Posttest can be found on page 146.

The Effect of Music Reinforcement for Non-Nutritive Sucking on Nipple Feeding Of Premature Infants

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In this randomized, controlled multi-site study, the pacifier-activated-lullaby system (PAL) was used with 68 premature infants. Dependent variables were a) total number of days prior to nipple feeding, b) days of nipple feeding, c) discharge weight, and d) overall weight gain. Independent variables included contingent music reinforcement for non-nutritive sucking for PAL intervention at 32 vs. 34 vs 36 weeks adjusted gestational age (AGA), with each age group subdivided into three trial conditions: control consisting of no PAL used vs. one 15-minute PAL trial vs. three 15-minute PAL trials. At 34 weeks, PAL trials significantly shortened gavage feeding length, and three trials were significantly better than one trial. At 32 weeks, PAL trials lengthened gavage feeding. Female infants learned to nipple feed significantly faster than male infants. It was noted that PAL babies went home sooner after beginning to nipple feed, a trend that was not statistically significant.

The premature infant's sucking ability is a critical behavior for both survival and neurological development, and must be sophisticated enough to sustain independent nipple feeding. Oral feeding is a complex task for the premature infant affected by many variables, especially the immaturity of the neurological system and its readiness to coordinate the suck-swallow-breathe response. Research suggests that promoting non-nutritive sucking (NNS) will facilitate nipple feeding, but more detailed investigation is needed for development of effective care protocols (McGrath & Braescu, 2004). Feeding opportunities offered too early may lead to negative physiologic outcomes, such as apnea and bradycardia. Delaying the initiation of feeding opportunities may unnecessarily prolong hospitalization. This study was designed to test specific parameters of a music reinforcement protocol to promote NNS and subsequent effects on duration of gavage feeding.

Development of Non-Nutritive Sucking

NNS is the first rhythmic behavior in which the infant engages and is theorized to contribute to neurological development by facilitating internally regulated rhythms (Goff, 1985). In fact, the appearance of sucking behavior coincides with the first appearance of fetal brain waves. NNS is a reflex requiring physiologic maturation but is capable of being altered by learning experiences (Anderson & Vidyasagar, 1979; Bernbaum, Pereira, Watkins, & Peckham, 1983). NNS significantly reduces distress and physiological responses of premature infants subjected to painful procedures (Boyle et al., 2006; Cignacco et al., 2007; Mathai, Natrajan, & Rajalakshmi, 2006; South, Strauss, South, Boggess,

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& Thorp, 2005). Therefore, the pacifier as a stimulant for NNS appears to be very important to the premature infant's well-being and care in the neonatal intensive care unit (NICU).

In the NICU, NNS opportunities (pacifiers) have been paired with gavage feedings and 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).

It is theorized that NNS calms infants and 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 of NNS during gavage feeding include decreased length of hospital stay and decrease in necessity for tube feedings (Bernbaum et al., 1983; Field et al., 1982). A meta-analysis on research assessing clinical outcomes of offering NNS during gavage feeding found it decreased length of hospitalization by an average of 6.3 days and allowed premature infants to begin bottle feeding an average of 2.9 days sooner (Schwartz, Moody, Yarndi, & Anderson, 1987). A more recent meta-analysis using NNS with gavage feeding also found a significant decrease in length of stay (Pinelli & Symington, 2005).

Feeding Problems of the Premature Infant

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 due to hunger quickly moves to a state of alertness with the infant focused for feeding. This occurs smoothly without detrimental physiological changes (McCain, 1992).

Unlike the term infant, 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 neurologically immature or shows poor behavioral state organization at feeding opportunities, heart rate increases, and respiratory interruptions create apneic episodes. Sucking responses may be weak or uncoordinated. Energy consumption and effort during nutritive sucking in premature infants can reduce oxygen saturation and can expend calories resulting in weight loss (Hill, 1992). Prior to 34 weeks adjusted gestational age (AGA), gavage feeding (oral-gastric [OG] or naso-gastric [NG] tube) is necessary but stressful for the premature infant.

Development of Feeding Ability

The development of sucking ability for feeding is correlated with neurological maturity, but not gestational age or birth weight (McCain, 1992; Medoff-Cooper & Gennaro, 1996). Specifically, higher sucking pressure, number of sucking bursts, and duration of pauses between bursts at 34 weeks gestational age correlate with higher psychomotor scores at 6 months of age. Palmer's (1993) assessment of premature infants consistently found an immature pattern of sucking, consisting of 3 to 5 sucks in a burst followed by a pause to breathe. More 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 becomes possible when myelination of the medulla has occurred (McGrath & Braescu, 2004). It 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. The 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. A Cochrane review of 19 studies on benefits of pacifiers with premature infants found that NNS significantly decreased number of hospital days. These studies ranged from 10 to 59 participants (Pinelli & Symington, 2000). Pacifiers given 10 minutes prior to nipple feeding increased the inactive awake state of the infant and decreased the total length of time for ingestion of nutrition (McCain, 1995). Due to adverse physiological 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 suck and increasing the rate of nutritional intake is frequently a step to reducing the length of a nipple feeding episode. Most infants who can demonstrate adequate oral intake of nutrition within the 30-minute interval are discharged within 24 hours (McGrath & Braescu, 2004).

