Sensory Intervention With the Preterm Infant in the Neonatal Intensive Care Unit

(child development disorders; infant, high risk; services, occupational therapy; sensorimotor stimulation)

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Sensory intervention, one aspect in the occupational therapy treatment of the high-risk, preterm infant in the neonatal intensive care unit (NICU), is discussed. Normal deviations in the healthy preterm baby's development at the equivalent age of the full-term baby are identified as a basis for intervention. Environmental factors affecting the preterm infant's interactions and therapeutic needs, such as the NICU environment and medical intervention, are reviewed. The rationale underlying the selection of sensory evaluation and treatment approaches is based on recent research. These approaches primarily focus on visual, tactile, proprioceptive, vestibular, and, to a lesser degree, auditory stimulation.

Two major factors influence the preterm infant's ability to assimilate and respond to sensory stimuli: gestational age and the degree of medical complications. The latter may include Respiratory Distress Syndrome (RDS), Intraventricular Hemorrhage (IVH), and elevated bilirubin levels (1). The effects of the hospitalization and the characteristics of the neonatal intensive care unit (NICU) environment also appear to have an impact on sensory processing (2-5). Whether these influences are transient or long-term needs further investigation.

In recent years, much research has been conducted on the effects of supplemental stimulation with preterm infants and on the maturational and capabilities of their sensory systems. Studies also indicate similarities and differences in the healthy preterm infant's behavior and motor abilities at the age equivalent of the full-term newborn (40 weeks postconception). Although this information increases the knowledge base for therapy, many questions remain. Occupational therapists treating this population must also observe the infant's response to sensory stimulation to guide them in determining the amount and duration of therapeutic input.

Knowledge of the parameters of the preterm infant's behavior and development serves as a foundation to occupational therapy intervention. Although deviations have been found in the preterm infant's development at the age equivalent of the full-term newborn, findings differ when healthy and ill preterm babies are compared with full-term newborns.

Review of Literature

The preterm infant is not simply a smaller version of the full-term newborn. Healthy preterm babies move in greater ranges of motion and may never completely achieve the full flexion posture of full-term newborns at the equivalent age (6). They also have shown decreased hand-to-mouth activity possibly

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due to reduced flexion (7, 8), as well as a strong preference for head positioning to the right side from 35 weeks on (9). This tendency is similar to the full-term infant’s preference to lie with the head turned to the right during the first two days of life, a posture not observed in the sick preterm population (10). Sick preterm infants moved less than low-risk preterm babies and exhibited prolonged postures. As the healthy preterm baby reaches the equivalent full-term age, hypotonicity reduces, and the activity level tends to increase. However, excessive tremor and startles may be present. (8, 11).

When compared with full-term newborns at the same age, preterm infants had more disorganized sleep states, a lower activity state, and decreased crying, and they were less able to be consoled by the stimulation of sucking (12). These observations were confirmed by Ferrari and associates (11). In contrast, Paludetto and associates (7) found no differences in self-quieting and ability to be consoled between healthy preterm infants at the term equivalent age and full-term newborns.

Sensory Systems: Visual and Auditory

Research has focused primarily on visual functioning, that is, the appearance and developmental progression of visual orienting responses and preferences, and secondarily on auditory orienting responses.

The visual orientation part of the Brazelton (13) Neonatal Behavioral Assessment Scale and the testing of visual preferences described by Fantz and Nevis (14) are two methods of assessing the preterm infant’s visual functioning and maturation. Studies show a high correlation between performance on these tests and later neurological or developmental abnormalities (15–17). For example, a retrospective study of 12 babies who died of Sudden Infant Death Syndrome showed that all 12 had abnormal visual functioning, such as nystagmus, eye rolling, and problems in tracking and focusing (18). In a follow-up study of 1,553 infants, neonates who scored low on fixation and following had suspect gross motor performance at 4 years (19).

