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Exploring Factors Related to Oral Feeding Progression in Premature Infants

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Abstract

Purpose—To identify infant and maternal characteristics associated with the pace of progression from the first oral feeding to complete oral feeding.

Subjects—One hundred forty-two stable premature infants who were fully or partially gavage feeding immediately after birth (29-34 weeks gestational age at birth).

Design—Exploratory secondary analysis.

Method—Data are from an ongoing randomized clinical trial of a developmental maternally-administered intervention (H-HOPE) for mother-infant dyads at high social-environmental risk.

Main Outcome Measures—Oral feeding progression (transition time from the first attempt to complete oral feeding).

Sample Characteristics—The convenience sample of preterm infants consisted of 48.6% male infants; the mean gestational age (GA) at birth was 32.4 weeks and mean birthweight was 1787 grams; African American mothers (47.9%, $n = 80$) and Latina mothers (52.1%, $n = 83$).

Principle Results—Multivariable linear regression results showed that, on average, the number of days for infants of Latina mothers to achieve complete oral feeding was 2.43 days longer than for infants of African-American mothers. In addition, lower birthweight and lower postmenstrual age (PMA) at first oral feeding were associated with longer feeding progression. Higher infant morbidity was correlated with longer feeding progression.

Conclusion—Infants with Latina mothers, lower birthweight, lower PMAs at first oral feeding, and higher morbidity scores had a longer transition from first to complete oral feeding. Identification of infants at risk for delayed transition from first to complete oral feeding may allow for the development and testing of appropriate interventions that support the transition from gavage to complete oral feeding.

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Keywords

oral feeding progression; birthweight; gestational age; post menstrual age; health status; premature infants

The mortality rate of preterm infants has significantly decreased due to advances in medical management and technology. However, preterm infants are often challenged in achieving complete oral feeding. Successful oral feeding is essential for growth and a key determinant of a preterm infant's readiness for hospital discharge.^{1, 2} While we know that gestational age at birth (GA), postmenstrual age (PMA - sum of GA and chronological age (CA)³), birthweight, infant sex, and health status of infants all influence the development of oral feeding skills,^{3,4,6-21} information is lacking regarding other characteristics that may affect the length of oral feeding progression such as maternal race/ethnicity, plurality, infant morbidity score, five minute APGAR score, and intake at first oral feeding. The purpose of the study was to identify infant characteristics associated with progression from the first to complete oral feeding in infants born between 29 and 34 weeks GA to mothers at high social-environmental risk.

Review of literature

In order to achieve successful oral feeding, preterm infants must be able to coordinate breathing, sucking, and swallowing.³ The components of sucking, swallowing, and breathing develop at different times.³ The coordination of these three components also matures at different rates.³ The rates of maturation and coordination are greatly influenced by infant GA and PMA.^{4,6-14} Additionally, researchers have shown an early GA is significantly correlated with an increase in transition time from partial oral feeding to complete oral feeding.^{7, 8, 9} Compared with full-term infants (born at 40 weeks GA or greater), preterm infants (born between 26 and 29 weeks GA) exhibited a significantly shorter sucking cycle time (measured from the peak of one sucking pattern to the peak of the next sucking pattern),¹⁰ smaller intensity of sucking pressure (measurement of the depth from the highest peak to the lowest point in one sucking pattern),¹⁰ shorter length of time between sucks,^{4, 6} decreased number of sucking bursts (length of suck between pauses),^{4, 6} lower sucking frequency (number of sucks per minute),¹¹ and lower swallowing frequency (number of swallows per minute).¹¹ The average milk transfer (amount of milk (mL) per minute) and bolus size (amount of milk (mL) per swallow) were significantly lower in the preterm infant than full-term infant.¹¹ The rate of milk transfer increased over time within the preterm group indicating infant feeding skills improved over time and were associated with older GA at birth.¹¹ These findings suggest that GA influences oral feeding skills and patterns in preterm infants, and therefore may affect their oral feeding progression.

In addition to GA, advancing PMA influences oral feeding progression.^{11, 12, 13} From 34 weeks PMA and beyond, the number of sucks, intensity of sucking pressure, average time between sucks, average time between bursts, and sucks per burst were significantly different when compared with infants less than 34 weeks PMA.^{13,14,15} With maturation (older PMA), the preterm infant's ability to coordinate respiration with swallowing was greatly improved, which supported the transition from gavage to complete oral feeding.⁶ In breastfed preterm infants, from 29 weeks PMA and older, obvious rooting, repeated short sucking burst, and effective latching were recorded.¹⁵ Occasional long sucking bursts and repeated swallowing were noted from 31 weeks PMA.¹⁵ Researchers also suggested that sucking behaviors and the ability to maintain a more alert state were significantly improved in older PMA infants¹³ which further suggests that PMA may play a major role in preterm infant oral feeding progression.

