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A discussion of evidence-based music therapy to facilitate feeding skills of premature infants: The power of contingent music

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ABSTRACT

Due to neurologic immaturity, premature infants must be fed by tube until approximately 34 gestational weeks and many have subsequent problems with transition to oral feeding. In the United States, infants whose only problem is ineffective feeding remain in the Neonatal Intensive Care Unit at an average cost of $2000/day until independent nippling with regular weight gain is achieved. This is a serious and prevalent problem that increases medical costs and risk of developmental delays. Research shows that infants generally thrive more in the home with home-based nursing support and medical monitoring than in the hospital and the earliest possible discharge date is preferred.

The appearance of the non-nutritive sucking reflex is an indication of physiologic maturation that can be affected by learning experiences. One learning experience, music reinforcement activated by pacifier sucking, can facilitate feeding ability of premature infants. Contingent music for non-nutritive sucking increases sucking frequency, duration, and endurance leading quickly to proficient nippling and earlier discharge. This article discusses the feeding problems of premature infants and provides an overview of the research and the clinical applications of using contingent music to facilitate feeding.

Introduction

The incidence of premature births in the United States is increasing as are medical costs related to this problem. Research in music therapy (MT) has shown benefits for facilitating medical treatment and for nurturing premature infants for more than 20 years (Standley, 1991; Standley & Walworth, 2010). Results of a recent meta-analysis on music therapy in the Neonatal Intensive Care Unit (NICU) found significant and consistent benefits for measures of heart rate, behavior state, oxygen saturation, sucking/feeding ability, and length of hospital stay. Live music therapy conducted by a NICU trained Board Certified Music Therapist (MT-BC) (NICU-MT) was significantly more beneficial than the use of recorded music. Music techniques used with the most severely premature babies early in their development were most beneficial (birth weight < 1000 g, birth post-menstrual age < 28 weeks). Results recommend use of the following evidence-based NICU-MT protocols in best practice standards for NICU treatment of preterm infants: music listening for pacification, music reinforcement of sucking/feeding ability, and music as a basis for pacification during systematically accumulating layers of multimodal stimulation (Standley, in press).

This meta-analysis also demonstrated that two of the benefits for NICU-MT are significantly earlier discharge dates and a consistent pattern of increases in weight gains. A study was conducted to determine if clinical applications of these evidence-based protocols impacted infant outcomes and substantiated research results. This *post hoc* clinical analysis of a NICU-MT program in effect for over 7 years included referrals for multi-modal stimulation for neurologic enhancement and Pacifier-Activated-Lullaby (PAL) treatment for feeding (Standley & Swedberg, 2011). The medical records of all infants born with low birth rate (<2499 g) and born prior to 36 gestation weeks who were treated in the NICU in 2006 ($N = 208$) were analyzed with differentiation for receipt of NICU-MT or not. Results showed that the smallest, lowest birth-weight infants were more often referred for music therapy. Infants receiving NICU-MT gained more weight/day than did infants not referred for NICU-MT. Those born very early (24–28 gestational weeks) were discharged sooner than non-music infants in that age range. Therefore, it was determined that premature infant outcomes from clinical NICU-MT were congruent with results of research trials for both the multi-modal procedures and PAL use to facilitate feeding skills.

The purpose of this article is to discuss one of these evidence-based protocols; specifically, the use of music reinforcement activated by pacifier sucking to facilitate independent oral feeding (nippling) and early learning capabilities of premature infants. The

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non-nutritive sucking reflex is an indication of physiologic maturation that can be affected by learning experiences. A highly effective learning experience for the neurologically immature infant is contingent music for non-nutritive sucking.

Non-nutritive sucking (NNS) and feeding problems of premature infants

Sucking behavior appears during the third trimester of fetal development and is the first rhythmic behavior in which the fetus engages. It is critical for survival after birth and is theorized to contribute to neurological development by facilitating internally regulated rhythms (Goff, 1985). NNS activates the vagal nerve, causing the release of the gastrointestinal hormones that stimulate gastro-intestinal activity, growth, and production of insulin. Insulin enhances the infant's energy economy (Dieter & Emory, 1997).

Appearance of the NNS reflex indicates physiologic maturation and can be made more effective through learning experiences (Anderson & Vidyasagar, 1979; Bernbaum, Pereira, Watkins, & Peckham, 1983). The suck–swallow–breathe coordinated response necessary for nipple feeding is not neurologically possible until 34 gestational weeks. Until that time, the premature infant must be fed by tube, a procedure that is necessary, but stressful. The infants often respond to the sensation of formula "dumping" into their stomach by tensing their abdominal muscles. This forces the nutrition back up the tube and prolongs the duration of the feeding attempt.