Visual fixation has been observed in healthy infants at the early age of 30 weeks’ gestation. Visual fixation time increases from 30 to 35 weeks’ gestation and coincides with a gradual increase in the infant’s ability to sustain the quiet, alert state (20). Before 36 weeks’ conceptual age, short periods of eye opening lasting up to five minutes were observed in healthy preterm infants (9). These periods gradually decreased and were replaced after 36 weeks with continuous periods of open eyes similar to those observed in the full-term newborn.

The mature visual orientation pattern of the full-term newborn that includes fixation and tracking is reached by 33 to 34 weeks’ gestation (15). In fact, visual preference and fixation were demonstrated at 32 weeks’ gestation in many infants, with the fully mature pattern appearing by 34 to 35 weeks’ gestation. Visual preferences include patterned over plain surfaces, curvilinear over straight contours, brightness-contrastability, and large patterned elements (15).

The most striking differences in the neurobehavioral status between low birth weight (LBW) infants at 40 weeks’ conceptual age and full-term babies were found in visual and auditory orienting responses (21). Two thirds of the LBW infants fell below the performance of the full-term babies. Visual following was assessed using a black-and-white target, a human voice, and a human face. A rattle, a bell, and a human voice were administered outside the visual field to the side of the head to evaluate auditory responses. Most orienting deficits involved not only lack of head turning but also failure to manifest alerting and attentional responses.

Daum and associates (16) found no significant increase in visual or auditory tracking in respirator preterm babies from 33 to 41 weeks’ postconceptual age. By contrast, the healthy preterm group showed linear development in visual and auditory tracking. In the follow-up, all of the respirator babies were deviant on the Bayley Scales of Infant Development at 7 months’ corrected age. Paludetto (8), however, did not find improved auditory orientation with age. Auditory responses remained the same at 35 and 44 weeks’ postconceptual age, suggesting that auditory development is established early in life.

Ruff and colleagues (17) examined visual following of moving objects in full-term and preterm infants at 44 and 48 weeks’ postconceptual age. Few differences were found between the two groups. However, when the preterm group was divided on the basis of early measures of neurobehavioral function, deviant preterm babies were slightly behind the normal preterm and full-term babies at one month. They reached the one-month level at two months and demonstrated significantly lower levels of visual following with decreased tracking of large objects than the normal preterm and full-term groups.
In a second study of visual recognition memory in 6-month-old preterm and full-term infants, Rose (22) found that preterm and full-term infants had similar performance as long as the familiarization time was lengthened for the preterm infants. This study was compared with a previous study done with similar subjects. In the first study, preterm babies, after a brief familiarization period, failed to differentiate between novel and familiar stimuli, while the full-term group demonstrated significant preferences for two out of three novel stimuli. However, the performance of preterm infants who had received tactile and vestibular stimulation for two weeks after birth was indistinguishable from the performance of the full-term group. The results of these studies suggest that preterm and full-term babies have similar abilities to store and retrieve visual information; however, preterm babies may have a deficit in the speed of information processing. Furthermore, early tactile and vestibular stimulation may have positive long-term effects on the preterm infant’s sensory performance.

The NICU Environment: Sensory Experiences and Effects of the Medical Intervention

Many preterm infants undergo intensive medical and surgical intervention, with life sustained by mechanical support systems. Once the acute distress is stabilized, the infant may still have to endure prolonged hospitalization to gain physiological stability, nutritional growth, and neurodevelopmental development. This recovery phase often progresses in a nonlinear fashion with recurrent medical setbacks, especially with the critically ill preterm infant. These long, difficult hospitalizations may have a detrimental effect on perceptual, motor, language, and emotional development. Preterm infants are also at risk for distortions in their interpersonal relationships. In a comparative study of mothers of preterm babies with long- and short-term illnesses, mothers of long-term illness babies showed a uniformly low rate of interaction with their babies (23). This finding suggests that a prolonged recovery period has a powerful effect on early mother-infant interaction.

Holmes and associates (2) found that preterm and full-term infants who required intensive care performed significantly more poorly than healthy full-term infants on the motor and interactive items of the Brazelton Assessment Scale regardless of gestational age. Furthermore, the three groups with prolonged hospitalization (preterm and full-term babies in the NICU and healthy full-term infants hospitalized as a function of maternal illness) performed more poorly on state organization items than the control group. A possible interpretation of these findings is that the preterm infant’s problems in behavioral organization may be attributed not only to prematurity but also to the severity of medical complications, the prolonged hospitalization, and the influence of environmental factors.

