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Premature Infants Seek Rhythmic Stimulation, and the Experience Facilitates Neurobehavioral Development

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ABSTRACT. This was a clinical trials study of self-regulation of rhythmic stimulation in preterm infants. Infants were enrolled in three regional hospitals and followed in four outlying hospitals. Forty-five premature infants, 22 males and 23 females, enrolled at 29–33 weeks conceptional age (CA) received in the isolette either a "breathing" teddy bear (set to breathe at one-half the infant's quiet sleep respiration rate) or a nonbreathing bear. Using time-lapse videorecording at a 60:1 ratio, subjects were recorded for 3 days at the beginning of the Intervention period and again for 3 days, 2 weeks later. After discharge from the hospital, the sleep of the subjects was monitored in the home for a 24-hour period on weeks 1, 2, 3, 4, and 5 after expected date of birth (postterm). Infants with a breathing bear spent more time in contact with the bear, and increased their contact over the two weeks. Postterm, the "breathing bear babies" showed more quiet sleep and a greater increase in quiet sleep over weeks. The results indicate that premature infants ("prematures") are capable of organizing their motility to express a preference for rhythmic stimulation, and that the experience facilitates neurobehavioral development. *J Dev Behav Pediatr* 12:11–18, 1991. Index terms: *prematures, prematures:stimulation, prematures:sleep, prematures:intervention.*

INTRODUCTION

Considerable progress has been made in recent decades in the medical care of prematurely born infants. At the same time, interest in the earliest environment of these vulnerable babies has grown, and this has led to the introduction of numerous forms of social and sensory stimulation for premature babies while they are being cared for in the neonatal intensive care unit (NICU). Some of these interventions have been studied extensively, especially the waterbed designed by Korner,[1–3] maternal forms of stimulation,[4,5] and even procedures for reducing and individually regulating stimulation.[6,7] Most of these studies report beneficial effects for the infants, based on a variety of outcome measures, including weight gain, hospital stay, amount of crying, activity, sleep, or frequency of apneas.

However, efforts to design environmental enrichment for premature infants are still beset by unresolved, basic questions, including: Is the premature infant more like a fetal organism, more like a small full-term infant, or is the premature a unique and evolutionarily novel organism with its own behavioral repertoire and stimulus needs? Should one be concerned about the need for additional stimulation for prematures, or should one be more concerned about overstimulating these vulnerable infants? Clinicians and researchers vary in their views of prematures and, therefore, in their views of the appropriate approach to optimizing environmental circumstances for premature infants. However, there is a general awareness that the same intervention can have very different effects on different infants or even the same infant at different ages. Accordingly, there is agreement that almost any intervention regimen runs the risk of being seriously inappropriate for some infants. Guidelines are not available to identify the needs or sensitivities of infants at any age or stage.

We have bypassed these issues with a new intervention strategy, one which permits stimulation to be adapted to the needs of each individual infant, as these vary with age and condition. The intervention has the following characteristics: (1) it provides a source of rhythmic stimulation which is optional for the infants rather than being imposed on them; (2) the stimulation reflects one of the major biological rhythms of infants, namely, their respiration; and (3) the rate of oscillation is matched to the individual infant.

The intervention consists of a "breathing" teddy bear which is placed in the isolette for the baby to touch, cuddle, or leave alone.[8] To avoid imposing a change on the biological rhythms of a baby, the bear's breathing rate is based on the baby's own breathing rate. Our expectation was that the baby's irregular breathing could thus be entrained to the very regular rhythm of the bear's breathing.[9–11] We specif-

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TABLE 1. Demographic Information: Mean Values (SD)

	Original Sample (n = 45)		Follow-up Sample (n = 33)	
	Breathing Bear	Nonbreathing Bear	Breathing Bear	Nonbreathing Bear
Male	13	9	8	7
Female	10	13	8	10
Birth wt (g)	1125.1 (273.3)	1147.1 (221.3)	1038.6 (270.9)	1188.9 (220.3)
Gestational age (wk)	28.8 (2.4)	28.8 (1.9)	28.3 (2.6)	29.0 (1.8)
Maternal age (yr)	27.1 (5.7)	27.0 (5.3)	25.8 (4.7)	28.4 (4.5)
Conceptional age at enrollment (wk)	32.7 (1.1)	32.6 (1.3)	33.0 (1.0)	32.5 (1.5)
No. of days with bear	21.7 (8.3)	24.3 (9.1)	22.1 (9.4)	23.4 (9.6)
Obstetric complications[a]	10.7 (4.0)	11.7 (2.4)	11.6 (4.3)	11.5 (2.2)
Neonatal complications[b]	3.9 (1.7)	4.4 (1.8)	4.3 (1.9)	4.1 (1.8)

