asleep, and had undergone a recent painful event were less likely to demonstrate behavioral and physiologic indicators of pain. Johnston and her associates conceded that it was possible that the 20% of the 120 infants enrolled in their study who did not register pain behaviors following an invasive stressor might not have felt the stimulus. However, the authors argued convincingly that it was more likely that the nonresponders actually experienced the painful stimulus, but they were incapable of demonstrating an overt interpretable pain response.

Although the research presented in this dissertation did not examine the infants' behavioral responses to the interventions tested, the results suggested that the development of physiologic responses paralleled behavioral development. The more mature infants in this study demonstrated more robust adaptive responses to stress and were more responsive to consoling support. The less mature infants more often demonstrated reduced ability to mount a physiologic response, while at the same time demonstrated greater autonomic volatility. Craig, Whitfield, Grunnau, Linton & Hadjistravropoulos (1993) reported similar results, as they examined behavioral and physiological indices of pain in preterm neonates. They determined that the responses of the premature infants they studied became stronger, were sustained for a longer period, and were more easily interpretable as they developed and grew to maturity.

The infants in the current study were observed for only 30 minutes prior to initiating the interventions. It is possible some painful event might have occurred prior to the beginning of the premanipulation observation period that might have altered the infants' response to the intervention experienced in the study. Further, during the premanipulation period, the infants were left undisturbed and securely swaddled or stabilized with positioning rolls in their isolettes. Hence, the majority of the infants were in light sleep or deep sleep before application of either the invasive stressor or the noninvasive stressor. According to Johnston, et al. (1999), each of these factors might have influenced the responses observed by this researcher. The fact that distinct patterns emerged suggested that stress reactivity in premature infants was susceptible to environmental influences. Further, these observations confirmed that stress reactivity of premature infants could be effectively measured and modified through intervention.

The results of this study were consistent with previous research that identified measurable changes in physiological measures in response to an invasive nociceptive stressor in preterm infants (Anand, 1998; Brown, 1987; D'Apolito, 1984; Gonsalves & Mercer, 1993; Lutkus, 1991; Mangano, Gardner & Karmel, 1991; McIntosh, VanVeen & Brameyer, 1993; Owens & Todt, 1984; Stevens & Johnston, 1994; VanCleve, Johnson, Andrews, Hawkins & Newbold, 1995). In the research reported for this dissertation, when basal measures were compared with peak index heelstick measures in both the bed and SSC treatment condition, on average, the mean values of salivary cortisol and heart rate increased, and measures of SpO_2 levels decreased. The mean respiratory rate decreased from the baseline to heelstick period during the bed condition, but the rate increased during the SSC condition when baseline values were compared with heelstick period values.

Gestational age had a greater effect on the cortisol values and respiratory responses than on the heart rate and oxygen saturation levels. An interesting disclosure revealed a pattern of higher cortisol values and larger standard deviations among the less mature members of the cohort than among the more mature infants' responses, during both bed and SSC treatment conditions. The infants that were chronologically younger also demonstrated higher premanipulation baseline cortisol values in both conditions. The older infants exhibited less change between periods in cortisol measures with less variability. When the responses of the younger and older infants in the study were compared for differences in the bed and SSC conditions, greater difference of cortisol values occurred between periods and greater range of heart rate and SpO_2 values were demonstrated in the bed condition in the younger infants. Two conclusions were drawn from these observations: (1) All premature infants demonstrated physiologic response to stressor events, and (2) SSC intervention was more effective to moderate the adrenocortical responses of the older infants than the younger infants in the study.

These findings concurred with several similar studies that reported that younger, less mature preterm infants demonstrated increased autonomic volatility compared with older, more mature infants. Lutkus (1991) compared changes between basal and stressor cortisol values on 47 healthy, preterm infants during the course of their NICU hospitalization. She reported a decline in mean scores and stressor cortisol levels during the course of the NICU stay. Lutkus'study further noted that the basal measures remained consistently lower than the stressor period measures throughout the hospital stay.

Several authors compared the levels of cortisol at birth of infants born as young as 26 weeks gestation. These studies consistently reported lower cortisol levels between infants born by caesarian delivery compared with those stressed by a vaginal delivery (Murphey, 1982; Procianoy, Cecin & Pinnheiro, 1983; Lagercrantz & Bistoletti, 1973). When the findings of this dissertation research were compared to the findings presented above, similar patterns were identified. The differences in scores between baseline and intervention periods and the range of measures in the current research were less among the more mature infants compared with the less mature infants. This finding suggested that physiologic coping mechanisms that are available for infants to respond to stressful events change perceptibly during the gestational period of development when extremely low birth weight infants are typically hospitalized in the NICU.

Levels of adrenocortical responsiveness during the neonatal period have been shown to correlate with temperament and self-regulatory skills later in childhood. Gunnar's research demonstrated that large increases in cortisol, heart rate and crying in the healthy term infant following stressors like a heelstick have been shown to directly correlate with robust self-regulatory behaviors at six months of age (Gunnar, Porter, Wolf, Rigatuso & Larson, 1995).

For over a decade, research has examined the relationship between early patterns of behavior and analogues of later organizational difficulties (Als, 1985; Als & Duffy, 1989; Als, Duffy & McAnulty, 1989). Documented research exists that shows a high proportion of prematurely born children have some degree of learning disabilities that cannot be clearly related to the presence of known cerebral insult (Cohen & Parmelee, 1988; Knobloch & Pasamanick, 1980).

Dissertation Results Related to Theoretical Perspective

Current research examining the effect of individualized developmental support programs applied in the NICU on long-term follow up have pointed to a direct correlation between the type of environmental input during the earliest days of life and later behavioral phenotypic expression. To explain these findings, it has been suggested that the premature birth itself has important consequences for the subsequent neural development of the child. Termed the continuity of perinatal causality, authors supporting this concept suggest that some of the medical and developmental problems resulting from premature birth arise from the immature organism's difficulty in adapting to the caregiving environment outside the womb (Duffy, Mower, Jensen & Als, 1994; Wilson-Costello, Borawski, Friedman, Redline, Fanaroff & Hack, 1998).

The concept that early experiences correlate with subsequent temperament development supports the bioecological theory of development. Bioecological theory postulates that the ultimate phenotypic complement of an individual results from a dynamic interactive process between the organism and the environment. According to Bronfenbrenner and Ceci (1994), human potential is realized through the connection of inner reserves with outer resources mediated through two-way intervening mechanisms between an organism and the environment that occurs over time. Bioecological theory posits that the individual neural substrate that results in the ultimate phenotypic complement of an individual is not caused by passive transference of genotypic potential into phenotypic expression. Rather, the ultimate phenotypic expression of an individual is produced as externalized processes are internalized and internal processes are externalized throughout the life span.

When the results of this study are considered in light of the bioecological model of development, the resilience demonstrated by an infant's self-regulatory behavior repertoire is seen as being directly related to, and dependent upon, the environmental influences available. Therefore, the moderating effect of parent-mediated interventions such as SSC has potential implications for both short-term and long-term outcomes of development. Viewed from the common perspective of continuity of perinatal causality and bioecological theory, a plausible interpretation of the results was that as the SSC intervention strengthened the proximal processes of the infants, the mismatch between the organism and the environment was reduced and the adaptive responses of the infant were enhanced. Such interventions, consistently applied throughout the hospital course, could serve to enhance resiliency in this population to stressors encountered, thereby reducing the stress reactivity of the infants that might potentiate a deleterious phenotypic expression of genotypic endowment.

The results of this study demonstrated that carefully applied interventions provided by parents in the NICU enhanced adaptive responses in premature infants. Skin-to-skin care was found to be a non-stressful intervention for the participants when carefully applied according to hospital protocols as measured by adrenocortical responses. The responses of infants' HR, pulse, RR and SpO_2

did not differ between the bed baseline condition or when they were being held by their mother in SSC. The implication of this finding suggested that SSC was a safe intervention that could be provided for intermediate care preterm infants in the NICU to help reduce stress reactivity.

The findings of this dissertation research further substantiated Sameroff and Chandler's (1975) transactional theory of development. The transactional model asserts that a robust, sustained and easily interpretable behavioral response in infancy leads to improved organization of the infant/caregiver interaction behaviors. The co-regulatory nature of human infant development is thereby enhanced. The infant's robust physiologic responses "fuel" a sustained, and easily interpreted, behavioral response. The infant's behavior, in turn, elicits a predictable response from the caregiver. The caregiver's intervention reinforces either adaptive behaviors and modulated physiologic responses or maladaptive increases in stress for the infant, which, in turn, reinforces and modifies future interaction encounters between the parent-infant dyad (Sameroff & Chandler, 1975; Ventura, 1982; Dunn, 1988). Interventions, such as SSC applied in the NICU, help synchronize the parent's approach with the infant's behavioral signals and provide opportunity for co-regulation to occur between the parent-infant dyad.

Family systems theory provides another appropriate theoretical backdrop against which to view the results because the parent / child dyad is an appropriate focus when examining stress reactivity in preterm infants. The scores recorded by the parents on the PSS:NICU revealed that the stressors encountered by the hospitalized preterm infant in the NICU produced concomitant change in other family members as well. Bowen's theoretical perspective sheds light on this phenomenon by pointing out that the experience of a premature delivery within a family unit results in irrevocable alterations to the entire family system. Challenging events, such as the family experiences during an NICU hospitalization, produce inevitable opportunities for the family unit to grow and develop (Bowen, 1978; Horowitz, 1992). Change that occurs to one member necessarily produces dyadic interactive effects among other members of the family system.

Family systems theory postulates that development is a dynamic interactional process. Therefore, the ability of a family to cope successfully with the stressors of an NICU experience depends ultimately on the ability of the family members to discover positive and creative strategies for dealing with changing situations. For the infants in this study, the interactive nature of adaptive coping was reflected by the moderating effect of parent-mediated, consoling support on the infants' physiologic responses to invasive stressor events. For the parents, the importance of dynamic interaction was demonstrated in several ways. The parents' willingness to be involved with their infants' care and to explore better methods of reducing stress during painful procedures attested to their desire to enhance the resilience of their infants in the face of unavoidable stress.

The strong relationship between staff behaviors and perception of stress by parents pointed to the fact that positive staff interaction experience could have a powerful moderating effect on the parents' perception of stress associated with the NICU experience. Of note was the fact that parental stress perceptions were more closely tied to staff behaviors than they were to infant birth weight, maturity level, length of stay in the hospital, or maternal age. Examples of staff behaviors that served to moderate parents' perception of stress associated with the NICU hospitalization of their child were provided in the open-ended comment section of the PSS:NICU. Parents with the lowest overall stress scores and the lowest scores on the staff behavior dimension of the PSS:NICU indicated a high degree of confidence in the staff's ability to care for their infant. This group of parents expressed less anxiety associated with leaving their infant, knowing that the staff was competent and caring, and had deep and sincere appreciation for the relationship-based care their infant received. Drawing again on Bronfenbrenner's ecological model of development, this phenomenon might also be explained by interactive influence of the mesosystem on the microsystem family unit (Bronfenbrenner, 1979 b; Bronfenbrenner, 1986).

Implications for Practice

Examining the physiologic adaptability of premature infants to common procedural stressors encountered during the hospitalization period in the NICU is important for medical professionals to promote optimal autonomic stability in this vulnerable population. Better understanding of the stress reactivity of these fragile infants could lead to reduction of the developmental risk associated with premature delivery. This study added to current understanding of how fragile infants respond to different procedures. Clearly defined differences were identified in the physiological responses of the infants in this study in response to SSC according to gender, birth weight, maturation, and time of day the bed session was administered. The infants responded differently to the SSC and heelstick interventions, and they demonstrated differences when the same intervention—i.e. heelstick—was administered under different conditions. This information could assist medical professionals develop intervention plans for hospitalized infants in the NICU.

Before optimal physiologic adaptability of preterm infants to environmental stressors can be supported, caregivers must know how this population typically responds to the procedures they receive during their hospitalization. Medical professionals must understand the physiologic effects of early chronic stress exposure, and what interventions best support optimal adaptive responses. This study added to the existing body of knowledge related to stress reactivity in premature infants and enhanced what is known about the potential moderating effects of parent-mediated, co-regulatory interventions. The findings reinforced the position that optimal medical care for these tiny infants necessitates a thorough understanding of the potential benefits to be gained from a team approach. They highlight the importance of recognizing that the parents are the constant in the child's life that define many of the proximal processes that strongly influence the early course of development. Parents have the potential to act as a major protective factor that could influence heritability of genotypic endowment. This study provided a renewed appreciation for the importance of maintaining consistent, positive proximal family influence from the earliest days of life, thereby supporting the premise that family-centered care principles are appropriate and necessary to implement in the NICU. The premise that medical professionals should recognize the family as integral and essential members of the health care team was supported.