The NICU environment provides varied, sometimes noxious stimuli that are not found in the home environment. Studies suggest that preterm infants in NICU, are not deprived of adequate amounts of stimulation; rather, they receive inappropriate patterns of stimulation that may be detrimental to intrasensory integration (4, 24). Orienting responses may not be consistently reinforced. Uncoordinated sensory experiences may not provide the opportunity to integrate sensorimotor information from the environment.

The total care-giving time of the preterm infant, defined as any tactile contact through holding, feeding, diapering, or technical intervention, is one-third less per day in the NICU than the time given the full-term baby cared for in the home (25). During the acute phase of the preterm infant’s medical treatment, too much handling may be contraindicated because of the infant’s need for rest and energy conservation. Care giving during this phase may be irregular according to the infant’s physiological needs. Even with the implementation of a primary care giver approach, continuity of care is sometimes difficult to maintain. The environment may not provide the consistent care that the baby needs to organize sleep and awake patterns. Day and night cycles do not exist, and consistent handling and play interaction may be difficult to establish. The NICU infant must adapt to the needs of the environment since the care giver does not usually adjust to the cyclic states of the individual infant.

The preterm infant’s tactile experience in the NICU may be inconsistent, unpleasant, and painful. Painful stimulation produced by blood tests, intravenous tubes, and other procedures may cause withdrawal and distress responses such as tightly closed eyes and grimacing (3). The environment of the incubator provides minimal positive tactile interaction unless parent visiting is extensive (3, 24). Reduced active postural tone and reduced spontaneous movement may cause decreased tactile exploration. Furthermore, medication like phenobarbital for seizure disorders tends
to produce lethargy and reduce movement exploration (26). With certain infants, the upper extremities are restrained to prevent attempts at pulling out endotracheal and feeding tubes. Restraints inhibit hand-to-mouth activity, which is important for self-consolation, and restrict tactile exploration. Lopez's study (5) confirmed that extensive restraint gradually reduced tactile exploration over the period of the hospitalization.

Those preterm babies who require nasogastric feeding either to gain weight or to sustain life experience the unpleasant stimulation of the tube and a decreased opportunity to suck unless nonnutritive sucking is encouraged. They are also deprived of the normal sensation of liquids in the mouth.

Research indicates that levels of auditory stimulation are excessively high and potentially hazardous in the NICU. One study (4) found sound pressure levels in the intermediate nursery and intensive care units comparable to traffic at a busy street corner. Another study (3) found not only that incubators subjected infants to the relatively loud and constant nonspeech sounds generated by the incubator itself, but also that the nonhuman mechanical or metallic sounds caused by slamming or squeaking doors penetrated the incubator more clearly and loudly than human voices and coincided with startle, jerk, or jump responses in the infant during the first weeks. Human voices were obscured unless they were directed through the incubator doors toward the infant. Stewart and Abramovich (27) concluded that although sensorineural hearing loss in preterm infants is probably caused by hypoxia in the newborn period rather than ambient noise levels in incubators, careful attention should be given to noise levels in NICUs.

Reduced language stimulation can also affect the infant's sensory experience. Although adult speech is abundant in the NICU, it is not usually directed toward the infant. States of distress and lowered levels of arousal may also decrease the infant's receptiveness to language input. In one study (3), preterm infants with histories of respirator intervention vocalized less than healthy preterm infants. Vocalization consistently decreased with the number of days in the NICU. At discharge, these infants were totally silent unless stimulated by an adult or an adverse stimulus.

Infants on ventilators or with intravenous tubes inserted in the neck or head are frequently maintained in supine or semisideling positions, and thus may be deprived of lying prone, the position considered best for developing early head control (28). Vestibular stimulation may also be reduced due to static positioning for prolonged periods or as a result of decreased holding and rocking during the acute phase of care.