[a] Scored on Prechtl (1968) scale. Possible number of nonoptimal events ranges from 0 to 42.
[b] Scored on Postnatal Complications Scale (Littman and Parmelee, 1978). Possible number of nonoptimal events ranges from 0 to 10.

ically did not aim to modify the baby's breathing rate, first, because there are no empirical guidelines with respect to what an "ideal" rate of breathing would be for any individual infant at any age. Second, previous research "points to the importance of not violating the infant's biological rhythms which are likely to be necessary for healthy functioning" (p. 175).[12]

The bear is set to "breathe" at one-half of the baby's respiration rate during quiet sleep, the time of the baby's most regular breathing. This rate was selected because nurses and parents judged the bear's breathing to be "too fast" when set at the baby's absolute breathing rate. The half-rate is highly reasonable to use for entrainment purposes because a subharmonic of a basic frequency is considered to be almost as effective for entrainment as the matching rate.[13] It should also be noted that a baby does not have to breathe in synchrony with the bear for entrainment to be effective.[14]

In our first study of the breathing bear intervention,[8] we found that prematures have the competence to seek stimulation: those with breathing bears spent more time touching and cuddling with them than infants with nonbreathing bears or no bears (i.e., the equivalent space in the isolette). We also found evidence of entrainment of the infants' respiration to a more regular pattern as a function of this stimulation—the babies with a breathing bear spent more time in quiet sleep, and thus, more time breathing regularly. The increase in quiet sleep also indicated that maturation of the central nervous system (CNS) was facilitated by the infants' experience of self-regulating their stimulation.

The first objective of the present study was to assess the generality of our earlier findings with the breathing bear, using a clinical trials research design. Subjects were enrolled at three major hospitals, and transported infants were observed at four outlying hospitals. No constraints were placed on the care of the infants in the neonatal intensive care units (NICU), to insure that circumstances were "naturalistic" for each NICU. In addition, minimal criteria were set for selection of infant subjects, to insure heterogeneity in the sample, so that the sample would reflect the heterogeneity found in prematures as a population.

The second objective of this study was to extend the previous one by assessing longer-term neurobehavioral effects of the experience of self-regulating stimulation by prematures. The infants' naturally occurring sleep was monitored in the home during the early weeks after expected date of birth (postterm), using an automated recording procedure developed in this laboratory.[15,16] The procedure permits 24-hour sleep monitoring without attaching anything to the infant for the purposes of the recording.[17]

METHODS

Subjects

The subjects were 58 premature infants, born at or transferred to three regional hospitals with level-III neonatal intensive care units (NICUs) and followed at four outlying hospitals. Infants were potential subjects if they were physiologically stable, free of multiple prolonged apneas, and without known neurological dysfunction by 33 weeks conceptional age (CA).

Successive pairs of infants were randomly assigned at each hospital to either a breathing bear or a nonbreathing bear group. Of those enrolled, two had recurrent medical problems, five infants had to be dropped because of equipment failure [pump, video cassette recorder (VCR), camera] or shortage of electrical outlets in the NICU, and four were transported to another hospital before we initiated procedures for continuing the study in outlying hospitals. Two additional infants were dropped after serving as subjects because data analysis indicated that they had been restrained by blanket rolls or by being swaddled more than 90% of the time (more than 2 standard deviations above the mean for the group) during the final 3-day observation period. Clearly, they had little opportunity to move to the bear.

Of the remaining 45 infants, there were 13 males and 10 females in the breathing bear group and 9 males and 13 females in the nonbreathing bear group. Sixteen subjects were cared for at hospital A, 8 at hospital B, and 21 at hospital C. None of the subjects had any known neurological dysfunction. Demographic characteristics of the two groups are presented in Table 1. The groups did not differ on any of these variables.

