Developmental Care Does Not Alter Sleep and Development of Premature Infants

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ABSTRACT. *Objective.* **The Neonatal Individualized Developmental Care Program (NIDCAP) for very low birth weight (VLBW) preterm infants has been suggested by Als et al to improve several medical outcome variables such as time on ventilator, time to nipple feed, the duration of hospital stay, better behavioral performance on Assessment of Preterm Infants' Behavior (APIB), and improved neurodevelopmental outcomes. We have tested the hypothesis of whether the infants who had received NIDCAP would show advanced sleep-wake pattern, behavioral, and neurodevelopmental outcome.**

Methods. **Thirty-five VLBW infants were randomly assigned to receive NIDCAP or routine infant care. The goals for NIDCAP intervention were to enhance comfort and stability and to reduce stress and agitation for the preterm infants by: a) altering the environment by decreasing excess light and noise in the neonatal intensive care unit (NICU) and by using covers over the incubators and cribs; b) use of positioning aids such as boundary supports, nests, and buntings to promote a balance of flexion and extension postures; c) modification of direct hands-on caregiving to maximize preparation of infants for, tolerance of, and facilitation of recovery from interventions; d) promotion of self-regulatory behaviors such as holding on, grasping, and sucking; e) attention to the readiness for and the ability to take oral feedings; and f) involving parents in the care of their infants as much as possible. The infants' sleep was recorded at 36 weeks postconceptional age (PCA) and at 3 months corrected age (CA) using the Motility Monitoring System (MMS), an automated, nonintrusive procedure for determining sleep state from movement and respiration patterns. Behavioral and developmental outcome was assessed by the Neurobehavioral Assessment of the Preterm Infant (NAPI) at 36 weeks PCA, the APIB at 42 weeks PCA, and by the Bayley Scales of Infant Development (BSID) at 4, 12, and 24 months CA.**

Results. **Sleep developmental measures at 3 months CA showed a clear developmental change compared with 36 weeks PCA. These include: increased amount of quiet sleep, reduced active sleep and indeterminate sleep, decreased arousal, and transitions during sleep. Longest sleep period at night showed a clear developmental effect (increased) when comparing nighttime sleep pattern of infants at 3 months with those at 36 weeks of age. Day-night rhythm of sleep-wake increased significantly from 36 weeks PCA to 3 months CA. However, neither of these sleep developmental changes showed any significant effects of NIDCAP intervention. Although all APIB measures showed better organized behavior in NIDCAP patients, neither NAPI nor Bayley showed any developmental advantages for the intervention group. The neurodevelopmental outcome measured by the Bayley at 4, 12, and 24 months CA showed 64% of the NIDCAP intervention group at the lowest possible score compared with 33% of the control group. These findings could not be explained by the occurrence of intraventricular hemorrhage or the socioeconomic status of the parents, which showed no significant group effect.**

Conclusion. **The results of this study, including measures of sleep maturation and neurodevelopmental outcome up to 2 years of age did not demonstrate that the NIDCAP intervention results in increased maturity or development.**

Buehler et al (*Pediatrics*. 1995;96:923–932) have reported that premature infants (N = 12; mean gestational age 32 weeks, mean birth weight 1700 g) who received developmental care compared with a similar group of infants who received routine care showed better organized behavioral performance on an APIB assessment at 42 weeks PCA. None of the medical outcome measures were significantly different in this study. Although our APIB results are in agreement, the results of the NAPI, the Bayley and sleep measures do not show an increase in neurodevelopmental maturation. In the earlier report by Als et al (*Journal of the American Medical Association*. 1994;272:853–858), both medical and neurofunctional improvements were found in very low birth weight premature infants (mean gestational age 27 weeks, mean birth weight ~870 g) in which 20 infants who received NIDCAP were compared with 18 infants who received routine care. At 42 weeks PCA the APIB was better in the intervention group as was the Bayley at 6 months CA. Later neurodevelopmental assessments in this study population have not been reported. Furthermore, as was indicated in the editorial by Merenstein in the same issue of the *Journal of the American Medical Association*, a significant problem with the study was that the number of intraventricular hemorrhages was higher in the control group (10 of 18 vs 1 of 20) and the study was conducted before the widespread use of surfactant and prenatal steroids. The study was performed in a single nursery with nurses who volunteered for developmental intervention and cared for the experimental group. No assessment was performed on differences in nursing, intervention, lighting, or sound between the two groups. Apnea, bradycardia, and desaturation data were not reported also. NIDCAP has been shown to reduce stress and agitation in the infants in our study (Heller C, et al. *Journal of Perina-*