A number of factors must be considered when assessing the effects of the NICU environment. The characteristics of a NICU and care giver approaches vary from one center to another. Their effects on infants should be assessed before an occupational therapy program is implemented. Some preterm infants may be successful at shutting out unpleasant stimuli, while others become habituated to repetitive noxious input. Still others may be at the mercy of the sensory environment because of their less organized central nervous systems (CNSs) or individual temperaments. If sensory input has an impact on the infant's behavioral and motor interactions, early sensory experiences may also affect the delicate reciprocal reinforcement system between parent and infant, and possibly parent-child interaction.

A Developmental Therapy Program

The developmental therapy program in the NICU at Downstate Medical Center in Brooklyn, New York, was designed to detect and remediate developmental delays and deviations in neonates who are at risk for later developmental problems. Sensory intervention is one component in this treatment program, which also includes handling, positioning, treatment of oral-feeding problems, and intervention with parents (29). This program, which was initiated as an occupational therapy and physical therapy team approach, has been in progress at State University Hospital since June 1980.

Evaluation

The occupational therapy assessment of high-risk infants includes the evaluation of sensory system maturation and responsivity; muscle tone, posture, and movement; behavioral organization; and feeding and oral reflexes. Before an assessment is made, data on pregnancy, delivery, postnatal interventions, and family social issues are obtained from the medical record. Although an observational format is used for evaluation in this program, occupational therapists can consider using other instruments, such as the Amiel-Tison Neurologic Evaluation of the Newborn and the Infant (30) or The Albert Einstein Neonatal Neurobehavioral Scale (31).

An infant may be referred to occupational therapy at any point...
during the NICU stay; however, most are referred after they are medically stable. In this setting, preterm babies referred for therapy include the markedly premature (those with extensive histories of respirator intervention), those with feeding difficulties, and those with hydrocephalus or other complications.

Assessment principles from Brazelton's Neonatal Behavioral Assessment Scale (13) have been incorporated into the evaluation procedures. For example, the objective during evaluation is to encourage the infant's optimal response. Behaviors are elicited only when the infant is in the appropriate state. During assessment the infant's response to selected treatment activities is observed. Improved behavioral and motor control with intervention indicates a capacity for performance that reflects a certain degree of CNS integration.

To assess visual and auditory orienting responses, optimally, the infant should be in the quiet, alert state. The baby should be fed and have received all necessary care to maximize receptiveness for testing. If a baby is not in an optimal state, the therapist can attempt to bring the baby to the desired level of alertness. Since these attempts are not always successful, testing may have to be deferred until the appropriate state appears in a later evaluation session. In addition, some nonmedicated infants tend to be lethargic and excessively sleepy, and are therefore difficult to assess accurately.

A skein of red wool, a black-and-white target, or the examiner's face can be used to assess visual fixation and horizontal and vertical tracking. According to Dubowitz (15), the infant should be propped in a 30° supine position with background lighting kept low for good eye opening, and the stimulus should be presented 18 cm (7 in.) from the eyes for optimal response. Infants appear to display preferences for certain stimuli over others. For example, some infants will visually track the red skein more often than the black-and-white target, while others will prefer animate stimuli such as the therapist's face.

The auditory orienting response is evaluated by using the therapist's voice or a rattle positioned at the side of the infant's head outside his or her visual field. Tactile and proprioceptive responses are evaluated during therapeutic handling. Evaluated are the infant's response to being touched or to self-touch, and his or her reactions to proprioceptive input such as weight bearing and swaddling. Oral sensitivity is evaluated when infants exhibit feeding difficulties.

The vestibular system is assessed by observing a baby's reaction to movement transitions and responses to inhibitory or facilitatory vestibular input, as indicated by the needs of the individual baby. The infant's gestational age at the time of testing; the degree of disorder, including the effects of the medical complications (i.e., RDS; medication; and the medical history are considered when the results of the evaluation are interpreted.