Effects of Music Therapy In the NICU

Research has shown that a variety of stimulation techniques administered to pre-term infants can offset some adverse neurological effects of premature birth and the adverse consequences of prolonged hospitalization (Britt & Myers, 1994; Gomes-Pedro et al., 1995; Harrison, 1985; Oehler, 1993; Rauh et al., 1987). Music, particularly, has been effective with premature infants in increasing weight gain, reducing observed stress behaviors, reducing length of hospitalization by up to 11 days for female (not male) infants, and increasing oxygen saturation levels for short periods of time (Caine, 1992; Cassidy & Standley, 1995; Chapman, 1979; Standley, 1998; Standley & Moore, 1995; Whipple, 2008). Survey results show that 72% of U.S. NICUs play music for premature infants (Field, Hernandez-Reif, Feijo, & Freedman, 2006).

Auditory capability is an early, discriminative ability of the fetus (Cheour-Luhtanen et al., 1996). It has been documented that as early as 18 weeks gestational age, loud sounds cause the fetal heart rate to increase, and at 25 weeks, the major structures of the ear are essentially in place. At 25 to 27 gestation weeks, most fetuses begin to respond inconsistently to sound by moving or kicking (Cheour-Luhtanen et al., 1996). At 30 to 35 weeks, the infant hears maternal sounds, responds to these sounds, and begins 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 benefit from auditory input.

At term birth, females are more developed with regard to hearing (Cassidy & Ditty, 2001), have better tactile and oral sensitivity, and are more responsive to smiling, sweet tastes, talking, eye-to-eye contact, and the pacifier. Cerebral blood flow in girls is significantly lower than in males. Male infants demonstrate more startles, more muscle activity, and more physical strength. With regard to auditory capability at birth, male infants actually have shorter cochlea, fewer hair cells, and less response to aural stimuli. Female infants hear high frequencies better than males, which is particularly advantageous when listening to music with its wide range of frequencies (Cassidy & Ditty, 2001).

A meta-analysis of studies using music in the NICU demonstrated significant clinical benefits across a variety of physiological and behavioral measures (Standley, 2002). Linguistics research showed that lullabies of all cultures combine language information and use calming, rhythmic stimuli. Because it is desirable to reduce stress and calm premature infants in the NICU and because infants leaving the womb too early are missing language input from their mothers' voices, lullabies are the music of choice for pacification and language development of premature infants (Standley, 1998, 2003a).

Prior studies have shown that contingent music (such as pacifier-activated lullabies [PALs]) increased pacifier sucking rate of premature infants more than 2.5 times (Standley, 2000) and also increased subsequent feeding rate (Standley, 2003b). Infants given one PAL trial 30 minutes prior to a late afternoon oral feeding attempt significantly increased the amount of nutrition ingested/minute when compared to their feeding rate during a morning oral feeding attempt. Cevasco and Grant (2005) used the PAL in multiple trials with 62 premature infants and found strong trends for increased weight gain with increasing age and PAL trials, though these increases were not substantial enough to be statistically significant. Little other research exists to determine the most appropriate age to begin music reinforcement for NNS or the number of trials necessary to facilitate nipple feeding of premature infants.

Table 1.
Design and Number of Subjects by Gender

PAL Trials by Gestational Age	Male *n*	Female *n*	Total *n*
32 Weeks AGA			
No-contact control	4	4	8
1 PAL trial	4	4	8
3 PAL trials	4	4	8
34 Weeks AGA			
No-contact control	4	4	8
1 PAL trial	4	4	8
3 PAL trials	3	3	6
36 Weeks AGA			
No-contact control	3	4	7
1 PAL trial	4	4	8
3 PAL trials	3	4	7
Total *n*	33	35	68

Note: PAL = pacifier-activated lullaby.

Purpose of Study

The purpose of this study was to ascertain the effect of the pacifier-activated lullaby system (PAL) on cessation of gavage feeding of premature infants due to oral feeding achievement. Cessation of gavage feeding was operationally defined as the date of the last gavage feeding given by NICU personnel. Specific aims were to:

- Determine whether gender affects achievement of nipple feeding skills resulting from PAL usage.
- Determine whether number of PAL trials (0, 1, or 3) affect nipple feeding skills.
- Determine whether age at PAL intervention (32, 34, or 36 weeks AGA) affects nipple feeding skills.