There is a lack of standard practice related to parent-mediated interventions during stressful procedures in the NICU. The National Association of Neonatal Nurses has produced infant developmental care guidelines for practice that address parent involvement in the NICU. These guidelines recommend that parents be included in caregiving throughout the infant's hospital stay, and that they be encouraged to assist in the implementation of those interventions that seem to facilitate adaptation in their individual infant (NANN, 1993). But the methods for implementation of these guidelines are poorly defined. Medical professionals must take an advocacy role in promoting family centered care principles in the NICU.

In conclusion, by examining the response of multiple measures under different levels of stress, this study determined that the immature adrenocortical and cardiopulmonary systems respond to stress. It further examined the effects that parent-mediated regulatory support may have on cortisol and cardiopulmonary regulatory capacities in the preterm population. In relatively healthy premature infants, the adrenocortical system did not appear to be significantly dampened by potentially stressful events normally experienced in the NICU. These infants demonstrated adaptive cortisol responses to invasive stressors, and they demonstrated variable cortisol and cardiopulmonary responses according to maturity levels. In addition, a relationship of patterns of response between cortisol and cardiopulmonary responses to stressful events was established. Moreover, beyond the infants studied here, these findings suggested that cortisol measures could be used, not only to understand but also to identify, other groups of infants who may be at-risk for arousal regulation problems.

Future Research

As this study concludes, several important questions regarding the benefits of parent-mediated co-regulatory support for hospitalized preterm infants during stressful events remain unanswered. The data revealed significant relationships between overall levels of parental stress and parental attitudes toward staff behaviors, altered parental roles, and infant appearance. The infants demonstrated improved adaptive adrenocortical responses when parent-mediated, co-regulatory support was provided. Of note was the observation that several of the infants demonstrated higher volatility after being removed from SSC and returned to their bed than they did following the invasive heelstick procedure performed while being held in SSC. Due to the design constraints of the study, causation could not be attributed to the SSC intervention. Future research that seeks to further elucidate the exact nature of these relationships would be of value. Additionally, more precise examination of the relationship between the cardiopulmonary and adrenocortical systems is needed. This would better determine whether the discrepancy between results noted in this research was due to lack of precision of cardiopulmonary monitoring equipment (Ludington-Hoe & Kasper, 1995; Sontheimer, Fischer, Scheffer, Kaempf & Linderkamp, 1995), study design constraints that masked actual volitality of the cardiorespiratory responses, or variable responsivity in preterm infants between these two systems to stressors encountered in the NICU.

Further research could also be directed toward identifying outcomes in parent-child interaction and attachment among couples that experienced differing parent support measures in the NICU. As mentioned earlier, it is not known to what extent parent-mediated interventions in the NICU could affect completion of psychological tasks necessary in the assumption of the parental role and ultimate attachment to the child. Comparing the outcomes of traditional and non-traditional family units would be of benefit when examining these issues.

There would be merit in an investigation of the effects of different treatment approaches in modification of stress reactivity in premature infants. At this time, information remains limited on the relative benefits of individualized developmental care to enhance resilience and reduce the risk of later developmental compromise—both in the individual child and in the family unit. Research to answer this question would enhance the likelihood of effective intervention being provided by medical professionals across disciplines that encounter these clients in their practice.

Limitations

Finally, it is important to note the limitations of this study. All data were collected from infants, whose parents admitted them to a single medical institution. While this enhanced consistency of caregiving patterns, it reduced the generalizability of the results. The small sample size reduced variability of ethnic representation of families enrolled. Although a wide maternal age-span was present among the participants, the majority of the parents were either married, in married-like relationships, or benefited from strong extended family support resources. It is not known to what degree individuals in non-traditional family units may have varied in response from the participants in the current study.

Although several of the participants had experienced a prolonged post-natal critical care period, all were relatively healthy at the time they were enrolled in the study. These factors may have influenced the resiliency of the parent-infant dyad to the stressors examined. All participants were volunteers. It is not known how these families could have differed from others who were aware of the study but chose not to volunteer to participate. A single quantitative instrument (PSS:NICU) was used to address parental stress perception. Using a multi-modal approach might have permitted a more comprehensive assessment of parental stressor issues.

Therefore, it is recommended that this study be replicated with a larger and more heterogeneous sample. Repeating the study with a more diverse pool of participants from NICUs from multiple medical institutions in differing geographic locales would expand the generalizability of the findings to a larger, more diverse population.

RESEARCHER'S NOTE

A change in NICU procedures implemented during the enrollment phase of the study necessitated a revision of the data analysis planned for this study. In the original study design, data were collected during each heelstick performed on participants from the time of enrollment in the study until discharge from the NICU. Two months into the enrollment phase of the study, the medical staff of the NICU implemented a protocol that resulted in the insertion of mid-line catheters for the smaller, more fragile infants in the NICU. The mid-line catheters were used to draw blood samples to perform routine blood analyses. The majority of the blood samples being drawn from the midline catheter following the implementation of the revised policy had previously been drawn by heelsticks. The result of this procedural change was a marked reduction in the number and frequency of heelsticks ordered for the infants eligible for enrollment in the study. This necessitated a revision in the research design to examine a single paired sample of one bed condition and one SSC condition for each infant enrolled.

Three of the infants enrolled in the study had experienced an SSC session previous to the one reported in the data analyzed for this report. For one infant, the volume of saliva collected during the first SSC session was insufficient to permit laboratory analysis of the cortisol concentration, necessitating rejection of the session from data analysis. When a SSC session other than the initial one was used for data analyses, the choice of which session to include was made according to the following criteria: (a) The mean postconceptual age at the time of enrollment was calculated for the participants enrolled in the study; (b) The paired bed and SSC session that occurred closest to this mean age were identified for each of the infants with multiple bed and SSC sessions; (c) The data collected during the sessions that occurred on the dates closest to the mean age of the infants who experienced a singular bed and singular SSC session were used for data analyses.

Data were collected on duplicate bed sessions for nine infants. The researcher identified the bed session that occurred nearest to the date of the SSC session being reported for each infant to determine which bed condition heelstick to include in the data analyses.

Autonomic stability in preterm infants varies according to post-conceptual age. For the infants for which data had been collected on multiple bed and/or SSC sessions, the rationale for the sessions reported in this dissertation was based on a determination to establish a study cohort that demonstrated optimal maturational homogeneity. Therefore, the bed session that occurred on the date closest to the date of the SSC session reported was chosen. The data collected from the SSC sessions that most closely aligned the infants with duplicate SSC sessions to the mean post-conceptual age of the rest of the study cohort were reported.

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APPENDICES

APPENDIX A

TABLES

Table A – 1

Medical Diagnoses of Infants

Diagnosis	# of cases
Rrespiratory Distress Syndrome / Respiratory Distress	10
Rule out Sepsis	6
Intrauterine Growth Retardation	2
Patient Ductus Arteriosis	2
Gastroesophageal reflux	3
Hyperbilirubinemia	6
Intra ventricular Hemorrhage	
Grade I	2
Grade II	0
Necrotizing Entercholitis	
Grade I	1
Grade II	0
Grade III	0
Feeding intollerance	1
Dysmotility of prematurity	1
Peripheral pulmonic stenosis	1
Meningitis	1
Nuchal Cord	1

Medical diagnoses of Mothers:

Oligohydraminos
Preecclampsia
Abruptio placenta
Calcification in placenta
Trichomonas infection
Footling breech presentation
Delphius uterus with large fibroid within uterus
Seizures
Mild mental retardation

Table A - 2

Descriptive Statistics for Characteristics of the Participants

Sample (N=12)

Variable	Mean	SD	Range
Birth weight	1062.4 grams	318.24 grams	618-1,600 grams
Gestational Age	29.5 weeks	2.06 weeks	26 – 34 weeks
Age at Enrollment			
PCA	32.9 weeks	1.9 weeks	29.5 – 35.4 weeks
PNA	23.5 days	14.5 days	6 – 49 days
Age – Bed condition			
PCA	34.07 weeks	2.3 weeks	29 – 36 weeks
PNA	32.5 days		
Age – SSC condition			
PCA	34.25 weeks	1.8 weeks	30 – 36 weeks
PNA	33.8 weeks	16.2 days	8 – 68 days
APGARS			
One minute	5	2.08	2 – 9
Five minutes	7.5	.9	6 – 9
Length of stay	50	22.76 days	16 – 95 days

Gender	Males	42% (n = 5)
	Females	58% (n = 7)
Inborn	100%	
Birth order	1 / 1	83% (n = 10)
	1 / 2	8% (n = 1)
	2 / 2	8 % (n = 1)
Size:	AGA	67% (n = 8) (appropriate for gestational age)
	SGA	33% (n = 4) (small for gestational age)

Table A - 3

Maternal Characteristics of the Sample

N = 12

Variaable	Mean	Standard Deviation	Range
Maternal age	27.75 years	9.09 years	16 – 42 years

Marital status			
Married	67%	(n = 8)	
Single	33%	(n = 4)	
Birth History			
1st pregnancy	33%	(n = 4)	
2nd pregnancy	33%	(n = 4)	
3rd pregnancy	17%	(n = 2)	
5th pregnancy	17%	(n = 2)	
Delivery			
Vaginal	17%	(n = 2)	
Caesarian section	83%	(n = 10)	
Ethnic			
Caucasian-American	67%	(n = 8)	
Black – American	33%	(n = 4)	
Reported drug use			
Cigarettes	25%	(n = 3)	1 pack per day

Table A - 4

Summary of Outcome Variables Reported by Period Within Bed Condition

Values During Premanipulation Baseline Period

N = 12

Variable	Mean	Standard Deviation	Range
Salivary Cortisol	.34713	.20482	.089 - .663
Heart Rate	162.5587	9.8929	147 – 182
Pulse	162.1844	9.9861	147 – 182
Respiration Rate	56.2917	10.0976	39.18 – 72.19
SpO2	96.3191	1.3123	94 – 98

Values during Heel Stick Treatment in Bed

N = 12

Salivary Cortisol	.45096	.26752	.136 - .994
Heart Rate	169.0328	10.7485	153 – 189
Pulse	168.0776	10.2287	153 – 187
Respiration Rate	55.5622	10.0054	45 – 77
SpO_2	95.7156	2.0810	91 – 97

Values during Postmanipulation Observation Period

N = 12

Salivary Cortisol	.36350	.34253	.133 – 1.336
Heart Rate	167.4453	10.4354	149 – 181
Pulse	166.5630	10.3368	148 – 181
Respiration Rate	59.1048	12.7896	43 – 85
SpO_2	95.7787	2.8428	90 – 99

Table A - 5

Summary of Outcome Variables Reported by Period Within Skin-to-Skin Treatment Condition

Values during Premanipulation Baseline Period

N = 12

Variable	Mean	Standard Deviation	Range
Salivary Cortisol	.55571	.43823	.115 – 1.324
Heart Rate	163.5571	9.8716	145 – 179
Pulse	161.8316	10.2688	142 – 178
Respiration Rate	55.2692	8.7888	42 – 68
SpO2	95.4998	2.5250	88 – 98

Values during Skin-to-Skin Intervention Period

N = 12

Salivary Cortisol	.46917	.42739	.095 – 1.560
Heart Rate	161.5559	11.7392	147 – 184
Pulse	159.5435	11.9187	146 – 182
Respiration Rate	58.2175	10.2904	38 – 72
SpO_2	94.3213	2.8894	90 – 98

Values during Heel Stick Treatment During SSC

N = 12

Salivary Cortisol	.59888	.80532	.079 – 3.046
Heart Rate	168.6569	11.2357	153 – 188
Pulse	166.5884	9.8175	154 – 183
Respiration Rate	58.7641	8.1263	46 – 74
SpO_2	94.5214	3.0000	87 – 98

Values during Postmanipulation Observation Period

N = 12

Salivary Cortisol	.65263	.77682	.112 – 2.880
Heart Rate	162.6700	10.4036	138 – 173
Pulse	160.5534	10.0704	139 – 173
Respiration Rate	57.3717	8.3455	44 – 73
SpO_2	95.7644	2.2900	97 – 99

Table A – 6

Significant Correlations Among Dependent Variables Within Periods For Bed and SSC Conditions

Periods Examined	**Statistical Values**
Bed premanipulation (O1)	
HR and pulse	T=.94, p=.00
Bed heelstick (X1)	
HR and pulse	T=.97, p=.00
Bed postmanipulation (O2)	
HR and pulse	T=.91, p=.00
SSC premanipulation (O3)	
HR and pulse	T=.88, p=.00
SSC intervention (X2)	
HR and pulse	T=.88, p=.00
HR and RR	T=.46, p=.04
HR and SpO_2	T=.50, p=.023
Pulse and RR	T=.58, p=.009
Cortisol and SpO_2	T=-.50, p=.023
SSC heelstick (X3)	
HR and pulse	T=.79, p=.00
Cortisol and HR	T=.52, p=.02
Cortisol and pulse	T=.55, p=.014
Cortisol and SpO_2	T=-.55, p=.014

