LONGITUDINAL FOLLOW-UP OF PREMATURELY BORN CHILDREN: PREDISCHARGE OUTCOMES OF HOSPITAL STIMULATION PROGRAMME

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The purpose of this paper is (a) to present findings from current research of the effect of taped voice and music on the short-term development of the preterm infant and (b) to examine implications for clinical practice suggested by such findings.

ORIENTATION TO THE PROBLEM

In 1980, in an excellent tertiary level neonatal intensive care unit 91% of infants over 750 grams (1 pound, 10 ounces) survived (Shennan & Milligan, 1980). The capacity to save virtually all viable preterm infants may be associated with an increasing morbidity later in these survivors. Previous follow-up studies of preterm infants in the United States (Lubchenco, Delivoria-Pagadopoulos, & Searls, 1972), in Canada (Fitzhardinge & Ramsey, 1973) and in France (Dargassies, 1977) have shown that the majority of preterm infants demonstrate some type of morbidity. Commonly reported impairments are: IQs less than 90 (Drillien, 1967; Fitzhardinge & Ramsey, 1973); behavioural problems (Dargassies, 1979; Douglas, 1960; Robinson & Robinson, 1965); motor disorders (Dargassies, 1979); and difficulties in school performance (DeHirsch, Jansky, & Langford, 1966; Drillien, 1967; Fitzhardinge & Ramsey, 1973).

STATEMENT OF THE PROBLEM

A disproportionate number of children born prematurely prior to 1970 demonstrated subsequent morbidity. Regionalization of perinatal services in North America (Swyer, 1970) over the past decade has contributed to a much lower mortality rate in this population. Will the decrease in mortality add to the existing incidence of morbidity already evident in the preterm population?

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LITERATURE REVIEW

Three ideas directed the literature review: the rationale for morbidity abatement; supplemental stimulation as intervention; and means used to assess intervention.

Rationale for Morbidity Abatement

In 1963, a nurse, Eileen Hasselmeyer, proposed that one factor which might be related to the later morbidity of the preterm infant was the quality of the environmental stimulation afforded such an infant as a neonate. Giles (Note 1) in a review of the nursery policies that existed in the early 1960s noted that they were primarily concerned with asepsis and survival of the fittest. The concept of bonding was not in fashion and there was no facilitation of physical proximity immediately after birth between the premature and the parents. In fact, not only was the premature separated immediately from the parents at birth but no visitors, including parents, were permitted into the nurseries of the 1960s. In addition, Giles reported that if an infant was born at 30 or fewer gestational weeks it was "allowed" to die. Moreover, it was believed that surviving prematurely born infants should be disturbed as little as possible in an attempt to prevent infection. It now seems inconceivable that such policies ever existed.

The rationale underlying the proposition that the later morbidity of the premature was related to the inadequacy of his/her environment as a neonate was based on the following considerations:

1. The natural environment for the last trimester of human fetal growth and development is a dynamic one filled with minute-by-minute patterned stimulation in the tactile, vestibular, kinesthetic, and auditory modalities (Chapman, 1980, p. 12).

2. Experiments on animal models have shown that deprivation of such stimuli has resulted in detrimental changes in the structural complexity and chemical composition of the animal's developing brain (Schapiro & Vukovich, 1970).

3. In a busy neonatal intensive care unit the total amount of both aversive and nutritive stimuli that the non-nippling premature receives has been found to average only five minutes per hour (Barnard, 1979, p. 56).

Hence it was proposed that simulation of some aspects of the dynamic intrauterine environment be implemented in neonatal intensive care units.