Method

Participants and Design

The design of this study was a 3x3-block design contrasting number of repetitions of PAL trials by gestational age at the beginning of the trial. Table 1 details the design and number of participants in each group. Following referral and receipt of informed consent, premature infants who were born prior to 32 weeks gestational age as measured by Dubowitz criteria were randomly assigned by gender to three intervention groups (no-contact control, 1 PAL trial, or 3 PAL trials) and further divided into time of intervention occurring at 32, 34, or 36 weeks AGA. These age groupings were chosen for the following reasons: NICU personnel disagree on when to intervene to begin oral feeding training. Some believe the infant is too neurologically immature to benefit from intervention prior to 34 weeks. Others believe that starting intervention before 34 weeks facilitates the infant's transition from gavage feeding at 34 weeks. Infants still not nipple feeding at 36 weeks are considered seriously delayed, and benefits of typical NICU interventions are questioned. Therefore, it was decided to test intervention at 34 weeks AGA and the two weeks before and after this midpoint. One trial vs. three trials were contrasted because prior research with the PAL showed that infants learned to suck frequently enough to sustain the music in one trial and improved their oral feeding rate after only one trial. It was unknown whether only one trial might affect the number of days until independent nipple feeding was achieved, and three trials seemed sufficient to note changes in nipple feeding benefits if they would occur due to PAL intervention.

Dependent variables were:

- Days prior to nipple feeding computed by counting days from birth to date of last OG/NG feed recorded on each infant's daily chart by nurses.
- Days of nipple feeding prior to discharge computed by counting days from last OG/NG feed to discharge date. (Note: The two meas-

ures of feeding days when added together equal length of hospitalization.)
- Discharge weight recorded on the dis
- Weight gain computed by subtracting birth weight from discharge weight.

Participants were referred for the study by medical staff when the infant was deemed able to tolerate two simultaneous modes of stimulation (pacifier and auditory stimulation) and if still gavage feeding at time of study. Upon referral, the infant was randomly assigned to a trial condition by age group. If the infant achieved nipple feeding prior to attaining the randomly assigned age, the infant was not enrolled in the study. The protocol for the study excluded infants who:
- Were intubated at the time of the study.
- Had severe abnormalities that affected ability to suck, feed, or learn, including abnormalities of the oral cavity, hydrocephalus, Down syndrome, and significant neurological disorders, such as intraventricular hemorrhage of levels III or IV, periventricular leukomalacia, or hypoxic-ischemic encephalopathy.
- Had positive results on screen for illegal drug use by the mother.

Criteria for referral included the infant:
- Was determined to be able to tolerate two simultaneous modes of stimulation (pacifier and auditory stimulation).
- Had no indication of infection requiring quarantine.
- Was ready to begin some OG feeds.

Protocol was as follows:
- Medical staff of the NICU made referral for PAL.
- PAL was presented at least a half hour prior to a scheduled feeding. The nurse caring for the child gave permission on the day the PAL was presented, affirming that additional stimulation was appropriate for the child at that time. (Sometimes infants had had a stressful day, and further stimuli were contraindicated.)
- Music was located adjacent to and outside the crib or incubator with decibel level averaging 60 to 65 dB measured at infant's ear (Scale C, 1 volume bar on PAL machine).
- The protocol stipulated that the use of PAL would be discontinued if signs of infant distress were observed, including irregular respiration or apnea, flushing or mottling of skin, tremors, startles, flayed fingers or hand in stop position, eye rolling or floating, whimpering, hiccoughing, spitting up, and gagging. No such responses were noted in response to the PAL.
- Infants were not held but remained in the crib or incubator lying on their backs or sides to reduce additional stimulation.
- PAL pacifier pressure = one bar on machine menu to begin training.
- Treatment duration = maximum of 15 minutes opportunity for sucking.
- Discontinue when infant rejects pacifier twice or falls asleep.

Researchers were not a part of the medical staff but were professionals who came to the NICU at the same time each day to run PAL trials. Medical staff that made referrals for the study and who determined readiness for discharge were blind as to whether the infants were subsequently enrolled in the study or to their random assignment of intervention group. Many infants received PAL clinical treatment by the research team, but medical personnel were not aware whether a specific infant's PAL usage occurred for the purpose of data collection for this study. Participants in this study received only the number of PAL trials specified in the group cohort to which they were randomly assigned.

