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Use of Oscillating Waterbeds and Rhythmic Sounds for Premature Infant Stimulation

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Twenty-two healthy infants born at gestational ages of 28–32 weeks were randomly assigned to experimental or control groups within the first 4 days following birth. Experimental infants were placed in incubators equipped with oscillating waterbeds and rhythmic sounds. Control infants were placed in traditional incubators. All infants remained in their respective environment for 4 weeks. Measures of treatment effects included weight gain, head measurement, weekly 2-hour observations of state organization, and the Brazelton Neonatal Behavioral Assessment Scale (BNBAS). No significant differences were obtained between the two groups on any of the physical measures. A priori cluster scores on the BNBAS showed significantly greater developmental progress in motoric and state organization processes for the experimental group. A statistically significant interaction effect was found between the two groups for the amount of time they spent in active sleep during the treatment period and at the time of discharge. These results suggest that general developmental progress was enhanced in the experimental group by the stimulation procedure.

The application of stimulation procedures to human infants for the purpose of enriching developmental progress has borrowed some of its principles from the animal studies that investigated the effects of deprivation and enrichment on newborn animals (Denenberg, 1967; Harlow, 1958; Levine, 1960). The general finding that a deprived environment hinders development in animals and that stimulation enriches development has led to the hypothesis that similar effects might be found when stimulation is applied to the human newborn, especially to infants born prematurely. In a recent review of the literature on prematurity and infant stimulation, Schaefer, Hatcher, and Barglow (1980) have noted that the use of rhythmic sounds such as heartbeat and the use of tactile and vestibular-proprioceptive stimulation have all been researched at length. These authors conclude that although stimulation studies have suffered methodological flaws, there is strong evidence in support of the efficacy of stimulation for the preterm infant.

More recent research has shown that long-term developmental prognosis for infants born at very early gestational ages is improving, and yet these infants still remain at higher than average risk for developmental delay (Schaefer et al., 1980). The concern about environmental factors contributing to this risk begins in the nursery. There has been some agreement that the usual environment of the neonatal intensive care unit is deficient in normal developmental experience. Lawson, Daum, and Turkewitz (1977) studied the quality and quantity of the stimulation that preterm infants received in the intensive care unit and concluded that it is inappropriate in both its extreme intensity and in its lack of rhythmicity and contingency. Therefore, later developmental deficiencies in these infants may be due to a combination of the medical complications of prematurity, the degree of central nervous system abnormal-

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ities at birth, and the developmentally deficient environment of the intensive care nursery.

However, the opinion that preterm infants may be positively or negatively affected by environmental factors is a point of controversy in the current literature. Cornell and Gottfried (1976) note that there is no firm support for the assumption that preterm infants in the intensive care setting experience sensory deprivation. Parmelee (1981) disagrees with the hypothesis that preterm sensory experiences alter developmental progress. He believes that the preterm maturation of the human nervous system is for the most part genetically rather than environmentally controlled.

An account of the formulation of the stimulation procedures used in the present study may be found in the writings of Barnard (1972, 1974, Note 1), Korner (Note 2, Note 3), Korner, Kraemer, Haffner, and Cosper (1975), and Kramer and Pierpont (1976). Korner (Note 3) hypothesized that prematurely born infants have been deprived of an essential period of intrauterine stimulation. She placed infants on oscillating waterbeds as a compensatory vestibular-proprioceptive stimulation similar in kind to that which she hypothesized would occur in utero. Barnard (Note 1) has suggested that the rhythmic stimulation that occurs naturally in utero is intended to enhance neurological maturation in the developing fetus and that this maturing process in turn aids the development of state behavior organization. Barnard placed premature infants in incubators equipped with a rocking mechanism and heartbeat sounds. She found that these babies developed more quiet sleep during the immediate neonatal period and had better weight gain than the control group. Kramer and Pierpont (1976) provided oscillating waterbeds and auditory sounds to a group of preterm infants and found that their weight gain and biparietal head diameters were significantly greater than a group of control infants; however, they found no neonatal behavioral differences.

The population, methodology, and dependent variables of the present study are similar to those of Kramer and Pierpont (1976), but several important changes were made. Unlike Kramer and Pierpont's study in which the duration of the experimental treatment was allowed to vary, depending on how long the infant was kept in the incubator, in the present investigation the duration of treatment was held constant for all infants in order to establish experimental control. Also, in the Kramer and Pierpont (1976) study, the mechanical rocking took place for only 1 hour prior to each feeding, whereas in the present study, the waterbed oscillation and auditory sounds were continuous during the 4 weeks of treatment. This increased amount of stimulation in the present study was designed to produce a greater experimental effect. Premature infants in this study were of earlier gestational age than those studied by Kramer and Pierpont. Drillien (1964, 1970) has shown that the earlier the prematurity, the greater the risk for developmental problems. Thus, it seems reasonable that the greater the potential deficits, the more potential for demonstrating the effectiveness of intervention.