Table A – 7

Significant Correlations Among Dependent Variables Between Periods of Bed and SSC Conditions

Variable	Period	Statistical Value
Cortisol	Bed heelstick (X1)and bed postmanipulation (O2)	T=.79, p=.001
	SSC premanipulation (O3) and SSC intervention (X2)	T=.73, p=.001
	SSC premanipulation (O3) and SSC heelstick (X3)	T=.64, p=.004
	SSC premanipulation (O3) and SSC postmanipulation (O4)	T=.46, p=.04
	SSC intervention (X2) and SSC heelstick (X3)	T=.79, p=.00
HR	Bed premanipulation (O1) and bed heelstick (X1)	T=.61, p=.006
	Bed heelstick (X1) and bed postmanipulation (O2)	T=.73, p=.001
	Bed premanipulation (O1) and bed postmanipulation (O2)	T=.76, p=.001
	SSC premanipulation (O3) and SSC intervention (X2)	T=.58, p=.009
	SSC premanipulation (O3) and SSC heelstick (X3)	T=.58, p=.009
	SSC intervention (X2) and SSC heelstick (X3)	T=.82, p=.00
Pulse	Bed premanipulation (O1) and bed heelstick (X1)	T=.52, p=.02
	Bed heelstick (X1) and bed postmanipulation (O2)	T=.61, p=.006
	Bed premanipulation (O1) and bed postmanipulation (O2)	T=.67, p=.003
	SSC premanipulation (O3) and SSC intervention (X2)	T=.58, p=.009
	SSC premanipulation (O3) and SSC heelstick (X3)	T=.67, p=.003
	SSC intervention (X2) and SSC heelstick (X3)	T=.67, p=.003
RR	Bed premanipulation (O1) and bed heelstick (X1)	T=.76, p=.001
	Bed heelstick (X1 and bed postmanipulation (O2)	T=.67, p=.003
	Bed premanipulation (O1) and bed postmanipulation (O2)	T=.67, p=.003
	SSC intervention (X2) and SSC postmanipulation (O4)	T=.52, p=.02

SpO_2	Bed premanipulation (O1) and bed postmanipulation (O2)	T=.73, p=.001
	SSC premanipulation (O3) and SSC postmanipulation (O4)	T=.62, p=.006
	SSC heelstick (X3) and SSC postmanipulation (O4)	T=.62, p=.006

APPENDIX B

FIGURES

Figure B - 1

Research Study Treatment Conditions

Treatment Condition 1: Bed Condition

(O_1, X_1, O_2)

O_1 = Premanipulation Baseline Period
X_1 = Invasive Stressor: Heelstick in Bed
O_2 = Postmanipulation Baseline Period

O_1
30 minutes
Premanipulation baseline observation period

X_1
30 minutes
Invasive Stressor

O_2
30 minutes
Postmanipulation baseline observation period

Treatment Condition 2: Skin-to-Skin Condition

(O_3, X_2, X_3, O_4)

O_3 = Premanipulation Baseline Period
X_2 = Noninvasive stressor: Skin-to-Skin Period
X_3 = Invasive stressor: Heelstick in Skin-to-Skin
O_4 = Postmanipulation Baseline Period

O_3
30 minutes
Premanipulation baseline observation period

X_2
30 minutes
Noninvasive Stressor:
Skin-to-Skin Care Period

X_3
30 minutes
Invasive Stressor;

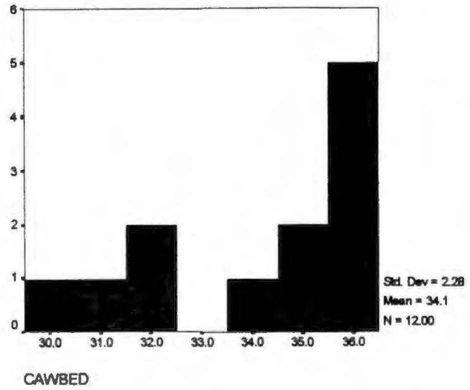
Heelstick in SSC

O_4
30 minutes
Postmanipulation baseline observation period

Figure B – 2.1 to B - 2.5

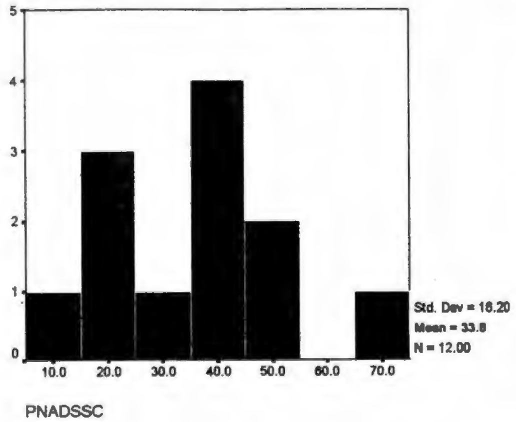
Graphs of Demographic Variables

Fig B-2.1 Histogram of Postconceptual Age at Bed Session (in weeks)



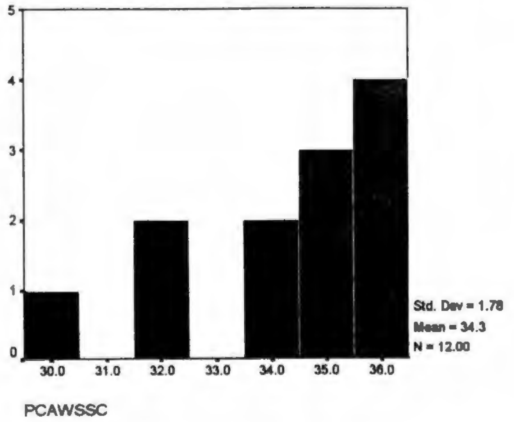
X axis = post conceptual age in weeks
Y axis = number of infants that developmental age at the bed session

Fig B - 2.2
Histogram: Postnatal Age at SSC Session (in days)



X axis = post natal age in days at SSC session
Y axis = number of infants
that chronological age

Fig B – 2.3
Histogram: Postconceptual Age at SSC Session (in weeks)



X axis = post conceptual age in weeks at SSC session
Y axis = number of infants that developmental age

Fig B - 2.4
Box Plot: Comparison of Variables Describing Maturity of Participants

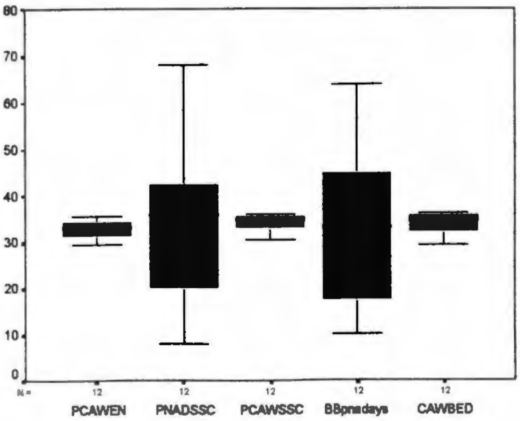
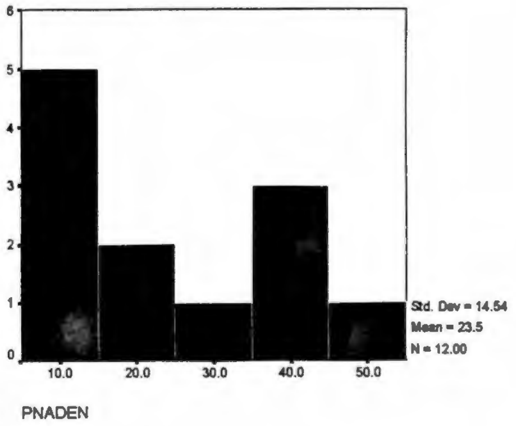


Fig B - 2.5
Histogram: Postnatal Age of Participants at Enrollment (in days)



Bar 1 = Post conceptual age in weeks at enrollment
Bar 2 = Post natal age in days at SSC session
Bar 3 = Post conceptual age in weeks at SSC session
Bar 4 = Post natal age in days at bed session
Bar 5 = Post conceptual age in weeks at bed session

X axis = PNA in days
Y axis = Number of infants

Figure B - 3: Graphical representation of relationships examined and differences explored for dependent variables within and between periods in the bed and SSC treatment condition

N = 12

Bed Condition

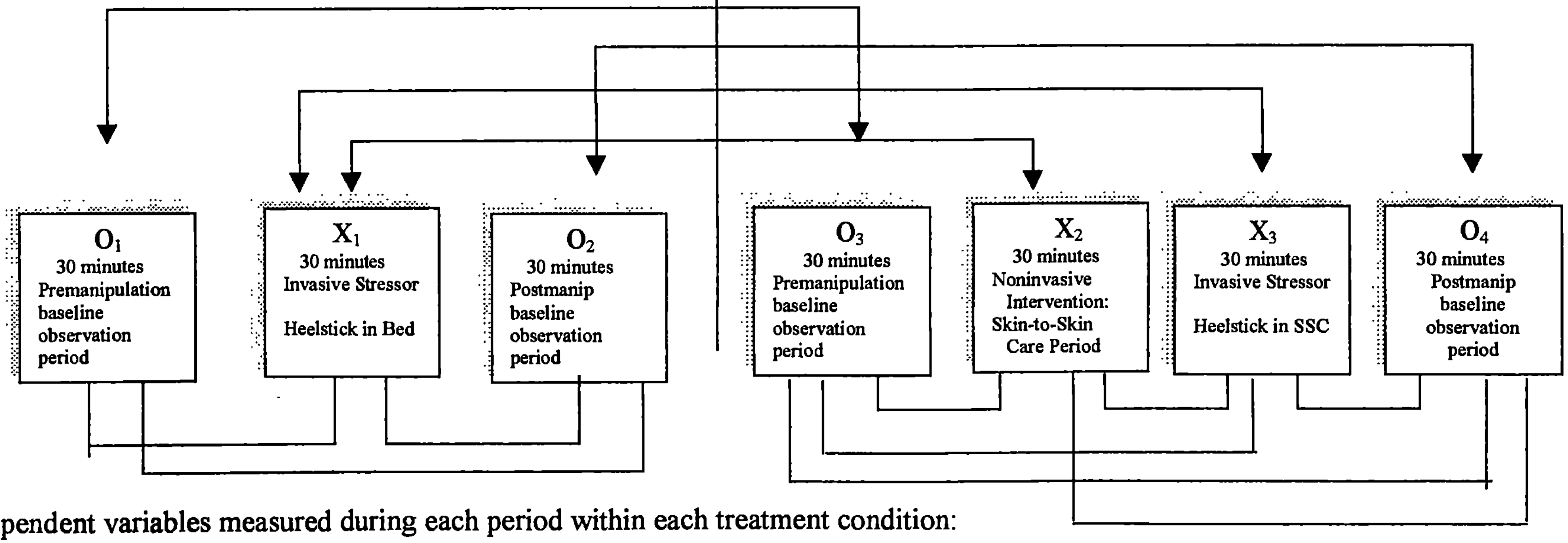
(O_1, X_1, O_2)

O_1 = Pre-Manipulation Baseline Period
X_1 = Invasive Stressor: Heelstick in Bed Period
O_2 = Post-manipulation Baseline Period

Skin-to-Skin Condition

(O_3, X_2, X_3, O_4)

O_3 = Pre-Manipulation Baseline Period
X_2 = Noninvasive intervention: Skin-to-Skin Period
X_3 = Invasive stressor: Heelstick in Skin-to-Skin
O_4 = Post-Manipulation Baseline Period



Dependent variables measured during each period within each treatment condition:

- Cardiopulmonary: Heart Rate, Pulse, Respiratory Rate, Oxygen Saturation (SpO_2)
- Adrenocortical: Salivary Cortisol

Figure B – 4

DemographicVariables

Gender	PCA (weeks)	PNA (days)	Order of sessions	Time of day
Male n = 5	Less Mature < 32 weeks n = 6	Younger < 23 days PNA n = 6	Bed/SSC n = 6	Before 7:00 am n = 8
Female n = 7	More Mature > 32 weeks PCA n = 6	Older > 23 days PNA n = 6	SSC/Bed n = 6	After 7:00 am n = 4

Figure B – 5.1 – Figure B – 5.74

Legend: Figures B-5.1 – B-5.74 are bar graphs where each bar represents the mean value of the dependent variable listed for one (1) 30 minute period as described in Figure B-1.