Sites

The study was conducted by music therapy researchers from four major universities at four critical care nurseries in regional hospitals in the southeast. It was approved by the Human Subjects Committees at each university and by the Institutional Review Boards at each hospital. The sites included Site A, a 40-bed Level III NICU; Site B, a 68-bed Level III NICU; Site C, a 10-bed special care nursery; and Site D, a 48-bed Level III newborn critical care center.

Procedure

Contingent music was delivered via the PAL (Standley, 2000). With this equipment, an infant sucks on a Wee Soothie® pacifier fitted with an adaptor housing a computer chip that activates a CD player outside the incubator. The music stimulus was a continuous selection of lullabies sung by a young female with minimal accompaniment. The lullabies were traditional lullabies selected by the music therapists for their soothing effects and were especially recorded to reduce alerting musical stimuli. Recording criteria included no changes in tempo, no changes in volume level, no key changes, and no changes in accompaniment style. The music was presented at 65 dB (Scale C) via small speakers placed binaurally in the incubator above the infant's head. The music sustained for 10 seconds and subsequently shut off unless reactivated by another suck, therefore making the presentation of music stimuli contingent on the sucking behavior of the infant. All infants were lying on their backs or sides during PAL trials. Although it did not occur, provisions were made in the protocol to discontinue use of the pacifier if signs of infant stress were observed. PAL settings allowed music reinforcement after one trigger (suck) and at the lowest amount of pressure change (weakest suck).

The experimental infants received either one 15-minute trial with the PAL or three trials within a 5-day period at the time of their achieving the randomly assigned age and still relying on gavage feeding. PAL trials occurred at the same time each day between 4:00 to 5:00 p.m. and were not given in relationship to feeding times of individual participants. A prior study that had compared morning and afternoon feeding rates had shown the PAL intervention to be effective in this time frame (Standley, 2003b). The no-contact control groups met the same criteria but received no PAL intervention. Data were recorded by the researchers from the nurses' notes. Nurses were blind to the purpose of the study and to infants' status in the study. Data included date of birth, birth weight, gestational age by Dubowitz criteria at birth, date of last gavage (naso-gastric or oral-gastric) feeding, discharge date, and discharge weight.

Results

Because some sites completed many more participants than others, data were analyzed by site to determine if location affected results. Tables 2 and 3 show birth weight and gestational age at birth by site and gender.

SPSS Two-Way Analysis of birth gestational age by gender and site showed no differences for gestational age at birth among sites ($F = 2.522$, $df = 3$, $p = 0.066$) or for gender by site ($F = 1.286$, $df = 3$, $p = 0.288$). Overall, the gestational age at birth for all males was significantly earlier than that for

Table 2.
Mean Birth Weight in Kilograms by Site and Gender

Site	Male	Female	Overall Mean
Site A (*n* = 28)	1.0758	1.0824	1.0796
Site B (*n* = 18)	1.296	1.1572	1.165
Site C (*n* = 18)	1.2580	1.3896	1.3238*
Site D (*n* = 4)	1.2583	0.5530	1.0820
Overall Mean Weight	1.1949	1.1655	1.1798

Notes: $N = 68$; no significant difference by gender.
*$p < 0.05$, Site C babies significantly higher in birth weight than Site A and Site D babies.

Table 3.
Mean Gestational Age at Birth by Site and Gender

Site	Male	Female	Overall Mean
Site A (*n* = 28)	29.0	28.5	28.7
Site B (*n* = 18)	29.6	28.9	29.3
Site C (*n* = 18)	30.1	30.0	30.1
Site D (*n* = 4)	30.3	26.0	29.2
Overall Mean Weight	29.6*	28.9	29.2

Notes: $N = 68$; no significant difference by site.
*$p < 0.05$, males significantly older than females at birth.

Table 4.
Mean Subject Characteristics by Age at Study and by PAL Trials

PAL Trials by Gestational Age	Birthweight in Kg	Birth Age in Gestational Weeks
32 Weeks AGA		
Control (*n* = 8)	1.39	30.4
1 PAL trial (*n* = 8)	1.26	29.3
3 PAL trials (*n* = 8)	1.27	29.6
32-week total	1.31	29.8
34 Weeks AGA		
Control (*n* = 8)	1.09	28.9
1 PAL trial (*n* = 8)	1.25	29.3
3 PAL trials (*n* = 6)	1.42	30.6
34-week total	1.24	29.5
36 Weeks AGA		
Control (*n* = 7)	0.91	28.1
1 PAL trial (*n* = 8)	0.94	27.9
3 PAL trials (*n* = 7)	1.12	29.3
36-week total	1.18	28.4

Note: $N = 68$.

all females ($F = 5.529$, $df = 1$, $p = 0.022$). SPSS Two-Way Analysis of birth gestational age by randomly assigned age groups at time of study and by number of trials showed no significant difference among PAL trials groups ($F = 2.016$, $df = 2$, $p = 0.142$) and also showed that infants randomly assigned to the 36-week age group at time of study were born significantly earlier than infants in other age groups ($F = 4.11$, $df = 2$, $p = 0.021$). This was predictable and inevitable because infants born earlier have more difficulty learning to nipple feed and are more likely to still be gavage feeding at 36 weeks adjusted gestational age.