Pacifiers are very beneficial to premature infants, especially early in the NICU stay, by increasing infant oxygenation (Burroughs, Asonye, Anderson-Shanklin, & Vidyasagar, 1978). Later NNS use during tube feedings increases weight gain (Field et al., 1982), lowers heart rate (McCain, 1995; Woodson & Hamilton, 1988), and continues to increase oxygenation (Anderson & Vidyasagar, 1979). Pacifier sucking results in lower activity levels that conserve energy thereby promoting weight gain, increasing the duration of inactive alert state, and causing faster return to quiet sleep (DiPietro, Cusson, Caughy, & Fox, 1994; Gill, Behnke, Conlon, McNeely, & Anderson, 1988; McCain, 1992, 1995). A meta-analysis on NNS during gavage feeding found that length of hospital stay was shortened by 6.3 days on average with premature infants beginning to bottle feed 2.9 days sooner (Schwartz, Moody, Yarndi, & Anderson, 1987).

Another problem of the neurologically immature infant is that he/she does not exhibit behavior state organization. This means that identifiable cues of state (sleep, distress, alertness, etc.) are not apparent and transitions between states are prolonged or difficult. A premature infant has similar poor organization for feeding. Oral feeding attempts commonly result in heart rate increases and respiratory interruptions leading to apneic episodes. Sucking responses may be weak, consist of frantic bursts or are totally uncoordinated. Thus, nutritive sucking in premature infants frequently reduces oxygen saturation, expends energy, and causes weight loss (Hill, 1992). Palmer's feeding assessment (1993) consistently found that premature infants demonstrated an immature pattern of sucking consisting of 3–5 sucks in a burst followed by a pause to breathe. More neurologically advanced term infants sucked 10–30 times in a prolonged burst while alternating breathing with sucking. A nipple feeding opportunity for premature infants is usually limited to 30 min with any remaining nutrition given by tube (Gardner, Garland, Merenstein, & Lubchenco, 1997) to avoid negative physiologic responses.

In addition to other benefits, NNS has been shown to be an effective precursor to nipple feeding opportunities. When used 10 min prior to nipple feeding it increases the inactive awake state of the infant and rate of nutritional ingestion (McCain, 1995). Clinical intervention for premature infant feeding difficulty strives to facilitate mature nutritive sucking coordination, strengthened suck, and prolonged sucking bursts. This can be a highly ineffective and prolonged process.

Contingent music and infant learning

Music effectively reinforces learning in all ages of individuals from infancy through advanced adult age (Standley, 1996) though its impact on fetal learning is still under investigation. James (2010) reviewed fetal learning literature using habituation testing of fetal memory and exposure learning via vibro-acoustic stimuli. Classical conditioning experiments with preterm infants were not included in this review. He concluded that this inferential evidence demonstrated that learning occurs late *in utero* despite neurologic immaturity.

DeCasper and Carstens (1981) conducted one of the earliest learning experiments with newborns and demonstrated that music reinforcement altered sucking behavior of 2-day-old term infants. Experimental research in contingent cause/effect learning of premature infants is sparse. An experiment at three months after premature birth showed impaired speed and amount of learning when compared to term infants (Haley, Grunau, Oberlander, & Weinberg, 2008). Solkoff and Cotton (1975) demonstrated contingency awareness and discrimination in premature infants at 31 gestational weeks. Schunk (1993) played background music contingent upon sucking. Her results with a very small sample size were inconclusive, however, positive changes in infant behavior were observed during music.

Standley (2000) developed a device to activate music via NNS and conducted a series of 3 studies to determine its impact on premature infants' feeding ability. The first study investigated whether contingent pacifier activated music would reinforce NNS rates of premature infants at 34–36 gestational weeks. The PAL (pacifier-activated-lullaby) device for this study used a Minimam Newborn Orthodontic Pacifier by Ross Laboratories (#50486) in a closed air circuit with a transducer that allowed a suck of predetermined strength to activate the electrical signal to a cassette tape player. Sucking pressure to activate the electoral signal was set at the minimal level with music duration at 10 s, a period that reset with each suck. Each music activation also lit red an indicator on the control box for sucking frequency and duration that was used for data collection. Subjects served as their own control in an ABAB designacross 14 min: silence condition for the first 2 min of baseline (A), followed by 5 min of contingent music (B), followed by another 2-min period of silence (A), and another 5 min of contingent music (B). A selection of commercially recorded lullabies sung by female vocalists played free field at 65–70 dB, Scale C (Cassidy & Ditty, 1998) was the music stimulus. The dependent variable was sucking duration/5-s interval as indicated by the signal light and recorded by two trained observers with 96% reliability. Trials occurred between 4 and 5 p.m. in the interval of at least 1 h past the last feeding and at least 1 h prior to the next feeding. The pacifier was carefully placed in the infant's mouth and held there with light pressure but with no further manipulation which might have activated sucking. We planned to cease the trial if any infant showed distress symptoms as per Rauh, Nurcombe, Achenbach, and Howell (1987); however, no instances of overstimulation were observed during this study.

Results reflected a clear learning curve with mean sucking rates consistently increasing across time during the first contingent music interval then dropping substantially during the second baseline condition. Sucking rates were highest overall in the first minute of the second contingent music condition. Sucking rates during music were 2.43 times as great as those during silence. It was obvious that infant learning and discrimination of music occurred.