Bars 1 – 3 in each graph represent the three periods in the bed sessions
(Bar 1 = O_1 ; Bar 2 = X_1; Bar 3 = O_2)
Bars 4 – 7 in each graph represent the four session in the SSC sessions
(Bar 4 = O_3; Bar 5 = X_2; Bar 6 = X_3; Bar 7 = O_4)

Fig B-5.1 – B-5.12
Salivary Cortisol, HR, RR and SpO_2 by Post conceptual age at enrollment

0 = more immature group (pca < 32 weeks) ; n = 6
1 = less immature group (pca > 32 weeks) ; n = 6

Fig B-5.1 Salivary Cortisol

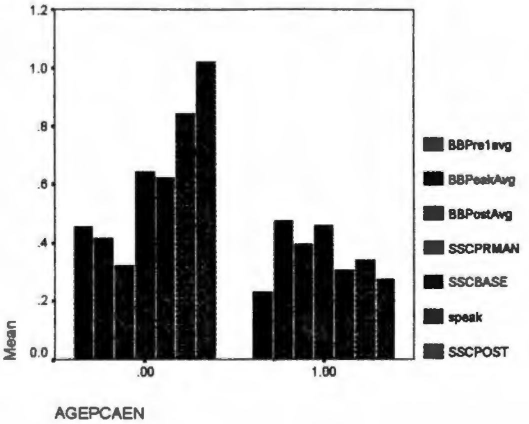


Fig B-5.2 Heart Rate

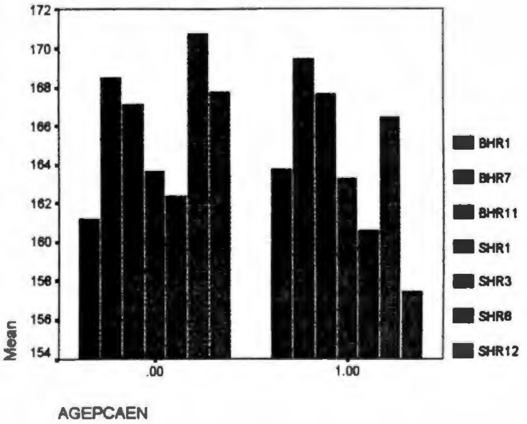


Fig B-5.3 Respiratory Rate

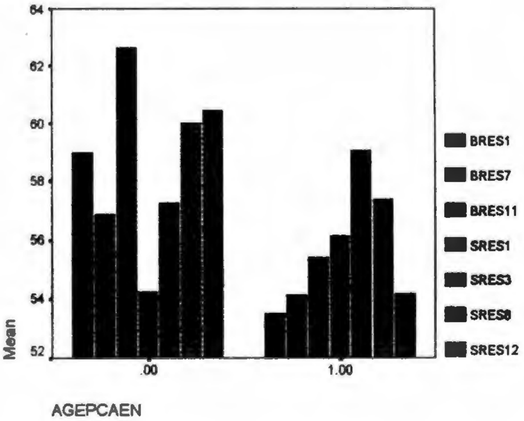


Fig B-5.4 Oxygen Saturation (SpO_2)

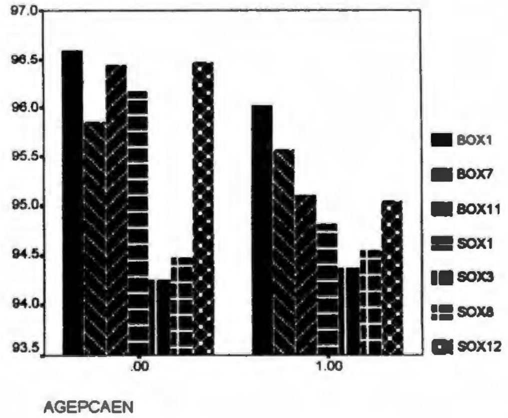


Fig B-5.5 Cortisol changes across periods: by individual participant

Less Mature Group (n = 6)

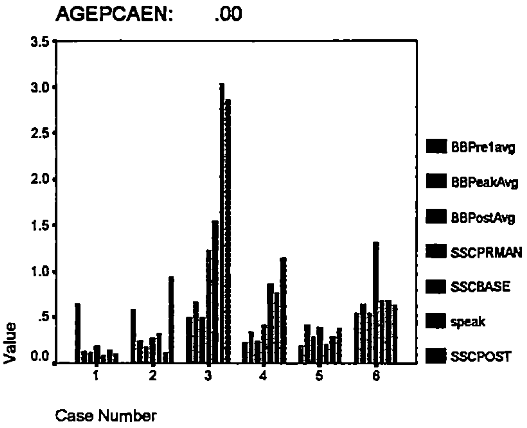


Fig B-5.6 Cortisol changes across periods: by individual participant

More Mature Group (n = 6)

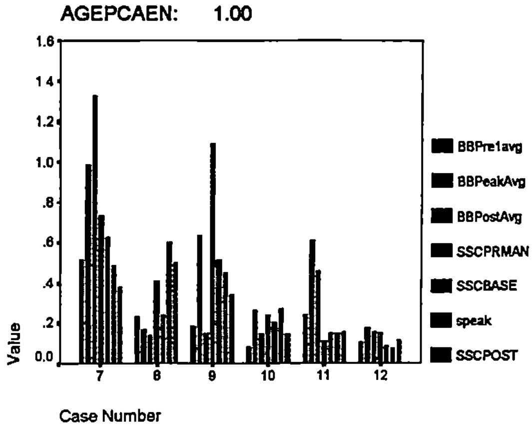


Fig B- 5.7 Heart Rate: Less Mature (n=6)

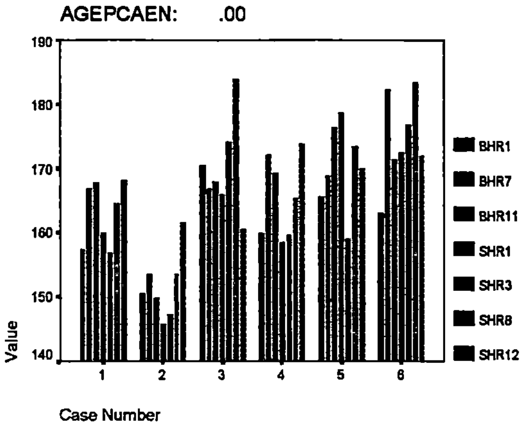


Fig B-5.8Heart Rate: More Mature (n=6)

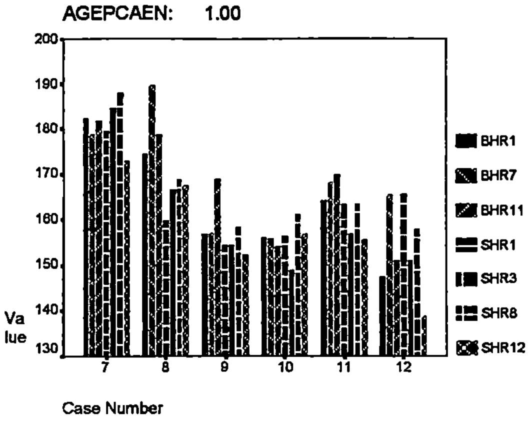


Fig B- 5.9 Respiratory Rate: Less Mature Group (n = 6)

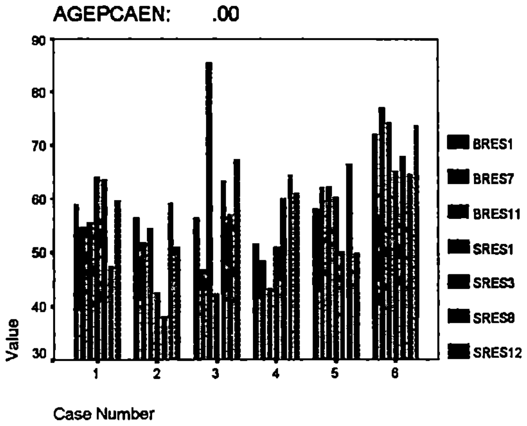


Fig B-5.10 Respiratory Rate: More Mature (n = 6)

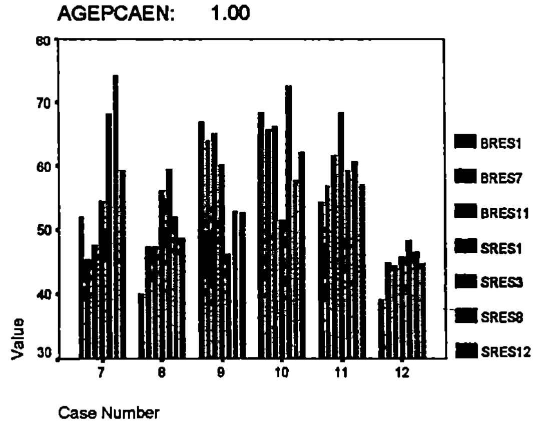


Fig B-5.11 Oxygen Saturation (SpO$_2$)
More Immature Group
(n = 6)

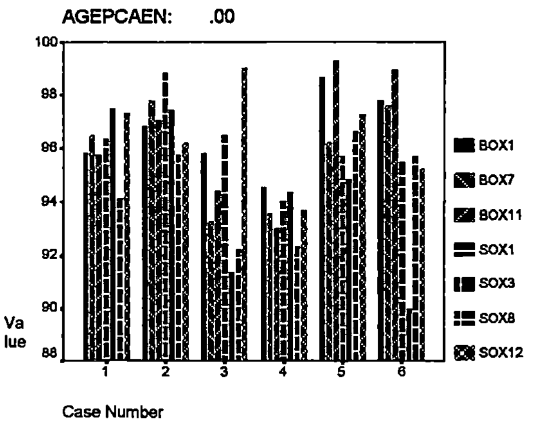


Fig B-5.12 Oxygen Saturation (SpO$_2$)
Less Immature Group
(n = 6)

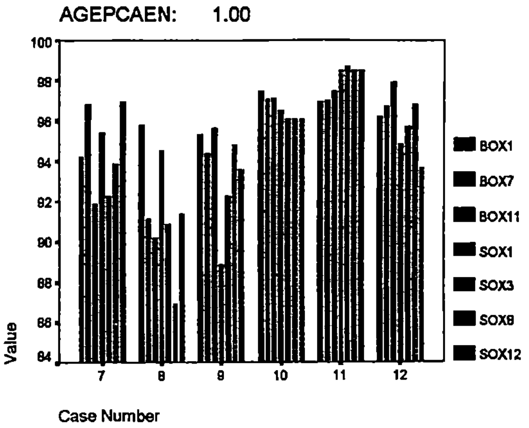


Fig B- 5.13 – B-5.24

Maturity variable: Post Natal Age at Enrollment

0 = < 23 days post natal age at enrollment (n = 6)

1 = > 23 days post natal age at enrollment (n = 6)

Fig B- 5.13 Younger Infants: Salivary Cortisol

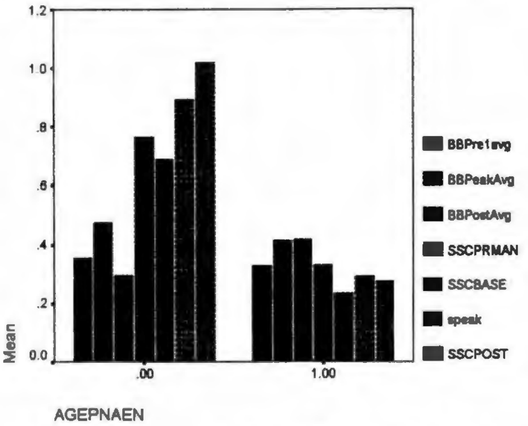


Fig B – 5.14 Older Infants: Heart Rate

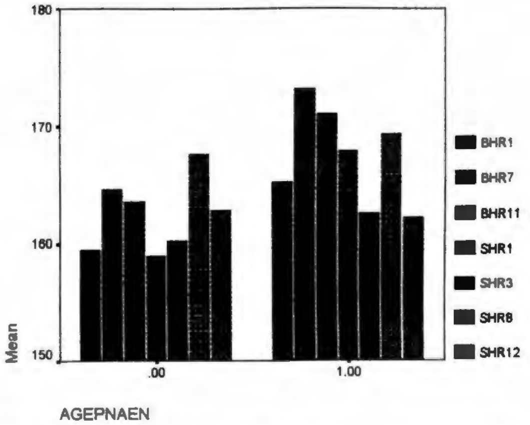


Fig B- 5.15 Younger Infants: Respiratory Rate

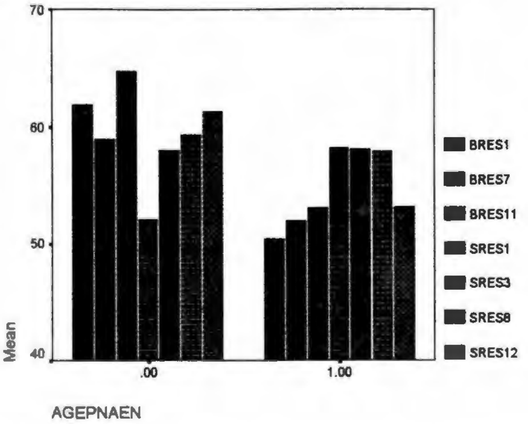


Fig B – 5.16 Older Infants: OxygenSaturation

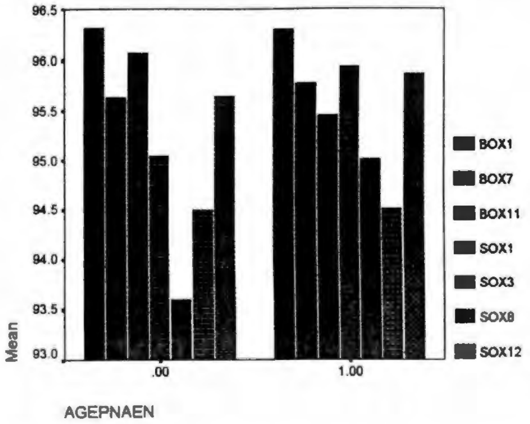


Fig B – 5.17 Cortisol changes across periods: by individual participant Less Mature Group (n = 6)