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tology. **1997;17:107–112); however, there was no difference in the incidence of apnea or bradycardia.**

Additional studies are needed to determine which specific interventions facilitate recovery in the high-risk preterm infant when interventions are efficacious, what may be adverse or ineffective, and what mechanisms are involved. Distinctions should be made between medical improvement, neurobehavioral responses (APIB), and neurodevelopmental maturation. Not only the duration of NICU hospitalization, but indeed, long-term outcomes must be carefully evaluated. We recommend that clinicians should be aware that preterm infants who have received NIDCAP during their hospitalization do not appear to be more mature at the time of discharge home. *Pediatrics* 1997;100(6). URL: http://www.pediatrics.org/cgi/content/full/100/6/e9; *sleep, circadian rhythms, NIDCAP, neurodevelopment, infants.*

ABBREVIATIONS. NIDCAP, Neonatal Individualized Developmental Care and Assessment Program; VLBW, very low birth weight; NICU, neonatal intensive care unit; CA, corrected age; PCA, postconceptional age; MMS, Motility Monitoring System; ET, E. Thoman (Laboratory); AS, active sleep; A-Q-Tr, active-quiet transition sleep; QS, quiet sleep; S-W-Tr, sleep-wake transition; W, wakefulness; TIC, time in crib; LSP, longest sleep period; ANOVA, analysis of variance; NAPI, Neurobehavioral Assessment of the Preterm Infant; APIB, Assessment of Preterm Infants' Behavior; BSID, Bayley Scales of Infant Development.

The Neonatal Individualized Developmental Care and Assessment Program (NIDCAP) for very low birth weight (VLBW) [≤1250 g] neonatal intensive care unit (NICU) infants has been shown to decrease the need for mechanical ventilation, shorten the time to full enteral or bottle/breast feedings, decrease hospital days, lower charges for hospital care, and improve behavioral organization. Some early (9 months corrected age [CA]) developmental outcome also favors the intervention group.[1–3] Fleisher and co-workers[4] from our NICU had designed a study to verify the effectiveness of developmental intervention in our practice. The purpose of the present study was to determine if the improvement in medical outcomes was associated with improved sleep or developmental outcome.

METHODS

The infants in this study received care in the intensive and intermediate care nurseries at Lucile Salter Packard Children's Hospital at Stanford. The study was approved by The Administrative Panel on Human Subjects in Medical Research and informed written consent was given by the infant's parent(s).

Subjects

Infants in this study met the enrollment criteria for the above mentioned report[4]: a) birth weight ≤1250 g; b) gestational age (GA) ≤30 weeks; c) mechanical ventilation begun in the first 3 hours and continued for more than 24 of the first 48 hours of life; d) singleton or sole survivor of multiple gestation; e) no chromosomal or major genetic anomalies; f) no congenital infection; and g) parents' willingness to participate in long-term follow-up after discharge. Forty subjects entered during the 2-year (1992 to 1994) study of the effects of individualized care. Five of the enrollees died. Twenty-eight of the 35 surviving infants were available for sleep studies as our recruitment for this component of the study began in October 1992 and 23 were seen at 2 years CA. The maternal and neonatal characteristics are shown in Table 1.

TABLE 1. Neonatal and Demographic Information (Mean, SD) for 28 Patients Undergoing Sleep Studies

	NIDCAP (N = 14)	Control (N = 14)
Gestational age at birth (wks)	26.4 (2.1)	26.1 (1.8)
Birth weight (g)	884.1 (182.0)	811.7 (210.8)
5-minute Apgar	6	5
Mother's age (y)	25.1 (6.8)	30.0 (7.6)
Mother's education (years of school)	13.2 (3.6)	13.4 (2.8)
Number of males	9	9
Number of first-born	7	9
Number transferred from outlying hospital	3	5

The maternal and neonatal characteristics of the two groups were similar.