Evidence suggests birthweight may be a significant predictor of oral feeding progression from gavage to complete oral feeding.¹⁶ Researchers also reported that the infant's birthweight was a significant predictor of feeding efficiency.¹⁶ Larger birthweight was significantly associated with more coordinated breath, suck, and swallow cycles.¹⁷ Infants with higher birthweights swallow at either mid-expiration or during apnea which was shown to significantly reduce the risk of aspiration.¹⁷ However, premature infants with very low birthweight (VLBW) exhibit a significantly shorter sucking cycle length (amount of time from the peak of one suck to the peak of the next suck) and low sucking pressures (measured in mmHg as the strength of the suck – e.g. the depth from the lowest pressure to the peak pressure of one suck), thus confirming that infants with lower weights have more difficulty with oral feeding.¹⁰

The relationship between neonatal mortality and the “male disadvantage” has been recognized for almost half of century.¹⁸ Among low birthweight infants, male infants demonstrated higher perinatal mortality and morbidity when compared to their female counterparts.¹⁹ Male infants were less stable than female infants and had more difficulties adjusting to the external environment after birth as evidenced by low Apgar scores, higher incidence of respiratory distress syndrome, lung related injuries, greater need for physical and pharmacological assistance, intubation, or resuscitation medication.^{19, 20} Female sex had been described as an advantage for survival as well as short and long term outcomes for extremely low birthweight infants.²¹ In infants who weighted between 501-1500 g at birth, the short-term mortality rate for males was higher, 22% versus 15% for females.²⁰ Additionally, males had a higher risk for adverse neonatal outcomes.²⁰ Especially in premature infants, researchers reported male sex was a significant biological risk factor for poor cognitive and motor development.²² Since infant sex greatly influences infant health status and development, it is possible that infant sex may also affect oral feeding progression.

The Problem Oriented Perinatal Risk Assessment System (POPRAS) was designed to predict medical risk for mortality in the perinatal and neonatal period with higher POPRAS scores indicating more severe neonatal morbidity.^{22,23} High neonatal morbidity is significantly correlated with an increase in transition time from partial oral feeding to complete oral feeding.⁸ Medical complications including certain diagnoses related to respiratory, digestive, neurological and cardiac status have also been found to be positively correlated with the length of transition time from gavage to complete oral feeding.⁷ POPRAS scores have also been shown to correlate with one and five minute Apgar scores,^{22,23} suggesting the Apgar score may be an early indicator of morbidity, in turn affecting feeding progression.

In summary, various parameters, including GA, PMA, birthweight, infant sex, and health status, have been associated with the development of oral feeding skills in premature infants.^{2,4, 6-23} However, evidence regarding the potential relationships among maternal race/ethnicity, plurality (singleton, twin or triplet), amount of first oral intake and oral feeding progression remains lacking. It is crucial to identify these relationships to help clinicians identify infants who are at risk for slow feeding progression and apply appropriate interventions to support safe progression to complete oral feeding.

Purpose

The purpose of this study was to identify infant and maternal characteristics associated with the pace of progression from the first oral feeding to complete oral feeding. Identification of infants at risk for a longer transition from gavage to complete oral feeding may allow for more thorough clinical assessment of these factors prior to initiation of oral feeding.

Method

Study Setting

The study was conducted in two inner city community-based Chicago medical centers, one with a level II and one with a level III Neonatal Intensive Care Unit.

Study Design

This exploratory study was conducted via a secondary analysis of a larger randomized clinical trial of a maternally-administered developmental intervention (H-HOPE).²⁴ Since infants in the intervention group did not differ from those in the control group with respect to the outcome of feeding progression, we used infants in both groups for this study.

Sample Selection

Research participants for the larger study were recruited between 2008 and 2011. The target population was healthy premature infants born between 29 and 34 weeks GA whose mothers had two or more social-environmental risks. These social-environmental risks included self-identification as African-American or Latina, less than high school education, less than 18 years of age, history of current mental illness, or depression, family income less than 185% of the federal poverty level, more than one child younger than 24 months, 4 or more children under 4 in the household, and residing in disadvantaged neighborhood. For mothers of twins, one of her infants was selected randomly to participate in the study. Exclusion criteria for infants included congenital anomalies, necrotizing enterocolitis, positive finding on head ultrasound, receiving assisted ventilation at the time of enrollment, chronic lung disease, and prenatal drug exposure. Mothers were not eligible if they were identified in the medical record as substance abuse, HIV positive, or if they were not the infant's legal guardian.