Supplemental Stimulation as Intervention

In the 1960s the first four studies employing supplementary tactile and/or vestibular stimulation were instigated (Freeman, 1969; Hasselmeyer, 1963; Solkoff, Yaffe, Weintraub, & Blase, 1969; Freedman, Boverman, & Freedman, Note 2). Outcomes suggested that such interventions may promote short-term increments in weight gain, reduce crying, and have potential long-term effects on motor development. The decade of the 1970s saw eight further studies introduce supplementary tactile stimulation either alone or in combination with vestibular or kinesthetic stimulation (Korner, Kraemer, Haffner, & Cosper, 1975; Kramer, Chamorro, Green, & Knudtson, 1975; Neal, 1970, 1977; Powell, 1977; Siqueland, 1973; Solkoff & Matuszak, 1975; White & Labarba, 1976). These studies continued to indicate that weight gain was facilitated, as was the predischarge level of infant development in the tactile-stimulated subjects. Improvement in experimental subjects' respiratory and digestive functions was also noted. In 1981 Rausch administered a daily 15-minute tactile-kinesthetic regime over 10 days to 20 premature infants. She also concluded that gastrointestinal function was improved in experimental subjects.

Three supplementary auditory stimulation studies using taped parental voices or Brahms' lullaby also were introduced in the 1970s (Chapman, 1978; Katz, 1971; Segall, 1971). Again experimental subjects had better weight gain and also had higher scores on cognitive, motor, and sensory tests prior to discharge. Five studies which combined auditory and vestibular or combined visual and tactile stimulation also were completed in the 1970s (Barnard, 1973; Groom, 1973; Kramer & Pierpont, 1976; McNichol, 1973; Wright, 1971). Such multimodality stimulation appeared to aid weight gain, or increase head circumference, facilitate neurological development and help the infant cope better under stress.

Means Used to Assess Intervention

Three major yardsticks used to measure the "success" of the supplementary stimulation intervention have been anthropometric measurements, level of subjects' activity, and use of standardized developmental scales prior to discharge.

Anthropometric measurements. Gains in weight, length, and head circumference are scrutinized as well as the number of days required to regain birth weight.

Activity measurements. In the 1960s studies, simple rating scales of the activity levels of subjects were used (Hasselmeyer, 1963; Solkoff et al., 1969). In 1978 Chapman had a watchmaker design a valid and reliable instrument called an accelerometer to measure quantitatively the limb movement of premature infants. This instrument looks like a miniature watch and can be worn comfortably on the wrist or ankle of a premature infant prior to discharge. For smaller infants a sensor which detects movement can be placed within the incubator's mattress (Campbell, Kuyek, Lang, & Partington, 1971). Maturation is thought to be reflected by a decrease in purposeless movements. During active sleep there are accompanying limb movements 80% of the time (Parmelee, K. Bruck, M. Bruck, Wenner, Akiyama, Stern, & Flescher, 1967). Active sleep decreases markedly between the 28th and 37th week of gestation (Parmelee et al., 1967); hence one would anticipate movement during sleep would decrease. Since the neonate prior to the 37th week spends 75%-80% of 24-hour period in sleep (Hasselmeyer, 1961) it seems feasible to measure the maturational progress in terms of activity level during these time periods.

Standardized developmental scales. Two scales, the Graham-Rosenblith (Rosenblith, 1961) and the Neonatal Behavioral Assessment Scale (NBAS) (Brazelton, 1973) have been used to assess the predischarge behavioural repertoire of the premature infant. The Graham-Rosenblith assesses motor strength, adaptation to tactile stimuli, vision, hearing, motor tone and general maturation. It has been used to assess outcomes in four of the supplementary stimulation studies (Katz, 1971; McNichol, 1973; Neal, 1970, 1977). The NBAS is a more sophisticated test but was found to be disorganizing for the infant under 34 gestational weeks and Kang and Barnard (1979) caution that its validity for testing the preterm infant is yet to be established.

Summary

The literature reveals that there has been a vast change in accepted policies governing nursery practices in the past 20 years, that provision of supplementary stimulation has been found to be efficacious and that tools have been devised to assess the outcomes of nursing interventions.

THE PURPOSE

The purpose of the study presented here was to assess the effect of one type of supplementary stimulation, taped voice and music, on subsequent developmental attainment as demonstrated by (a) anthropometric measurements including days to regain birth weight, (b) activity level as a maturational index during hospitalization and at discharge as measured by mattress sensors and on accelerometers, and (c) developmental scores on the Graham-Rosenblith test.

RESEARCH HYPOTHESIS

The research hypothesis formulated a priori was that subjects exposed to a supplementary regimen of taped voice and music during hospitalization would score significantly better on all outcome measures than those not exposed to supplementary stimulation.