The NIDCAP Intervention

The details for the NIDCAP intervention have been described in detail in previous publications.[1–5] The goals for NIDCAP intervention were to enhance comfort and stability and to reduce stress and agitation for the infants by: a) altering the environment by decreasing excess light and noise in the room and by using covers over incubators and cribs; b) use of positioning aids such as boundary supports, nests, and buntings to promote a balance of flexion and extension postures; c) modification of direct hands-on caregiving to maximize preparation of infants for, tolerance of, and facilitation of recovery from interventions; d) promotion of self-regulatory behaviors such as holding on, grasping, and sucking; e) attention to the readiness for, and the ability to take oral feedings; and f) involving parents in the care of their infants as much as possible. The intervention was closely monitored by certified developmental specialists.[4]

Procedures for Sleep Recordings

The sleep of all 28 infants was recorded for 48 hours at least once. Twenty-four infants were monitored in the hospital at 36 weeks postconceptional age (PCA), 25 infants were monitored in the home at 3 months CA, and 21 infants were recorded at both ages. The infant's sleep was recorded using the Motility Monitoring System (MMS), an automated, nonintrusive procedure that has been described in detail in previous reports from E. Thoman's (ET) laboratory.[6–11] These reports provide evidence for reliability and validity of the measures of sleep obtained from the MMS recording procedure. Briefly, the system consists of a capacitance-type sensor pad that was placed in the infant's crib under the bedding. The pad was connected to a battery-powered amplifier and a recorder. A single channel analog signal produced by the infant's respiration and body movements was continuously recorded for 2 consecutive days. No changes in caregiving, other than ensuring optimal pad placement, were needed as nothing was attached to the infant. The recordings were processed by ET's laboratory where data were downloaded to a computer and scored in 30-second epochs for sleep/wake states, using a pattern recognition program. ET was not informed of the infant group assignments. The five states scored were: Active Sleep (AS), Active-Quiet Transition Sleep (A-Q-Tr), Quiet Sleep (QS), Sleep-Wake Transition (S-W-Tr), and Wakefulness (W) during the time in crib (TIC). Examples of signals for four of these states are presented in Fig 1.

Measures Obtained From MMS Sleep Recordings

For each 24-hour recording, the times spent in AS, QS, and A-Q-Tr were calculated and expressed as a percentages of the total sleep time. Times spent in S-W-Tr and W were calculated and expressed as a percentages of the TIC. In addition to percentages for the above five states, the following measures were calculated for each recording:

TIC

The amount of time spent in the crib as a percent of the total recording time (24 hours).

