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The transition to oral feeding in low-risk premature infants: Relation to infant neurobehavioral functioning and mother–infant feeding interaction

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ABSTRACT

Background: The achievement of oral feeding is a critical task for the premature infant–mother dyad, yet neurobehavioral and relational factors associated with feeding difficulties of low-risk premature infants during hospitalization are not well understood.
Aim: To examine the relations between infant neurobehavioral functioning, the transition to oral feeding, and the emerging mother–infant feeding relationship in premature infants.
Study design and subjects: Ninety-seven low-risk premature infants (birth weight>1000 g; gestational age>30 weeks) and their mothers were followed at the NICU. Neurobehavioral functioning was assessed with the Rapid Neonatal Neurobehavioral Assessment Procedure.
Outcome measures: The duration of the transition to oral feeding and specific feeding difficulties during the transition were assessed. Infant feeding robustness, suck and milk transfer rates, and maternal adaptability, affect, intrusiveness and distractibility were coded from videotaped mother-infant feeding interactions prior to discharge from the NICU.
Results: Thirty percent of the infants presented feeding difficulties during the transition to oral feedings. Infants with abnormal neurobehavioral functioning (37% of the cohort) showed more feeding difficulties, slower suck rates, and lower feeding robustness, and their mothers displayed less adaptive and more intrusive behavior. Maternal intrusiveness was related to lower feeding robustness and to lower suck and milk transfer rates. Neurobehavioral functioning and maternal feeding behavior predicted feeding robustness.
Conclusions: Less intact neurobehavioral functioning in the neonatal period is related to difficulties during the transition to oral feeding and to less optimal early mother–infant feeding interactions. Low-risk premature infants with poor neurobehavioral functioning should receive special attention and care.

1. Introduction

Among the central challenges of modern neonatal care is to provide adequate nutritional intake for the growth and development of the fragile premature infant [1], while supporting a favorable environment for the emerging mother–infant feeding relationship [2]. Successful feeding is a complex developmental process [3] and a major criterion for hospital discharge [4]. Feeding is therefore one of the most important tasks to be mastered by the mother–preterm infant dyad during the neonatal period. Although recent research has focused on the feeding difficulties of high-risk preterm infants [5], little is known about feeding difficulties in low-risk infants and on the relations between the infant's neurobehavioral functioning and the mother–infant feeding relationship at the transition from gavage to nipple feeding in the NICU.

Non-optimal neurobehavioral functioning is common among premature infants, even among those born at low-risk with uncomplicated hospitalization [6,7]. Neurobehavioral maturation provides the necessary framework for the infant's ability to progress to oral feeding. Postural control, sleep–wake regulation, sucking maturation, and suck–swallow–breath coordination are known as neurobehavioral markers associated with the ability to feed orally [8,9]. We propose that neurobehavioral dysfunctions, even when mild and discrete, are likely to be related to difficulties in regulating feeding at the neonatal period.

Studies on the sucking patterns of premature infants point to the emergence of an increasingly organized and mature feeding pattern over time [10]. Among the manifestations of this maturation is the infant's gradual transition from gavage to independent oral feeding during the hospitalization period [3], typically around 34 weeks

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postconceptional age [11]. Due to the anatomical, physiological, and neurobehavioral immaturity that accompany premature birth, the achievement of independent oral feeding during hospitalization is particularly challenging for the preterm infant and his/her mother. Reduced intestinal motility and absorption, delayed gastric emptying, low esophageal tone, poor coordination of suck and swallow, cardiovascular and respiratory instability, and difficulty in maintaining awake state are some of the common problems in the transition to oral feeding of preterm infants [9,12,13].

In addition to feeding orally, neurobehavioral functioning enables infants to display clear behavioral responses to environmental stimuli [7,14], which in turn assist the mother in developing a sensitive feeding relationship that corresponds to the infant's signals. In general, premature infants are more dependent on the mother's sensitive and supportive care giving to reach optimal development [15]. At the same time, mothers of premature infants experience more anxiety and depression [16], tend to be more stimulating and intrusive, and show lower levels of sensitivity during interactions [17,18]. The combination of sub-optimal infant neurobehavioral functioning and more intrusive parenting may disrupt the development of an optimal feeding relationship, a central context for the infant's growth and thriving.

