Critical Review: In preterm infants, which form of oral stimulation best establishes the non-nutritive suck in order to accelerate the transition time to oral feeding: the NTrainer patterned orocutaneous therapy or oral stimulation delivered by a pacifier?

Trevisonn, A. L.
M.Cl.Sc. (S-LP) Candidate
University of Western Ontario: School of Communication Sciences and Disorders

This critical review examines whether oral stimulation via NTrainer patterned orocutaneous therapy is more effective than a pacifier at establishing the non-nutritive suck (NNS) in order to accelerate the transition time to oral feeding in preterm infants. Overall, research suggests that both forms of oral stimulation establish the NNS and have a positive effect on feeding outcomes. However, it was found that when mechanical stimulation (NTrainer) was administered, there was an overall more effective increase in transition time to oral feeding.

Introduction

One of the most frequently encountered problems in preterm infants is oral feeding difficulties (Jadcherla & Shaker, 2001). These may include a disorganized sucking pattern and discoordination of the typical suck-swallow-breathe cycle. Sucking patterns begin to appear in-utero between 15 and 18 weeks gestational age (GA), and the non-nutritive suck (NNS) appears between 28 and 33 weeks GA. As such, the NNS is well-patterned and stabilized by 34 weeks GA.

The suck central pattern generator (sCPG) is developed preterm (Tanaka, Kogo Chandler, & Matsuya, 1999). Consequently, infants born prematurely miss this crucial time of development in the womb and are often born without an NNS, or exhibit a disorganized NNS pattern. Because of deficits in sucking behaviour, feedings are then administered via enteral routes (e.g. nasogastric tube) which do not rely on the suck for the acquisition of nutrients. Sensorimotor development after birth is further compromised for this population by the presence of invasive breathing tubes occupying their upper airway. Sensory and motor experiences to facilitate the development of feeding skills are believed to be compromised with longer durations of intubation (Bosma, 1973, Hensch, 2004).

The NNS has been reported by many researchers to promote the coordination of sucking and swallowing for feeding (DiPietro, Cusson, Caughy, & Fox, 1994; Pickler, Frankel, Walsh, & Thompson, 1996). Therefore, feeding readiness in preterm infants is often evaluated through an assessment of the NNS. In past studies, oral stimulation strategies to establish the NNS have proven beneficial in developing feeding skills in premature infants (Fucile, Gisel, & Lau, 2002). Stimulation delivered to the baby's oral musculature has been found to entrain or synchronize neural sensorimotor pathways to modify the sCPG in order to improve oral movements needed for feeding (Barlow & Estep, 2006).

Pickler & Reyna (2004) have suggested that the mechanisms involved in the NNS are different from those needed for the nutritive suck (NS), and therefore would not recommend the use of NNS intervention to teach NS for feeding. However, there is an abundance of evidence that supports the use of oral stimulation techniques to establish NNS as efficient interventions for feeding outcomes for preterm infants, particularly related to the transition time to oral feeding. Though, the most effective form of oral stimulation to establish the NNS in preterm infants has yet to be determined.

If speech-language pathologists had evidence which stated that one form of intervention to mature the NNS proved to have a more consistent benefit on the preterm infant in transitioning to oral feedings, they could use it as a guideline for their practice. As well, this information would perhaps decrease stress on the caregivers, and most importantly, potentially allow the preterm infant a more efficient means to develop the skills needed to thrive.

Research has shown that both oral and oromechanical stimulation (ex. pacifier and NTrainer, respectively) interventions have been effective in developing the NNS in preterm infants in order to accelerate transitions to oral feedings and potentially improve their overall clinical course.

Objectives

The primary objective of this paper is to provide a critical evaluation of existing research on which oral stimulation intervention (NTrainer patterned orocutaneous therapy or oral stimulation delivered by a pacifier) on premature infants best establishes the

NNS in order to accelerate the transition time to oral feeding. Recommendations will be discussed in order to provide evidence-based information to guide appropriate intervention options, as well as suggestions for future research.

Methods

Search Strategy

Literature searches were completed on the PubMed database using the following search terms: ((preterm) OR (premature)) AND ((oral stimulation) OR (NTrainer) OR (pacifier)). The search was limited to articles written in English and relevant literature referenced within the acquired articles was sought.

Selection Criteria

All studies included in this critical review were required to examine the effectiveness of oral stimulation (NTrainer patterned orocutaneous therapy vs. delivered by a pacifier) on preterm infants in best establishing the NNS in order to accelerate transition time to oral feeding.

Data Collection

Results of the literature search yielded the following types of articles (selected using the above mentioned criteria): four quasi-randomized clinical trials and one randomized crossover design.