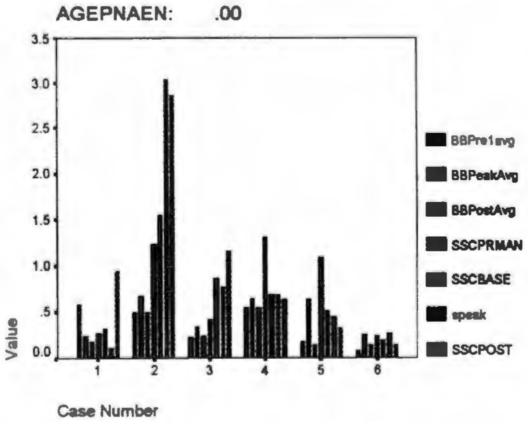


Fig B-5.18 Cortisol changes across periods: by individual participant More Mature Group (n = 6)

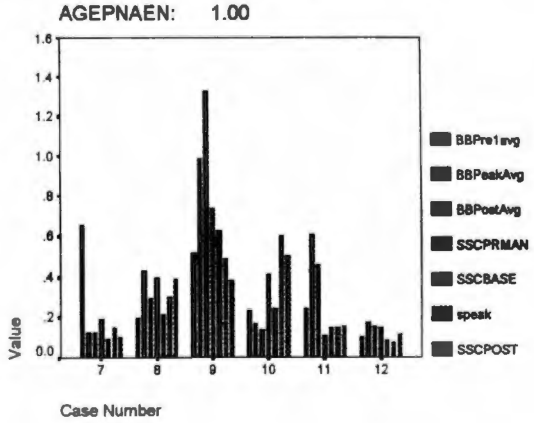


Fig B-5.19 Heart Rate: Younger Infants

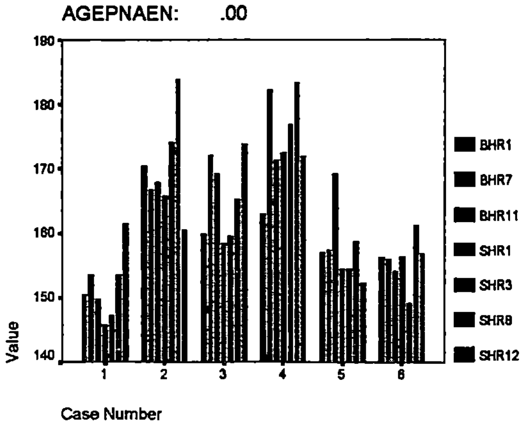


Fig B-5.20 Heart Rate: Older Infants

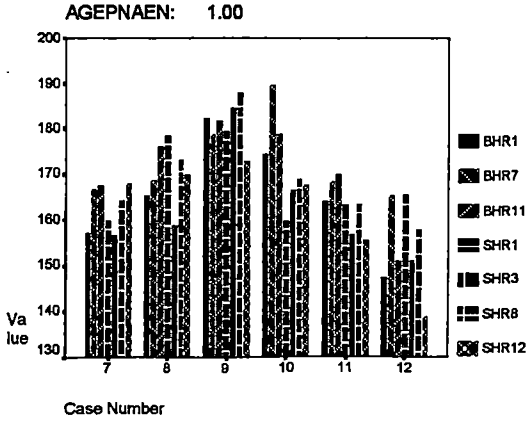


Fig B-5.21 Respiratory Rate: Younger Infants

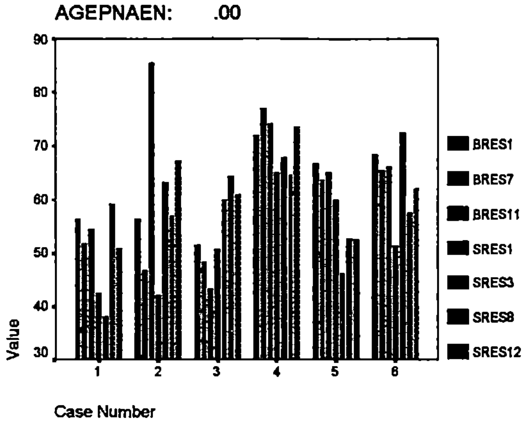


Fig B-5.22 Respiratory Rate: Older Infants

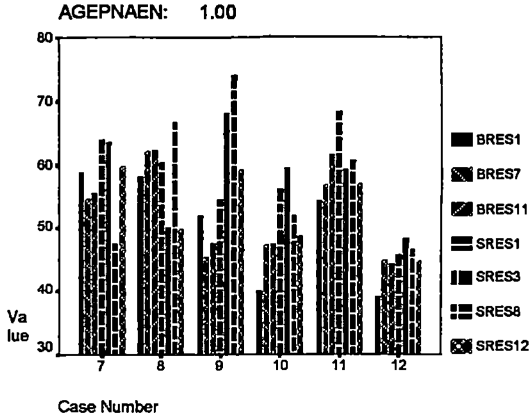


Fig B-5.23 Oxygen Saturation: Younger Infants

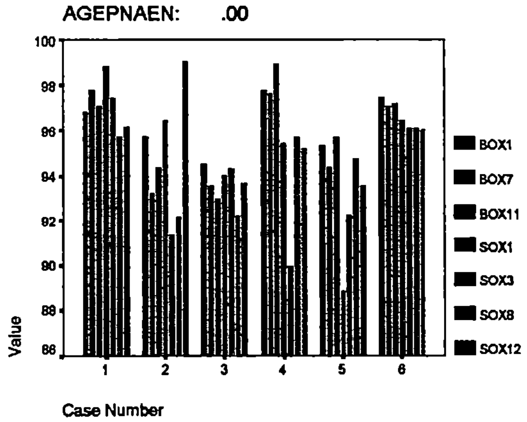


Fig B-5.24 Oxygen Saturation: Older Infants

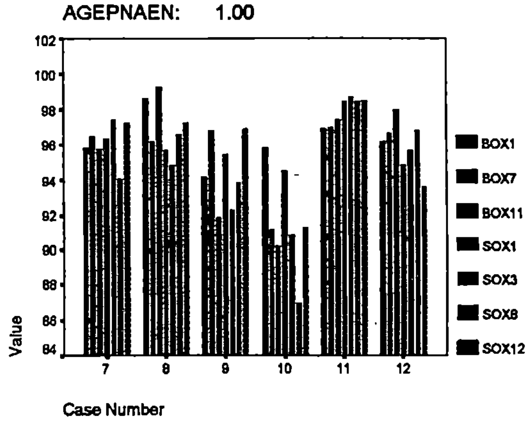


Figure B – 5.25 – B- 5.36 Gender

1 = Females (n = 7)
2 = Males (n = 5)

Fig B-5.25 Salivary Cortisol

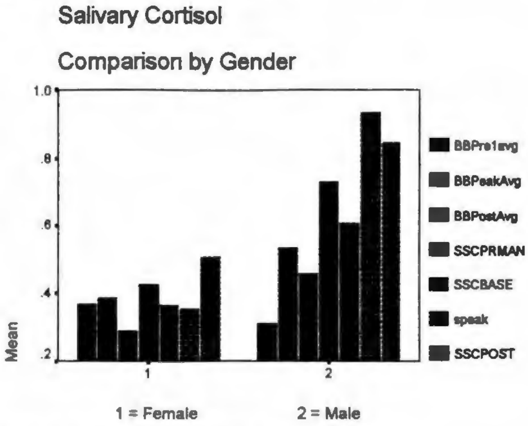


Fig B-5.26 Heart Rate

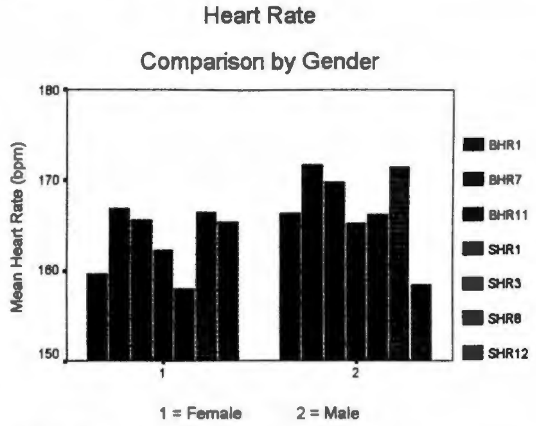


Fig B-5.27 Respiratory Rate

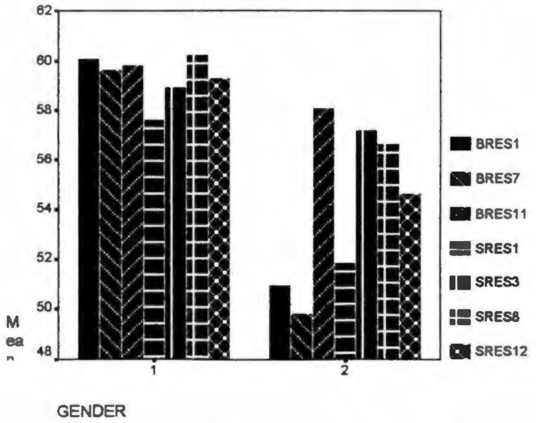


Fig B-5.28 Oxygen Saturation

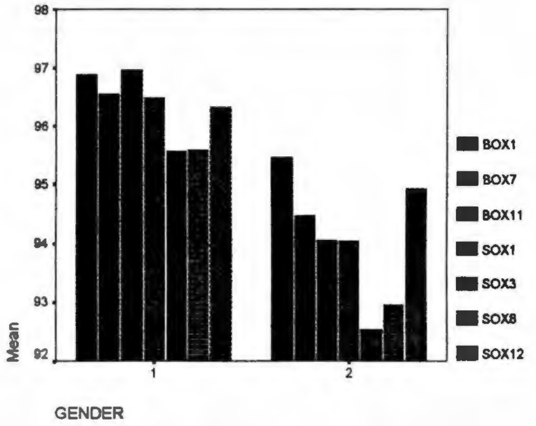


Fig B – 5.29 Females: Salivary Cortisol (n = 7)

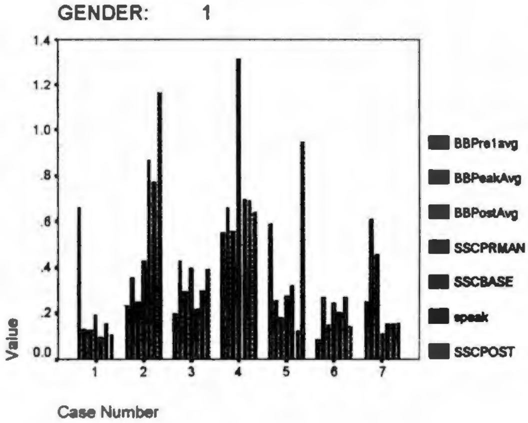


Fig B-5.30 Males: Salivary Cortisol (n = 5)

