

Early relationship environments: physiology of skin-to-skin contact for parents and their preterm infants

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Over the millennia, both animal and human babies have survived the rigors of infancy due to a particularly effective protective, nutritive, and regulating practice. By holding, feeding, and nurturing their infants in close physical contact, mothers have provided the physiologic and behavioral regulation necessary for not only survival but also socio-emotional growth. No expensive equipment, hours of preparation, or special procedures are necessary to carry out this sometimes lifesaving and life prolonging practice. As intensive care for premature and high-risk infants evolved, the practice of close physical contact between parents and their offspring was curtailed, with separation of mothers and infants more the norm than the exception. In the last two decades, the physiologic and socio-emotional benefits of close physical contact between parents and high-risk infants have been revisited, with the practice increasing dramatically in neonatal intensive care units (NICUs) world wide.

This article reviews the historical emergence of skin-to-skin care practices in NICUs, describes the physiologic and behavioral regulatory practices that are supported in the continuum of the maternal fetal and early infant relationship during physical contact, and details implementation challenges in an intensive care environment. Finally, a discussion that reconceptualizes the early physical and socio-emotional environment for high-risk newborns and presents a new paradigm for considering NICU environmental design is offered.

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Historical perspective

Before inventions such as baby carriers, strollers, and car seats, infants were transported by their primary caregiver, typically in close contact, if not skin of the mother to skin of the baby contact [1–3]. Indeed, in many countries, this practice remains the typical way of carrying and caring for young infants [3,4]. From delivery on, infants in these cultures have been provided physiologic and cognitive regulation that contributes to the attachment relationship and typically includes exclusive breast-feeding. Some cultures have identified less infant crying and better state organization, which has been attributed to the practice of close physical contact between the primary caregiver and the baby [3,4].

Care for infants born prematurely or at high risk for medical problems has developed to include specialized intensive care units (NICUs) with their enhanced technology, pharmacologic interventions, and intricate care practices. Environments of these intensive care units have incorporated many amazing “high-tech” interventions, with their concomitant sound, light, odor, taste, and activity levels [5–8]. Infants are warmed, fed, and nurtured in the context of these technological approaches rather than the expected ecological niche of a typically developing baby [9,10]. The transition from the natural uterine environment to the expected envelopment by the parents’ bodies is interrupted by early or complex birth circumstances and substituted by the artificial protection and physiologic regulation of the incubator or warming table, drugs, ventilators, and procedures. Parents have historically been excluded from being able to experience close and unrestricted interactions with their baby, either due to transport issues or to other limitations of typical NICU policy [11]. Although recent changes in practice have become more inclusive of parents and family members in the NICU, these environments seldom provide privacy, comfort, or space for relaxed and intimate parent-infant exchanges.

Out of necessity, the practice of Skin-to-Skin (STS), or Kangaroo Mother Care (KMC), was developed in 1979 in Colombia as a substitute for incubators. Rey and Martinez [12] recognized that they were unable to provide incubators for many of the low birth weight infants that were born in their hospital. They developed a technique of placing the infants upright and prone between their mother’s breasts in skin-to-skin contact, beginning in the hospital, and then at home, with close monitoring of the infant’s progress. The infants were exclusively breast-fed in a self-regulatory manner. The surprisingly successful outcomes spurred a large number of randomized trials, for example, in South America [13], Europe [14], Southeast Asia [15], Israel [16,17], and in the United States [18].

A recent Cochrane review of KMC provides further indication of the worldwide interest in KMC practice [19]. This review reported a meta-analysis of three non-United States randomized trials involving 1362 mother-infant pairs. Findings indicated STS care was associated with reduced risks of nosocomial infection at 41 weeks’ corrected gestational age as well as fewer severe illnesses and lower respiratory tract disease at 6 months follow-up. KMC infants had

gained more weight per day by discharge, and scores on mother's sense of competence according to infant stay in hospital and admission to NICU were better in KMC than in control group. There was no evidence of a difference in infant mortality. The reviewers warn that concerns with the methodological quality of the included trials weaken credibility in these findings, and they encourage further randomized trials before recommending the practice for all infants.

Results of a national survey of all hospitals in the United States identified as providing neonatal intensive care services ($N = 1133$) indicated that of the 537 respondents (59%), 82% actively practiced STS in their units and that nurses were knowledgeable about this practice [20]. Primary barriers to the practice of STS included concerns for safety of infants and reluctance by nurses, physicians, and families to initiate or participate in STS care. This survey emphasized difficulties in initiating STS with special subsets of infants who may be on vasopressors or high-frequency ventilation, and with other complications typical in preterm infants. To date, clear data are not available to address safety issues for initiating STS when many of the complex medical issues that a particular infant might have are present. However, low birth weight and gestational age do not seem to be primary reasons why nurses do not implement the practice.