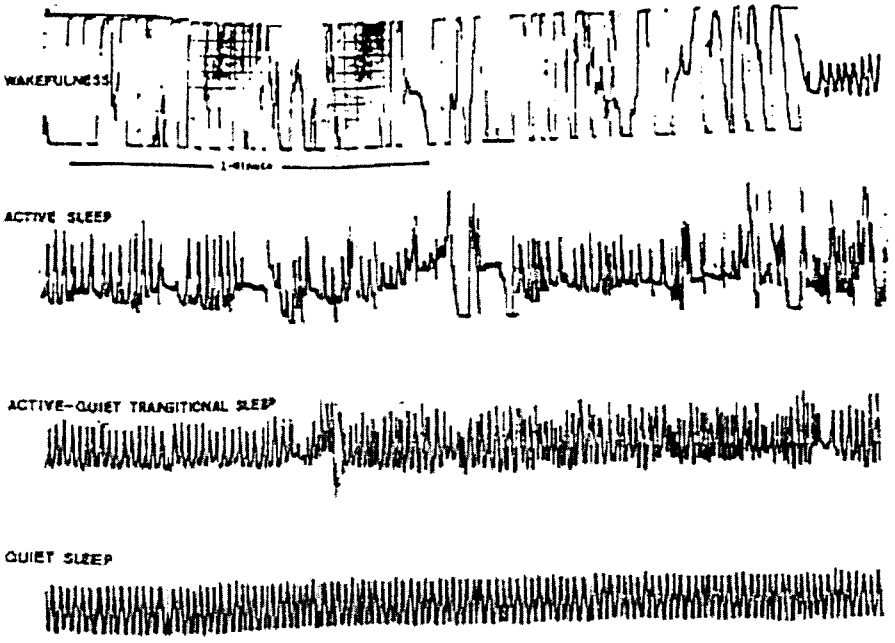

Fig 1. depicts examples of MMS recording patterns. Top to bottom: Wakefulness, Active Sleep, Active-Quiet Transitional Sleep, and Quiet Sleep. The complete signal-file was printed out and visually edited.

Arousal in QS (Ar-in-QS)

Movement that occurred during QS for at least 25 seconds. According to the rule of 3 minutes for a state change, if the arousal persisted for as long as 3 minutes, a change in state (to wakefulness) was scored.

Arousal in AS (Ar-in-AS)

Movement that occurred during AS for at least 25 seconds. According to the rule of 3 minutes for a state change, if the arousal persisted for as long as 3 minutes, a change in state (to wakefulness) was scored.

Mean Bout Length of QS (QS-BL)

Mean duration of all bouts of QS in the 24-hour recording. If a bout of QS occurred at the beginning or end of a period in the crib, it was included in the calculation of the mean QS-BL only if the length of that bout was equal to or greater than the median of all bout lengths of QS for the recording.

Mean Bout Length of AS (AS-BL)

Mean duration of all bouts of AS in the recording. If a bout of AS occurred at the beginning or end of a period in the crib, it was included in the calculation of the mean AS-BL only if the length of that bout was equal to or greater than the median of all bout lengths of AS for the 24-hour recording. This adjustment was made to diminish the effects of the mother's putting the infant in the crib or picking the infant up during AS.

Active Sleep/Quiet Sleep Ratio (AS:QS)

Ratio of Active Sleep to Quiet Sleep.

Longest Sleep Period (LSP) at Night and Day-Night Rhythm of Sleep

We were also interested in examining the effect of NIDCAP intervention on the development of settling or sleeping through the night. Conventionally, an infant is developmentally matured and settled at night when (s)he sleeps without waking during the hours from 12 midnight to 5 AM, usually the time when parents are asleep. To measure this we have calculated, according to Anders and Keener,[12] the percentage longest sleep period (%LSP) (ie, number of minutes of sleep divided by 300 multiplied by 100). Another important developmental change in the organization of sleep-wake patterns is the appearance of diurnal (or circadian) rhythms.[10,13,14] As an adjunct of circadian rhythm development, sleep becomes more consolidated at night and wakefulness increases during the day. The degree of circadian rhythm maturation can be assessed by dividing the recording into subjective day (7 AM to 7 PM) and subjective night (7 PM to 7 AM) and expressing the amount of sleep as percentages of each 12-hour period. Two measures of sleep consolidation were determined to evaluate the effect of NIDCAP on the diurnal sleep pattern. The first was to determine the time of day in which the LSP occurred and to express it as a percentage. The second was to arbitrarily divide the 24-hour period into 07:00 to 19:00 (daytime) and 19:01 to 06:59 (nighttime) and express these as percentages of the 12-hour periods. Analyses of variance (ANOVAs) were performed on both of these measures.

Neurobehavioral Assessment of the Preterm Infant (NAPI)

The NAPI[15] is a measure of relative neurological maturity and consists of seven cluster scores: 1) scarf sign, 2) popliteal angle, 3) motor development, 4) alertness and orientation, 5) irritability, 6) cry quality, and 7) percent asleep. The unique characteristic of the NAPI is that it uses an invariant sequence of item presentation, so that reliable comparisons can be made between subjects or groups of subjects and on repeated assessments on the same individual.[16] Thirty-one infants were tested at 36 weeks PCA. Four were too fragile to be tested.