Results

Poore, Zimmerman, Barlow, Wang, and Gu (2008) examined the use of oral stimulation in the form of the NTrainer patterned orocutaneous therapy in improving sucking and oral feeding in preterm infants. Thirty-one medically stable preterm infants (mean gestational age = 29.3 weeks) with minimal or no NNS output and minimal oral feeding (<25% of nutrition by mouth) were selected. Using a block design twenty-one, infants were assigned to the NTrainer treatment group or the non-treatment group. The treatment group received three minute epochs of patterned orocutaneous stimulation during gavage feeds using the NTrainer device, up to four times a day until the infant attained 90% oral feeds for two consecutive days. The control group was given a Soothie© pacifier during gavage feeds and oral feeding was also measured. Equipment was used to measure the force generated by the tongue, lips, and jaw during sucking behaviour and digitized in real-time using NeoSuck RT software. The NNS pattern stability was then analyzed using the Non-Nutritive Suck Spatiotemporal Index software on a weekly basis.

Data were analyzed using mixed multiple regression analyses. At the initiation of the study, NTrainer and control infants had similar Non-Nutritive Suck Spatiotemporal Index scores and similar percent oral feeding. Results revealed that only treated infants demonstrated a significant and disproportionate improvement in both these areas related to the NTrainer treatment. Treated infants produced more organized suck bursts, more stabilized NNS patterns and a 16.8 fold (compared to control group: 3 fold) increase in percent oral feeds. Overall, the authors concluded that the NTrainer patterned orocutaneous therapy effectively accelerates NNS development and oral feeding success in preterm infants.

The study by Poore et al. (2008), used quasi-randomized group assignment and appropriate parametric statistical tests which contributed to the validity of these results. Validity would have been further increased if allocation of participants was completely randomized. To increase the likelihood that the NNS samples were representative of the infant's oromotor ability, the data was averaged across two weekly sessions. As well, controls were age-matched to treated infants pre-and-post NTrainer therapy by post-menstrual age (PMA) to control for maturational effects. However, there was no mention of blinding to investigators, Neonatal Intensive Care Unit (NICU) staff and/or parents which could have biased decisions about feeding progression. A sample size calculation was not included, therefore it is unknown whether the sample is large enough to support results without type II error. Overall, it is suggestive that stimulation to preterm infants using NTrainer patterned orocutaneous therapy yields accelerated development of NNS and increased transition to oral feeding.

Barlow, Finan, Lec, and Chu (2008) furthered the work done by Poore et al. (2008) by assessing the effects of the synthetic orocutaneous entrainment intervention (NTrainer) in preterm infants on the development of the NNS and advancement to oral feeding. A total of thirty-one preterm infants who were medically stable, primarily tube-fed and had a minimal or absent NNS participated in this study. The infants were quasi-randomly assigned to the NTrainer treatment group (20 premature infants) or the control group (11 premature infants). During gavage feeds, the treatment group received three minute epochs of patterned oral somatosensory stimulation using the NTrainer device, three to four times per day over a ten day period, or until the infant attained 90% oral feeds for two consecutive days. The control group was given Soothie© pacifiers during gavage feeds. Enfamil Grad-U-Feed nurser

was given to all infants while the transition from nasogastric (NG) tubes to oral feeds using standard feeding practice.

The NNS compression pressure waveforms were digitized for analysis. The NNS suck variables were measured at two weekly sessions before the stimulation phase (PRE) and again two weekly sessions following the introduction of the patterned orocutaneous NTrainer stimulation (POST).

A repeated measures multivariate analysis of covariance was completed for seven dependent variables. The Bonferroni adjustment for multiple comparisons adjusted for differences in the covariates. There was no significant group difference in the PRE scores except for NNS bursts per minute and NNS Cycles%Total measured at their second session. Results indicated that treated infants had accelerated development of the NNS and had a significantly greater success in achieving oral feeds (72.8% daily oral feeds versus 23.3%). Researchers concluded that the patterned orocutaneous stimulus can induce the sCPG in preterm infants who lack an organized suck to accelerate development of NNS and consequently increase transition to oral feeding.

The use of appropriate parametric and non-parametric statistical tests and blinding of NICU nurses and doctors who determined feeding readiness contributes to the validity of these results found by Barlow et al. (2008). Validity was further increased by accounting for maturational effects by matching infants according to birth gestational age (GA), birth weight, oxygen supplementation history and oral feed level. However, it is unknown whether this sample size is a large enough representation of the population as a sample size calculation was not included, therefore at risk for type II error. Overall, this study demonstrated solid evidence that providing a mechanical stimulation as a habilitation strategy accelerates production of the NNS in preterm infants and as a result, increases feeding success.