As in the Kramer and Pierpont study, the Brazelton Neonatal Behavioral Assessment Scale (BNBAS) was used in the present study as a measure of the infant's interactive behavior. The literature on the BNBAS is very broad and complete (Sameroff, 1978), and recent advances in statistical analysis of the scores (Als, 1978) have made its results interpretable and, therefore, meaningful. Sell, Luick, Poisson, and Hill (1980) have successfully used the BNBAS with preterm infants as early as 36 weeks conceptual age and have used the a priori clusters (Als, Tronick, Lester, & Brazelton, 1977) to analyze BNBAS results. Sostek, Quinn, and Davitt (1979) also used the BNBAS with preterm infants at 36 weeks conceptual age and interpreted scores using cluster scores.

To provide a complementary measure with the BNBAS, state observations were added as an additional dependent variable. Although the BNBAS assesses many sets of behaviors at one point in time, state observations recorded one set (state) over many points in time. Head circumference, biparietal head diameter, and body weight measures were also collected for group comparisons.

The purpose of the present study was to demonstrate that special stimulation in the form of oscillating waterbeds and rhythmic sounds provided for preterm infants would enhance their development, as measured by physical parameters, BNBAS, and state behavior observations.

Method

Subjects

Twenty-two infants between 28 and 32 weeks gestational age, determined by the mother's last menstrual period, were randomly assigned to treatment and control groups. Random assignment to groups was accomplished, with each new subject using a blind card system derived from a table of random digits. Every infant who entered the Special Care Nursery at Prentice Women's Hospital during the 10 months of the study and who fit subject criteria was enlisted in the study. Infants were excluded from the study if they required mechanical ventilation beyond 5 days of life, if they were born to drug-addicted mothers, or if they had major central nervous system, gastrointestinal, or cardiac anomalies. The physical and background characteristics of the samples are listed in Table 1.

Procedure

A Classics Product waterbed filled with 22 lb. of warm water and covered with a ½-inch layer of foam insulation was placed in the infant's incubator. A 500 cc Penlon anesthesia bag connected to a Bird Mark 7 Intermittent Positive Pressure Breathing (IPPB) machine was placed under the waterbed, and the inflation and deflation of this bag produced an oscillation motion at a frequency of 16 oscillations per minute. The anesthesia bag was placed under the foot of the water mattress so that the wave motion was from foot to head, with a wave amplitude of no greater than ¼ inch when the infant was lying on the mattress. A 2½-inch speaker was placed at the head of the waterbed in each incubator. It was connected to a continuous loop cassette which played a recording of the intrauterine sounds of a pregnant woman (Murooko, Capitol Records, 1974) that was judged to be approximately 65–80 db by a biologic check. Each experimental infant was placed in this environment by the 4th day of life and remained there for 4 weeks. Control infants were given routine care in a standard incubator for a similar period. All 22 infants were given the same medical and nursing care, and all parents were allowed equal access to their infants. Daily weight was recorded as was weekly head circumference and biparietal diameters. Weekly state organization observations of 2 hours' duration were collected during the 4 weeks of the experimental procedures and again at discharge. Observations were begun between 10:30 A.M. and 2 P.M. Nurses generously scheduled interventions so that nonemergency interruptions would not occur during observations. However, when major intrusive interruptions occurred, the observation was discontinued for ½ hour. Eight state categories, adapted from Thoman (1975), were defined as follows: quiet sleep, active sleep, REM sleep, drowsy, cognitive alert, motoric alert, fussing, and crying.

Table 1
Subject Characteristics

Characteristic	Experimental	Control
Sex		
Male	4	5
Female	7	6
Race		
Black	3	5
White	6	4
Spanish	2	2
Gestational age at birth (weeks)		
M	29.7	29.8
SD	1.6	1.5
Days of hospitalization		
M	50.5	49.0
SD	17.1	15.5
Conceptual age at discharge (weeks)		
M	36.3	36.2
SD	1.7	1.8
Weight at birth (g)		
M	1,240	1,201
SD	193	236
Weight at end of treatment (g)		
M	1,604	1,601
SD	238	314
Biparietal diameter (cm)		
Beginning of treatment	6.5	6.3
End of treatment	7.2	6.8

For each 10 sec sampling interval, a single coding of the predominant state was recorded. A single observer who had 90% reliability with two outside observers completed all of the state observations. The BNBAS was administered just prior to discharge from the hospital by a trained examiner who was blind to the subject group assignment.

Results

No significant differences between experimental and control groups were found on weight, head circumference, or biparietal measures either at the beginning of the study or on the gain scores obtained at the end of the 4 weeks of experimental treatment. Since the discharge weight of each infant in the study was the same (4½ lbs.), there were by design no weight differences at discharge; no significant differences were found between the experimental and control groups in number of days required to reach the criterion weight for discharge (Table 1).