Assessment of Preterm Infants' Behavior (APIB)

The APIB[17,18] measures the organization of the infant's behavior in five items including the autonomic, motor, state, attentional, and self-regulatory systems. The amount of examiner facilitation is also assessed. Thirty-five infants in this study were tested at 42 weeks PCA.

Bayley Scales of Infant Development (BSID)

The BSID[19] is a standardized evaluation of the developmental status of children from 1 to 42 months of age providing separate scores for mental function reported as the Mental Developmental Index and motor function reported as the Psychomotor Developmental Index. After 24 years the Bayley has been renormed in 1993 to correct the upward drift and to more accurately reflect the diversity of our current population.[20] The BSID II edition was released during the course of our study and was used for the infants assessed at 24 months. Twenty-three of the original 35 infants in this study were tested at 24 months CA. The infants lost to follow up were less severely ill than those who were seen and there were no intergroup differences in severity of illness.

RESULTS

Sleep

As indicated in Table 2 and Fig 2, the following states changed significantly over age: %AS decreased, %QS increased, %AS:%QS decreased, %S-W-Tr decreased, Ar-in AS decreased, Ar-in-QS decreased and %LSP increased (see Table 3). %A-Q-Tr, %W, AS-BL, and QS-BL were not significantly different, though the AS-BL decrease in the intervention infants was nearly significant. TIC was less at 3 months CA and the amount of time asleep in crib is greater which supports that the parents usually placed their infant in the crib to sleep. The percent time awake while in the crib was similar in both groups. There were similar sleep, sleep/wake transitions, and arousals in both groups but significantly fewer arousals at 3 months CA in both active and quiet sleep. Quiet sleep bout length had a trend for increase with age and active sleep bout length had a trend for decrease at 3 months CA. A two-factor ANOVA on LSP, expressed in % of the period between midnight and 5 AM, yielded no significant effect of NIDCAP intervention alone or with age and the intervention. However, there was a significant age effect; NIDCAP 76 ± 14% at 36 weeks PCA, 91 ± 9% at 3 months PCA and Control 74 ± 13% at 36 weeks PCA, 88 ± 9% at 3 months PCA (Fisher's protected least significant difference (PLSD) $P = .0005$). No significant NIDCAP intervention effects were seen on sleep parameters.

Figure 2 is a graphic summary of sleep parameters in percent of total sleep time for 36 weeks PCA and at 3 months CA.

The three-factor ANOVA showed no significant effect of NIDCAP intervention on day versus night or by age, or by day/night, nor by age and day/night. However, age (Fisher's PLSD $P < .0001$), day/night (Fisher's PLSD $P < .0001$), and age by day/night (interaction $P < .0001$) were all significant (Table 3).

Behavioral and Developmental Assessments

NAPI

Thirty-one of the 35 infants in the NIDCAP study were tested with the NAPI assessment at 36 weeks PCA. Four infants were still mechanically ventilated and too fragile to be tested.

The cluster scores in the seven test modalities are presented in Table 4. The Student *t* test (unpaired) analysis did not show a significant effect with the NIDCAP intervention.

APIB

All of the original 35 infants were assessed at 42 weeks PCA using the APIB. The results are shown in Table 5. All APIB scores showed better organized behavior for the NIDCAP intervention patients.

BSID

To date, our longest developmental outcome data are BSID-I scores at 4 and 12 months and BSID-II scores at 24 months CAs which are presented in Table 6. An unpaired *t* test of the Bayley results showed no NIDCAP intervention effect. The NIDCAP and control groups were similar with regard to socioeconomic status and background neonatal variables.

DISCUSSION

Several investigators have reported that NIDCAP improves early medical outcome variables such as time on ventilator, time to nipple feed, duration of hospital stay and charges for hospital care in VLBW prematures.[1–4] Although a difference in behavioral

TABLE 2. Sleep Analysis Summary (Unpaired t Tests; N = NIDCAP Group; C = Control Group)