The feeding and growth of premature infants remain major topics of concern for both parents and pediatric care teams [19,20]. Nevertheless, neonatal intensive care has traditionally emphasized oral intake achievement and overlooked the quality of the mother–infant feeding interaction [21]. The role of early caregiving experiences in supporting the infant's physical, emotional, and cognitive development has been well-documented [22,23]. However, few studies examined the achievement of oral feedings in low-risk premature infants within a comprehensive framework that considers neurobehavioral (e.g., integrity of neonatal reflexes, muscle tone, sensory-motor adaptation, state control, etc.), functional (e.g., suck and milk consumption rates; duration of transition), and relational–emotional (e.g., positive behaviors during the feeding interaction) components of the infant's feeding competencies during hospitalization.

In light of the above, the goal of the present study was to examine the relationships between the infant's neurobehavioral status prior to hospital discharge, the transition to oral feeding, and the mother–infant early feeding interaction in low-risk preterm infants. We hypothesized that a less optimal neurobehavioral status would be related to a longer and more complicated transition to oral feedings and to less efficient sucking behaviors prior to discharge. In addition, mothers of infants with a less optimal neurobehavioral status would engage in less appropriate feeding interactions, in terms of lower maternal adaptability and higher intrusiveness. Finally, we hypothesized that both functional and relational determinants of the feeding interaction would be uniquely predictive of the infant's robustness of feeding as well as of the level of maternal intrusive behavior during the feeding interaction.

2. Methods

2.1. Participants

Ninety-seven premature infants and their mothers participated in this study. Infants were born at the Sheba Medical Center Neonatal Intensive Care Unit (NICU), a level III medical center in Israel, from February 2004 to April 2006. A low-risk sample was selected to eliminate the potential effects of neurological damage and high psychosocial risk on feeding performance and early mother–infant interactions. Infants included in the study were of low medical risk, whose mean gestational age (GA) was 32.5 weeks (standard deviation [SD]: 1.4; range: 30–35.1 weeks), and mean birth weight was 1690 g (SD: 349.7; range: 1010–2540 g). Exclusion medical criteria were intraventricular hemorrage grades II, III and IV, perinatal asphyxia, metabolic, genetic, or syndromatic disease. To limit the potential effect of socio-emotional stress, exclusion psychosocial criteria were teenage pregnancy, single parenthood, and unemployment of both parents. All mothers were above 21 years, living with the infant's father, with no report of using psychoactive drugs or psychiatric medication. Families were considered to be of middle class by Israeli standards [24]. Families were recruited to participate in a longitudinal follow-up of infant development in the first two weeks following birth. The study was approved by the Institutional Review Board of Sheba Medical Center and informed consent was obtained from all participants. Thirty percent of the mothers approached declined to participate, citing time constraints, partner's refusal, or not feeling ready to deal with developmental issues as main reasons. These mothers and infants did not differ from the participating families on any of the demographic or medical variables.

2.2. Procedure

The transition to oral feeding was assessed daily from the infant's clinical charts starting at the infant's first oral feeding attempt until the attainment of full oral feedings. Oral feedings were initiated according to the unit's medical protocols when the infant was approximately 34 weeks GA and weighed approximately 1700 g. Bottle feeding was chosen in this study to allow for accurate measurements of outcome measures. Participating infants were bottle-fed during their stay in the NICU in at least 4 out of 8 daily feedings. Approximately 2 days prior to discharge (GA = 36.4 ± 1.1 weeks) neurobehavioral assessment was conducted with the Rapid Neonatal Neurobehavioral Assessment Procedure (RNNAP) [25], a mother–infant feeding interaction was videotaped, and mothers completed self-report measures of depression and social support. RNNAP testing was conducted by a senior neonatologist trained and certified by the team who developed the tool. This assessment was performed in the presence of the mother in a quiet room next to the NICU before a morning feed when the infant was alert and responsive.