METHODOLOGY

Design

A posttest-only control group design was used (Campbell & Stanley, 1963). The design incorporated two hospital interventions and one control group. The hospital intervention consisted of intermittent, patterned auditory stimulation — either a lullaby during the first half of hospitalization, later replaced by parental voice(s), for 5-10 minutes at the mid-point of each feeding interval (hospital sequential group) or the lullaby alternated with speech at midpoint intervals throughout hospitalization (hospital alternate group). Selection of this specific independent variable was based on the following considerations:

1. Sound had been found to be more effective than the visual or tactile modalities in reduction of neonatal activity (Wolff, 1966, p. 40).

2. Molfese (1977) demonstrated that speech sounds evoke stimulation of the left hemisphere whereas musical notes produce stimulation in the right hemisphere. Hence an auditory regime which contained both speech and music would have the potential for stimulation of both hemispheres of the developing neonate's brain.

Sample

The sample comprised 259 infants born between November 4, 1975 and September 26, 1979. Fourteen subjects, seven with cerebral palsy and seven subsequently found to have severe developmental problems are not, as Tilford (1976) recommends, included in this analysis but will be analyzed separately. The 245 remaining subjects were assigned at random to one of the three groups. The control group had 82 subjects, the sequential group 83, and the alternate group 80 sujects. There were 121 females and 124 males comparably divided among the three groups (see Table 1).

Table 1

Randomized Assignment of Subjects to Three Treatment Groups

	Treatment Group		
Sex	Control	Sequential	Alternate
Male	42	42	40
Female	40	41	40
Total	82	83	80

In the total remaining sample the average gestional age at birth was 226 days (32 weeks, 2 days); the average birth weight was 1553 grams (3 pounds, 7 ounces). Twenty-two percent of the subjects came from a multiple birth. Of the 241 with complete labour records 54% (130) of the mothers had sedatives and/or analgesics administered during labour; 37% (91) of the subjects were delivered by caesarian section — 31% were delivered by emergency caesarian section. Approximately two-thirds of the subjects were born to parents who were both Caucasian (fathers 163; mother 170); approximately 13% were Black (fathers 30; mothers 35), 7% were East Indian (18 parental sets), 4% were Chinese, 4% were Philippino, and 2% were "other". At the time of birth 89% of the families were two-parent families (213 were married; 23 were living common-law); 11% (25) were born to a single parent. In 47% of the cases the subject was the first live born child for the family, 32% of the families had one other child, 15% had two other children and 6% had three or more other children.

Settings

The sample was drawn from the premature nurseries of three university teaching hospitals. The design incorporated stratification of treatment group by hospital. Table 2 demonstrates that in each hospital there was comparable representation among the three treatment groups.

Table 2

Stratified Random Assignment
of Subjects to Three Hospitals

	Hospital assignment			
Hospital Code	Control	Sequential	Alternate	Total
1	13	15	18	46
2	20	21	19	60
3	49	48	42	139

Procedure

During the first four days of the subject's life the investigator or her delegate visited the infant's parent(s) to explain the study and to secure written consent for the child's inclusion. Parents were provided with poems, rhymes, or short stories in their native tongue that they might use, or were free to tape what they wished. A master tape was made for each subject and, after pretest screening for hearing, the auditory regime was instigated on the 5th day of life.

The anthropometric measurements of weight, length, and head circumference at birth were recorded and the number of days required to regain birth weight was noted. Mattress sensors were used to obtain a 4th-day, 3rd-week, and predischarge activity measurement over and eight-hour period. Accelerometers were placed on the ankle and wrist of subjects over a 24-hour period for an Adaptation Day, a Test Day One; and a Test Day Two, in the three-day period prior to discharge. For 50 percent of the sample two blind testers each independently performed the Graham-Rosenblith test just prior to discharge; for the other 50 percent a single tester assessed the subject. Anthropometric measurements were again recorded at discharge.

Statistical Plan for Data Analysis

Since the computer program used (SAS) deletes all variables for the case if even one observation is missing, multivariate and univariate analysis was used in the examination of outcome variables. Chi-square was used to examine the distribution of descriptive variables among treatment or hospital groups. The alpha level for the study, determined a priori, was $p = .05$.