Physiologic regulation in the perinatal period

Physiologic regulation between the fetus and the mother during pregnancy is apparent. However, evidence of the precursors for early and long-lasting physiologic stability, neurobehavioral organization, and feeding success in the perinatal period is beginning to emerge. Early exposure to the mother's circadian activity and neurohormonal cycles prepares the fetus for establishment of its own state and physiologic organization [21,22]. Exposure to odorants and flavonoids in the mother's diet, which are found in the amniotic fluid, prepares the fetus to orient to the mother's milk odor and taste at birth [23–26]. The mother's voice is readily transmitted to the fetus during pregnancy, providing familiarity with and reactivity to her particular intonation and language postnatally [27–30].

Thus the fetus emerges in the perinatal period prepared for the continuation of his or her early experiences, which are primarily sensory and physiologically based, neurobehaviorally appropriate for gestational age, and dependent on the external environment for regulation, survival, and early learning [24,27–29, 31–34]. In most cases support for sensory and physiologic organization during this transition is provided by the natural environment of the mother's body and results in strengthening of the early infant-mother attachment relationship.

From studies in early infant-parent animal research, Hofer and Polan [35–37] have examined effects of initial and prolonged separation on the physiology and behavior of mother-infant rats soon after birth. After the mothers and pups were separated, pups showed autonomic, thermal, hormonal, and behavioral changes that were linked to a specific component of proximity of the pair, such as touch,

nursing, or heat. They demonstrated how examination of the proximity of the pup and dam reveals a complex system of biobehavioral regulators, which were termed “hidden regulators” as they are typically not observable. When the pups were separated from the mother, the regulating influence of her closeness was absent, resulting in physiologic and behavioral disorganization [35–37]. Other studies investigated the effects of early separation on behavioral regulation in mothers of preterm infants, who had necessarily been separated from some or all of the birth and caregiving experiences for their infants. When comparing these mothers to those of term baby mothers, attachment behaviors and mental representations of their baby, necessary in early relationship development, decreased as the duration of separation from their infant increased. Thus, the importance of early mother-premature infant proximity is essential not only for physiologic and behavioral organization in the neonatal period but also for later mental health outcomes [38,39].

Early physical contact between the premature infant and mother thus becomes a model for understanding the role of regulation in early infant-parent proximity and resulting interactions. The following discussion will highlight current knowledge regarding infant and maternal physiologic regulation and its contribution to early relationships and potential improved long-term outcomes.

Although far less information is available for father-infant STS interactions, when studied, similar outcomes have typically been observed and will be included in the discussion, as appropriate.

Evidence base for physiologic regulation during skin-to-skin caregiving

Thermoregulation

Thermoregulation is a basic component of intensive care for preterm infants, and any challenge to its disruption, such as removal from a neutral thermal environment, contributes to concern for physiologic stability and growth. Early studies of skin-to-skin care focused on ensuring that holding of premature infants by the mother would not adversely influence the infant’s ability to maintain adequate body temperature. Indeed, a number of studies have shown that not only did infants maintain adequate temperatures, in many instances the baby increased rather than decreased his or her temperature [40–48], in particular, when held by fathers [48]. Bauer et al [44] found that temperature during STS care was significantly associated with gestational age, with 26–27 week infants showing less stability during the first week after birth than older infants. Similarly, Bohnhorst et al [49] found significant increases in temperatures during STS and hypothesized that apneic and bradycardic episodes may have been due to heat stress. These studies indicate that sufficient warmth can be provided by the naturalistic environment of the mother’s body during STS, but care should also be taken to ensure monitoring of temperature, particularly for more physiologically unstable infants.

Cardiorespiratory

Cardiorespiratory changes that might be hypothesized to occur during STS in preterm infants have also been studied fairly extensively, with most studies indicating that there were no adverse changes in heart rate [40,41,45–47], oxygen saturation [46], oxygen consumption [43,44,50], respiratory rate [40,45,46], or apnea [46]. Measures of cardiovascular changes in father holding were similar to those for mother holding [43]. In some studies, oxygen saturation was higher in STS than when the infant randomly received typical NICU caregiving [40,41,45]. However, Bohnhorst and colleagues [49] found an increase in bradycardia, hypoxemia, and less regular breathing, possibly related to heat stress, providing rationale for monitoring the temperature of very premature newborns during STS.