2.3. Measures

Infant medical risk was measured with the Clinical Risk Index for Babies (CRIB) [26].

2.3.1. Transition to oral feedings

(a) Feeding difficulties during transition—difficulties were documented daily from the infant's clinical charts and by directly asking the mothers. Difficulties considered for analysis included the occurrence of the following clinical events during the transition to oral feeding: (1) feeding-related apnea, bradycardia or both [3,27], (2) milk spitting or vomiting [28], (3) long feeding sessions (more than 25 min) [29]. Infants were categorized as those presenting or not presenting any of the aforementioned difficulties during the transition period. (b) Duration of the transition period—the number of days from the infant's first oral (i.e., bottle) feeding attempt to full (i.e., 8 feeds per day) oral feeding was assessed by daily examination of the clinical chart during the progression from gavage to oral feedings.

2.3.2. Neurobehavioral (NB) assessment

The RNNAP is a clinical evaluation of the infants' neurobehavioral functioning, which assesses the integrity and organization of the infant's sensory-motor system. The RNNAP has shown reliability and validity in differentiating premature infants at various levels of neurological risk and in predicting developmental outcome [25].

The assessment includes 17 behavioral subcategories that test the integrity of neonatal reflexes, reactivity to visual and auditory stimulation, passive and elicited motor responses, and state control. The infant's performance in each subcategory is rated as normal or abnormal based on clinical judgments. Administration requires training. The criteria for abnormality are determined according to the following guidelines: Visual attention—infant unable to differentially fixate on a pattern paired with a blank stimulus, or unable to follow a pattern smoothly across midline. Auditory attention—unable to consistently turn the head from midline to rattle and voice presented on right and left. Sensory asymmetry—better visual or auditory orienting to one direction. Head/neck control—floppy, weak, and little attempt to lift or pull head up. Extremity movements/tone—hypo or hypertonicity of arms, legs and trunk. Lateral asymmetry—better tone, amount or quality of movement on one side of the body. State control—very highly aroused, very irritable, or very low arousal, difficult to rouse, unresponsive. Jitteriness—fine or gross tremors of arms and legs, spontaneous or elicited. For a full description of the procedure, scoring and abnormality criteria see Gardner et al. [25,30]. Lower NB functioning is reflected in an increased RNNAP total score. The feeding subcategory that is part of the standard RNNAP was excluded from score calculation in the present study, and eight infants categorized as having an abnormal NB assessment solely based on the feeding item were excluded from the present analysis. All of the 89 remaining infants received a NB score based on categories unrelated to feeding. The subcategories and proportions of infants with abnormal performance in each subcategory are presented in Table 1.

Infants included in the analysis (n=89) were divided into two groups: infants with normal performance in all RNNAP subcategories (normal group, 56 infants) and infants with abnormal performance on any of the subcategories (abnormal group, 33 infants).

2.3.3. Mother–Infant feeding interaction

All mothers in the study bottle-fed their infants at least once a day. Most participating mothers (91%) expressed breast milk for at least one daily feed. In addition to providing expressed breast milk, 65% of mothers' breast fed their infants occasionally. Moreover, 60% of mothers provided occasional skin-to-skin care. There were no differences between groups in provision of breast-feeding and skin-to-skin care. A morning feeding session was videotaped approximately two days before discharge. At this time, all infants were completely weaned from gavage feeding and reached full independent oral feeding. Observed feeding sessions were naturalistic to the NICU environment and took place at the infant's bedside, as routinely done in the unit. Following hospital practice, infants remained connected to a vital-signs monitor and nursing staff was available throughout the feeding session. Mothers were instructed to feed their infants as they normally do. During the first 2 min of the feeding, a close-up of the infant's face was videotaped to allow for a detailed observation of the infant's sucking movements. Following, the feeding session was videotaped using a wider frame that allowed for the observation of both mother and infant. Six minutes of feeding interaction were coded in a university laboratory on a computerized system (The Observer, Noldus Co.), by experienced observers blind to the infant's NB status. Feeding interactions were available for 87 mother–infant dyads.