SPSS Two-Way Analysis of birth weight data by gender and site showed no significant difference by gender ($F = 2.342$, $df = 1$, $p = 0.131$) but differences by site. Infants from Site C had significantly higher birth weights ($F = 2.910$, $df = 3$, $p = 0.042$) than the infants at Site A ($p = 0.014$) and at Site D ($p = 0.040$). SPSS Two-Way Analysis of birth weight data by age at study and by trials showed no significant differences among trials ($F = 1.345$, $df = 2$, $p = 0.270$). Again, as expected, the infants in the 36-week age group at the time of the study were born with significantly lower birth weights than those in all other age groups ($F = 6.867$, $df = 2$, $p = 0.002$).

Because infant characteristics data showed few statistical differences by site or gender, data were pooled for subsequent analyses. Table 4 shows pooled birthweight and gestational age at birth data for participants by age at study and trials.

Data for each of the four dependent variables were subjected to Two-Way Analyses of Variance for comparison by gender and trials. Females ($M = 7.03$) nipple fed significantly longer prior to discharge than did males ($M = 5.70$, $p < 0.0001$). This means they succeeded in nipple feeding sooner than males. This result was expected because female premature infants generally show faster maturation than male infants (Standley, 2003a). There were no other gender differences on any of the four dependent variables or by number of trials.

Analysis by site showed that infants at Site A were discharged at significantly lower weights than other sites ($F = 14.919$, $df = 3, 60$, $p = 0.0001$), but they were also born at slightly lower birth weights than the other participants. Subsequently, their weight gain was also significantly less while in the hospital ($F = 4.883$,

Table 5.
Results: Means and (Standard Deviations) by PAL Trial Groups and Age at Study

PAL Trials by Gestational Age	Gavage Days	PO Days to Discharge	Discharge Weight	Weight Gain
32 Weeks AGA				
Control (n = 8)	33.25* (8.50)	6.63 (3.74)	2.1974 k (0.4086)	0.8025 k (0.2523)
1 PAL trial (n = 8)	46.75 (17.33)	5.13 (2.36)	2.2759 k (0.5998)	1.0193 k (0.5920)
3 PAL trials (n = 8)	48.50 (15.89)	6.00 (3.59)	2.4533 k (0.5670)	1.1829 k (0.5033)
34 Weeks AGA				
Control (n = 8)	58.88 (13.10)	10.25 (12.19)	2.5100 k (0.3962)	1.4233 k (0.4772)
1 PAL trial (n = 8)	46.88* (14.67)	3.88 (2.75)	2.2816 k (0.3636)	1.0340 k (0.4245)
3 PAL trials (n = 6)	35.17* (8.40)	4.17 (1.83)	2.1808 k (0.1776)	0.7597 k (0.3073)
36 Weeks AGA				#
Control (n = 7)	67.71 (13.39)	6.711 (3.90)	2.2514 k (0.4853)	1.3487 k (0.4518)
1 PAL trial (n = 8)	68.88 (25.34)	6.50 (2.45)	2.2426 k (0.2831)	1.3049 k (0.3100)
3 PAL trials (n = 7)	64.71 (21.48)	7.86 (3.53)	2.6280 k (0.6168)	1.5097 k* (0.6055)

Notes: N = 68.
*$p < 0.05$, significantly different within age group, PAL trials significantly shortened length of gavage feeding for 34-week babies, and 3 trials were significantly better than 1 trial. PAL trials significantly increased length of gavage feeding for 32-week babies.
# $p < 0.05$, significantly different across age groups, all 36-week AGA infants were gavage fed significantly longer than the other two groups. Overall, 36-week AGA infants gained significantly more weight than the other age groups.

df = 3, 60, p = 0.004). Overall, data showed little difference among variables by site, and gender was equalized in the random assignment among groups; therefore, it was assumed these groupings did not affect overall results of PAL trials, and data were pooled for further analyses.

Results for each of the four dependent variables were subjected to Two-Way Analyses of Variance for comparison by age at study and number of PAL trials. Table 5 shows means, standard deviations, and significance comparisons among means using Tukey post hoc analysis.