Breast-feeding

Enhanced breast-feeding outcomes have also been observed and documented among mother-infant dyads that have participated in studies of STS. Breast milk with breast-feeding is clearly the best food for full-term infants, and additional studies indicate the benefits for preterm infants as well. However, mothers of infants born preterm are particularly challenged to initiate and sustain breast-feeding. Mothers who initiate and sustain STS care are able to produce larger volumes of breast milk and lactate for a longer duration than mothers who do not engage in STS care while in the NICU [14,51]. Additionally, cholecystokinin release, which stimulates the parasympathetic nervous system and in turn supports growth, is increased with STS contact [52–54]. These encouraging observable outcomes may support the mother's continuation of breast-feeding, given adequate support [14,45,53].

Providing STS experiences for preterm infants encourages breast-feeding and enhances milk production [55]. The nurturing, feeding relationship between a mother and her infant that results from this intimate, individualized relationship provides further rationale for its implementation.

Neurobehavioral outcomes

Neurobehavioral outcomes for infants who experience STS include not only physiologic organization, but also state stability, movement during the inherent handling, and self-regulatory capacities. Ludington-Hoe and Swinth [56] have summarized many of the studies that have indicated that infants in STS have longer duration of quiet sleep, increased duration of sleep bouts, lower total sleep, almost no crying during STS, and less crying at 6 months of age. Additionally, alertness and attempts to interact with their mother were repeatedly reported among the studies reviewed.

Feldman and colleagues [16,57] and Ohgi et al [58] have extensively examined both the short and longer term neurobehavioral functioning of infants who received STS in the NICU. Ohgi's data indicate that infants who experienced STS had significantly higher Brazelton Neonatal Behavioral Assessment Scale

(NBAS) scores on orientation and state regulation. On the Carey Infant Temperament Scale, infants had lower intensity scores and higher mood scores at 6 months. At 12 months, their developmental scores on the Bayley Scales of Infant Development were significantly higher. Feldman found better state organization, longer periods of quiet sleep, shorter periods of active sleep, and more alert wakefulness in infants at term. In addition, those infants exposed to STS care had a more mature neurodevelopmental profile on the NBAS, in particular on habituation.

At 3 months, the STS infants had higher thresholds to negative emotionality as well as better arousal modulation while they were asked to attend to complex stimulation. At 6 months, they were able to better share attention with their mothers, and have extended exploration, necessary for cognitive development. These longer-term outcomes indicate that infants who experienced STS in the perinatal period and had opportunities for physiologic and behavioral regulation by their mothers may show better behavioral organization and regulation by 6 months. If these longer-term neurobehavioral outcomes prove to endure, they have the potential for supporting better cognitive and emotional organization into the school years.

Effects of skin-to-skin care on maternal physiology and relationships with their infants

Early attachment relationships lay the foundation for positive developmental cognitive and socio-emotional outcomes [59]. Because of the conditions under which preterm infants are born, there is typically a great deal of stress and emotional upheaval for parents, leaving them few opportunities for relaxed and intimate interactions with their infants [11,59]. However, implementation of STS can be not only physiologically and behaviorally stabilizing for the infant but also for the mother.

For the infant, the familiarity of the mother's odor, voice, and taste initiate efforts toward the mother's breast where the infant receives nourishment, thermal regulation, and cardiovascular stability [60–62], important for the infant to survive and thrive. Early efforts of the infant to grasp on to the mother's body and initiate sucking on her areola provide release of breast milk and secretion of oxytocin. Oxytocin in turn causes involution of the uterus, psychological changes, reduction of stress, and initiation of maternal caregiving behavior [63–67]. These physiologic and behavioral interactions during the newborn period are important in fostering the attachment relationship.

Uvnas-Moberg [63,64] and Carter and colleagues [68] have identified neuroendocrine mechanisms involved in positive social interactions. Their work describes the role of oxytocin and its effects on the hypopituitary adrenal axis in reducing perceived stress, reducing depression, and promoting maternal behavior such as is provided in early mother-infant interaction. Mothers are noted to smile at their infant more, increase cuddling, fondling, and soothing, and

increase time spent with the infant. Uvnas-Moberg's work indicates that the release of oxytocin during STS and early breast-feeding can have a positive impact on maternal physiology and behavior toward her preterm infant. The infant-maternal regulation may be viewed as "mutual psychophysiological caregivers" in the newborn period [69].