Two classes of variables were coded: (a) Sucking efficacy—(*1*) *Suck rate*—discrete sucks on the 2-minute close-up video were marked. A suck rate measure (sucks/min) [31] was then obtained by dividing the total count of sucks by the duration of the observation. (*2*) *Milk transfer rate*—milk volume taken by the infant and the duration of the feeding session were measured at the end of the feeding indicating the volume of milk transferred per time unit (ml/min) [11].

(b) *Mother–Infant Interaction* was coded by the CIB—newborn version (Feldman, 1998), a well-validated system for the coding of mother–newborn interactions [32] that contains both micro-level codes and global rating scales. [33,34].

Micro-analytic coding was conducted along the following categories and codes within each category were mutually exclusive. (1) Infant Feeding Robustness—robust (mouth well closed around nipple, well defined and vigorous sucks), weak (mouth relaxed around nipple, weak and shallow sucks), or not feeding; (2) Maternal Gaze—gaze oriented to infant, to bottle, or away; (3) Maternal Vocalization—“motherese” talk to infant, adult-like talk to infant, talk to others, or no talk. The proportion of time for each behavior out of the total observation time was calculated. A Maternal Distractibility factor was computed as the sum proportions of time mothers spent gazing away and talking to others (α=0.68). Inter-rater reliability was computed for 12 sessions and reliability exceeded 85% in all categories. Mean reliability was 92%, *kappa*=.84 (range=.78–.91). The 3 global codes from the CIB-newborn system were rated on a scale of 1 to 5 and included: Maternal Adaptability—the degree to which mother adjusts her behavior and involvement to the infant's signals; Maternal Positive Affect—maternal delight and enjoyment during feeding; and Maternal Intrusiveness—mother's attempts to stimulate her infant to feed even when infant gives signs of fatigue or disengagement. Inter-rater reliability for the global codes averaged 97%, intraclass r=.94.

2.3.4. Self report measures

Maternal depressive symptoms were assessed with the Beck Depression Inventory [35], a well-validated instrument for the detection of depressive symptoms. The social support network was assessed with a measure adapted from Crockenberg [36].

2.4. Data analysis

The prevalence of feeding difficulties during the transition for the two NB groups was calculated with χ^2. Each of 4 outcome clusters was analyzed with a separate Univariate or Multivariate Analysis of Covariance (ANCOVA or MANCOVA), with NB group (normal/abnormal) and gender as the between-subject factors. Infants' GA and length of hospitalization were entered as covariates. Univariate analysis followed significant main effects. The 4 clusters were: 1) transition to oral feedings (duration); 2) sucking efficacy (suck rate; milk transfer rate); 3) infants' behavior during feeding (feeding robustness); 4) maternal behavior during feeding (distractibility, affect, adaptability, and intrusiveness). Associations between feeding behavior variables were examined with Pearson correlations. Two hierarchical multiple regressions were used to predict infant feeding robustness and maternal intrusiveness from infant neurobehavioral functioning, dyadic feeding behavior, and the mother's background variables.

3. Results

Medical and demographic information for the normal and abnormal NB groups are presented in Table 2. Infants with an abnormal NB assessment had lower GA and thus, statistical analysis was conducted with GA as covariate. Both groups were comparable on the other medical and demographic variables.

