Quantitative assessment of nutritive sucking patterns in preterm infants

Ariel A. Salas et al.

Citation of published version:
Salas, A. A., Meads, C., Ganus, S., Bhatia, A., Taylor, C., Chandler-Laney, P., Imtiaz, M. H., & Sazonov, E. (2020). Quantitative assessment of nutritive sucking patterns in preterm infants. In Early Human Development (Vol. 146, p. 105044). Elsevier BV. https://doi.org/10.1016/j.earlhumdev.2020.105044

HHS Public Access
Author manuscript
Early Hum Dev. Author manuscript; available in PMC 2021 October 12.

Published in final edited form as:
Early Hum Dev. 2020 July ; 146: 105044. doi:10.1016/j.earlhumdev.2020.105044.

Quantitative assessment of nutritive sucking patterns in preterm infants

Ariel A. Salas[a,*], **Claire Meads**[b], **Shae Ganus**[b], **Anisha Bhatia**[a], **Caitlin Taylor**[a], **Paula Chandler-Laney**[c], **Masudul H. Imtiaz**[d], **Edward Sazonov**[d]

[a]Department of Pediatrics, University of Alabama at Birmingham, Birmingham, AL 35249, USA

[b]Department of Physical Medicine & Rehabilitation, University of Alabama at Birmingham, Birmingham, AL 35249, USA

[c]Department of Nutrition Sciences, University of Alabama at Birmingham, Birmingham, AL 35249, USA

[d]Department of Electrical and Computer Engineering, University of Alabama, Tuscaloosa, AL 35487, USA

Abstract

Objective: To assess patterns of nutritive sucking in very preterm infants ≤32 weeks of gestation.

Study design: Very preterm infants who attained independent oral feeding were prospectively assessed with an instrumented feeding bottle that measures nutritive sucking. The primary outcome measure was nutritive sucking performance at independent oral feeding.

Result: We assessed nutritive sucking patterns in 33 very preterm infants. We recorded 63 feeding sessions. The median number of sucks was 784 (IQR: 550–1053), the median sucking rate was 36/min (IQR: 27–55), and the median number of sucking bursts during the first 5 min of oral feeding was 14 (IQR: 12–16). Maximum sucking strength correlated with the number of sucks ($r = 0.62$; $p < 0.01$). No safety concerns were identified during the study.

Conclusion: The quantitative analysis of nutritive sucking patterns with a newly developed instrumented bottle in stable, very preterm infants is safe and feasible. More research is needed to develop and refine the instrument further.

Keywords

Neonatal feeding; Oral feeding skills; Sucking behavior; Oral readiness; Premature infants

[*]Corresponding author at: Division of Neonatology, University of Alabama at Birmingham, 1700 6th Ave South, Women & Infants Center Suite 9380, Birmingham, AL 35233, USA. asalas@peds.uab.edu (A.A. Salas).

CRediT authorship contribution statement
Ariel A. Salas: Conceptualization, Methodology, Supervision, Formal analysis, Resources, Writing - original draft. **Claire Meads:** Conceptualization, Data curation, Investigation. **Shae Ganus:** Conceptualization, Data curation, Investigation. **Anisha Bhatia:** Conceptualization, Data curation, Investigation. **Caitlin Taylor:** Investigation, Data curation. **Paula Chandler-Laney:** Methodology, Writing - review & editing. **Masudul H. Imtiaz:** Software, Methodology, Visualization. **Edward Sazonov:** Supervision, Software, Methodology, Resources, Writing - review & editing.

Declaration of competing interest
AAS, PCL, and ES submitted an intellectual property disclosure and filed a patent application for the instrumented bottle used in this study.

1. Introduction

Unlike term infants, preterm infants often lack oral skills to breastfeed or bottle-feed immediately after birth [1]. Tube feeding before oral feeding is a medical necessity for preterm infants [2,3] who usually undergo lengthy transition phases from tube feeding to independent oral feeding. Attaining independent oral feeding is crucial for development [4] and essential for safe discharge of very preterm infants (≤ 32 weeks of gestation) [5]. Delayed attainment of independent oral feeding increases the risk of adverse neurodevelopmental outcomes and prolongs hospitalization in preterm infants [4,6,7].

Most experts agree that the complexity of mastering the suck-swallow-breath mechanism is not the only cause of delay in attaining independent oral feeding among preterm infants [8–10]. The subjectivity in the bedside clinical assessment of nutritive sucking can also contribute to delays in attaining independent oral feeding [6]. Assessing oral skills without objective information on nutritive sucking [11–14] often leads to trial-and-error approaches that delay the transition from tube to oral feeding and prolong hospital stay of pre-term infants [2,3].