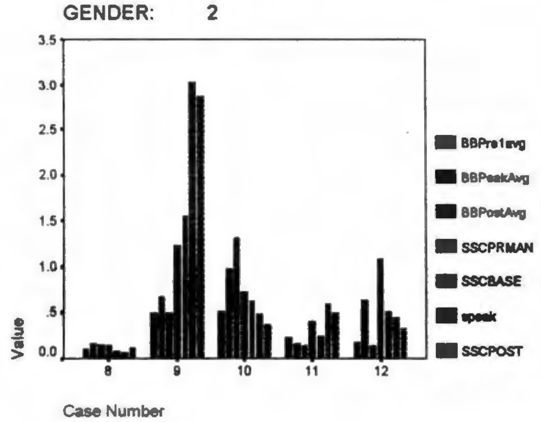


Fig B- 5.31 Females: Heart Rate
(n = 7)

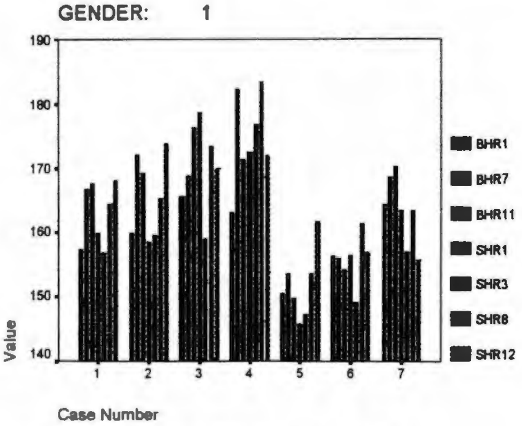


Fig B – 5.32 Males: Heart Rate
(n = 5)

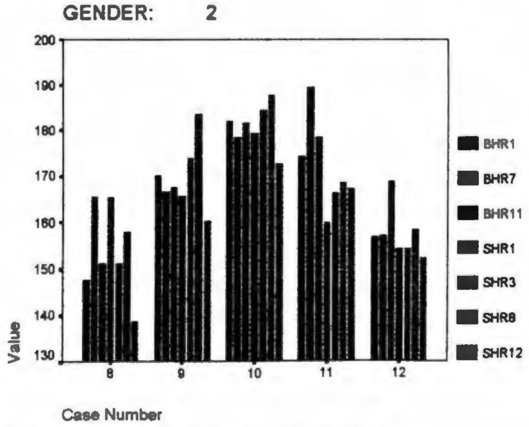


Fig B- 5.33 Females: Respiratory Rate
(n = 7)

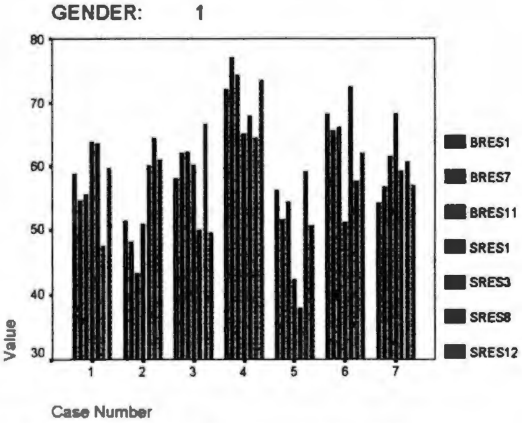


Fig B- 5.34 Males: Respiratory Rate
(n = 5)

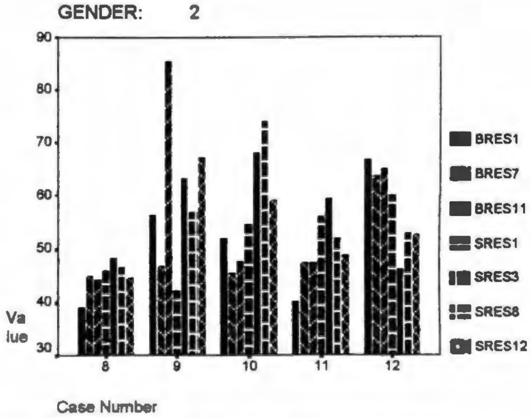


Fig B-5.35 Females: Oxygen Saturation

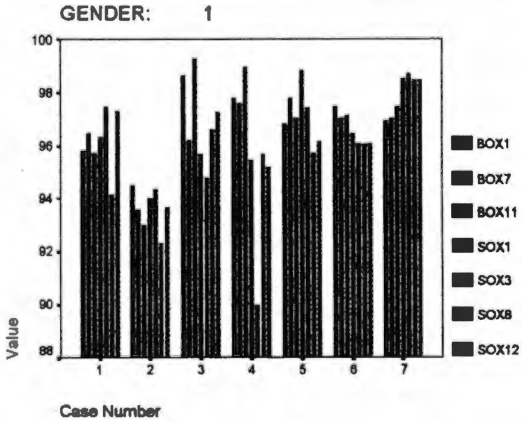


Fig B – 5.36 Males: Oxygen Saturation

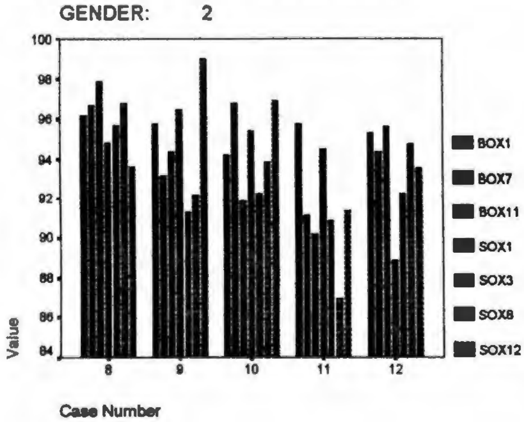


Fig B – 5.37 – B – 5.48 Order of Treatment Sessions

1 = Bed session 1st / SSC 2nd (n = 6)
2 = SSC session 1st / Bed 2nd (n = 6)