One hundred fifty-eight infants from the larger study were fully gavage or only partially oral feeding at enrollment, and were eligible for this exploratory study. One infant did not achieve 100% oral feeding before discharge and another was transferred to another hospital so feeding data were not available. Both were excluded from this analysis. In addition, 14 infants demonstrated highly abnormal feeding patterns. All of these infants achieved complete oral feeding for three consecutive days, but then regressed to gavage feeding for several days before returning to complete oral feeding. Half of these infants showed a pattern of weight loss prior to regressing to gavage feedings, indicating an event or illness disrupted their ability to feed orally. These infants were also excluded from the analysis. The final analytic sample included 142 infants.

Sample Description

The sample consisted of 49.3% ($n = 79$) male infants. Infants had a mean gestational age (GA) at birth of 32.4 weeks, and mean birthweight was 1791 grams. African-American mothers (47.9%, $n = 80$) and Latina mothers (52.1%, $n = 83$) participated in the study. Please refer to Table 1 for the full sample description.

Measures

Feeding progression—Feeding progression was measured as the number of days from first oral feeding to 100% oral feeding. After manual examination of feeding patterns from the medical record, we defined the first day of oral feeding as the first of at least three days when infants received 10% or more of their total gut nutrition orally. This eliminated early, brief oral attempts that were followed by long stretches of gavage feeding. Achievement of 100% long as complete oral feeding was maintained for at least two additional consecutive days, or the infant was discharged home within that time period. According to this

definition, an infant could have a value of zero if he or she achieved 100% oral feeding on the first day that the bottle was offered.

Procedure

Infant characteristics obtained from the medical record, included infant sex, plurality (singleton, twin or triplet), gestational age (GA) at birth, birthweight, infant morbidity (measured by the Problem Oriented Perinatal Risk Assessment System (POPRAS) score), postmenstrual age (PMA) at first oral feeding, five minute Apgar score, and proportion oral to gavage intake on day of first oral feeding (first oral intake). Maternal race/ethnicity was obtained from maternal interview.

The Institutional Review Boards at the university and the two clinical sites approved the original (H-HOPE) research. After confirming the mothers' eligibility and willingness to participate, informed consent was obtained. Infant characteristics and feeding progression data were obtained from the medical record by a member of the research team. For the feeding progression data, a neonatal intensive care nurse on the research team abstracted the exact amount of breastmilk and/or formula that was given to each infant gavage or oral on each day of hospital stay.

Statistical Analysis

Categorical infant characteristics were individually examined for their association with feeding progression using *t*-test. Pearson's correlation was used to explore the association between each continuous infant characteristic and feeding progression. A multivariable linear regression model was conducted using manual backward selection to choose factors significantly related to feeding progression after simultaneously controlling for other factors. Alpha was set at 0.05.

Results

The number of days from first to complete oral feeding ranged from 0 (two infants achieved complete oral feeding on the first day it was attempted) to 27 for preterm infants in our sample and the mean was 7.6 days (*SD* = 5.6). Significant negative correlations were detected between longer oral feeding progression and lower GA ($r = -0.28, p < 0.001$), lower birthweight ($r = -0.28, p < 0.001$), lower proportion of oral to gavage intake on first day of attempted oral feeding ($r = -0.19, p = 0.02$), and lower PMA at first oral feeding ($r = -0.19, p = 0.03$). A significant positive correlation was identified between higher infant morbidity and longer oral feeding progression ($r = 0.22, p < 0.01$). A trend toward a significant association was identified between maternal race/ethnicity and oral feeding progression ($p = 0.09$). No significant associations with feeding progression were noted for infant sex, plurality, and five minute APGAR score. Please see Table 1.

In a multivariable linear regression, infant birthweight, PMA at first oral feeding, infant morbidity, and maternal race/ethnicity were significantly associated with feeding progression. Lower birthweight in kilograms ($\beta = -4.16, p < 0.001$) and lower PMA at first oral feeding in weeks ($\beta = -0.95, p = 0.01$) were both negatively associated with longer feeding progression. In addition, higher infant morbidity were associated with longer feeding progression ($\beta = 0.05, p = 0.02$). The time in days from first to complete oral feeding was 2.43 days longer, on average, for infants of Latina compared with African American mothers ($p < 0.01$). The other infant and maternal variables considered were dropped from the final model because they were not significant at $p < 0.05$. See Table 2.