With instruments to assess nutritive sucking patterns quantitatively, clinicians could identify preterm infants with abnormal patterns early and assess responses to oral interventions objectively. This type of quantitative assessment may promote early attainment of independent oral feeding, reduce the length of hospital stay, and thus lower healthcare costs in preterm infants at high risk for prolonged hospitalization [15]. We recently instrumented a regular feeding bottle to measure nutritive sucking patterns objectively. The aim of this study was to quantitatively assess nutritive sucking patterns in very preterm infants using a novel instrumented bottle (IB).

2. Material and methods

Very preterm infants ≤32 weeks of gestation admitted to a neonatal unit were screened to determine study eligibility after initiation of oral feeding. Inclusion and exclusion criteria were assessed when infants were close to attaining independent oral feeding. Only infants who attained independent oral feeding were included. Infants with congenital anomalies were excluded. Infants with severe comorbidities (intraventricular hemorrhage grade 3 or 4, periventricular leukomalacia, posthemorrhagic hydrocephalus, necrotizing enterocolitis stage 3, or history gastrointestinal surgery) were also excluded. When an infant was deemed to be eligible for inclusion in the study, their parents or legal guardians were approached by a study team member to obtain written informed consent. This study protocol was approved by an Institutional Review Board.

The primary study intervention was the quantitative assessment of nutritive sucking with the IB. This novel system contains a pressure sensor inside the bottom of a commercially available feeding bottle (Playtex Baby VentAire® with Drop-Ins®) that detects variations in air pressure inside the bottle as nutritive sucking collapses the disposable liner that separates the milk from the sensor [Fig. 1]. The IB also contains an accelerometer that detects bottle orientation and a camera that captures infant facial expressions to evaluate responsiveness and activity level during feeding.

The first quantitative assessment of nutritive sucking was performed on either the first or the second day of independent oral feeding in all infants. Up to two additional assessments were performed during subsequent days in some infants who were able to be assessed more than once. All infants were assessed between 11 a.m. and 3 p.m. to minimize the variability of oral feeding performance according to time of day. Each feeding session with the IB was conducted with the infant in an elevated side-lying position under continuous cardiorespiratory monitoring. Infants were fed by a speech-language pathologist who collected information on the amount of volume administered, the total duration of oral feeding, and the occurrence of transient episodes of oxygen desaturation, apnea, or bradycardia. A slow flow nipple (NaturaLatch® Playtex Baby) was used for all the feeding sessions with the IB.

Nutritive sucking patterns were determined using generic algorithms applied to both sucking strength and sucking density data. Quantitative information on sucking density (i.e., number of sucks over the entire feeding session) was analyzed to calculate the number of sucks per feeding session, the number of sucks per minute (i.e., sucking rate), and the number of sucking bursts. A sucking burst was defined as an organized pattern of high-frequency suction preceded or followed by a pattern of low-frequency suction. These patterns of low and high-frequency suction were identified in a normalized sucking density scale created from infant-specific sucking density data (Fig. 2). For this type of digital signal processing, the raw sucking density signal was smoothed with a Gaussian window function. Once the smoothed sucking density signal was generated, a peak detection algorithm was applied to the smoothed data to ascertain the beginning and end of a sucking burst. Prespecified, physiologic cutoffs defined in term infants [16] were not used to detect these patterns of low and high-frequency suction in the smoothed sucking density scale illustrated in Fig. 2B. In this figure, sucking bursts were denoted with an asterisk, and the sucking burst with the highest number of sucks was assigned a value of 1.0 (100%). All the other sucking bursts with a lower number of sucks were assigned values lower than 1.0 using the sucking burst with the highest number of sucks as reference. For instance, if a sucking burst with 30 sucks was followed by a sucking burst with 15 sucks, the first sucking burst was assigned a normalized sucking density value of 1.0 (100%), and the following sucking burst was assigned a normalized sucking density value of 0.5 (50%). In this normalized sucking density scale, the occurrence of a sucking burst was quantified, but the duration of a sucking burst in seconds was not determined. Information on bottle orientation, specifically the angle of the nipple in relation to gravity, was also captured to determine the number of brief feeding interruptions during an entire feeding session.

Baseline characteristics were summarized as means ± standard deviations (SDs), medians and interquartile ranges (IQRs), and frequencies and proportions. Linear correlations were analyzed with the Pearson correlation coefficient. The association between the number of sucks and the number of sucking bursts was measured in unadjusted and adjusted linear regression models. Longitudinal data on nutritive sucking were analyzed with a repeated measures mixed model. The covariates in the adjusted models were gestational age at birth,

birth weight, sex, race, and corrected gestational age. All statistical analyses were performed using JMP Pro 14.0 (SAS Institute, Cary, NC).

3. Results

Forty-two infants were recruited for the study, but nine were excluded from the analysis after certification that their IB data were missing or unreadable. Nutritive sucking data from 33 infants were included in the final analysis. The baseline characteristics of these infants are shown in Table 1. The median gestational age was 28 weeks, and the mean birth weight was 1182 g.