Table 1
Proportion of infants with neurobehavioral abnormalities in the RNNAP

Neurobehavioral category	Sub-category	% Abnormal
Attention	Visual	14.6
	Auditory	10.1
Sensory asymmetry	Visual	7.8
	Auditory	7.8
Head–neck control	Extension	7.8
	Flexion	1.1
Extremity movements/tone	Hypertonic arms	3.4
	Hypotonic arms	3.4
	Hypotonic legs	2.2
	Hypertonic legs	13.5
	Hypotonic trunk	2.2
	Hypertonic trunk	1.1
	Arms/legs asymmetry	2.2
Lateral asymmetry		4.5
State control		7.8
Jitteriness		1.1

Table 2
Family demographic and infant medical variables

	Normal NB(n=56)		Abnormal NB(n=33)		P
	M	SD	M	SD	
Birth Weight (g)	1753.4	340.09	1644.8	341.71	.150
GA (weeks)	32.9	1.19	32.1	1.39	**.004**
GA (weeks) at NB test	36.4	1.19	36.5	1.01	.723
CRIB	0.3	0.76	0.8	0.62	.120
Apgar 1 min	8.7	0.81	8.3	1.01	.066
Apgar 5 min	9.8	0.49	9.5	0.79	.124
Mother age (years)	33.8	5.78	32.0	4.04	.128
Mother education(years)	14.9	2.41	14.6	2.71	.615
Father age (years)	36.4	5.89	36.1	5.88	.871
Father education (years)	14.5	2.70	14.7	2.69	.713
Gender (male/female)	29/27		18/15		.829
Singleton/twin	37/19		20/13		.652
Primipara/multipara	26/30		15/18		.553

3.1. Infants' neurobehavioral functioning and the transition to oral feeding

Fifty-six infants (63%) had a normal score, i.e., performed optimally in all tested neurobehavioral subcategories. The remaining 37% had some degree of NB abnormality: 12% of infants presented abnormalities in just one subcategory; the remaining 25% performed abnormally in two or more subcategories.

Clinical and feeding variables for the two NB groups are summarized in Table 3. Infants' NB status was related to the length of hospitalization, which was entered into the following analysis as a covariate. Infants in both groups were comparable on the rest of clinical and feeding variables.

3.1.1. Feeding difficulties during transition

During the transition to oral feeding, 27 of the 89 infants (30.3%) presented feeding difficulties. Difficulties were twice as frequent in the abnormal NB group, with 45% of infants experiencing difficulties as compared to 21% in the normal NB group, $\chi^2_{(1,\ N=89)}$=5.67, p<.05).

3.1.2. Duration of transition

Attempts at oral feeding were initiated at an average of 35.0± 1.16 weeks GA (range: 33.5–40), and full independent oral feeding was achieved at 35.9±1.25 weeks GA (range: 33.9–40.3). The duration of the transition period was 6.2±3.33 days (range: 0–17 days) for the whole cohort. An ANCOVA conducted for the duration of transition showed no significant difference between the normal and abnormal NB group (5.8± 3.01 days and 7.0±3.72 days, respectively; $F_{(1,83)}$<1.0; NS).

3.1.3. Sucking efficacy

A MANCOVA conducted for sucking efficacy variables (suck and milk transfer rates) with NB group and gender as between-subject factors showed an overall main effect for NB group ($F_{(2,74)}$=4.68; p<.05). Univariate tests showed that infants with abnormal NB status had a significantly slower suck rate (22.9±10.59 sucks/min) as compared to infants with normal NB status (33.8±14.78 sucks/min; $F_{(1,75)}$=9.39; p=.003; Fig. 1). No significant difference was found for milk transfer rate.

Table 3
Clinical and feeding variables

	Normal NB(n=56)		Abnormal NB(n=33)		p
	M	SD	M	SD	
Days in hospital	29.1	11.27	35.8	12.86	**.012**
GA (weeks) at discharge	37.1	1.46	37.2	1.30	.694
Weight loss during hospitalization (% of BW)	9.3	3.59	10.8	3.84	.060
Weight gain during transition (g/kg/day)	14. 1	7.55	14.9	7.11	.659
GA (weeks) at first oral feeding	35.0	1.29	35.1	0.91	.952
Expressed milk feeds (out of 8 feeds)	4.7	2.64	4.5	2.26	.826