A priori clusters developed by Als (1978) were used to analyze the BNBAS scores. This analysis integrates the 47 scores of the BNBAS into four dimensional scores that provide summary descriptions of the quality of the infant's functioning. Each of the dimensional scores is expressed on a 3-point scale, (1 = well organized, 2 = average, and 3 = worrisome). Therefore, the closer the dimension score is to 1, the more organized is the infant. As shown in Table 2, both the motoric organization cluster and the state organization cluster score were significantly better for the experimental group than for when a one-tailed t test analysis was performed. If a more conservative two-tailed analysis were used, the motoric organization cluster would remain fairly firm, whereas the state organization cluster would be of only marginal significance ($p < .08$).

The percentage of time spent in each of the eight state categories was used to compare the two groups at the end of the 1st week of the study and again at the time of discharge. The only category that demonstrated significant relationship was that of active sleep. The percentage of time spent in active sleep was analyzed as a 2 × 2 factorial, with measures repeated at Week 1 and discharge. Although significant main effect differences were not obtained between groups, a significant interaction was obtained between experimental and control groups for the time spent in active sleep at Week 1 and discharge, $F(1, 16) = 4.53$, $p < .05$. This interaction is illustrated in Figure 1.

Table 2
Dimensions of the Brazelton Examination

Dimension	Experimental *M*	Experimental *SD*	Control *M*	Control *SD*	*t*
Interaction organization	2.72	.47	2.60	.52	.54
Motoric organization	2.09	.30	2.55	.52	2.50†
State control organization	1.55	.53	2.00	.63	1.84*
Physiological organization	1.18	.60	1.45	.82	.89

Note. For each group, $N = 11$.
* $p < .05$, one-tailed.
† $p < .05$, two-tailed.

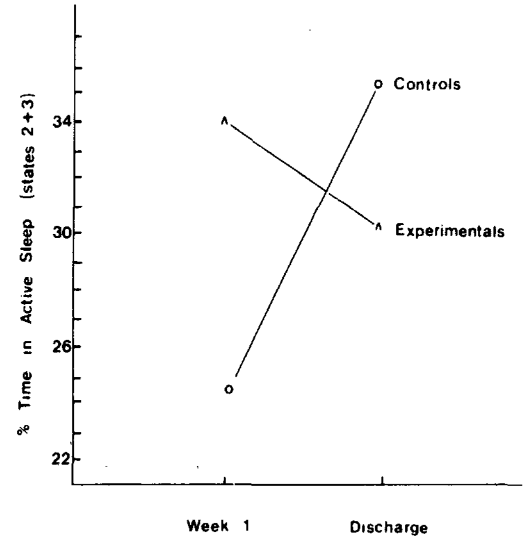

Figure 1. Interaction between groups and weeks for time spent in active sleep.

Discussion

Based on the findings of previous studies, it was hypothesized that the gentle rolling movements of the oscillating waterbed and the rhythmic sound would provide a beneficial climate for the enhancement of physical growth parameters, developmental progress, and state organization. Contrary to the findings of Kramer and Pierpont (1976), no significant differences were found between the two groups in any of the physical parameters measured. Although Kramer and Pierpont (1976) were unable to obtain indications of differences on the BNBAS, positive findings were obtained in the present study on two dimensions of this scale. The experimental group received significantly higher scores than did the control group on the motoric organization dimension and marginally significant scores on the state organization dimension of the BNBAS. The finding of advanced motoric development for the experimental infants is of special importance because motor organization is frequently delayed in preterm infants (Parmelee, 1981).

In regard to the finding on the BNBAS of enhanced organization of state control, researchers have repeatedly found that the effects of rhythmic movement and sound have a soothing effect on the state of infants (Barnard, 1972; Hasselmeyer, 1964; McNichol, 1974; Scarr-Salapatek and Williams, 1973). Thus, it was not surprising that both BNBAS and state observation findings suggested that state control was enhanced by the waterbed treatment in this study. Experimental and control groups differed significantly in whether percentages of active sleep time increased or decreased from treatment to discharge, with experimental infants decreasing and control infants increasing the percentage of time in active sleep. This reduction in active sleep for the experimental group was part of an 8.4% decrease in total sleep time. The control group, on the other hand, increased the total sleep time by 6.8% between Week 1 and discharge. State control findings on the BNBAS were notable, since the mean age of the infants at the time of testing was 36 weeks, whereas the exam is designed to assess infants at 40 weeks. It appears that the experimental procedure applied to these preterm infants influenced their development enough to provide differences measurable even at this early age.

The findings in this study suggest that the use of rhythmic vestibular-proprioceptive and auditory stimulation in the case of very preterm infants may enhance their development. Since rhythmic sounds and oscillating movements were combined in the treatment phase, there is no way of knowing the unique contributions of each. One limitation of the present investigation was the very small sample size. Although further study is needed with a larger sample, the instrumentation available at the present time is very cumbersome and expensive, making it very difficult to collect this data. Progress, however, is being made to fill this technological gap.[1]

[1] Medpro, Inc., 175 Highway 18, East Brunswick, New Jersey 08816.

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