Thirty-three of these infants were followed with 24-hour sleep recordings in the home during the first 5 weeks postterm: 16 in the breathing bear group, eight males and eight females; and 17 in the nonbreathing bear group, seven males and ten females. The smaller number of subjects in the follow-up sample is accounted for as follows: seven mothers refused to give consent for follow-up recordings, one could not be located to seek permission in time for the first recording, two were dropped when the family moved to a different geographical location, and two gave permission but could not be consistently recorded because the families were in very disruptive circumstances. Because the sample is smaller during the follow-up period, Table 1 also presents demographic information for the two groups of infants in the postterm subsample. The groups do not differ significantly on any of the variables, indicating that selective factors were not introduced by the reduction in sample size for the postterm observations.

Equipment for Preterm Intervention Period

Time-lapse video equipment was designed to fit onto the infant's isolette. The camera was suspended over the isolette from a pole attached to the side of the isolette, and the VCR and power supply were placed on a rolling platform which was attached underneath the isolette (see Fig. 1). Thus, the recording system did not require floor space in the NICU, the isolette was completely mobile during video recording, and infant caretaking was not obstructed by the recording procedures.

The bears were made of blue-dyed sheepskin and were designed to present a uniform ventral profile to the infant: hence, the infant could attain contact with the bear's abdomen without being impeded by its snout or limbs. If the infant was assigned a breathing bear,[18] a rubber bladder inside the bear was connected via plastic tubing to a lightweight pump placed on a shelf beside the isolette. The pumps were custom-engineered by Harvard-Ealing Co. (S. Natick, MA) to produce a sinusoidal "respiratory" waveform for the bear, which simulates the breathing pattern of a healthy neonate. The pump's rate and volume were adjustable. Infants assigned a nonbreathing bear received an identical bear that was not connected to a pump.

Equipment and Procedures for Postterm Sleep Recordings

For monitoring the infant's sleep in the home, a thin (⅛ inch), pressure-sensitive pad is placed on the infant's crib mattress. The infant's respiration and body movements produce analog signals which are recorded on a small, battery-driven, 24-hour Oxford recorder placed under the crib. In the laboratory, the signals are demodulated, digitized, and entered into an IBM-PC computer. A computer program for pattern recognition permits scoring the record in 30-second epochs for five states: active sleep, quiet sleep, active-quiet transition sleep, sleep-wake transition, and wakefulness. The reliability and validity of scoring these motility signals[19–22] and of the computer scoring[15,16,23,24] have previously been demonstrated.

Signals from each complete 24-hour recording are printed out and visually reviewed for electrical artifacts or computer scoring error.

General Procedures

The parents were interviewed for consent as soon as their premature infant was physiologically stable. Group assignment was unknown to the researcher who selected infants as potential subjects. Another researcher interviewed the parents. And a third individual, who was not aware of any of the hospital activities, drew the random sequence of assignments of subjects for each hospital. Group assignment was communicated to the researcher who interviewed the parents just prior to the interview.

Once consent had been obtained, a breathing bear or a nonbreathing bear was placed in the isolette, depending upon group assignment. The video recording equipment was set up, with continuous time-lapse recording at 60:1 ratio. The intervention and video recording continued until the baby graduated from the isolette to a nursery crib. The mean intervention period was 21.7 days (SD = 8.3, range = 12–47 days) for the breathing bear babies and 24.3 days (SD = 9.1, range = 12–50 days) for the nonbreathing bear babies.

At the conclusion of the intervention period, the parents were given a letter of thanks, a "graduation certificate," and a small teddy bear for the baby. The parents were again interviewed and consent was sought for the sleep observations to be made in the home. For the infants with consent,

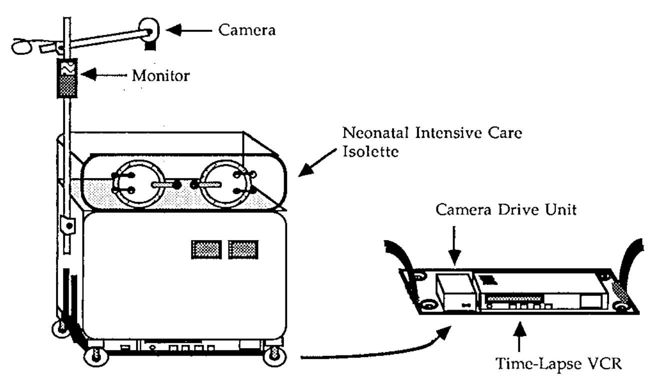

FIGURE 1. Video equipment used in time-lapse recordings of premature infants in the neonatal intensive care nursery.

five weekly 24-hour sleep recordings were made in the home, starting when the infants were 40 weeks CA. For these recordings, the sleep-recording system was taken to the home and set up in the infant's crib. The equipment was retrieved from the home approximately 24 hours later, and the data tapes were processed in the laboratory.