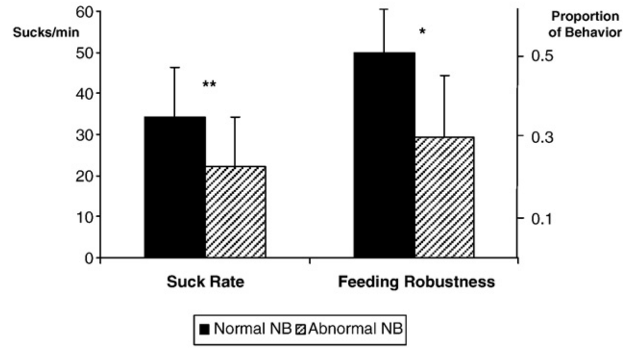

Fig. 1. Feeding behavior of infants with normal and abnormal NB.

3.2. Mother and infant behavior during feeding interaction

3.2.1. Infant feeding robustness

ANCOVA with NB and gender as between-subject factors revealed that infants with abnormal NB status spent less time in robust feeding (31±20% of observation) as compared to infants with normal NB status (49±15% of observation; $F_{(1,75)}$=5.84; p=.018; Fig. 1).

3.2.2. Maternal behavior

A MANCOVA for maternal behavior (maternal distractibility, affect, adaptability, and intrusiveness) with NB group and gender as between-subject factors showed a main effect for NB group ($F_{(4,74)}$=6.13; p<.001). Univariate tests showed lower maternal adaptability (3.3±1.17; $F_{(1,77)}$= 5.88; p=.018) and higher maternal intrusiveness (2.8±1.35; $F_{(1,77)}$= 18.56; p=.000) among mothers of infants with abnormal NB compared to those with normal NB (3.9±1.14 and 1.6±0.94, respectively; Fig. 2). No differences were found for maternal affect and distractibility. A main effect was also found for infant gender ($F_{(4,74)}$=2.69; p<.05). Univariate tests showed higher maternal distractibility when feeding female (17.0± 13.4) than male (12.5±9.10) infants ($F_{(1,77)}$=6.20; p=.015). No other gender effects or gender by NB interactions were found.

3.2.3. Associations between infant and mother feeding behavior

Infant feeding robustness was related to a lower (i.e., more optimal) neurobehavioral score (r=−.23; p<.05), to faster suck and milk transfer rates (r=.48; p<.01 and r=.47; p<.01, respectively), to higher levels of maternal distractibility (r=.32; p<.01), and lower levels of maternal intrusiveness (r=−.31; p<.01). Maternal intrusiveness was negatively related to infants' suck and milk transfer rates (r=−.40; p<.01 and r=−.33; p<.01, respectively), pointing to the relationship between neurobehavioral functioning, feeding efficiency, and maternal and infant's feeding behaviors.

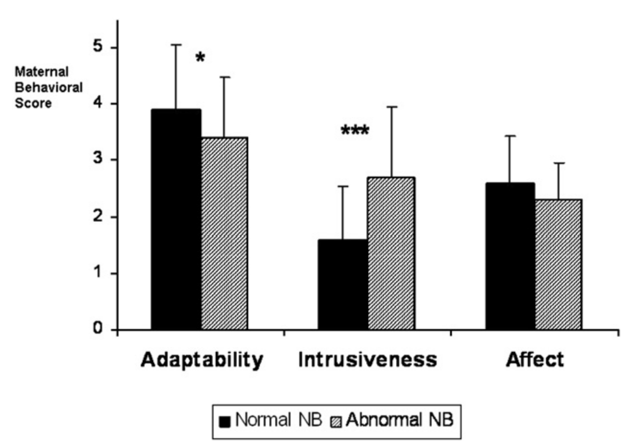

Fig. 2. Maternal feeding behavior scores in normal and abnormal NB dyads.