Sensory Treatment

Principles of neurodevelopmental treatment and the use of sensory integrative techniques form the basis of this intervention program with preterm infants. Sensory treatment is individualized based on an interpretation of the evaluation findings. The primary goals are the following:

- to provide specific sensory input to infants deprived of coordinated, positive sensory experiences due to the effects of medical intervention, prolonged stay in the NICU, or both;
- to facilitate the occurrence of more mature developmental patterns through specific stimulation approaches; and
- to effect change in muscle tone, movement patterns, or both, through specific sensory input during handling.

With infants born very prematurely or with critically ill infants, sensory intervention may consist of applying a single stimulus. When an infant appears to tolerate more than one stimulus, several modalities may be integrated. During a treatment session, the therapist carefully monitors the infant's behavior and reactions to the input. Signs of overstimulation include hiccuping, increased drowsiness and fussiness, yawning, regurgitation, and eye aversion (32). When these signs of overtaxation occur, the intervention activity is immediately terminated or altered to soothe and reorganize the distressed infant. Nonnutritive sucking (pacifier, hand-to-mouth), swaddling, and gentle rocking and verbalization are effective methods of encouraging behavioral reorganization.

Visual Stimulation. An environment with low background lighting is most conducive to optimal visual focusing and tracking. A skein of red wool, a red ball, a black-and-white target, a mirror, the therapist's face, or appropriate toys provided by the infant's parents may be used to stimulate visual fixation and tracking. Visual stimulation is
frequently coordinated with movement in treatment. When rolling an infant from side to side in a supine position, one of these objects can be used to encourage visual attention and head turning. However, the infant’s ability to attend for any length of time may be limited by gestational age, behavioral state, or the effects of the medical condition. Thus, the amount of stimulation must be carefully monitored.

Mobiles constructed by taping Ping-Pong balls to tongue depressors with wool are hung in the incubators or taped to the sides of the bassinet for additional visual stimulation (33). Red and black magic markers are used to draw dots and bull’s-eye forms on the Ping-Pong balls. If the evaluation shows that an infant responds to one stimulus over another, these individual preferences are incorporated into a mobile.

Mobile construction has been an effective activity to use with parents. It gives parents a sense of active participation in facilitating their infant’s development. When the infant is attracted to focus, track, and sometimes swipe at the mobile, it provides the parents with immediate feedback on the child’s progress and a sense of accomplishment and success. The demonstration of visual capabilities is a positive experience; some parents are surprised that their baby can see, and others are relieved that their baby’s vision has not been grossly affected by the oxygen received in earlier care.

**Tactile and Proprioceptive Input.** Tactile and proprioceptive input, provided through specific techniques, is a focus of the sensory intervention program. Light touch is avoided because it tends to increase behavioral disorganization (34). Full-term newborns are highly sensitive to light moving touch, partially because their skin is densely packed with receptors such as Meissner’s corpuscles (35).

Facilitation of self-generated tactile exploration through hand-to-mouth, -face, -head, -ear, -nose, and -eyes is emphasized initially, and hand-to-mouth activity is encouraged throughout the NICU stay. The rationale for selecting this type of tactile stimulation is based on a study of full-term newborns in which infants exhibited hand-to-mouth exploration at a median age of 167 minutes after birth and onset of hand-to-face, -head, -ear, -nose, and -eyes movement, in this sequence, during the first three days of life (36). Furthermore, nonvisual hand-to-mouth activity emphasized by Brazelton and others (34) for self-calming may be an important precursor to the infant’s later ability to reach, grasp, mouth, and visually inspect objects, according to Bruner (37).

Hand-to-hand activity (occurring at a median age of 12 weeks), hand-to-knee activity (median age of 16 weeks), and hand-to-foot activity (median age of 19 weeks) may be encouraged while an infant is in a supine position with the pelvis flexed. Although these abilities occur several months after the newborn period in full-term babies, they are emphasized with the preterm infant to provide tactile stimulation and flexion input. Additional tactile input may be provided by positioning infants on sheepskin, through a distal-proximal massage of the extremities, or as a secondary effect of therapeutic handling.

In several critically ill infants receiving extensive medical intervention, tactile defensive responses, primarily in the shoulder girdle area, have been observed. Upon touch to the shoulders, excessive shoulder elevation immediately occurs. To remediate tactile defensiveness and reduce increased tone in the shoulder girdle, the therapist can use the following techniques: a) traction while handling the upper extremities above the elbows to avoid the defensive area or b) weight bearing with compression through the shoulders in the prone position.