Discussion

In this current study, infants with lower GA at birth, birthweight and PMA at first oral feeding and higher morbidity demonstrated a longer progression from first to complete oral feeding. These variables are related and should be considered as indicators by clinicians during assessment of readiness to initiate oral feeding. Of interest was the finding that infants of Latina mothers also demonstrated an increase in the length of time to progress from gavage to complete oral feeding. No previous report has identified maternal racial/ethnic identity as a predictor of oral feeding progression for preterm infants. The initial bivariate analysis identified a significant relationship between lower intake at first oral feeding and longer progression from gavage to complete oral feeding. This variable was not significant in the multivariable analysis.

It is well known that GA at birth affects the length of oral feeding progression in premature infants.^{9, 25} Infants born at 34–35 weeks GA exhibited disorganized oral motor behaviors.²⁶ In a sample of preterm infants with a mean GA of 29 weeks (range = 23 – 35 weeks) and mean birthweight of 1230 grams (range = 560 – 2180 grams), Pickler and colleagues (1997) identified that infants at lower GA and birthweight progressed to complete oral feeding at a much slower rate and achieved complete oral feeding at an older PMA.²⁶ A retrospective study by Dodrill et al. (2008) also revealed that younger GA was a significant risk factor for an increased transition time from the initiation of oral feeding to successful complete oral feeding.⁸ Similarly, in preterm infants born between 29 and 33 weeks GA, White-Traut and colleagues (2005) reported that older GA at birth was a significant predictor of higher frequency of feeding readiness behaviors (such as mouthing, hand-to-mouth, hand swipes at mouth, and sucking on tongue prior to feeding).¹⁶ Feeding efficiency was greatly influenced by the frequency of feeding readiness behaviors,¹⁶ thus, GA at birth may be a useful predictor of feeding efficiency. Our finding of longer transition time from first to complete oral feeding for infants with younger GA is consistent with previous research, and thus should be considered an important predictor of oral feeding progression.

PMA is another important indicator of oral feeding efficiency (ml oral intake/total feeding time) and progression to complete oral feeding.^{16, 26} Previous investigators have demonstrated that PMA affects the frequency of pre-feeding behavioral cues, behavioral states, as well as the maturation of the ability to suck, potentially leading to improved feeding efficiency.^{12, 16, 27} White-Traut et al. (2005) reported a positive correlation between PMA at the time of initiation of oral feeding and number of feeding readiness behaviors which in turn was predictive of improved feeding efficiency.¹⁶ Similarly, Lau et al. (2000) reported a significant positive correlation between PMA and sucking ability.¹² Preterm infants with older PMA demonstrated more advanced sucking patterns and were better able to use the rhythmic alternation of suction and expression and compression.¹² Additionally, oral feeding performance was significantly enhanced with more advanced sucking patterns.¹² Medoff-Cooper and colleagues (2000) reported that premature infants were noted to be more alert during feeding when they were at 34 weeks PMA or older.¹³ Alert behavioral states are considered to be the optimal state immediately prior to oral feeding in premature infants.²⁸ These findings suggest that older PMA is a significant predictor of oral feeding efficiency. The negative correlation between PMA at first oral feeding and longer oral feeding progression in the current study, combined with findings from previous research, confirms the importance of PMA as an indicator of readiness to initiate oral feeding.

Birthweight has been used by clinicians as another indicator for initiating oral feeding in premature infants.¹⁶ White-Traut et al (2005) suggested that birthweight was positively correlated with the number of feeding readiness behaviors and indirectly predicted feeding

efficiency.¹⁶ Additionally, birthweight is related to improved coordination of breathe, suck, swallow leading to more efficient feeding.¹⁷ Matsubara et al. (2005) compared sucking bursts for eight VLBW with seven full-term infants and reported that VLBW infants exhibited lower sucking pressures and shorter sucking bursts, reducing feeding efficiency.¹⁰ Our findings of the negative association between lower birthweight and longer oral feeding progression supports previous findings. Birthweight should continue to be used as one criterion during assessment for initiation of oral feeding.

Previous research has linked high neonatal morbidity and medical complications with delay in the transition from gavage to complete oral feeding.^{8, 9} Our homogenous sample consisted of premature infants at low risk for medical complications, yet a relationship between increased morbidity and lengthier feeding progression was still identified. In our sample there was no relationship between the five-minute APGAR score and oral feeding progression. The findings suggest that infant morbidity throughout hospitalization may better predict length of transition from first to complete oral feeding in clinically stable preterm infants than the five minute APGAR scores and should be used as a more complete assessment of infant morbidity before initiating oral feeding in premature infants.