Preterm Variables, Measures, and Statistical Analyses

Behaviors Recorded from the Videotapes. The time-lapse video tapes were scored over two 3-day periods, one at the average age of 33 and the second at 35 weeks CA. These two ages were selected because they provided a window of time when the greatest number of subjects could be included, based on their age at the beginning of the intervention and on the duration of their intervention period. The tape at 33 weeks represented the first three days of intervention for 32 of the 45 subjects (18 of the breathing bear group and 14 of the nonbreathing bear group). The minimum intervention period for including a subject was set at 12 days.

The video tapes were scored in 5-second epochs, corresponding to 5 minutes of real time. The variables recorded in each epoch and their definitions are as follows:

Contact: Some part of the baby's body is touching the bear.

Nurse-Initiated Contact (NIContact): The baby is put down in contact with the bear following caregiving (this code is scored until an epoch in which the baby has moved either closer to or away from the bear).

Caregiving: The baby is being handled (e.g., changing, feeding, medical care, etc.), or is out of the isolette.

Propped: The baby is physically obstructed from achieving or increasing contact with the bear (with blanket roll or swaddling).

Obstructed view: Camera's view of the baby is obstructed by an object temporarily placed on top of the isolette.

Baby available: The view of the baby and bear is not obstructed, no caregiving is ongoing and the baby is not propped.

Sleep-wake states, including: *quiet sleep,* little or no movement, with the exception of isolated jerks or startles; *active sleep,* sporadic low magnitude, variable frequency activity with slight to moderate positional displacement—includes visable REMs and twitches in the face or extremities; *wakefulness,* ongoing moderate or high magnitude, high frequency movements, usually accompanied by fussing or crying. Also scored during quiescent periods if the baby's eyes are open.

Measures of Behaviors Recorded from the Videotapes. Contact and NIContact were measured as a percent of baby available time during each 24-hour day.

Each of the states and propped were measured as a percent of the 24-hour day, less the time spent in caregiving and obstructed view.

Caregiving and obstructed view were measured as a percent of the 24-hour day.

The mean lengths of quiet sleep and active sleep bouts occurring during periods of sleep or wakefulness were measured (bouts initiated or terminated by caregiving were not included in the mean values).

The duration of the longest sleep period at each age was measured.

In addition, the rate of change between quiet sleep, active sleep, and wakefulness was calculated as the number of state changes per hour. The longest sleep period was also recorded.

Other Preterm Dependent Measures. Additional measures included conceptional age at discharge from the hospital and the number of days in the hospital from the date of birth.

Analyses of Preterm Data for Group Comparisons. The groups were compared on relevant measures using group (2) × sex (2) × observation (repeated: 2) mixed design analyses of variance and hospital (3) × group × observation ANOVAs. Thus, hospital effects were considered for all measures.

Postterm Variables, Measures, and Statistical Analyses

Behaviors Recorded from the Postterm Sleep Recordings. For the five weekly sleep recordings at 1 to 5 weeks postterm, the following states were scored for each 30-second epoch throughout the 24-hour recording, in accordance with procedures previously described:[16] quiet sleep, active sleep, active-quiet transitional sleep, sleep-wake transition, and waking.

The states were coded for all periods when the baby was in the crib. Epochs of in- and out-of-the-crib were also coded.