Several studies have shown that mothers have a better sense of competence and of the mother-infant attachment process shortly after the experience when their babies were close to term [70–72]. Feldman and colleagues [17] examined both short and long-term behavioral effects of mothers who experienced STS in the NICU and found less depression and more pro-social interaction with their infants at 37 weeks. Additionally, they found at 3 months that mothers and fathers who participated in STS in the NICU were more sensitive and provided a home environment that supported cognitive and emotional functioning. These findings of significant effects of the STS experience on the parents provide further evidence for the benefits to development of the early attachment relationship and later positive developmental outcomes.

Thus, the mother and infant at birth are ready to develop optimal attachment relationships and to work together toward organized cognitive, social, and emotional development. Developmental tasks of the newborn involve successful feeding, state organization, including extended times of restful sleep, and gradually extended positive social interaction with their primary caregiver. Additionally, newborns work toward moving smoothly through space, calming themselves when disorganized or crying, and taking in environmental stimuli such as sounds, light, and activity [73]. To be successful at these tasks, newborns need both buffering from overwhelming stimuli or experiences and supportive regulation of responses from their primary caregiver. Someone who is familiar and consistent in organizing and shaping the infant's early experience ideally provides timing and pacing of interactions and guidance toward organized responses. Opportunities for engaging in STS with their mother gives the infant familiar, optimal, buffered, organized, and physiologically regulated experiences and provides a secure base from which the infant can develop self-regulatory skills, necessary for later cognitive and socio-emotional development.

Challenges in implementation of skin-to-skin care

Most studies report positive outcomes and few deleterious effects from STS. However, as the technique has begun to be implemented over the past three decades, changes in survival rates have occurred, so that smaller and sicker infants are now admitted to many NICUs. Most studies of STS have been implemented with older, more stable infants. However, there is a trend toward providing younger infants dependent on technology for stability with STS experiences. In a recent survey, Franck and colleagues [74] found that only 30% of NICUs report having policies or procedures for holding infants. Efforts toward standardized recommendations for holding infants skin to skin have now been published [75,76].

Until recently, no standard technique for moving an intubated baby from incubator to mother's body had been recommended, even though physiologic stability has been shown to be compromised by the move itself [77]. Reports of apnea and bradycardia during STS in the youngest infants in the first week after birth are not surprising, as these infants are typically physiologically unstable and behaviorally active [44,50]. The publication of a recommended protocol for intubated infants adds to the ability to standardize the approach to providing STS for fragile, intubated infants [75].

Reconceptualizing early environments for high-risk infants

The cumulative physiologic, neurobehavioral, and attachment relationship benefits of early STS care for preterm infants and their mothers provide a foundation for reconceptualizing the meaning of the influence of early environments for fragile babies. The parent's body can be seen as the most optimal, appropriate, and physiologically stabilizing environment for these infants. The essential buffering of distal environmental input, coordinating the appropriate sensory stimulation, and regulating the infant's responses provide a sensitive and individualized proximal environment in which the baby can grow and thrive.

These early interactions between mothers and babies begin the process of learning self-regulation, emotional responsiveness, and positive social interaction. All of these early processes are extremely important for the later emergence of optimal cognitive and behavioral functioning and reflect more organized brain development [78].

The importance of the parents' bodies as early environments for fragile infants must be recognized as the new paradigm for caregiving environments in NICUs. Policies and procedures that not do not "allow" but instead "encourage" parents to be present with their baby are essential. Examination of both overt and covert restrictions of parents being with their infants in the NICU, both attitudinal as well as procedural, must be accomplished. Change toward more flexible and supportive opportunities for caregiving must be implemented. "Visitation policies" should be examined for wording that is perceived as restrictive, and changed to "parent participation guidelines" that view parents as active participants in their infant's care rather than as visitors [79]. Provision of comfortable space for parents then becomes the focus of the design of NICUs. If parents are provided with space designed so they can meet daily work and hygiene needs and engage in private family interactions, they will be better able in turn to provide the necessary environments for their infant on an ongoing basis.

Summary

Skin-to-skin care practices for premature infants in NICUs provide significant support for physiologic stability, behavioral organization, and positive attachment relationships. With care, even the smallest intubated infants can benefit from this

practice. Additionally, there are benefits to the mother that include stress reduction, better breast-feeding outcomes, and more positive attachment behavior. STS care benefits the infant by providing both a buffer from the physical environment of the NICU as well as assistance with regulation after environmental disruption. Thus, the parent's bodies may be conceptualized as the most optimal environment for the fragile infant. Providing supportive NICU environments for parents can facilitate active participation in the infant's caregiving, thus providing significant benefits to the developing infant.

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