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Feeding outcomes and parent perceptions after the pacifier-activated music player with mother's voice trial

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Feeding difficulties common in preterm infants often delay their initial discharge to home (1). Neonatal intensive care unit (NICU) graduates are then at high risk for rehospitalisation during the first year of life, and feeding problems such as aspiration contribute significantly to this morbidity. Gastrointestinal and respiratory diagnoses, primarily aspiration and feeding disorders, account for one-quarter of all readmissions and are among the most expensive readmissions (2). One possible aetiology for these problems is that feeding skills of preterm infants continue to mature to the level of term infants well after discharge from the NICU (3). The acquisition of optimal basic feeding skills in preterm infants before discharge to home can establish a solid basis for later learning of more complex skills and prevention of serious complications.

Effective non-nutritive sucking (NNS) is the basis for more complex oral feeding skills and the focus of multiple feeding interventions (4,5). In a trial of a pacifier-activated music (PAM) player with mother's voice, preterm infants treated between 34 and 36 weeks postmenstrual age showed an improvement of NNS and feeding outcomes with five intervention sessions (6). The intervention, based on operant conditioning of suck with positive reinforcement using mother's voice, improved suck strength and shortened time to oral feeding. Currently, there are no published follow-up studies with patients who received this intervention. In addition, concerns were raised that infants would later not feed orally unless they heard their mother singing or that this technique may create later oral feeding problems (6). We designed a follow-up study using parental report and medical chart audit to test the hypothesis that infants in the PAM intervention group, given their earlier establishment of a basic feeding skill, would have no worse acquisition of developmental feeding milestones than infants in the control group in the first year after discharge to home. As an additional safety measure, we reviewed the medical charts for severe feeding-related morbidities.

Institutional Review Board Approval was obtained to contact parents of previously enrolled infants, to review the infants' medical records and administer by phone a follow-up questionnaire modified (to ensure English was at the level of six years of school) from the Pediatric Feeding History and Clinical Assessment Form (six months and older) section `C6:

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Current Nutritional Status/Feeding History/Responses to Food/Current Skills' created by American Speech-Language-Hearing Association (7). Parents of participants, mean age of 17 months CA, were contacted by phone every day, no more than twice a day, and if not available after one month, were labelled `unreachable'. Required responses were numeric, multiple choice, and yes/no, with opportunities for elaborating on responses as needed. Medical record review identified number of hospitalisations related to feeding problems, documentation of feeding therapy services, aspiration events, result of most recent swallow study, and any new feeding diagnoses. Analyses of group differences were conducted using ANOVA with correction for multiple comparisons for continuous variables and Fisher's exact test for logistic variables.

Of the initial 94 infants in the study, two were deceased, 18 were unreachable, and 72 consented to the study (78.3%). Characteristics of the entire cohort can be found in the original report (6). There were no measurable differences in between infants in the intervention and control groups, or between those lost to follow-up and those who participated (Table 1). All questionnaires were complete. No parent, including those in the intervention group, reported a need for contingent singing in order for their infants to feed at any time between discharge and follow-up. There were no differences between the groups in reflux diagnoses, difficulties with transition to pureed foods or solid foods, drinking from a cup, frequency of mealtimes greater than 30 minutes, nor parental mealtime stress perception. All infants in the intervention group were introduced to pureed food prior to 10 months corrected age, while two of 37 control infants were introduced to pureed food after 10 months, with one reporting difficulties introducing solids as well. Parents of three control group infants reported that their children received feeds via nasogastric or gastrostomy tube after discharge and up to 12 months, confirmed in the medical records. There were no reports or medical record instances of enteral feeds in the PAM group. Parents of two control group infants and no PAM infants reported severe sensory-oral aversions. On medical chart review, infants assigned to the PAM intervention had fewer hospitalisations due to feeding difficulties in the first year of life ($p < 0.001$) and fewer aspiration events requiring intervention during the first three months after discharge ($p = 0.05$).

Our study shows that use of PAM with mother's voice to optimise the acquisition of NNS in preterm infants during NICU hospitalisation does not result in worse developmental progression of feeding milestones or increase the risk of documented feeding-related medical morbidities during the first year of life (Table 2). Infants in the intervention group fed without contingent singing as these behaviours extinguished when the initial reinforcement (singing) was replaced with a stronger reinforcement (food) (8). The developmental progression of feeding skills was not adversely altered by early acquisition of NNS, and there was no increase in feeding aversions as hypothesised in a critique of the original study. Furthermore, all intervention group infants had successful introduction to textured food by 10 months of age, decreasing their likelihood of consuming inadequate food volumes or refusing solids (9). Although it is unlikely that NNS training directly resulted in oromotor and orosensory improvements by 10 months of age, it is possible that a successful and safe early experience with liquid foods resulted in positive reinforcement of early oral feeding behaviours.