Measures from Postterm Sleep Recordings. Each of the postterm states were measured as a percent of time spent in-the-crib. Out-of-the-crib time was measured as a percent of the total (24-hour) observation. In addition, the mean bout lengths of quiet sleep and active sleep, the rate of state

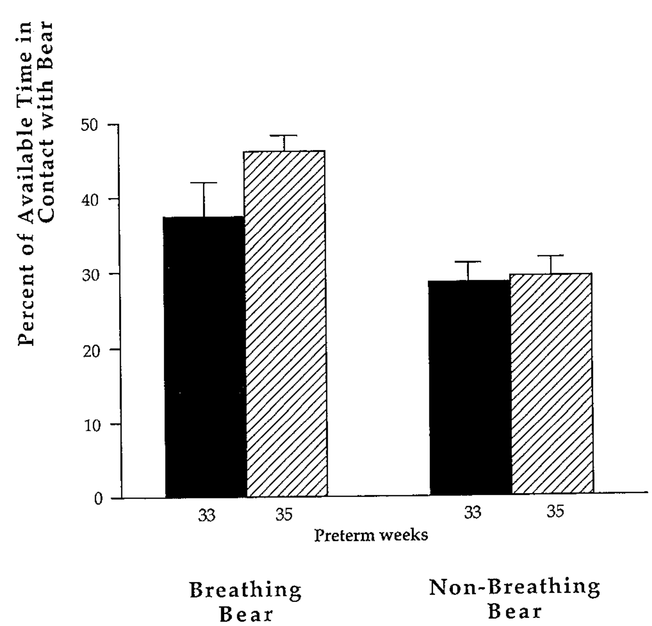

FIGURE 2. Contact with the bear at 33 and 35 weeks conceptional age for the breathing bear group and the nonbreathing bear group.

TABLE 2. Mean Amount of Contact, Caregiving, and Propping at Each Hospital at 33 and 35 Weeks Conceptual Age (SD)[a]

	Hospital A		Hospital B		Hospital C	
Preterm Wk	Breathing Bear (n = 8)	Nonbreathing Bear (n = 7)	Breathing Bear (n = 4)	Nonbreathing Bear (n = 4)	Breathing Bear (n = 9)	Nonbreathing Bear (n = 11)
	(a) Mean Amount of Contact as % of Available Time (SD)					
33	17.44	21.94	49.32	30.26	52.05	32.47
	(19.81)	(11.84)	(8.17)	(9.83)	(12.38)	(12.27)
35	40.84	25.01	52.92	32.80	49.91	31.02
	(11.93)	(7.68)	(5.39)	(10.63)	(8.36)	(14.00)
	(b) Mean Amount of Caregiving as % of 24-hour Day (SD)					
33	14.59	14.84	15.95	16.36	14.46	17.63
	(2.91)	(3.89)	(4.35)	(3.12)	(1.94)	(3.30)
35	16.26	17.18	15.92	18.41	17.44	19.17
	(4.39)	(2.78)	(3.82)	(3.84)	(3.10)	(4.42)
	(c) Mean Amount of Propping as % of 24-hour Day (SD)					
33	58.01	52.99	5.25	25.82	7.74	19.29
	(28.56)	(21.14)	(6.68)	(20.34)	(7.35)	(16.65)
35	27.61	38.65	7.80	10.34	18.08	21.84
	(21.95)	(22.85)	(10.75)	(11.78)	(15.49)	(21.64)

[a] Two subjects were excluded from hospital analyses because they were cared for primarily at outlying hospitals.

change and the longest sleep period were calculated for each 24-hour observation.

RESULTS

Preterm Data Analyses

Contact with the Bear. Figure 2 indicates the mean amount of contact (percent of available time) for the two groups at the beginning and end of the 2-week preterm observation period, i.e., at 33 and 35 weeks conceptional age (CA). There were no significant differences between the groups at 33 weeks. At 35 weeks, infants in the breathing bear group showed significantly more contact with the bear than those in the nonbreathing bear group (F = 25.72, df = 1, 41, $p < 0.001$). In addition, the breathing bear group showed a significant increase in contact over the 2 weeks (F = 5.94, df = 1, 21, $p < 0.05$: repeated measures F-test), whereas the nonbreathing bear group did not show a change in contact time over this age period.

Contact as a Function of Individual Hospital. The mean amount of contact at each of the three hospitals, for each age, is presented in Table 2(a). The means differ significantly (F = 10.44, df = 2, 37, $p < 0.001$) at both ages. There was no hospital × group interaction; thus, there is no evidence that the difference in the amount of contact between the two groups is related to hospital.

Contact as a Function of Specific Caregiving Practices at the Three Hospitals. Since the overall amount of contact differed among the hospitals, two major hospital measures, caregiving, and propping (or physical restraint), were examined to assess their possible contribution to this effect.