Oral tactile techniques may be indicated for infants experiencing difficulty with the transition from nasogastric to nipple feeding or with weak, inconsistent, poorly coordinated suckle-swallow reflex. Oral sensitivity can be facilitated by moving the infant’s hand externally on the face in motions toward the mouth or by stroking the upper and lower gums with a nipple from the back to the front of the mouth to midline. Placement of the therapist’s thumb and index finger on the infant’s cheeks while moving the cheeks forward to increase lip closure is a successful method to facilitate the suckle-swallow with many preterm infants. Members of the nursing staff are encouraged to maintain oral sensitivity by simultaneously providing nonnutritive sucking with a pacifier when nasogastrically feeding a child. Nonnutritive sucking is provided to many infants during a treatment session to strengthen the suckle-swallow response.

Proprioceptive input is provided through specific weight-bearing experiences, traction, and joint compression to facilitate normal movement patterns during therapeutic handling. According to Newman (3), premature babies maximize contact with stable surfaces such as the sides of incubators. They are frequently observed
with their feet or bodies touching the walls of the incubator. Infants are put in sidelying position with blanket rolls against the sides of the incubator or bassinet to provide this desired proprioceptive input.

Swaddling, an effective method of providing proprioceptive input, appears to have the secondary effect of calming many babies. Depending on individual needs, infants are positioned in flexion with their hands near the mouth before being wrapped in a blanket. Infants are generally swaddled toward the end of a treatment session. Babies who have progressed to a bassinet are usually swaddled in the appropriate position between feedings or nursing care.

Vestibular Input. To maintain motor inhibition the infant is rocked in various planes and positions while being swaddled. Slow, even, rhythmical input most frequently in an anterior-posterior plane is used with distressed, disorganized, or high-tone infants. When fast, arrhythmical input is needed, it is applied gradually with careful observation of the infant's response. With any vestibular stimulation, infants are continuously monitored for grimaces, nystagmus, change in behavior, or level of arousal. When a baby responds favorably, other positions (sidelying, prone) and planes (side-to-side, occasionally linear, inverted only after the 29th week) may be included.

Infants who become distressed in movement transitions are treated on the therapist's lap while the therapist is seated in a rocking chair or on a gymnastics ball. Infants are gently rocked through the changes in position. Infant swings padded with blanket rolls for appropriate positioning can be used for vestibular input or positioning. In some centers, infant carriers such as Snuggles are used with irritable babies to calm them. Snuggles also provide vestibular input through the therapist's movements.

Auditory Stimulation. As part of the treatment the therapist talks in a high-pitched voice when an infant is in a quiet, alert state and therefore receptive to input. Toys with soft, low sounds (soothing music) can also be used. Sudden, harsh, mechanical input is generally avoided because it produces startling responses or increases disorganization in some babies.

Conclusions

Occupational therapy intervention in NICUs requires an experienced and skilled pediatric therapist who is aware of the latest research findings in pediatrics. Recent findings on the preterm infant's visual functioning and preferences have been critical for the assessment and development of treatment approaches in the developmental therapy program at Downstate Medical Center. However, the effects of a preterm infant's state and behavior on visualization still need to be defined, and methods for evaluating the tactile, proprioceptive, and vestibular systems still need to be determined.

The rationale for selecting some of the treatment activities used in this 5-year-old program was based on research findings regarding full-term babies or prenatal development. It is possible that the needs of preterm infants cannot be determined in this way. The following questions need study: What is the optimal frequency and duration of therapy? What is the appropriate balance between rest, energy conservation, and sensory input?

In our setting, therapy is initiated only after the medical status is fairly constant. Perhaps selected sensory input could facilitate physiological stability and growth if it were initiated earlier. Neurodevelopmental and sensory integrative techniques used in this intervention program appear effective; however, the influence of maturation versus intervention is difficult to assess in some babies at this young age.

REFERENCES