3.3. Predicting infant and maternal feeding behavior

3.3.1. Infant's feeding robustness

A hierarchical multiple regression model was computed to predict infant feeding robustness from neurobehavioral status, progression to oral feedings, maternal feeding behavior and maternal factors. Predictors were entered in four blocks: in the first block, infant's RNNAP total score was entered as a continuous variable; in the second block, transition duration and occurrence of feeding difficulties were entered as variables characterizing the progression to oral feedings; in the third block, maternal distractibility and maternal intrusiveness were entered as primary markers of sub-optimal maternal feeding behaviors; finally, in the fourth block, maternal depression and social support were entered as maternal socio-emotional factors.

As seen in Table 4, the infants' neurobehavioral functioning and maternal behavior, particularly lower intrusiveness, were each uniquely predictive of feeding robustness. A similar analysis including GA in the model as an additional factor did not affect the model, showing that GA did not account for the variance explained, and that feeding robustness was dependent upon the above factors irrespective of GA in this low-risk cohort.

3.3.2. Maternal intrusiveness during feeding

A similar hierarchical multiple regression predicting maternal intrusiveness by infant neurobehavioral status, progression to oral feedings, infant's feeding robustness, and maternal factors was computed. Predictors were entered in the same fashion as in the previous model, except for the third step, which included the infant's feeding robustness, to examine the contribution of this overt behavior to maternal intrusiveness, beyond other infant measures. As seen in Table 5, maternal intrusive behavior during feeding was predicted independently by infant feeding robustness. Infant's neurobehavioral functioning and infant's progression to oral feeding did not have a significant contribution to the variance explained in maternal intrusiveness. A similar analysis including GA as an additional factor showed that this factor did not account for the variance explained by the model.

4. Discussion

This study is among the first to examine the relationships between infants' neurobehavioral functioning, the progression to oral feedings, and the mother–infant feeding relationship in low-risk premature infants prior to hospital discharge. Results indicate that non-optimal neurobehavioral functioning of low-risk premature infants in the neonatal period are associated with less favorable outcomes in both the functional and the relational domains of feeding. As hypothesized, infants with an abnormal neurobehavioral status, even in a mild form, showed more feeding difficulties during the transition to oral feedings, slower suck rate, and a less robust feeding behavior upon hospital discharge, pointing to the links between the infant's neurobehavioral functioning and his/her emerging feeding competence [8]. Mothers of infants in the abnormal neurobehavioral group, in turn, were less adapted and more intrusive, showing an overall less optimal feeding behavior. The neurobehavioral assessment was useful in identifying medically low-risk infants who are susceptible for feeding difficulties and a sub-optimal mother–infant feeding interaction, regardless of birth weight or GA. As such, the findings highlight the increased risk for the emergence of early feeding problems in low-risk premature infants with poor neurobehavioral functioning, and underscore the need for early neurobehavioral evaluations and careful developmental monitoring of these infants that are not typically at the focus of NICU care.

Table 4
Mother–infant feeding interaction at NICU: prediction of infant's feeding robustness

	Beta	R^2 change	F change
NB (RNNAP)	−0.133	0.062	4.136*
Transition duration	0.217	0.040	1.368
Feeding difficulties	−0.315*		
Maternal distractibility	0.205	0.236	10.511***
Maternal intrusiveness	−0.429*		
Maternal depression	0.095	0.010	0.440
Social support	−0.065		

R^2 Total = 0.35; $F_{(7,57)}$ = 4.34, p < .01, *p < .05 ***p < .001.

Table 5
Mother–infant feeding interaction at NICU: prediction of maternal intrusiveness

	Beta	R^2 change	F change
NB (RNNAP)	0.122	0.041	2.705
Transition duration	0.272*	0.062	2.098
Feeding difficulties	−0.340*		
Infants' feeding robustness	−0.475***	0.199	17.060***
Maternal depression	−0.081	0.025	1.068
Social support	−0.152		

R^2 Total = 0.33; $F_{(6, 58)}$ = 4.68, p < .01, *p < .05 ***p < .001.

