The Effect of Music-Reinforced Nonnutritive Sucking On Feeding Rate of Premature Infants

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Premature infants are fed by gavage tube before 34 weeks adjusted gestational age and when nipple feeding results in detrimental changes in respiration and heart rate. Nipple feeding skill must be developed and correlates with length of hospitalization and neurobehavioral development. This study provided music reinforcement for nonnutritive sucking and assessed nipple feeding rates pre- and posttreatment for 32 infants referred as poor feeders. A pacifier fitted with a pressure transducer activated 10 seconds of recorded music in a one-trial, 15-minute intervention given to experimental infants (n = 16) 30 to 60 minutes before the late afternoon bottle feeding. Feeding rates were collected for bottle feedings pre- and postintervention and for a similar interval for a no-contact control group (n = 16). Results showed that the intervention significantly increased feeding rates. Music functioned as reinforcement and the sucking behavior transferred from a nonnutritive to a nutritive event.

THE INFANT'S SUCKING ability is a critical behavior for both survival and neurologic development. Nonnutritive sucking (NNS) is the first rhythmic behavior in which the infant engages and is theorized to contribute to neurologic development by facilitating internally regulated rhythms (Goff, 1985). NNS is a reflex requiring physiologic maturation but capable of being altered by learning experiences (Anderson & Vidyasagar, 1979; Bernbaum, Pereira, Watkins, & Peckham, 1983). Therefore, the pacifier appears to be very important to the premature infant's well-being and care in the Newborn Intensive Care Unit (NICU).

The well, term infant is born capable of feeding with a coordinated, suck-swallow-breathe response that occurs without detrimental changes in heart rate or respiratory capabilities. Further, the term infant's behavioral states are organized and easily read by caregivers. In the presence of food, crying caused by hunger quickly moves to a state of alertness with the infant focused for feeding. This occurs smoothly without detrimental physiologic changes (McCain, 1992). In contrast, the premature infant is neurologically immature and has impaired behavioral state organization. Cues are not easily read and transitions in state are not smooth. When the infant is immature or poorly organized for feeding, heart rate increases, respiratory interruption creates apneic episodes, and sucking responses may be weak or uncoordinated. Nutritive sucking in premature infants frequently reduces oxygen saturation, expends energy, and causes weight loss (Hill, 1992).

Before 34 weeks adjusted gestational age, gavage feeding (oral-gastric or nasogastric tube) is necessary, but stressful, for the premature infant. In the NICU, NNS opportunities have been paired with gavage feeding and have been shown to promote infant development in a variety of ways. NNS lowers heart rate (McCain, 1995; Woodson & Hamilton, 1988) and increases oxygenation (Burroughs, Asonye, Anderson-Shanklin, & Vidyasagar, 1978). It also increases weight gain of the infant even when nutritional intake is controlled (Field et al., 1982; Kanarek & Shulman, 1992). In theory, NNS facilitates lower activity levels, resulting in energy conservation and subsequent weight gain. This theory is supported by the finding that NNS with gavage feeding results in increased duration of inactive alert state and faster return to, and increased length of, quiet sleep (DiPietro, Cusson, Caughy, & Fox, 1994; Gill, Behnke, Conlon, McNeely, & Anderson, 1988; Goff, 1985; McCain, 1992, 1995). Other benefits

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of NNS during gavage feeding include decreased length of hospital stay and a decrease in the necessity for tube feedings (Bernbaum et al., 1983; Field et al.). A meta-analysis of research assessing the clinical outcomes of offering NNS during gavage feeding found that length of hospitalization decreased by an average of 6.3 days and premature infants began bottle feeding an average of 2.9 days sooner than those without NNS treatment (Schwartz, Moody, Yarndi, & Anderson, 1987).

The development of sucking ability for feeding is indicative of cognitive growth (Medoff-Cooper & Gennaro, 1996). It does not correlate with gestational age or birth weight, but with neurologic maturity (McCain, 1992). Specifically, higher sucking pressure, number of sucking bursts, and duration of pauses between bursts at 34 weeks gestational age correlate with psychomotor scores at 6 months of age. Palmer's (1993) assessment of premature infants consistently found an immature pattern of sucking consisting of three to five sucks in a burst followed by a pause to breathe. Mature, term infants sucked 10 to 30 times in a prolonged burst and alternated breathing with sucking. Mature nutritive sucking coordination would seem to be a highly important goal for premature infants for a variety of health, growth, and developmental reasons.

The coordinated suck-swallow-breathe response develops around the 34th week of gestation and is a precursor to nutritive sucking ability and nipple feeding. Medical procedures such as intubation can delay the development of a coordinated sucking pattern in premature infants. Transition from gavage to nipple feeding is often difficult for the premature infant and sometimes long-term problems develop such as nipple aversion or aversion to oral feeding (Palmer, 1993).