Caregiving Time. The mean amount of caregiving time at 33 and 35 weeks for each of the three hospitals is presented in Table 2(b). Caregiving increased over age from 15.6% at 33 weeks to 17.4% at 35 weeks (F = 12.17, df = 1, 37, $p < 0.005$). However, the three hospitals are very similar in the amounts of caregiving at both ages. There was no relationship between caregiving time and the amount of contact the babies had with the bear for either group at either age. Thus, caregiving time does not account for the differences found in the amount of contact among the hospitals.

Propping. The mean amount of time babies were propped at 33 and 35 weeks at each of the three hospitals is presented in Table 2(c). There was a significant hospital effect (F = 20.18, df = 2, 37, $p < 0.001$), with hospital A showing greater propping than either of the other two hospitals. Hospitals B and C did not differ on this variable. This result strongly suggests that the lower amounts of contact showed by both groups of infants at hospital A may be accounted for by the greater amount of time the babies were propped at that hospital. Support for this interpretation is provided by the finding that, for both groups, the amount of time the babies spent propped was negatively correlated with the amount of time they spent in contact when not propped (for the breathing bear group: $r = -0.50$, df = 21, $p < 0.05$; for the nonbreathing bear group, $r = -0.459$, df = 20, $p < 0.05$). Examination of the plotted data indicated that these correlations were carried primarily by the extremely high-prop values, and that these came primarily from hospital A. Most important for assessing the differences in contact between the groups across hospitals is the finding that there was not a significant hospital × group interaction effect for propping. Thus, the two groups were not differentially affected by this variable.

Preterm Sleep-Wake States

Individual Consistency in Each of the States. Significant individual differences were obtained for each of the states

TABLE 3. Mean Percent Time in Each State at 33 and 35 Weeks Conceptual Age (SD)

	Quiet Sleep		Active Sleep		Waking	
Preterm Wk	Breathing Bear	Nonbreathing Bear	Breathing Bear	Nonbreathing Bear	Breathing Bear	Nonbreathing Bear
33	10.01	10.94	55.86	56.85	34.13	32.20
	(4.00)	(4.38)	(5.97)	(5.54)	(7.86)	(7.26)
35	14.75	17.44	58.17	57.20	27.07	25.36
	(5.13)	(7.91)	(7.44)	(7.03)	(7.05)	(10.12)

across the 2-week observation period (33- to 35-week correlations of time spent in each state: Quiet sleep $r = 0.646$, $df = 43$, $p < 0.01$; active sleep $r = 0.387$, $df = 43$, $p < 0.05$; waking $r = 0.376$, $df = 43$, $p < 0.05$). The data therefore reliably describe the sleep and wake states of these infants.

Distribution of the States in the Two Groups at the Beginning and End of the Intervention Period. Table 3 presents the mean amounts of quiet sleep, active sleep, and wakefulness at 33 and 35 weeks for the two groups. There were no group differences on any of the states at either age. Neither were there differences in bout lengths of quiet sleep and active sleep, rate of state change, or duration of the longest sleep period.

Relationship of Group to Other Dependent Measures. The mean postnatal age at discharge from the hospital was 7.8 weeks for the breathing bear babies, and 8.9 weeks for the nonbreathing bear babies. The mean conceptional age at discharge from the hospital was 36.6 weeks for the breathing bear babies and 37.6 weeks for the nonbreathing bear babies. The two groups did not differ significantly on either of these measures.

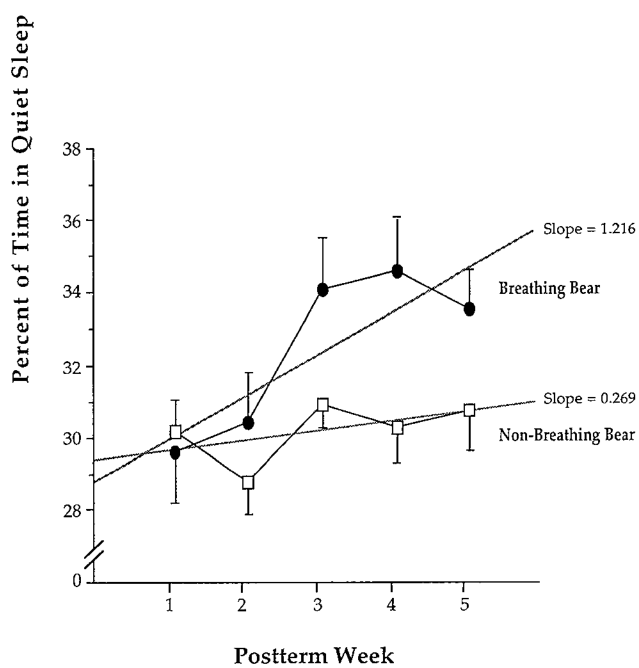

FIGURE 3. Amount of quiet sleep over the first 5 postterm weeks for the breathing bear and the nonbreathing bear groups.