Over a third of the infants in this low-risk sample showed an abnormal score in at least one of the assessed neurobehavioral subcategories. The occurrence of mild neurobehavioral difficulties among infants with an uncomplicated hospitalization course is consistent with previous research showing poorer neurobehavioral functioning in healthy premature infants at term age, as compared to full term infants [6,7]. Although feeding difficulties have been known to occur during the transition to oral feeding in premature infants [3], reports of their incidence in low-risk preterm samples are scarce. In our study, almost one third of the infants presented feeding-related difficulties during the transition, findings that underscore the relevance of these difficulties among low-risk cohorts.

Less robust infant feeding behavior, lower maternal adaptability, and higher maternal intrusiveness characterized the abnormal NB group, pointing to the associations between the infant's neurobehavioral status and the mother–child feeding behaviors. Specific risk signals for potential difficulties in the early mother–infant feeding relationship can be detected already at the NICU. The first regression model showed that lower maternal intrusiveness predicted the infant's feeding robustness. The second model, in turn, indicated that the infant's poorer feeding performance, as evidenced in less robust feeding, was predictive of higher maternal intrusiveness. These mutual effects resonate with a transactional perspective on early parent–infant relationships [37], which postulates that maternal and infant behavior affect each other in a mutual influencing manner, jointly shaping developmental outcome.

Infants' neurobehavioral competency appears to have an impact on the mother–infant relational system [38]. In light of the associations between less robust feeding and more intrusive and less distracted maternal behavior, we suggest that the infant's feeding robustness, an overt behavior directly observable by the mother, may play a pivotal role in the emergence of early mother–infant feeding interactions. During the interactions of infants whose feeding was less robust, mothers adopted a behavioral style characterized by more intrusiveness and less distraction from the feeding task. These behaviors seem to be in line with the maternal intrusive and controlling style previously reported for mothers of premature infants [18,39], which is thought to stem from the mothers' effort to promote the infant's growth and their difficulties in responding sensitively to the infant's cues [40,41]. However, in the present study a more intrusive maternal behavior was related to less optimal feeding outcomes in terms of infant suck rate and feeding robustness before hospital discharge. These results are consistent with previous research showing that higher maternal intrusiveness may be detrimental to feeding outcomes in infants in general [42], and in premature infants in particular [43]. It is important to note, however, that these results cannot be interpreted in terms of causal relationships. Further research is required to determine the directionality of influences between infant and mother within the dyad and to test whether lower NB functioning induced lower feeding robustness that ultimately affected maternal behavior, or whether higher maternal intrusiveness led to lower feeding robustness.

The lack of significant differences between groups in transition duration and milk transfer rates may reflect the use of a protocol of advancement to oral feeding that is based primarily on quantitative milestones (e. g., volume consumed, duration of feeding session) and overlooks behavioral manifestations of feeding competence. Our findings underscore the maternal and infant feeding behaviors as important determinants of the infant's competent achievement of oral feedings, supporting current caregiving trends that call for a more comprehensive, developmentally supportive approach to oral feeding progression in premature infants during NICU hospitalization [2,44].

Although the hospitalization course of low-risk premature infants can be medically uneventful, the frequent, albeit often mild, neurobehavioral and feeding difficulties that characterize these low-risk infants can potentially shape the very early dyadic feeding interaction. The findings might be important for pediatric care teams when addressing the potential difficulties of low-risk dyads in the domain of feeding. Moreover, our results highlight the period of NICU hospitalization as an important time-window for the emergence of positive mother–infant feeding interactions. We suggest that early detection of functional and relational feeding difficulties, prevention of intrusive maternal feeding behaviors, and promotion of maternal sensitivity to the infant's behavioral cues, should be part of NICU-based interventions aimed at optimizing these early interactions.

Limitations of the study relate to the fact that mother–infant feeding interactions were examined exclusively upon hospital discharge, a time when infants were capable of full independent oral feeding. The longitudinal observation of feeding interactions during the hospitalization period might provide a better understanding of the dyad's emerging feeding capacities and challenges. Furthermore, and in light of the high incidence of long-term feeding problems among NICU graduates [45], future research should address the continuity of feeding difficulties after hospital discharge and further examine neonatal predictors of later feeding difficulties in low-risk premature infants.

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