Oral feeding skill can be assisted through NNS. Pacifiers given 10 minutes before nipple feeding increase the inactive awake state of the infant and decrease the total length of time for ingestion of nutrition (McCain, 1995). Because of adverse physiologic reactions to prolonged feeding, the standard of care for premature infants usually limits a nipple feeding opportunity to 30 minutes (Gardner, Garland, Merenstein, & Lubchenco, 1997). After that time, the remaining nutrition is given by gavage tube. Strengthening the infant's suck and increasing the rate of nutritional intake are important goals for reducing the length of a nipple feeding episode.

Auditory capability is an early, discriminative ability of the fetus. At 30 to 35 weeks the fetus or premature infant is hearing maternal sounds, responding to these sounds, and beginning to discriminate among speech sounds, particularly with regard to pitch and rhythm (Lecanuet, Granier-Deferre, & Busnel, 1995). The premature infant ready for transition to nipple feeding has the ability to hear, discriminate, and appreciate auditory input. A meta-analysis of studies using music in the NICU showed significant clinical benefits across a variety of physiologic and behavioral measures (Standley, 2002). Lullabies combine language information and calming, rhythmic stimuli and are the music of choice for pacification of premature infants (Standley, 1998).

The Pacifier Activated Lullaby (PAL) mechanism, which uses lullabies as contingent reinforcement for sucking, has been shown to be an effective method for increasing the rate and endurance of NNS in premature infants (Standley, 2000). The purpose of this study was to determine whether the use of the PAL to reinforce NNS of premature infants evaluated as poor feeders by NICU personnel would also result in improved feeding skills. Approval was given by the hospital and Human Subjects Committee. Consent was obtained from appropriate parties.

METHODS

Participants

Participants were 32 premature infants (16 boys and 16 girls) who were divided randomly between experimental and control groups. Each infant had failed to make the transition to bottle feeding and was being given primarily gavage feedings with minimal opportunities each day for nipple feeding. All infants were referred for participation in the study by the NICU physical therapist, a specialist trained in premature infant development, with concurrence from the NICU nursing staff. Criteria for participation in the study were: infant showed ineffective nutritive sucking, had achieved approximately 34 weeks postconception age, and was able to tolerate two simultaneous types of stimulation (pacifier and auditory stimulation). Ability to tolerate stimulation was based on staff observation and informal assessment of infant's response to environmental stimuli.

The experimental and control groups each consisted of 16 infants, 8 boys and 8 girls. Multivariate analysis of variance showed no significant difference between the groups with regard to gestational age at birth, birth weight, adjusted gestational age at time of study, weight at time of study, or age at time of study. Table 1 shows group means and ranges for these subject demographics.

Table 1. Mean and Ranges of Group Demographics

Group	Gestational Age at Birth	Birthweight	Adjusted Gestational Age at Study	Weight at Study	Age at Study
Experimental					
Mean	31.8 wk	1,515.4 g	36.1 wk	1,883.3 g	30.8 d
Range	24-40 wk	640-2,640 g	34.1-41 wk	1,545-3,135 g	6-94 d
Control					
Mean	31.6 wk	1,606.9 g	36.1 wk	1,857.6 g	30.8 d
Range	25-36 wk	620-2,420 g	33-40 wk	1,375-2,235 g	4-87 d

NOTE. N = 32. For experimental group, n = 16; for control group, n = 16.

Equipment

A Minimam Newborn Orthodontic Pacifier was adapted so that a suck of predetermined strength activated a cassette tape recorder (Radio Shack CTR-62, Tandy Corporation, Fort Worth, TX) for a specified length of time via a pressure transducer (Standley, 2000). Pressure sensitivity and length of music activation could be varied. For the purpose of this study, the pressure criterion was the minimal level at which each infant could activate the tape recorder and music reinforcement duration was 10 seconds after each suck. Figure 1 shows a diagram of this equipment.

Design and Data Collection

The study used infants referred as poor feeders who were assigned randomly to the experimental or control condition. The experimental group received one 15- to 20-minute trial with the PAL between 4 and 5 PM approximately 30 to 60 minutes before the late afternoon opportunity for nipple feeding. This interval between PAL use and feeding time was approximate because nursing personnel were blind to the purpose of the study and no alterations owing to study conditions were made in any infant's feeding schedule.