Analysis of gavage feeding days showed significance for age at study (F = 14.137, df = 2, p = 0.0001). Tukey HSD post hoc analysis showed that all 36-week AGA infants took significantly longer to oral feed than the 32 or 34-week infants, and three PAL trials shortened the interval, but not significantly so. Analysis of gavage feeding days for age at study by trials was also significant (F = 2.758, df = 4, p = 0.036). No other comparisons were significant.

Analysis of total weight gain from birth to discharge was significant for age at study (F = 4.629, df = 2, p = 0.014). Tukey HSD post hoc analysis showed that the 36-week AGA infants gained significantly more weight than the other two age groups, but this was expected because they were born smaller and stayed in the hospital longer.

Analysis of weight gain for age at study by PAL trials was significant (F = 2.739, df = 4, p = 0.037). Tukey HSD post hoc analysis showed no significance for specific age by trial comparisons.

Discussion

The purpose of this study was to ascertain whether the PAL benefitted infant transition from gavage to nipple feeding, and if age of presentation or number of PAL trials affected benefits. PAL trials significantly shortened length of gavage feeding for 34-week babies, and three trials were significantly better than one trial. PAL trials significantly increased length of gavage feeding for 32-week babies. These results would indicate that the PAL is most effective when introduced at 34 gestational weeks, the point in time when most infants are deemed neurologically ready to nipple feed (McGrath & Braescu, 2004).

The sample was very small in the 36-week age group receiving three PAL trials due to the rarity of infants meeting criteria for continued inclusion in the study. Specifically, most infants enrolled at 36 weeks who were not nipple feeding began to do so after one PAL trial. Therefore, it was impossible to fulfill the planned cohort for the 36-week, three-trial group. This age group deserves further study with a design that does not require multiple PAL trials at this gestational age.

Overall, the results of this PAL protocol by age at study and trials do not demonstrate significant weight gain benefits except those related to longer stay in the hospital. Similar to findings by Cevasco and Grant (2005), there are trends that may warrant future research with revised protocols and design. Cevasco and Grant (2005) showed increasing weight gain with increasing age and increasing PAL usage; however, this study demonstrated such results in the 36-age group only. This study's results for weight gain by age may be primarily due to 36-week infants' longer stay in the NICU associated with necessity for completion of three trials prior to discharge.

It should be noted that there were several confounding factors in this study. Every infant from whom consent was received and who was randomly assigned to the 32 to 33-week age group completed participation in the project. However, some assigned to the 34 to 35-week age group and many more assigned to the 36 to 37- week age group "graduated" and failed to complete the study because they began nipple feeding or were discharged before conclusion of trials. Independent feeding is one main criterion for discharge, and infants who began to feed well were immediately sent home. Since the research design required that some infants at 34 or 36 weeks AGA still need gavage feeding throughout three PAL trials across 3 to 5 days, a bias for length of stay was created for the two older groups. Some participants excelled at acquiring nipple feeding skills and left before completing the research trials.

The PAL shows some potential for facilitating nipple feeding, and continued research is warranted to further refine the PAL intervention protocols. Nipple feeding is necessary for discharge. Infants begin training at 34 weeks AGA, and a few succeed immediately. However, very low birth weight infants and those intubated for longer periods have great difficulty with this task. Many infants remain hospitalized solely due to inability to oral feed. At a U.S. average NICU cost of approximately $2000/day, this can be an expensive and depressing period for the family awaiting discharge (Standley, 2003a). Interventions that can speed up this process without physiologic harm to the infant are highly desired. In prior research, one PAL intervention proved to be highly effective in increasing sucking rate and subsequent feeding rate. However, a specific PAL protocol testing age of presentation and multiple trials had never been attempted. This protocol proved effective in significantly shortening gavage days for 34-week AGA infants. Future research must be exact in assessing and comparing specific protocol parameters to improve care procedures. Much more research in this area is warranted.

Clinical Implications

A PAL intervention can significantly shorten gavage feeding days and length of hospitalization for premature infants when used at the specific gestation age of 34 weeks. The intervention protocol should begin with a PAL treatment of 15 minutes approximately 30 minutes prior to a feeding trial and should continue daily until the infant is independently nipple feeding. The lullaby selected for reinforcement of sucking should be in the native language of the infant's family if possible. In this way, the infant will be receiving critical language input while being reinforced for sucking. The protocol used in this study is recommended.

Criteria for Referral

- Infant is determined to be able to tolerate two simultaneous modes of stimulation (pacifier and auditory stimulation).
- Infant has no severe abnormalities that affect ability to suck/feed or to learn, including abnormalities of the oral cavity, hydrocephalus, Down syndrome, significant neurological disorders (PVL, IVH, HIE).
- Infant has no indication of infection requiring quarantine.
- Infant is not on ventilator or CPAP.
- Infant is ready to begin some OG feeds.