Researchers have reported that African-American infants have overall poorer outcomes including higher rates of preterm birth, lower birth birthweight, higher morbidity, and higher mortality when compared with Hispanic and Caucasian infants.²⁹⁻³⁴ However, this is the first report of maternal racial/ethnic identity as a predictor of oral feeding progression for preterm infants. This was especially surprising given that infants of Latina versus African-American mothers had higher birthweights (mean = 1844 and 1733, respectively, $p = 0.08$) and higher five-minute Apgar scores (mean = 8.61 and 7.85, respectively, $p < 0.0001$), on average. There were no other differences by maternal race/ethnicity in infant characteristics. This finding of longer progression to oral feeding among infants of Latina mothers is of interest and warrants further research to determine whether other demographic and obstetric factors that were not measured in this study may fully or partially explain the association between maternal Latina identity and slower feeding progression in preterm infants.

Although infant sex is considered a risk factor for high mortality and mobility¹⁸⁻²² which in turn can greatly affect oral feeding progression, in this study of healthy preterm infants, infant sex was not significantly correlated with oral feeding progression. It is possible that the “male disadvantage” is not as pronounced in healthy infants born between 29-34 weeks gestational age as it is for extremely low birthweight infants, who are typically born between 22 and 31 weeks gestational age.²¹

Strengths and Limitations of the Study

The generalizability of findings is limited to otherwise healthy infants born at 29-34 weeks gestation to Black and Latina mothers at high social-environmental risk. The narrow range of sample inclusion criteria yielded less variability in the sample. The strength of this study was the availability of data on daily intake of formula and breastmilk during hospital stay, and the proportion that was fed orally versus gavage. This allowed us to examine the transition to complete oral feeding in depth in an understudied population of infants born to mothers at high social-environmental risk.

Implications for Research and Practice

Maternal race/ethnicity, birthweight, PMA, and GA were predictive of an infant's rate of transition to complete oral feeding, suggesting that several indicators should be included in the assessment of infant readiness for initiation of oral feeding. Additionally, assessment of these characteristics may be useful to clinicians in identifying infants who are at risk for a

longer transition from gavage to oral feeding. Identification of preterm infants who are at risk may inform the development and testing of appropriate interventions that support the transition from gavage to complete oral feeding. Further research is needed to establish evidence-based guidelines regarding when oral feeding should be initiated.

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Table 1
Infant Characteristics and Their Association with Time in Days from First to Complete Oral Feeding ($n = 142$)

Infant Characteristic	Sample Mean (SD)	Range	Correlation with Feeding Progression (r)	p^*
Gestational Age (weeks)	32.4 (1.5)	29 - 34	-0.28	0.0007
Birth Weight (grams)	1791 (377)	1000 - 3146	-0.28	0.0007
Infant morbidity score	72 (18.5)	41 - 136	0.22	0.009
Oral intake first day of oral feeding, as proportion of total gut nutrition	0.4 (0.4)	0.10 - 1.00	-0.19	0.02
Post Menstrual Age (PMA) at first oral feeding (weeks)	33.4 (1.1)	30.1 - 36.1	-0.19	0.03
5 Minute APGAR score	8.2 (1.1)	5 - 9	0.12	0.17

Infant Characteristic	Sample %	Feeding Progression (days) mean (SD)	p^{**}	
Infant sex	Female	50.7%	7.4 (6.1)	0.69
	Male	49.3%	7.8 (6.4)	
Maternal race/ethnicity	African-American	47.9%	6.8 (5.6)	0.09
	Latina	52.1%	8.4 (5.6)	
Plurality	singleton	85.2%	7.6 (5.8)	0.98
	twin or triplet	14.8%	7.6 (4.4)	

* Pearson's correlation

** t -test

Table 2
Linear Regression Model of Factors Associated with Time in Days from first to 100% Oral feeding ($R^2 = 0.18$), $n = 142$

Variable		SE	<i>p</i>
Intercept	47.54	13.06	--
Latina vs African-American Maternal race/ethnicity	2.43	0.88	0.007
Birthweight (kg)	-4.16	1.18	0.0006
PMA at First oral feeding, wks	-0.95	0.38	0.01
Infant morbidity score (POPRAS)	0.05	0.02	0.02

The following variables were considered in the full model, but were dropped because they were not significant at $p < 0.05$: Gestational age, infant sex, plurality, five-minute Apgar score, experimental group, and proportion PO day of first oral feeding.