RESULTS

Anthropometric Measurements

Weight. There was no statistically significant difference in the three treatment groups' weight at birth, or predischarge. In addition, the initial weight loss and the number of days to regain birth weight did not differ among groups (see Table 3).

Length. There was no statistically significant difference in the three groups' length at birth or predischarge. In addition, the gain in length did not differ among groups (see Table 3).

Head circumference. There was no statistically significant difference in the three groups' head circumference at birth or predischarge. In addition, the growth in head circumference did not differ among the groups (see Table 3).

Activity Measurements

Mattress sensor measurements. There was no statistically significant difference in the total activity of the three treatment groups on the 4th day of life, during the 3rd week of life, or predischarge (see Table 4).

Limb activity recorded on accelerometers. Upper, lower, and total limb activity did not differ significantly among the groups on the Adaptation Day or on either Test Day One or Test Day Two (see Table 5).

Predischarge Developmental Test Measurement

Prior to examination of the groups' scores on the Graham-Rosenblith test it was ascertained that the gestational age of the subjects did not differ at the time of test. Hence the biological age at maturation did not affect these scores (see Table 6).

No statistically significant differences were found on any of the component parts of the Graham-Rosenblith Test (see Table 7).

DISCUSSION OF FINDINGS

Findings will be discussed in regard of anthropometric, activity and developmental measurements. Implications for practice in the care of prematurely born infants similar to those described in this sample are presented.

Table 3

Anthropometric Measurements for Three Treatment Groups

Anthropometric measurement	Treatment group						Sample		F	P
	Control		Sequential		Alternate					
	$\bar{x}$	s.d.	$\bar{x}$	s.d.	$\bar{x}$	s.d.	$\bar{x}$	s.d.		
Weight (grams)										
Birth	1569	303	1522	311	1568	305	1553	306	<1	n.s.
Predischarge	2181	186	2185	193	2187	196	2182	194	<1	n.s.
Initial loss	116	76	132	69	127	70	125	73	1.03	n.s
Time to regain birth weight (days)	11.95	6.01	13.90	6.39	13.25	6.10	13.1	6.17	2.06	n.s.
Length (centimeters)										
Birth	41.80	3.01	41.30	2.91	41.45	2.52	41.52	2.98	<1	n.s.
Predischarge	45.75	2.37	45.45	2.40	45.45	2.11	45.57	2.37	<1	n.s.
Increment	4.25	2.64	4.50	4.78	3.95	2.39	4.25	2.51	<1	n.s.
Head Circumference (centimeters)										
Birth	28.89	1.86	28.68	1.67	29.32	1.89	28.96	1.81	2.50	n.s.
Predischarge	33.02	1.49	33.25	1.76	33.15	1.17	33.13	1.55	<1	n.s.
Increment	4.21	2.04	4.46	2.02	3.82	2.05	4.15	2.04	1.89	n.s.

Table 4

Time of Mattress Sensor Measurement of Activity of Three Treatment Groups

Time of mattress sensor measurement	Treatment Group: Control		Treatment Group: Sequential		Treatment Group: Alternate		Sample		F	P
	$\bar{x}$	s.d.	$\bar{x}$	s.d.	$\bar{x}$	s.d.	$\bar{x}$	s.d.		
Fourth day	207	151	221	206	178	126	203	169	1.21	n.s.
Third week	168	138	202	165	209	190	194	167	1.39	n.s.
Predischarge	200	158	209	170	241	227	217	188	1.06	n.s

Table 5

Upper, Lower and Total Limb Accelerometer Scores for the Three Treatment Groups on the Adaptation Day, Test Day One and Test Day Two

	Treatment group						Sample		F	P
	Control		Sequential		Alternate					
Accelerometer score	$\bar{x}$	s.d.	$\bar{x}$	s.d.	$\bar{x}$	s.d.	$\bar{x}$	s.d.		
Adaptation day										
Upper limb	83	48	96	78	84	58	88	64	<1	n.s.
Lower limb	94	58	102	71	115	71	104	64	1.87	n.s.
Total activity	171	78	191	116	200	117	187	109	1.43	n.s.
Test Day One										
Upper limb	98	88	89	48	104	71	97	72	<1	n.s.
Lower limb	112	81	99	52	121	84	110	76	<1	n.s.
Total activity	210	149	186	74	223	137	206	127	<1	n.s.
Test Day Two										
Upper limb	100	93	86	43	88	42	91	71	<1	n.s.
Lower limb	110	60	105	69	103	58	106	64	<1	n.s.
Total activity	203	107	189	117	192	87	197	113	<1	n.s.