Bernbaum, Pereira, Watkins, and Peckham (1983) evaluated the effects of NNS on preterm infants by means of a pacifier during gavage feeding on sucking behaviour, growth, gastrointestinal function, readiness for oral feeding and hospital discharge. Thirty premature infants who were medically stable and an average of 10 days old participated in this study. The infants were stratified into either the treatment group, who received oral stimulation by means of a pacifier during all gavage feeds, or the control group who had no oral stimulation during feeding. Intraoral negative (suction) pressures and sucking patterns were assessed weekly and reported based on PCA. As well, the number of days needed for transition from partial to total feedings by mouth and the time needed to complete the first five bottle feedings were recorded. When the infant attained a weight of 1,700g, oral feedings were initiated.

An independent t-test was used to statistically analyze all data. The treated infants (with increasing age) demonstrated a greater number of sucks per burst and fewer sporadic sucks resulting in a significantly more organized pattern of sucking. In addition, treated infant's transition between total gavage and total oral feedings took approximately six days less compared to controls ($P<.001$). Authors concluded that providing NNS opportunities to preterm infants during gavage feeds increases the efficiency and organization of the sucking pattern, which in turn, accelerates transition time to oral feedings.

The findings reported in the work by Bernbaum, Pereira, Watkins, and Peckham (1983) may have been influenced by the quasi-random stratification of participants and the lack of blinding to all individuals involved with the study. As well, with a small sample size of thirty, type II error may be present as a sample size calculation was not reported. However, infants were pair-matched for birth weight and postnatal gestational age to control for maturational effects and NNS opportunities were only provided during gavage feeds to control for practice effects. Overall, the researchers provide suggestive evidence that providing NNS opportunities to preterm infants during feeding positively effects development of skills needed to thrive, specifically increasing transition time to oral feeding.

Measel and Anderson (1979) tested whether providing NNS opportunities before and immediately after tube feedings would improve the clinical course of preterm infants with respect to earlier bottle feedings, more rapid weight gain, earlier discharge from the hospital, and less morbidity. Fifty-nine preterm infants who were between 28-34 weeks GA were enrolled in the study. Infants were assigned to either the treatment group (pacifier offered during and for five minutes following every tube feeding) or the control group (no stimulation during feeding) by alternating sequential series. The last twenty infants were assigned controlling for race, GA, sex, birth weight, percentile rank, and assisted ventilation. A plastic bib with a trough and a feeding evaluation scale, both developed by the researchers, were used to calculate performance on their first bottle feeding.

Effects of the treatment were measured by the number of tube feedings, daily weight gain, days of hospitalization and discharge weight.

An analysis of variance was done with weight on date of entry as the covariate. Results found the treated infants to attain first bottle feeding on average 3.4 days earlier than the control group ($P<.05$). Researchers suggested that providing NNS opportunities before and after feeding may facilitate the clinical course of premature infants, however responsible mechanisms could not be determined.

Methodological limitations are apparent within the study by Measel and Anderson (1979). The two nurseries involved in this study followed different guidelines regarding infant's readiness for bottle feeding. As well, nurses, physicians and volunteers were not blinded to the group assignments, therefore affecting the methodologic quality of these findings. Duration of the treatment ranged from five to forty days, where only twenty of the infants were controlled for maturational effects. Inclusion criteria were broad yielding a vast variation in the population, resulting in eleven excluded participants. In addition, treatment effects were unclear because NNS opportunities were provided to both groups throughout the day and only controlled for during feeding. Overall, the validity of these results is questionable, however the importance of the information found may be suggestive that providing NNS opportunities to preterm infants may be a beneficial stimulation strategy.

Pickler and Reyna (2004) looked at the effects of NNS in preterm infants on nutritive sucking (NS), breathing, and behaviour during bottle feedings, as well as the relationship between NNS and NS. Ten preterm infants who were between 28 to 31 weeks gestational age at birth and 33 to 40 weeks post-conceptual age at time of observation participated in the study. All infants received NNS stimulation for two minutes before one bottle feeding and served as their own control at a second bottle feeding, where pre-feeding NNS was not allowed. The two feedings occurred within 24 hours of each other and treatment order was randomized. Data were collected during the 48 hours following the infant's first successful bottle-feeding attempt. A stretch sensitive chin strain gauge measured NNS and NS, a nasal thermistor measured breathing characteristics, behavioural characteristics were measured using the Newborn Individualized Development Care Assessment Program (NIDCAP), and routine prefeeding care was provided by the nursing staff.