Fig B – 5.37 Salivary Cortisol

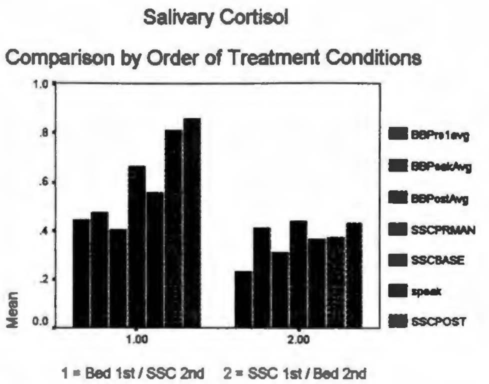


Fig B – 5.38 Heart Rate

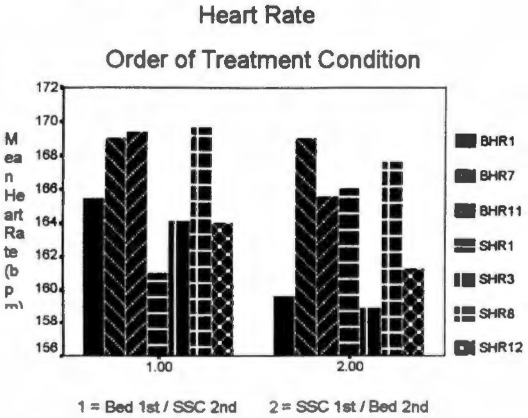


Fig B – 5.39 Respiratory Rate

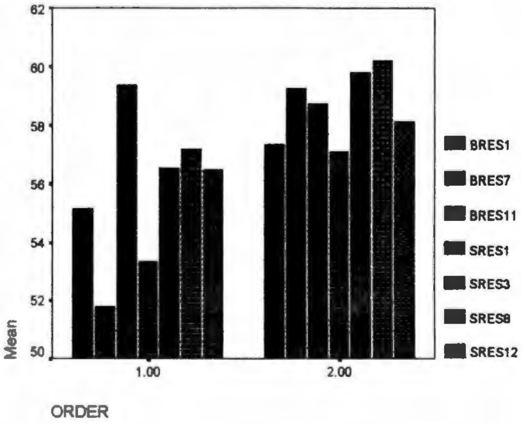


Fig B – 5.40 Oxygen Saturation

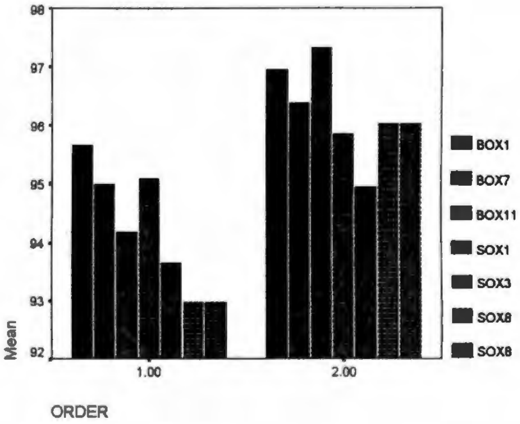


Fig B-5.41 Bed 1st Salivary Cortisol

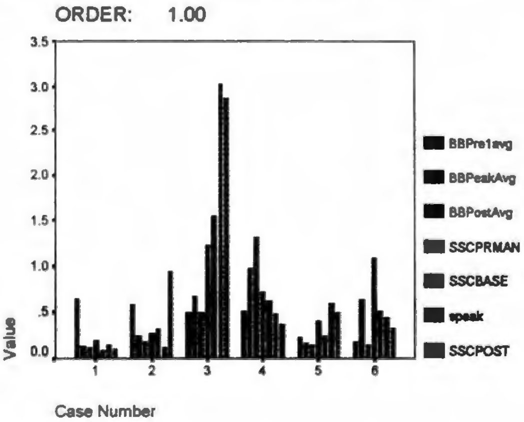


Fig B – 5.42 SSC 1st Salivary Cortisol

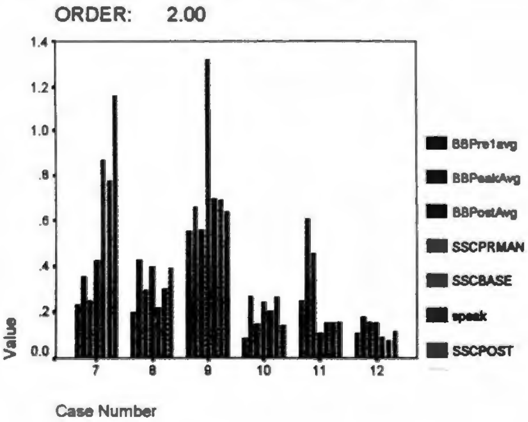


Fig B – 5.43 Bed 1st Heart Rate

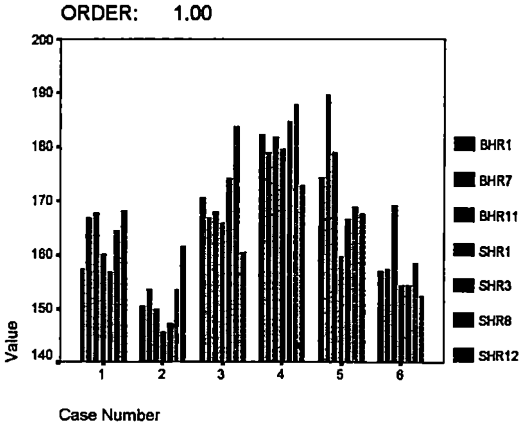


Fig B – 5.44 SSC 1st Heart Rate

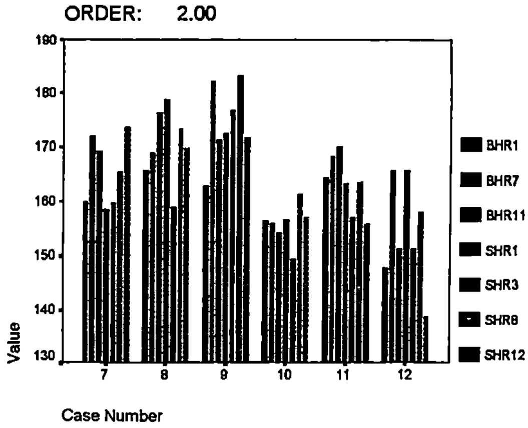


Fig B-5.45 Bed 1st Respiratory Rate

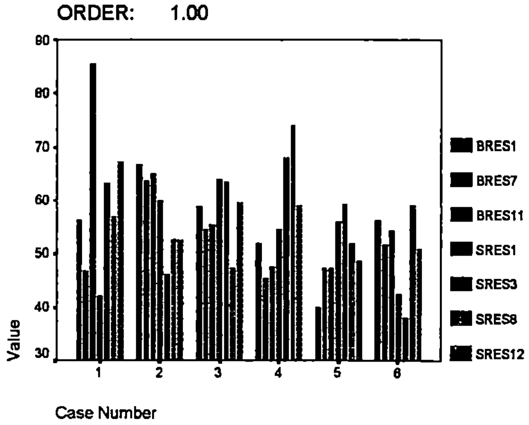


Fig B-5.46 SSC 1st Respiratory Rate

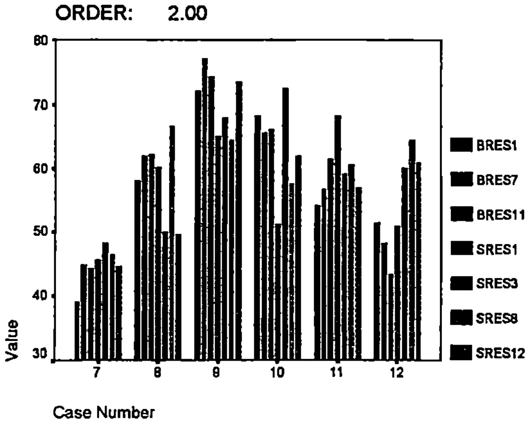


Fig B-5.47 Bed 1st Oxygen Saturation

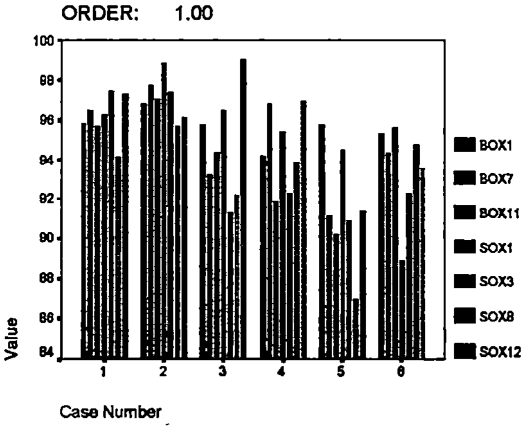


Fig B-5.48 SSC 1st Oxygen Saturation

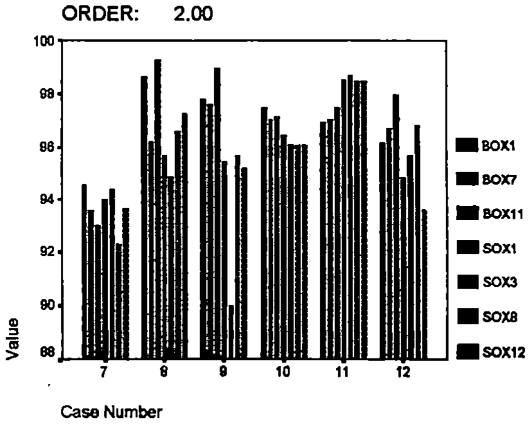
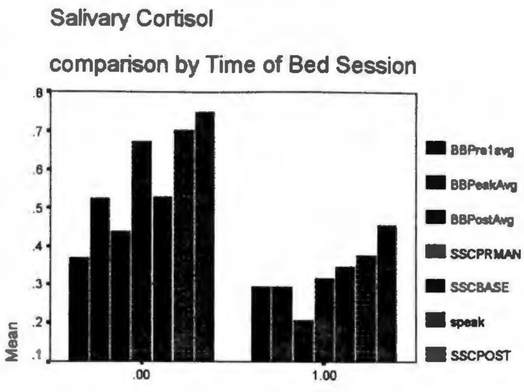


Fig B- 5.49 – 5.54 Time of Bed Session

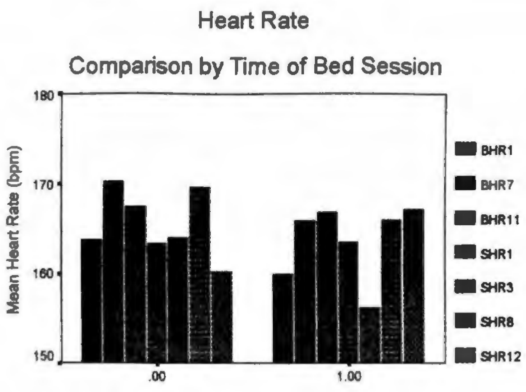
00 = Bed Session before 7:00 a.m. (n = 8)
01 = Bed Session after 7:00 a.m. (n = 4)

Fig B-5.49 Salivary Cortisol



1 = bed session before 7:00 am 2 = bed session after 7:00 am

Fig B-5.50 Heart Rate



1 = Bed session before 7:00 am 2 = Bed session after 7:00 am

Fig B-5.51 Respiratory Rate

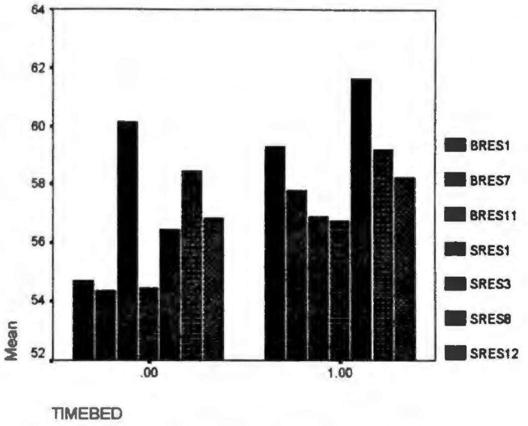


Fig B-5.52 Oxygen Saturation

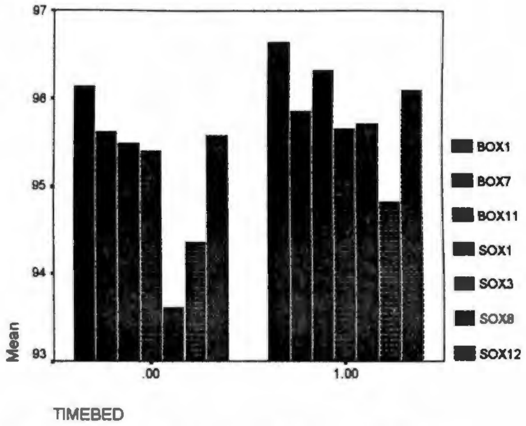


Fig B-5.53 Bed session before 7:00 am
Salivary Cortisol (n = 8)

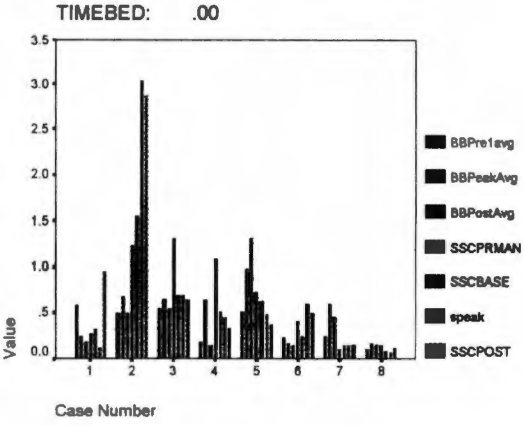


Fig B-5.54 Bed session after 7:00 a.m.
Salivary Cortisol (n = 4)

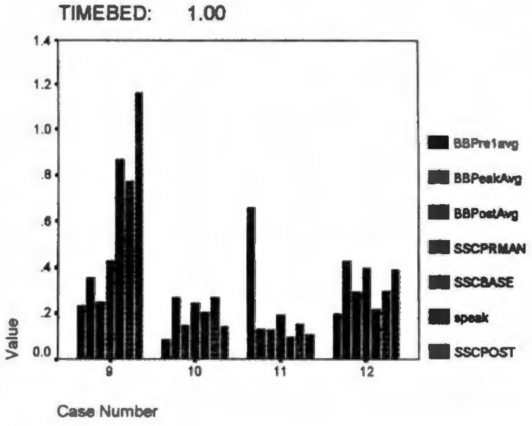


Fig B-5.55 Bed session before 7:00am Heart Rate

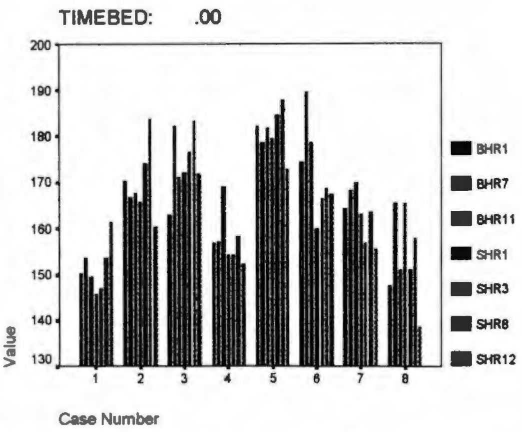


Fig B-5.56 Bed session after 7:00 am Heart Rate

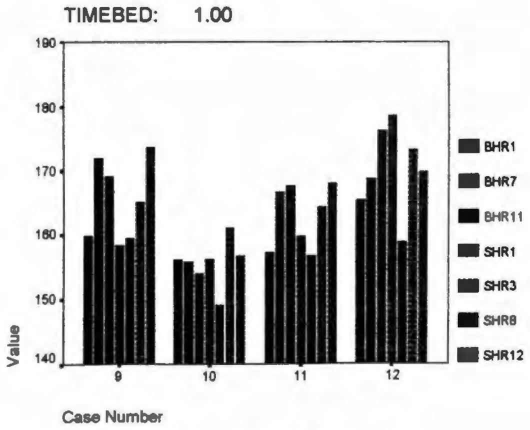


Fig B- 5.57 Bed session before 7:00 am Respiratory Rate

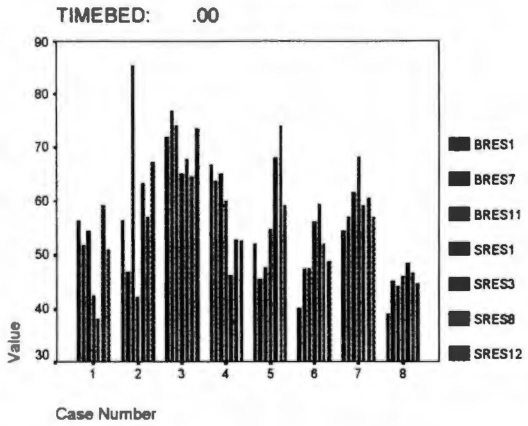


Fig B-5.58 Bed session after 7:00 am Respiratory Rate

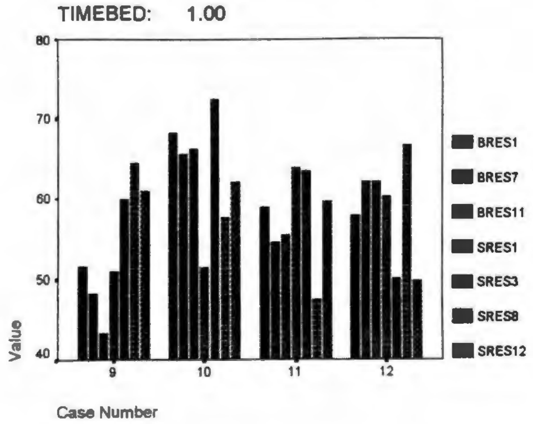


Fig. B- 5.59 Bed session before 7:00 am Oxygen Saturation

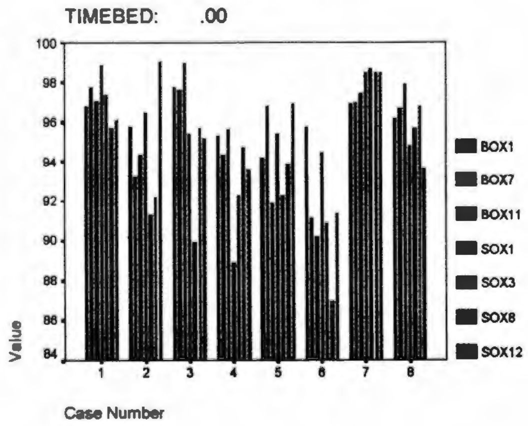


Fig B- 5.60 Bed session after 7:00 am Oxygen Saturation

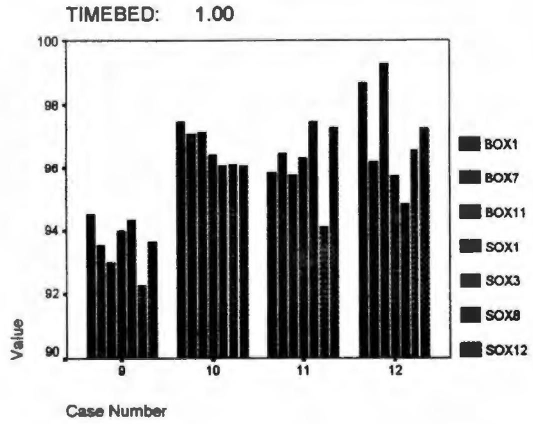


Figure B - 5.61 – B - 5.72 Birth Weight of Infants

00 = Infants with Birth Weight < 1062 gms
01 = Infants with Birth Weight > 1062 gms