Sleep Analysis Summary				
Parameter	Group	36 Weeks PCA N = 13; C = 11	3 Months CA N = 13; C = 12	Age Sig. (*P*)
		Mean (SE)	Mean (SE)	
%AS	N	63.9 (1.2)	52.9 (1.3)	.0001
(/TST)	C	61.9 (1.9)	56.0 (1.4)	.018
%QS	N	35.5 (1.3)	46.5 (1.3)	.0001
(/TST)	C	37.4 (1.9)	43.5 (1.4)	.017
%A-Q-Tr	N	.4 (.1)	.4 (.1)	.5
(/TST)	C	.4 (.1)	.4 (.1)	.4
%AS:%QS	N	1.8 (.1)	1.2 (.1)	.0001
(ratio)	C	1.7 (.1)	1.3 (.1)	.014
%W	N	11.7 (1.4)	13.6 (2.8)	.6
(/TIC)	C	16.0 (1.4)	13.1 (2.1)	.3
%S-W-Tr	N	10.2 (.7)	6.6 (.5)	.0003
(/TIC)	C	10.0 (.6)	5.8 (.5)	.0001
Ar-in-AS	N	17.7 (.8)	13.0 (.9)	.0001
(#)	C	17.9 (1.3)	10.2 (1.1)	.0001
AS-BL	N	47.4 (2.9)	41.6 (3.2)	.07
(min)	C	44.4 (3.3)	46.0 (2.2)	.2
Ar-in-QS	N	2.5 (.4)	1.3 (.4)	.02
(#)	C	4.0 (.7)	1.3 (.3)	.02
QS-BL	N	47.1 (2.1)	51.0 (1.9)	.9
(min)	C	44.5 (1.1)	49.1 (1.7)	.9
LSP	N	76 ± 14	91 ± 9	.0005
(% morning sleep)	C	74 ± 13	88 ± 9	.0005

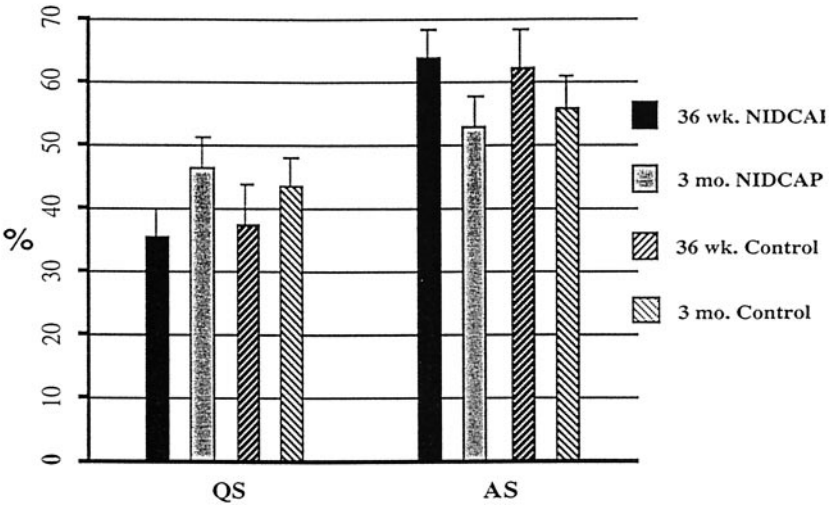

Fig 2. Sleep parameters in % of total sleep time at 36 weeks and 3 months postconceptional age. (QS = quiet sleep; AS = active sleep; PCA = postconceptional age; CA = corrected age). Note the amount of quiet sleep increased and active sleep decreases with age in both groups of infants.

TABLE 3. Percentage Sleep During Day (07:00 to 19:00) and Night (19:00 to 07:00) Periods

	Age			
	36 Weeks PCA		3 Months CA	
	Day	Night	Day	Night
Group				
NIDCAP	60 ± 23	73 ± 17	25 ± 24	66 ± 9
Control	65 ± 12	71 ± 10	18 ± 12	65 ± 11

Significant age effect (Fisher's PLSD $P < .0001$), day/night effect (Fisher's PLSD $P < .0001$), and age by day/night effect (interaction $P < .0001$).