References

Anderson, G., & Vidyasagar, D. (1979). Development of sucking in premature infants from 1 to 7 days post birth. *Birth Defects: Original Article Series, 15*(7), 145-171.

Bernbaum, J., Pereira, G., Watkins, J., & Peckham, G. (1983). Nonnutritive sucking during gavage feeding enhances growth and maturation in premature infants. *Pediatrics, 71*(1), 41-45.

Boyle, E., Freer, Y., Khan-Orakzai, A., Watkinson, M., Wright, E., Ainsworth, J., & McIntosh, N. (2006). Sucrose and non-nutritive sucking for the relief of pain in screening for retinopathy: A randomised controlled trial. *Archives in Disease in Childhood: Fetal and Neonatal Edition, 91*(3), 166-168.

Britt, G., & Myers, B. (1994). The effects of Brazelton intervention: A review. *Infant Mental Health, 15*(3), 278-292.

Burroughs, A., Asonye, U., Anderson-Shanklin, G., & Vidyasagar, D. (1978). The effect of nonnutritive sucking on transcutaneous oxygen tension in non-crying, preterm neonates. *Research in Nursing and Health, 1*(2), 69-75.

Caine, J. (1992). The effects of music on the selected stress behaviors, weight, caloric and formula intake, and length of hospital stay of premature and low birth weight neonates in a newborn intensive care unit. *Journal of Music Therapy, 28*(4), 180-192.

Cassidy, J., & Ditty, K. (2001). Gender differences among newborns on a transient otoacoustic emissions test for hearing. *Journal of Music Therapy, 38*(1), 28-35.

Cassidy, J., & Standley, J. (1995). The effect of music listening on physiological responses of premature infants in the NICU. *Journal of Music Therapy, 37*(4), 208-227.

Cevasco, A., & Grant, R. (2005). Effect of the pacifier activated lullaby on weight gain of premature infants. *Journal of Music Therapy, 42*(2), 123-139.

Chapman, J.S. (1979). Influence of varied stimuli on development of motor patterns in the premature infant. In G. Anderson & B. Raff (Eds.), *Newborn behavioral organization: Nursing research and implications* (pp. 61-80). New York: Alan Liss.

Cheour-Luhtanen, M., Alho, K., Sainio, K., Rinne, T., Reinikainen, K., Pohjavuouri, M., ... Naatanen, R. (1996). The ontogenetically earliest discriminative response of the human brain. *Psychophysiology, 33,* 478-481.

Cignacco, E., Hamers, J., Stoffel, L., van Lingen, R., Gessler, P., McDougall, J., & Nelle, M. (2007). The efficacy of non-pharmacological interventions in the management of procedural pain in preterm and term neonates. A systematic literature review. *European Journal of Pain, 11*(2), 139-152.

DiPietro, J., Cusson, R., Caughy, M., & Fox, N. (1994). Behavioral and physiologic effects of nonnutritive sucking during gavage feeding in pre-term infants. *Pediatric Research, 36*(2), 207-214.

Field, T., Hernandez-Reif, M., Feijo, L., & Freedman,J. (2006). Prenatal, perinatal and neonatal stimulation: A survey of neonatal nurseries. *Infant Behavior and Development, 29*(1), 24-31.

Field, T., Ignatoff, E., Stringer, S., Brennan, J., Greenberg, R., Widmayer, S., & Anderson, G. (1982). Nonnutritive sucking during tube feedings: Effects on preterm neonates in an intensive care unit. *Pediatrics, 70*(3), 381-384.

Gardner, S.L., Garland, K.R., Merenstein,S. L., & Lubchenco, L.O. (1997). The neonate and the environment Impact on development. In G.B. Merenstein & S.L. Gardner (Eds.). *Handbook of neonatal intensive care* (4th ed.) (pp. 564-608). St. Louis, MO: Mosby.

Gill, N., Behnke, M., Conlon, M., NcNeely, J., & Anderson, G. (1988). Effect of nonnutritive sucking on behavioral state in preterm infants before feeding. *Nursing Research, 37*(6), 347-350.

Goff, D.M. (1985). The effects of nonnutritive sucking on state regulation in pre-term infants. *Dissertation Abstracts International, 46*(8-B), 2835.

Gomes-Pedro, J., Patricio, M., Carvalho, A., Goldschmidt, T., Torgal-Garcia, F., & Monteiro, M. (1995). Early intervention with Portuguese mothers: A 2-year follow-up. *Journal of Developmental and Behavioral Pediatrics, 16*(1), 21-28.