Fig B- 5.61 Lighter Infants: Salivary Cortisol

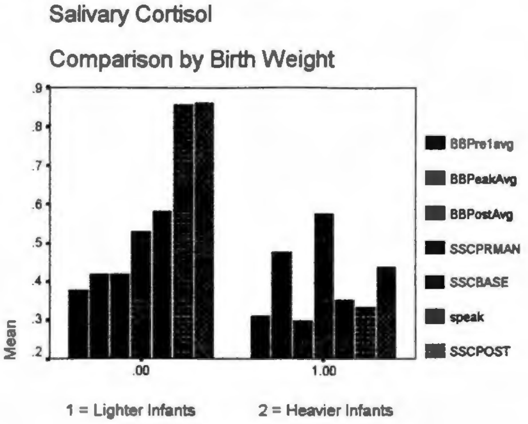


Fig B-5.62 Heavier Infants: Heart Rate

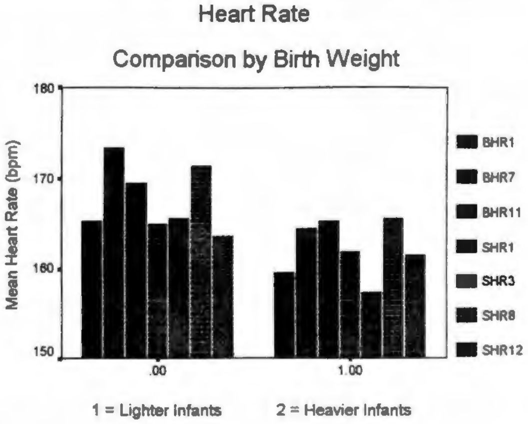


Fig B-5.63 Lighter Infants: Respiratory Rate

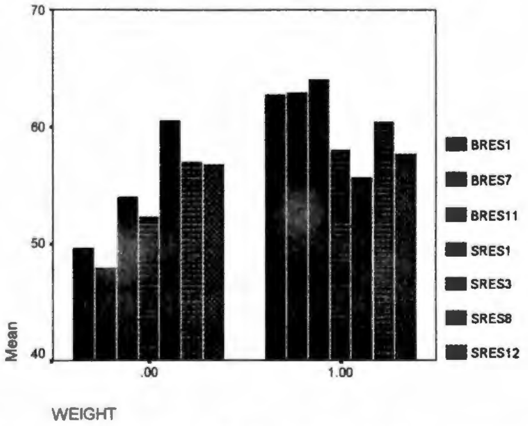


Fig B-5.64 Heavier Infants: Oxygen Saturation

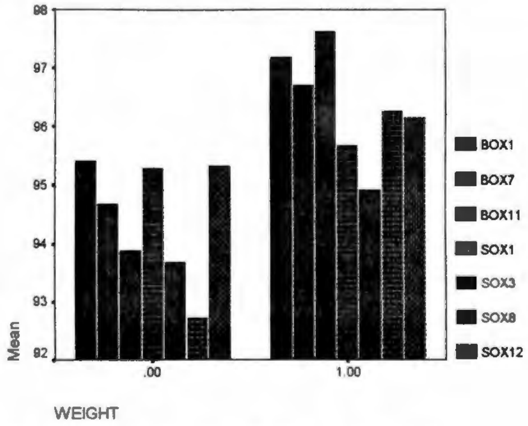


Fig B-5.65 Lighter Infants: Individual Responses Salivary Cortisol

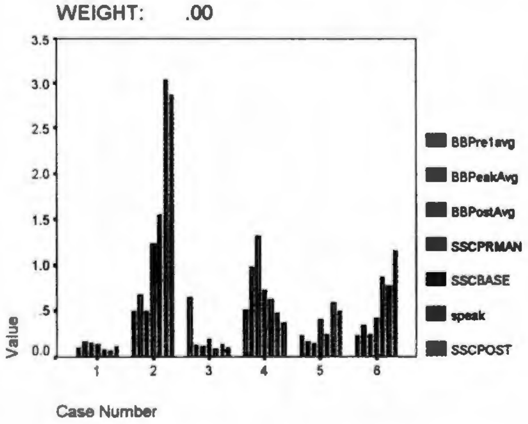


Fig B-5.66 Heavier Infants: Individual Salivary Cortisol

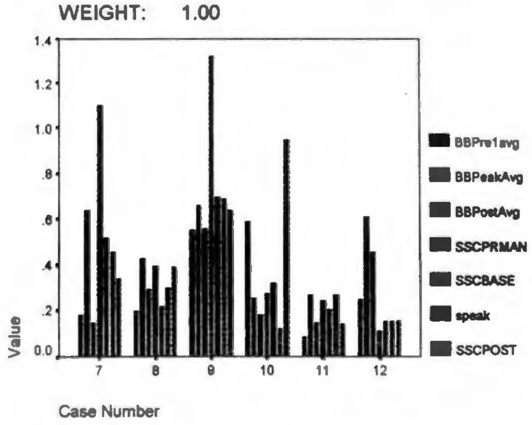


Fig. B-5.67 Lighter Infants: Heart Rate

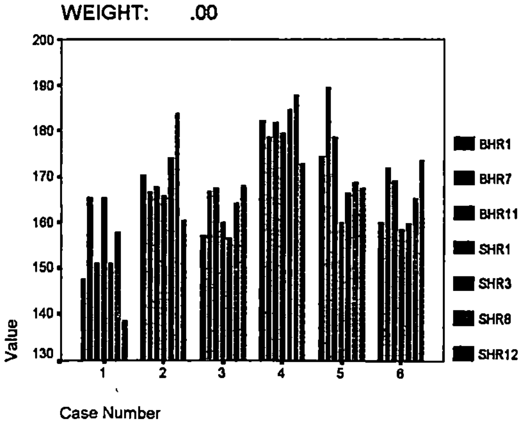


Fig B. B-5.68 Heavier Infants: Heart Rate

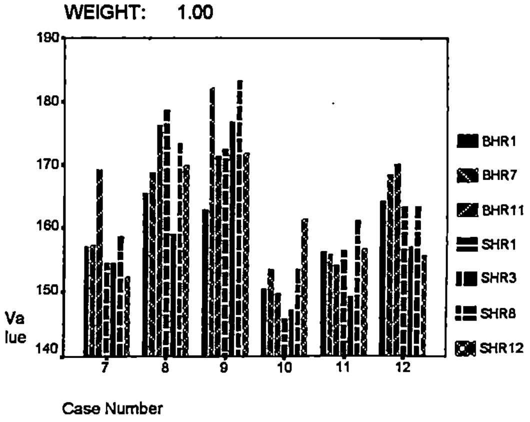


Fig B- 5.69 Lighter Infants: Respiratory Rate

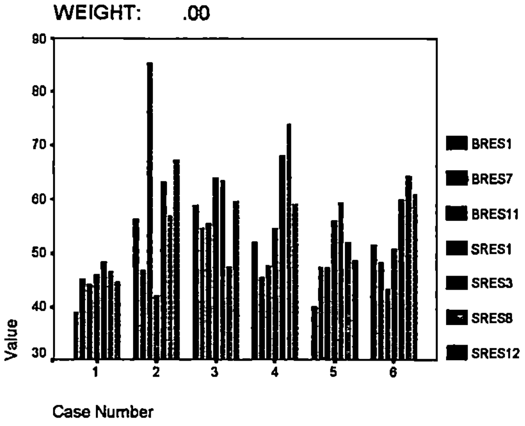


Fig B-5.70 Heavier Infants: Respiratory Rate

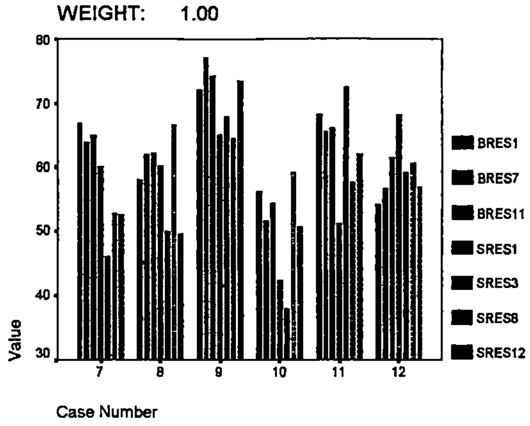


Fig B- 5.71 Lighter Infants: Oxygen Saturation

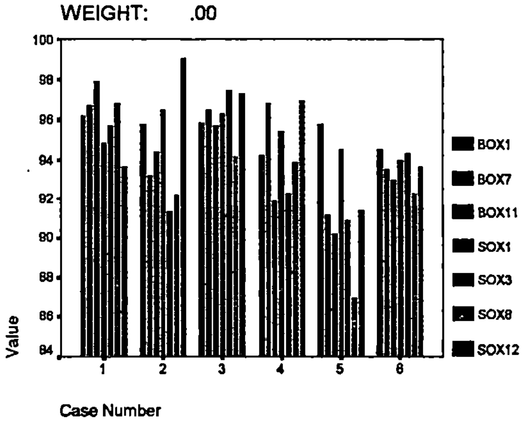


Fig B-5.72 Heavier Infants: Oxygen Saturation

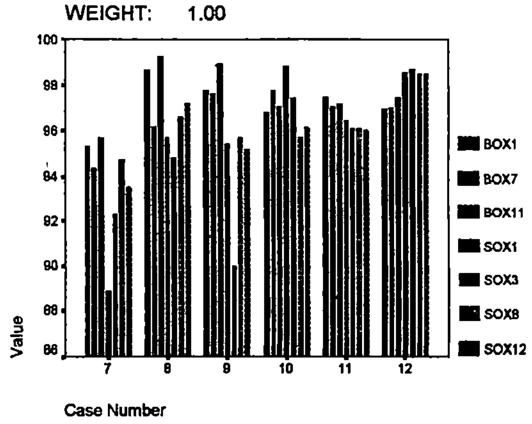
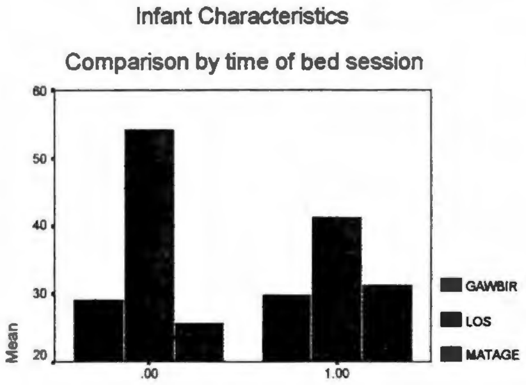
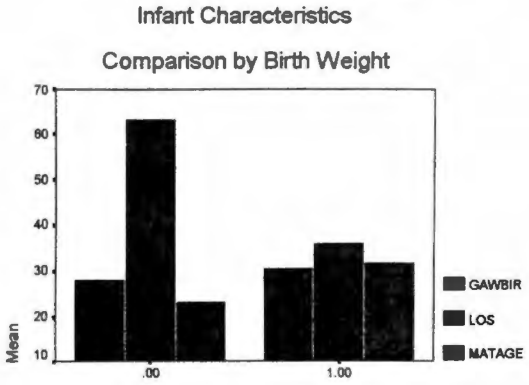


Fig B-5.75 Infant Characteristics by By Time of Bed Session



1 = bed session before 7:00 am 2 = bed session after 7:00 am

Fig B-5.76 Infant Characteristics by Birth Weight



1 = Lighter Infants 2 = Heavier Infants

Bar 1 = Gestational Age at Birth
Bar 2 = Length of Stay in the NICU
Bar 3 = Mother's Age at the time of the birth of this child

VITA

Catherine R. Smith holds the Doctor of Philosophy degree in Human Ecology from the University of Tennessee, Knoxville with a concentration in Child and Family Studies. She was awarded the Bachelor of Science in Physical Therapy from the University of Tennessee Medical Units in Memphis, Tennessee, and the Masters in Education with a concentration in Diagnostic and Prescriptive Special Education from the University of Tennessee at Chattanooga. She has been designated a Pediatric Clinical Specialist by the American Board of Physical Therapy Specialties. Professional certifications include Basic 8-week Neurodevelopmental Treatment Certification, Brazelton Neonatal Behavior Assesment Scale Certified Examiner, and certified NIDCAP (Neonatal Individual Care Assessment Plan) examiner.

Dr. Smith has worked in diverse practice settings as a pediatric physical therapist for 25 years and has 13 years experience working as a developmental specialist in the neonatal intensive care unit. She is currently an assistant professor in the Physical Therapy program in the School of Rehabilitation Sciences at the University of Tennessee at Chattanooga where she teaches the pediatric components of the physical therapy curriculum. Her research interests include examination of the efficacy of individualized developmental care for extremely low birth weight infants, parental stressors in the NICU and stress reactivity in infants born prematurely.