We can only speculate on the links between NNS training and decreased aspiration events and feeding-related hospitalisations. Aspiration occurs during the pharyngeal stage of swallowing when airway protective reflexes fail and allow a bolus to enter the lower airway below the vocal folds (10–12). This can lead to permanent damage to the lungs, hypoxic events, and interruptions to normal development (11,12). Chronic aspiration can cause inflammation and increase a child's risk for recurrent pneumonia, interstitial lung disease, bronchiolitis, and apnoea and eventually cause severe impairment of lung function (11,13). Silent aspiration, present in 90–100% of children with documented aspiration, increases the risk of growth failure, malnutrition, and developmental delays (13) and is associated with mealtime behaviour disturbances or oral aversions (12). PAM training increases amplitude and rate of swallowing (6), and NNS training improves the rhythmicity of sucking patterns (9). These gains may in turn benefit the suck–swallow–breathe relationship, acknowledging that reduced aspiration is most likely related to improved swallow–respiration coordination (14,15). Aspiration in early childhood affects preterm more than term infants and contributes to morbidity and mortality (11,13).

This follow-up study suggests that these infants may have fewer rehospitalisations due to feeding problems in the first year of life, possibly associated with more mature feeding skills, resulting in fewer adverse events. PAM's potential effect on oral feeding skills may therefore have economic consequences on postdischarge care of preterm infants. In the United States, the average hospital costs per readmission due to gastrointestinal and chronic respiratory diagnoses are $4153 and $9049 respectively (2). Although neither the initial trial nor the current study was powered to analyse cost-effectiveness, the potential gains from a decrease in length of stay during the initial hospitalisation and fewer subsequent readmissions suggest the need for further studies designed to address these questions (6).

This study suffered from the limitations inherent to questionnaires and chart reviews, such as potential recall bias or incomplete medical record documentation. A questionnaire may also lack the sensitivity to detect feeding difficulties not related to acquisition of developmental processes. Future studies using prospective, quantitative assessment of feeding skills (feeding volumes/rates/patterns, oropharyngeal assessment of deglutition or orosensory responses) and long-term neurodevelopmental outcomes would strengthen the widespread use of NNS training.

In conclusion, we have previously shown that PAM using mother's voice as positive reinforcement is an effective oromotor intervention to improve oral feeding skills in the NICU. Our follow-up study shows that a brief exposure to PAM in the NICU is not associated with a slower developmental progression of feeding skills in the first year of life and may be associated with fewer aspiration events and fewer rehospitalisations with feeding-related diagnoses. Further studies are needed to examine these potential long-term benefits.

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Abbreviations

CA	Corrected age
DC	Discharge
NICU	Neonatal intensive care unit
NNS	Non-nutritive sucking
PAM	Pacifier-activated music player.

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Table 1

Characteristics of follow-up cohort

	Intervention N = 35	Control N = 37	Lost to F/UP* N = 20
EGA in weeks (median, IQR)	31 (26, 32)	30 (26, 32)	30 (28, 32)
Sex (% female)	50	51	55
Severe WMI (% prior to discharge)	9	8	5
Any WMI (% prior to discharge)	19	19	5
PMA at discharge in weeks (median, IQR)	36 (35, 39)	36 (35, 40)	37 (35, 38)
Weight at DC in Kg (median, IQR)	2.41 (2.16, 2.88)	2.55 (2.22, 2.95)	2.52 (2.12, 2.86)
Head circumference, at DC in cm (median, IQR)	32 (30, 33)	32 (31, 33)	32 (30, 34)
Corrected age at follow-up in months (mean, SD)	17 (4.0)	17 (3.7)	

IQR = Interquartile range, (25th, 75th); EGA = Estimated gestational age at birth; PMA = Postmenstrual age.

Table 2

Feeding behaviours and medical morbidities in the first year of life

	Intervention N = 35	Control N = 37
Parent-report data in N (%)		
Refusal to feed without mother singing at anytime	0	0
Feeding difficulties first three months after discharge	7	10
Difficulties with reflux in first three months	7	7
Difficulties with coordination of SSB first three months	2	4
Feeding difficulties lasting more than three months	4	7
Feeding difficulty at time of survey	3	6
CA at introduction of pureed foods in months (median, IQR)	4.5 (1, 5)	5.0 (1, 7)
Introduction of pureed foods prior to 10 months CA	0	2
Problems taking pureed foods	3	8
Problems taking solid foods	2	3
Problems drinking from a cup	0	4
Problems chewing solid food	0	7*
Eating time >30 min	7	6
Mealtimes stressful	8	7
Medical chart review N (%)		
Hospitalisations related to feeding problems in the first year	2	15**
Aspiration events requiring intervention first three months	1	7*
Received SLT/Feeding therapy in the first year	1	4

Severe WMI: severe white matter injury defined as intraventricular haemorrhage grades III or IVH, periventricular leukomalacia, hydrocephalus).

Any WMI: all WMI including intraventricular haemorrhage grades I and II.

CA, corrected age; SSB, Suck–swallow–breathe; SLT: Speech language therapist; VFSS, Videofluoroscopic swallow study.

* p = 0.05

** p = 0.01;