Harrison, L. (1985). Effects of early supplemental stimulation programs for premature infants: Review of the literature. *Maternal-Child Nursing Journal, 14*(2), 69-90.

Hill, A. (1992). Preliminary findings: A maximum oral feeding time for premature infants, the relationship to physiological indicators. *Maternal-Child Nursing Journal, 20*(2), 81-92.

Kanarek, K., & Shulman, D. (1992). Non-nutritive sucking does not increase blood levels of gastrin, motilin, insulin and insulin-like growth factor 1 in premature infants receiving enteral feedings. *Acta Paediatrica Scandinavica, 81,* 974-977.

Lecanuet, J., Granier-Deferre, C., & Busnel, M. (1995). Human fetal auditory perception. In J.P. Lecanuet, W.P. Fifer, N.A. Krasnegor, & W.P. Smotherman, (Eds.), *Fetal development: A psychobiological perspective* (pp. 239-262). Hillsdale, NJ: Lawrence Erlbaum Associates.

Mathai, S. Natrajan, N., & Rjalakshmi, N. (2006). A comparative study of nonpharmacological methods to reduce pain in neonates. *Indian Pediatrics, 43*(12), 1070-1075.

McCain, G. (1992). Facilitating inactive awake states in pre-term infants: A study of three interventions. *Nursing Research, 41*(3), 157-160.

McCain, G. (1995). Promotion of pre-term infant nipple feeding with non-nutritive sucking. *Journal of Pediatric Nursing, 10*(1), 3-8.

McGrath, J., & Braescu, A. (2004). State of the science: Feeding readiness in the preterm infant. *Journal of Perinatal & Neonatal Nursing, 18*(4), 353-368.

Medoff-Cooper, B., & Gennaro, S. (1996). The correlation of sucking behaviors and Bayley Sclaes of Infant Development at six months of age in VLBW infants. *Nursing Research, 45*(5), 291-296.

Oehler, J. (1993). Developmental care of low birth weight infants. *Advances in Clinical Nursing Research, 28*(2), 289-301.

Palmer, M.M. (1993). Identification and management of the transitional suck pattern in premature infants. *Journal of Perinatal and Neonatal Nursing, 7*(1), 66-75.

Pinelli, J., & Symington, A. (2000). How rewarding can a pacifier be? A systematic review of non-nutritive sucking in pre-term infants. *Neonatal Network, 19*(8), 4-8.

Pinelli, J., & Symington, A. (2005). Non-nutritive sucking for promoting physiologic stability and nutrition in pre-term infants. *Cochrane Database of Systematic Reviews, 2005*(4): CD001071.

Rauh, V., Nurcombe, B., Achenbach, T., & Howell, C. (1987). The mother-infant transaction program: An intervention for the mothers of low-birth-weight infants. In N. Gunzenhauser (Ed.), *Infant stimulation: For whom, what kind, when, and how much?* Skillman, NJ: Johnson & Johnson Baby Products.

Schwartz, R., Moody, L., Yarndi, H., & Anderson, G. (1987). A meta-analysis of critical outcome variables in non-nutritive sucking in pre-term infants. *Nursing Research, 36*(5), 292-295.

South, M., Strauss, R., South, Al. Boggess, J., & Thorp, J. (2005). The use of non-nutritive sucking to decrease the physiologic pain response during neonatal circumcision: A randomized controlled trial. *American Journal of Obstetrics and Gynecology, 193(*2), 537-542.

Standley, J. (1998). The effect of music and multimodal stimulation on physiologic and developmental responses of premature infants in neonatal intensive care. *Pediatric Nursing, 24*(6), 532-538.

Standley, J. (2000). The effect of contingent music to increase non-nutritive sucking of premature infants. *Pediatric Nursing, 26*(5), 493-499.

Standley, J. (2002). A meta-analysis of the efficacy of music therapy for premature infants. *Journal of Pediatric Nursing, 17*(2), 107-113.

Standley, J. (2003a). *Music therapy with premature infants: Research and developmental interventions.* Silver Spring, MD: American Music Therapy Association.

Standley, J. (2003b). The effect of music-reinforced non-nutritive sucking on feeding rate of premature infants. *Journal of Pediatric Nursing, 18*(3), 169-173.

Standley, J., & Moore, R. (1995). Therapeutic effects of music and mother's voice on premature infants. *Pediatric Nursing, 21*(6), 509-512, 574.

Whipple, J. (2008). The effect of music-reinforced nonnutritive sucking on state of preterm, low birthweight infants experiencing heelstick. *Journal of Music Therapy, 45*(3), 227-272.

Woodson, R., & Hamilton, C. (1988). The effect of nonnutritive sucking on heart rate in preterm infants. *Developmental Psychobiology, 21*(3), 207-213.