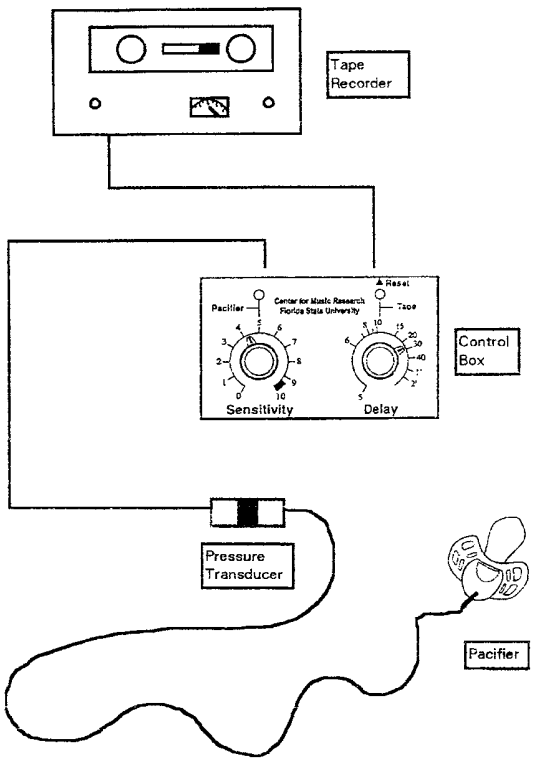

Figure 1. Equipment diagram.

The control group received no PAL training. Data were recorded by the researcher from the nurses' notes, who were blind to the purpose of the study, to infants' status in the study, and to the fact that feeding rate was a dependent variable. Data included the nutritional amount ingested and length of feeding time for the nipple feeding opportunity in the morning (pre-PAL presentation) and again in the evening (post-PAL presentation) for each infant on the selected day. For experimental infants, data were collected for these two feedings on the date of PAL presentation that occurred within 1 week after referral. Data for control infants for the morning and afternoon nipple feeding opportunities were collected on a selected day within 1 week of referral to the PAL intervention. Nipple feeding rates for each of the morning and afternoon feedings were obtained by dividing volume ingested by minutes of feeding.

Procedures

The music was a selection of commercially recorded lullabies sung by female vocalists played free field and originating directly from the tape recorder. The sound volume was approximately 65 dB(C)/58 dB(A), measured at the tape recorder, which was placed at the feet or to the lower side of the infant. This sound level was slightly louder than the unit background noise found in prior research to average 62 dB(C)/55 dB(A), measured free field during daytime quiet times (Standley, 1999).

Table 2. Feeding Rate Means and Ranges In CC/Minute

Group	AM Feeding Rate	PM Feeding Rate*
Experimental	2.21	2.97**
(n = 16)	.00-6.60	1.60-6.00
Control	2.34	1.86
(n = 16)	.84-5.00	.00-4.00

*Significant difference between groups, $\alpha < .05$.
**Significant difference pre/post for experimental group, $\alpha < .05$.

RESULTS

A t-test comparison was made between groups for morning feeding rates before PAL intervention. There was no significant difference between groups ($t = -.259$, $df = 30$, $\alpha > .05$). The t-test comparison between groups for the late afternoon feeding rate (post-PAL intervention) was significantly different ($t = 2.532$, $df = 30$, $\alpha < .05$). Table 2 shows groups means and ranges for these two intervals and shows that the experimental infants increased feeding rates in the same afternoon after PAL presentation, a significant increase from the morning rate ($t = 2.875$, $df = 15$, $\alpha < .05$). The control group, however, slightly decreased sucking rates in the afternoon ($t = -2.116$, $df = 15$, $\alpha > .05$). This was a nonsignificant decrease.

DISCUSSION

Results of this study show that reinforcement of NNS with lullaby music improved a subsequent nipple feeding rate of premature infants deemed poor feeders. One therapeutic approach to poor feeding skill in a premature infant of 36 or more weeks adjusted gestational age is referral to a physical therapist who often uses a variety of physical manipulations to assist the infant in feeding. Palmer (1993) says this is contraindicated and the preferred methodology for assistance would be teaching the infant to pace his/her sucking pattern. The PAL's adjustable rate of music reinforcement provides just such pacing feedback, which may partially explain its influence on premature infant feeding rates.

It is interesting to note that in the experimental opportunity, the infants appear to have practiced NNS that transferred to a feeding situation later in the day. In this NICU, the nurses often observe that some infants having difficulty making the transition to nipple feeding from gavage feeding over an extended period suddenly, one day, seem to get it, as though a light bulb had come on. These infants then seem to have the skill for all future feedings. The PAL seemed to help all of the experimental infants learn or get it in one trial. Music-reinforced NNS would seem to be an effective intervention for assisting achievement of a very important developmental milestone. This procedure is a viable treatment option for NICU infants deemed poor feeders during gavage to nipple feeding transitions.

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