Postterm Data Analyses

Distribution of the States during the Postterm Weeks. Table 4 presents the mean amount of quiet sleep, active sleep, and wakefulness for the two groups for weeks 1–5 postterm, from the home recordings. The only state which differentiated the groups was quiet sleep.

As predicted, the breathing bear group showed significantly more quiet sleep over the 5 weeks ($F = 3.54$, $df = 1, 29$, $p < 0.05$, one-tailed test). There was also a significant group $\times$ week interaction for amount of quiet sleep ($F = 2.25$, $df = 4, 122$, $p < 0.05$, one-tailed test), which reflects the fact that, whereas the first week [40 weeks conceptional age (CA)] showed no difference between the two groups, the breathing bear group showed a linear increase in quiet sleep on the four subsequent weeks. An ANOVA for weeks 2–5 indicated this difference was significant ($F = 5.55$, $df = 1, 29$, $p < 0.05$, two-tailed test). With respect to the individual slopes for changes in quiet sleep over the 5 weeks, the breathing bear group showed a greater mean slope for increase in quiet sleep over weeks ($F = 5.33$, $df = 1, 29$, $p < 0.05$, two-tailed test). Figure 3 shows the change in quiet sleep for the two groups over the 5 weeks. The groups did not differ on bout lengths of quiet sleep and active sleep, rate of state change, or duration of longest sleep period.

DISCUSSION

Despite widely differing nursery practices found in the three major hospitals and four outlying hospitals, and despite broader selection criteria for the infant subjects, the phenomenon reported in our original study[8] was replicated. Premature babies with breathing bears achieved more contact with them than did babies with nonbreathing bears. This differential responsiveness was unrelated to gestational age, birth weight, neonatal or postnatal risk factors, or to the hospital where the baby was cared for. The infants at one hospital were physically restrained by propping much more than those at the other two major hospitals, and this reduced the amount of contact the babies in both groups could make with their bears. However, the effect of propping on contact was not differential for the two groups. It should be noted that caregiving time was remarkably similar across hospitals and groups.

The phenomenon of seeking behavior in prematures has been reported in another study,[24] described as "range-finding" behavior. Range finding is described as a kind of orientation aimed at maximizing contact with a preferred surface. "Within the isolette, the most accessible stable surface is an inner Plexiglas heat shield. Some infants have

TABLE 4. Mean Percent Time in Each State during the 5 Postterm Weeks (SD)

	Quiet Sleep		Active Sleep		Waking	
Postterm Wk	Breathing Bear	Nonbreathing Bear	Breathing Bear	Nonbreathing Bear	Breathing Bear	Nonbreathing Bear
1	29.33	29.94	57.33	56.99	4.58	5.01
	(5.66)	(3.56)	(4.83)	(3.97)	(2.48)	(3.08)
2	30.16	28.51	54.60	56.07	7.05	6.45
	(5.64)	(3.61)	(6.31)	(3.92)	(6.14)	(4.25)
3	33.82	30.71	52.58	55.47	5.72	5.39
	(5.72)	(2.79)	(6.09)	(4.26)	(3.66)	(3.08)
4	34.38	30.05	53.29	55.58	4.78	6.06
	(5.84)	(4.13)	(5.20)	(5.07)	(3.30)	(3.61)
5	33.30	30.51	52.78	55.03	6.44	6.63
	(4.41)	(4.68)	(4.24)	(6.06)	(4.46)	(3.41)

at least two points of body contact with the heat shield at all times; most had at least one limb in touch, occasionally for extended periods of time, i.e., 20–30 minutes'' (p. 453). This description clearly fits the behavior of our infants with a bear, which can be considered as another stable surface, one which elicits much more contact if it ''breathes'' than if it does not. Remarkably, some periods of contact with the breathing bear persisted for as long as 2 hours. Newman interprets range finding behavior as ''intentional action'' (p. 453). When viewing the babies' responses to the breathing bear on the videoscreen, they clearly appear to be ''intentional.'' However, intentionality is a complicated concept, and we would use it only in this impressionistic fashion.