NNS and NS were compared quantitatively and qualitatively. The Pearson's *r* correlation coefficients were used to make comparisons of outcome measures at the interval level and paired *t* tests for measures using interval data or x^2 for measures with nominal level data were used to examine effects of treatment. Results found no quantitative differences between NNS and NS (sucks per burst and suck burst length); however qualitative differences (ex. rhythm, pattern, shape of waves and intervals between suck bursts) were noted. In addition, when infants received prefeeding NNS, they consumed approximately 13.5% more of their prescribed formula (compared to when no prefeeding NNS was offered). The authors suggested that the mechanisms involved in NNS are different from those needed for the NS, concluding that the use of prefeeding NNS does not affect NS. Therefore, they would not recommend the use of NNS as an intervention to facilitate NS.

There are several limitations found within the study conducted by Pickler and Reyna (2004) which may have compromised the significance of the results. The small sample size of 10 preterm infants is not a sufficient representation of the population (as seen by their sample size calculations) and as a result does not allow for findings to be generalized to similar populations. Additionally, participants serving as their own controls, having only two feeding observations made and maturational effects not being controlled for, may have all contributed to the inability to determine treatment effects. The findings may have further been impacted by biases of personnel within the study as they were not blind. Though these limitations exist, results are suggestive that providing preterm infants with prefeeding NNS may accelerate feeding efficiency and transition to oral feeds, and therefore is of importance in contributing to the successful clinical course of preterm infants.

Discussion

Oral stimulation techniques to establish the NNS have been supported by many researchers as an efficient intervention for increasing feeding skill success in preterm infants. Overall, results from all studies examined support both mechanical stimulation (NTrainer) and stimulation via pacifier in establishing the NNS, consequently increasing the transition time to oral feeding. However, it was found that transition time was consistently accelerated when the NTrainer stimulation was administered.

Still, the literature examined demonstrated limitations such as varying aspects of treatment administration

(time and duration), small sample sizes, and potential for participant bias on feeding readiness, which may have all contributed to diminished validity and reliability of results. The time and length of treatment, and variation in the population of preterm infants who participated in these studies made it somewhat challenging to compare their results. Additional confounds such as limited power to compare effect sizes and inclusion bias were also noted.

The integration of all results still proposes questions. Although evidence supports the NTrainer as a more efficient means of providing oral stimulation, it has yet to be determined which is the most proficient intervention treatment protocol to follow in order to facilitate feeding skills, particularly to increase transition time to oral feeding in this population. Secondly, preterm infants who took part in the studies were all medically stable but varied in weight and age, therefore not consistently predicting which preterm infants would attain the most benefit.

Despite these limitations (methodological issues and small sample sizes) the effects of oral stimulation (via NTrainer vs. pacifier) on establishing the NNS and accelerating transition time to oral feeding is heightened by the quasi-randomized or stratified assignment of preterm infants to groups in the hospital setting (with the exception of the study done by Pickler and Reyna (2004)), and the use of appropriate statistical testing. In addition, results displayed a positive effect of oral stimulation on the development of the NNS, as well as increasing the transition time to oral feeding. Overall, the literature presented in this critical review provides speech-language pathologists who want to facilitate feeding skills in preterm infants, positive support that oral stimulation enhances transition time to oral feeding, optimally when administered via mechanical stimulation.

Clinical Implications

Upon examination of the results of the appraised literature, and despite design limitations, the current available evidence supports oral stimulation as a means to establish the NNS in order to improve feeding outcomes in premature infants. Additionally, there is solid evidence that providing a mechanical stimulation as a habilitation strategy, for example the NTrainer patterned orocutaneous therapy, accelerates feeding success more efficiently than oral stimulation via pacifier, specifically increasing the transition time to oral feeds. Therefore, clinicians should practice and provide oral stimulation by means of patterned orocutaneous therapy (NTrainer) during gavage feeds to establish the NNS as an efficient intervention for facilitating development of feeding skills needed to thrive, particularly enhancing the feeding outcome of transition time to oral feeds. However, the standardization of intervention protocols has yet to be determined.

Future research should use group randomized control trial study designs with larger sample sizes and complete blinding to determine the duration and optimal time (before, during, or after gavage feeding) mechanical stimulation should be applied, in order for the most effective changes in feeding success to occur. As well, furthering the study done by Barlow et al. (2008), to see if the patterned orocutaneous stimulation therapy (NTrainer) has additional benefits on other skills needed for safe and efficient feeding, such as its potential effect on the coordination of the suck-swallow-breathe cycle. Furthermore, it would be beneficial to investigate whether the NTrainer has effects on specific populations of preterm infants (ex. those preterm infants who are not medically stable). These recommendations are made in the hopes that over time concrete intervention guidelines can be developed for speech-language pathologists to use in their practice for this population.

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