TABLE 4. NAPI Cluster Scores

	Mean (±1 SD)		
	NIDCAP (n = 16)	Control (n = 15)	*t* Test (*P*)
Scarf sign	68.77 (18.50)	62.23 (15.66)	.31
Motor	61.19 (15.24)	69.21 (13.61)	.13
Popliteal angle	64.59 (26.44)	64.45 (20.78)	.99
Alertness	52.54 (17.18)	50.76 (16.79)	.58
Asleep	8.93 (7.18)	20.80 (24.25)	.09
Irritability	57.15 (16.97)	49.00 (23.03)	.27
Cry quality	50.00 (40.82)	48.33 (44.79)	.91

TABLE 5. APIB System Scores (Mean ± SD)

	Treatment (n = 17)	Control (n = 18)	*P**
Autonomic	6.21 ± .80	6.88 ± 1.0	.09
Motor	5.72 ± .65	6.58 ± .86	.02
State	5.75 ± 1.0	6.59 ± .96	.03
Attention	6.90 ± 1.44	7.64 ± .55	.05
Regulatory	5.95 ± .84	6.88 ± .87	.02
Examiner facilitation	7.63 ± 1.16	8.24 ± .61	.07

* Two-tailed *t* test.

response was reflected in better APIB (assessment of premature infant's behavior) scores in this study, this finding appears to be independent of a developmental effect. Als and co-workers have speculated that the improvement, in part, may be due to less brain injury (less intraventricular hemorrhage[3]), however, this finding has not been replicated in our study.[4] Other possible, though unsubstantiated, mechanisms are: a) improvement in sleep by decreasing sleep fragmentation; b) improvement in sleep by advancing nighttime sleep development; c) advanced circadian organization[21–24]; d) improvement in clinical stability by decreasing adverse stimuli and decreasing frequency and duration or severity of bradycardia, apnea and oxygen desaturations; e) minimizing physical demands on the infant to reduce the metabolic needs.

The purpose of the MMS studies was to quantitatively assess the development of sleep at 36 and 52 weeks PCA. The amount of sleep and development of sleep (ie, active, quiet sleep and sleep transitions) were similar in the NIDCAP intervention and control infants at these PCAs. Sleep measures have been demonstrated to be very sensitive indices of central nervous system functional status.[9,11,25–28] Our MMS assessment was not performed during the earlier course of the intervention; therefore, we do not have data regarding the acute effects of NIDCAP on sleep. The hypothesis that there is improved central nervous system development as measured by sleep quantity and maturation resulting from individualized developmental (NIDCAP) care was not supported by the sleep measures in this study. However, sleep organization did change appropriately with age.

Although no direct measures for biorhythm were obtained, assessment of the longest sleep period and time of day for the % total sleep time were used to indirectly determine if there was a diurnal pattern for sleep. It was expected that with maturity the longest sleep period or longest consolidated sleep would occur during the nighttime as reported by Anders et al.[12] Again a definite maturation was seen with age but none with the intervention.

In our NIDCAP study[4] many of the outcome parameter improvements, and some APIB scores (at 42 weeks PCA) replicated the earlier findings of Als.[3] Additional neurobehavioral and developmental assessments were obtained at 36 weeks and at 4, 12, and 24 months CA. At 36 weeks PCA the NAPI scores were similar in the two groups. There was a trend for the NIDCAP infants to spend less of a percentage of time asleep during the assessment and

TABLE 6. Bayley Scores, adjusted for age (Unpaired *t* Test)

	Mean ± 1 SD (N)		
	NIDCAP	Control	(*P*)
MDI 4 mo	98.1 ± 15.7 (11)	100.0 ± 14.9 (11)	0.77
MDI 12 mo	96.3 ± 18.6 (13)	89.4 ± 15.0 (10)	0.35
MDI 24 mo*	80.3 ± 21.5 (11)	70.0 ± 14.7 (12)	0.19
PDI 4 mo	104.1 ± 19.8 (11)	100.3 ± 15.5 (11)	0.62
PDI 12 mo	81.7 ± 21.7 (13)	86.5 ± 19.4 (10)	0.59
PDI 24 mo*	72.9 ± 21.0 (11)	77.5 ± 20.2 (12)	0.60

MDI, mental developmental index; PDI, psychomotor developmental index; *BSIDII.