Other researchers, primarily those studying older infants, have emphasized the importance of giving an infant some control over the stimulation he or she receives as a means of arranging an environment which is more suited to the individual baby's particular needs. In prematures, this approach is a way of preventing the baby from being overstimulated, which can be as detrimental as being understimulated.[26]

Avoiding over- or understimulation is an important but not sufficient justification for an intervention. It must also be demonstrated that the baby benefits in some way. We have proposed that self-regulation of the breathing bear stimulation should facilitate maturation of brain function in the infants. This proposition was suggested by research which has shown that self-initiated activity leading to perceptual encounters with the environment is more conducive to learning about environmental stimuli than passive exposure to identical aspects of the environment.[27] Similarly, other research has shown that active interaction with environmental interventions is more effective for enhancement of brain development than is passive exposure.[28] Clearly, the evidence in the literature would argue that an opportunity to seek and control stimulation from the bear should be more appropriate for supporting central nervous system (CNS) development than passive exposure to the stimulation. Thus, in addition to the rhythmic stimulation *per se*, the very act of engaging in movements that achieve contact with the breathing bear may be a significant factor in its beneficial effects.

Consistent with the proposed benefits of the breathing bear, our first study provided evidence that this intervention facilitates neurobehavioral development: premature infants with the breathing bear showed evidence for entrainment and for a more mature sleep pattern in terms of greater amounts of quiet sleep. The increase in quiet sleep also suggested the possibility that entrainment had been effected by the rhythmic stimulation, because more quiet sleep means more time spent in a state with a regular breathing pattern.

In the present study, we did not replicate the findings of greater quiet sleep during the preterm period. There were several differences in the two studies which could have mitigated against such concurrent effects of the intervention. The subject sample of this study was much more heterogeneous, and the several hospitals differed in their styles of care for the infants. However, we reason that these were not the relevant factors, because the state measures showed a developmental change with age over the 2-week period, but there was remarkably little variability across individuals at both ages. Rather, we speculate that improved practices in the neonatal intensive care unit (NICU) which permit very effective control of weight gain in the infants may have accounted for the lack of variability in states as a function of near-optimal nutritional protocols for all infants. Nutritional status is known to have an effect on early CNS development and, thus, on sleep patterns.[29, 30]

By this logic, one might expect that the infants' postterm states should continue to show a lack of effects of the breathing bear. In fact, at 40 weeks conceptional age (CA), the 24-hour sleep recordings do not show a group difference. However, on subsequent weeks, the picture is dramatically different. The breathing bear babies showed significantly more quiet sleep over the remaining 4 weeks, and they also showed a significantly greater developmental increase in quiet sleep over the 5 postterm weeks. These results are consistent with those of our first study: the experience of self-regulating stimulation facilitates neurobehavioral development, and the effects extend beyond the intervention period into the postterm age.

In previous studies of infants' states during the early postterm weeks, we have found that organization in their sleep patterns is related to organization in their waking patterns.[31] We and others have also found that state parameters during infancy relate to later developmental status.[32, 33] Accordingly, it is reasonable to speculate that the sleep changes in the breathing bear infants may have implications for their waking behaviors, for social interactions and synchrony with the mother, for the mothers' feelings about their infants, or for the infants' later development. Such speculations provide starting points for future study of the breathing bear intervention. The present study clearly indicates effects more than 5 weeks beyond the period of treatment: these benefits warrant further study.

The longer term benefits from the breathing bear may be mediated, in some part, by indirect effects on caregivers. When enrolling subjects, we specifically avoided telling parents that the breathing bear would make a notable change in their babies. This was done so that we could make approximately the same statements about the intervention procedures to parents of breathing bear and nonbreathing bear babies. Nevertheless, only parents of the breathing bear babies became very excited about their participation, claiming that their babies "loved" the bear and, sometimes almost tearfully, expressing their gratitude for what the bear did for their babies. Accordingly, we would agree with Korner[2] that "if these changes can give greater comfort to the infants, their parents or the nursery personel while the infants are in the nursery, they are well worth making" (p. 268).

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