Table 6

Maturation of Subjects in Three Treatment Groups at Time of Graham-Rosenblith Test

	Treatment group						Sample		F	P
	Control		Sequential		Alternate					
Maturation of subjects	$\bar{x}$	s.d.	$\bar{x}$	s.d.	$\bar{x}$	s.d.	$\bar{x}$	s.d.		
Gestational age	261	15.56	263	13.09	263	15.09	263	15	<1	n.s.

Table 7

Predischarge Scores on the Graham-Rosenblith Test for the Three Treatment Groups

	Treatment Group						Sample		F	P
	Control		Sequential		Alternate					
Score	$\bar{x}$	s.d.	$\bar{x}$	s.d.	$\bar{x}$	s.d.	$\bar{x}$	s.d.		
Motor	4.60	1.70	4.70	1.76	4.45	1.57	4.60	1.68	<1	n.s.
Tactile-adaptive	7.55	1.73	7.25	1.82	7.40	1.66	7.40	1.76	<1	n.s.
General Maturation	12.20	3.01	11.95	3.24	12.50	3.15	12.38	6.17	<1	n.s.
Hearing	4.25	0.95	4.45	0.86	4.30	0.91	4.39	0.85	<1	n.s.
Vision	7.60	2.32	7.95	2.85	6.85	2.82	7.49	4.93	1.00	n.s.
Motor tone	5.10	0.37	5.15	0.53	5.10	0.66	5.12	0.57	<1	n.s.

Anthropometric Measurements

The change in weight, length and head circumference of the sample was monitored, on average, for a five-week period. Using the Canadian Usher and McLean (1969) curves for each of these three variables, the sample's head circumference growth curve between the 32nd and 37th week of gestation followed just below the 50th percentile. Length and weight curves, however, dropped precipitously to two deviations from the mean (at and below, respectively). Supplementary auditory stimulation did not alter this pattern in this sample. It took these subjects an average of 13 days — almost two weeks — to regain their birth weight.

Implications for practice. For the parents of the 1500-gram, 32-week gestational infant, nurses can allay their anxiety by telling them (a) that their infant is not expected to regain birth weight for about two weeks, and (b) that during the five weeks or so of hospitalization the most growth can be anticipated to occur in head size, which is important as that is believed to reflect brain growth.

Activity Measurements

Activity level as measured by mattress sensors or accelerometers was not different among the three groups. The 4th-day mattress sensor measurements probably were affected by the analgesics, sedatives, and anaesthetics that approximately 50% of the subjects' mothers received. Hence the 4th-day measurement probably represents an underestimate of activity level. Even so, the average activity score at 35 gestional weeks — the 3-week postbirth measurement — was slightly lower than the initial one. Hence, the expected pattern of fewer purposeless movements probably occurred. Prior to discharge, the activity rose and possibly reflects at 37-1/2 gestational weeks, longer alert states than sleep states.

When the "strange" accelerometers were first placed on the subjects' ankles and wrists prior to discharge, as had been found previously in prematurely born as opposed to full-term children, the subjects tended to move their limb less (Chapman, 1978) as if unable to adapt to the stress. The only group who did not evidence this pattern was the sequential group — those who had just approximately two weeks of taped parental voices. Did the human component of the auditory pattern help them adapt better?

Implications for practice. Parents can be told that the activity of their infant may be reduced through the effects of maternal medications during the first week of life. The tremors they observe in their sleeping infant should diminish by the 3rd week of life and are an indicator of their infant's maturation. Prior to discharge their infant will have longer alert periods accompanied by activity.