to be more irritable. This may be explained by the fact that intervention infants were contained in nests or buntings throughout their hospital stay and might have been less accustomed to noncontainment and neurological testing. Control infants had a trend showing more motor maturity. The motor cluster, in NAPI, included items such as spontaneous vigor, power of active movement, head raising, ventral suspension, crawling, and forearm recoil. A possible explanation for these differences is that the containment of NIDCAP intervention infants may have influenced the infant's ability to experience these motor skills. However, this trend in favor of motor maturity in controls, as measured by the NAPI, was not seen in the Bayley assessments at 4, 12, and 24 months CA. Sixty-four percent of the intervention group received the lowest possible score on the Bayley II Psychomotor Developmental Index compared with 33% of the control group. These findings could not be explained by occurrence of intraventricular hemorrhage or socioeconomic status of the parents.

NIDCAP has been shown to reduce stress and agitation by Heller et al[29] who found that infants who received intervention required less pharmacolgic sedation because less agitation was observed. The incidence of apnea and bradycardia was the same in the two groups. An obvious potential benefit expected with a decrease in agitation may be a lower metabolic rate and energy requirement, improved oxygen and carbon dioxide exchange, and fewer oxygen desaturations. Measures of metabolic rate or gas exchange have not been performed. Duffy et al have speculated that brain development may improve if agitation is reduced. However, measures of agitation have not been systematically studied in previous studies.[30,31] Recently, Buehler et al[32] reported that premature infants (N = 12; mean GA 32 weeks and mean birth weight 1700 g) who received developmental care compared with a similar group of infants who received routine care showed better organized behavioral performance and better modulation on neurologic examination on a APIB assessment at 42 weeks PCA. Our APIB results are in agreement with these findings. However, the results of the NAPI, the Bayley, and the sleep measures in the present study indicate that the NIDCAP intervention does not result in increased maturity as assessed by these methods. None of the medical outcome measures were significantly different in this study. In the earlier report by Als et al,[3] both medical and neurofunctional improvements were shown in VLBW premature infants (mean GA 27 weeks and birth weight about 870 g) in which 20 infants who received NIDCAP and were compared with 18 infants who received routine care. By 9 months postterm age, or approximately 6 months CA, the NIDCAP group had better BSID. Neuroelectrophysiological visual stimulus testing was performed and showed significant group differences. Positive APIB assessment differences were found again in the NIDCAP group but were not correlated with the electrophysiological results. Later neurodevelopmental assessments in this study population have not been reported to date. As was indicated in the editorial by Merenstein[33] in the same issue of the *Journal of the American Medical Association*, the problem with the study was that the number of intraventricular hemorrhages was higher in the control group (10 of 18 vs 1 of 20) and the study was conducted before the widespread use of surfactant and prenatal steroids were used in a minority of infants (10 of 18 vs 3 of 20). Furthermore, the study was performed in a single nursery with nurses who volunteered for developmental education who then cared for the experimental group.[33] No assessment was performed involving differences in nursing, interventions, lighting, or sound between the two groups. Apnea, bradycardia, and desaturation data were not reported.

CONCLUSION

NIDCAP interventions have been demonstrated to improve clinical outcome for VLBW premature infants,[3,4] but not for larger infants. Individualized developmentally appropriate care ie, care designed for the level of tolerance of each individual infant results in improved behavioral organization with consequent medical outcomes. The results of this study, including measures of sleep, neurobehavioral maturation, and neurodevelopmental outcome at age 2, did not demonstrate that the NIDCAP intervention results in increased maturity or development. Clinicians should be aware that infants who have received NIDCAP during their hospitalization may not be more mature. Studies are needed to determine which specific interventions facilitate recovery in the high-risk preterm infant, when interventions are efficacious, and what mechanisms are involved. Distinctions should be made between behavioral organization, maturation, and development. Not only the duration of NICU hospitalization, but indeed, long-term outcomes must be evaluated. Further systematic controlled studies in different nurseries are needed to determine if there is a long-term beneficial effect of NIDCAP. In addition it will be important to determine what interventions may be adverse or have no effect on development.

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