Developmental Measurements

Prior to discharge all subjects were assessed for general maturation and sensory functioning on the Graham-Rosenblith scale. This sample's scores on motor and tactile-adaptive items and hence total maturation score are higher than Rosenblith's (Note 3) own 1975 data on preterm infants of comparable gestational age. The mean motor score was 4.60 out of a possible total of 9.00. Similar scores were reported in two of the previous four supplementary studies (McNichol, 1973; Neal, 1977) of preterm infants in which no statistical differences among experimental and control groups were reported. Katz (1971) and Neal (1967), using auditory and vestibular supplementary stimulation respectively, had found significant differences between experimental and control groups. Their experimental subjects scored higher than the current sample. Since a decade ago infants were discharged at heavier weights, their experimental subjects had a longer exposure to the experimental treatment, which may account for the difference.

The mean tactile-adaptive score of 7.40 out of a possible 9 for this sample was comparable to Katz's (1970, p. 49) and Neal's (1967, p. 37) experimental groups' mean scores and higher than the other two reported studies' sample means (McNichol, 1973; Neal, 1977).

The highest hearing score mean (4.39 out of a possible 5) in the current sample was comparable again to Katz's (1970, p. 40) and Neal's (1967, p. 53) experimental groups and higher than the other two studies' means for the auditory scale (McNichol, 1973; Neal, 1977).

The vision mean score of 7.49 out of a possible 10 was higher than Katz's (1970, p. 40) subjects and similar to McNichol's (1973) tactile stimulation experimental group. Neal's results on vision (1967, 1977) were scored differently and cannot be compared.

The final score on the Rosenblith assesses muscle tension from flaccid (0) to marked tension (9), the normal being rated 5. The current sample's mean score of 5.12 falls, as did McNichol's (1973) sample and Katz's (1970, p. 43) experimental group, into the normal range. Katz's control group had lower scores.

Hence development as assessed on the Rosenblith, with the exception of motor strength, in this total sample including the control group was as good as or better than that reported in the experimental groups of the previous studies.

Implications for nursing. The weakest area of development predischarge as assessed by the Rosenblith in all these studies is the motor domain of the preterm infant. Encouragement of parent participation in all aspects of care to learn competent handling and support of their infant prior to discharge is warranted. Ground rules to prevent interested siblings from causing detrimental effects to their new arrival's immature motor system need to be established after discharge. A weak sucking capability may need monitoring by the public health nurse to ensure adequate caloric intake.

SUMMARY

In this study there was no discernable effect of taped voice and music on any of the outcome measures. It is possible that the total sample of premature infants in these university teaching hospitals received adequate amounts of nutritive stimulation and thus the additional supplementary auditory stimulation was superfluous. The current study is the most recent one and it is entirely possible that the findings of the earlier studies have influenced nursing practice. If, indeed, staff nurses themselves and the parents they teach daily plan to provide the premature infant with visual, tactile, kinesthetic, auditory, and vestibular stimulation, the fruition of 20 years of research may have been realized. The long-term effects of such changing nursing practices on subsequent morbidity are yet to be determined but preliminary findings are encouraging (Chapman, 1980).

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RÉSUMÉ

Suivi longitudinal d'enfants prématurés: résultats du programme de stimulation à la sortie de l'hôpital

Certains auteurs ont suggéré que la morbidité tardive observée chez l'enfant prématuré est liée à un environnement inadéquat à la période néonatale. Des recherches antérieures ont permis de constater qu'une stimulation additionnelle était efficace. L'objectif de la présente étude était d'évaluer les effets d'un type de stimulation additionnelle, en l'occurrence l'enregistrement de musique et de la voix des parents, en regard des caractéristiques anthropométriques, de l'activité et du développement de l'enfant. Pour le groupe témoin on a utilisé un devis-après-seulement. En tout, 245 sujets gardés en incubateur ou au berceau, ont été soumis à cette stimulation additionnelle. Aucune différence n'a été observée entre les sujets du groupe expérimental et les sujets du groupe témoin, à la sortie, dans chacune des trois caractéristiques mesurées. Les conséquences de cette recherche au niveau des soins infirmiers font l'objet d'une discussion.