The quantitative assessment of the nutritive sucking patterns at independent oral feeding was conducted at a median corrected gestational age of 37 weeks (IQR: 36–39). Numeric and graphic representation of nutritive sucking data were generated for each of the 63 feeding sessions with the IB [Fig. 2].

At independent oral feeding, the median number of sucks was 784 (IQR: 550–1053), the median sucking rate was 0.6/s (IQR: 0.5–0.9), the median number of brief feeding interruptions (i.e., bottle orientation changes) was 10 (IQR: 6–15), and the median number of sucking bursts was 52 (41–65). Corrected gestational age had a significant correlation with sucking rate ($r = 0.39$; $p < 0.001$) and maximum sucking strength ($r = 0.42$; $p < 0.01$). Maximum sucking strength significantly correlated with the number of sucks ($r = 0.62$; $p < 0.01$). A positive association between the number of sucks and the number of sucking bursts was found in unadjusted regression models ($R^2 = 0.38$; $p < 0.0001$). This positive association was also observed after adjusting for gestational age at birth, birth weight, race, sex, and corrected gestational age ($R^2 = 0.44$; $p < 0.0001$).

The results of the repeated measures analysis performed to account for individual variability in nutritive sucking patterns are provided in Table 2. This analysis indicated that the nutritive sucking patterns at independent oral feeding were sustained. Both univariate and multivariate analyses showed that sucking rate and the number of sucking bursts had the lowest individual variability.

No safety concerns related to the utilization of the IB to measure nutritive sucking at independent oral feeding were identified during the study. Serious adverse events that resulted in death, life-threatening events, prolonged hospitalization, or significant disability were not observed. More than two-thirds of the feeding sessions (68%) were classified as uneventful. Eventful feeding sessions were characterized by transient episodes of mild bradycardia or oxygen desaturations. No interventions beyond standard patient care were required for these episodes. The effects of these episodes on oral feeding performance were not analyzed.

4. Discussion

In this prospective study, we used a novel system to quantify the nutritive sucking patterns of clinically stable, very preterm infants. We characterized patterns of nutritive sucking at independent oral feeding and provided reference data for very preterm infants.

Among preterm infants assessed at independent oral feeding, measurements of sucking density showed less variability than measurements of sucking strength. The number of sucking bursts during the first 5 min of oral feeding, a measurement of temporal sucking density, consistently ranged between 12 and 16 during the majority of the feeding sessions. Furthermore, the median number of sucks, another measurement of sucking density, remained stable over time in the repeated measures analyses reported. The notion of separate maturation processes for the two pressure-dependent components of nutritive sucking – expression (positive pressure on the teat) and suction (negative pressure) – could explain the high variability in our measurements of sucking strength.

An essential advantage of monitoring sucking density instead of sucking strength is that a wide variety of feeding instruments accurately measure the number of sucks [17]. The Kron-Medoff-Cooper Nutritive Sucking Apparatus detects the number of sucks with a thin catheter in the bottle nipple [7,18–20]. The Oral Motor Kinetic (OMK) Monitoring System also uses a small catheter in the bottle nipple to measure nutritive sucking and integrates monitoring of sucking, swallowing, and breathing [9,21]. Nfant® Feeding Solution measures nipple movement [6,22], displays quantitative data on tongue movement against the nipple in real-time and makes use of this information to determine the number of sucks and sucking performance [22]. Other devices with wireless technology have also been developed [23]. Although most of these instruments have oral feeding data validated over the past 20 years, limited clinical evidence supports their use in hospital settings [21]. A recent meta-analysis of instruments to facilitate oral feeding in preterm infants concluded that no evidence is currently available to inform clinical practice [24].

Unlike assessment of non-nutritive sucking patterns, assessment of nutritive sucking patterns has not yet been evaluated in combination with bedside clinical assessments in randomized trials [25,26]. Few studies have attempted to predict which preterm infants will rapidly attain independent oral feeding [10,27]. Our results suggest that simple quantitative measurements of nutritive sucking can be integrated into current bedside clinical assessment [28] to predict readiness for progression to independent oral feeding. Early identification of preterm infants more likely to benefit from a rapid progression of oral feeding could reduce the burden of frequent and time-consuming assessments of oral feeding performance and expedite hospital discharge. In future studies, preterm infants progressing toward independent oral feeding could be longitudinally monitored with this novel system. If nutritive sucking patterns with steady increments in the number of sucks or sucking bursts are observed, analyses of these patterns in combination with current bedside clinical assessments of nutritive sucking could facilitate the successful progression toward independent oral feeding. Conversely, if patterns with declines in the number of sucks or sucking bursts are observed, analyses of these patterns would indicate limited ability to attain or sustain independent oral feeding and validate bedside clinical assessments indicative of poor oral feeding performance. This strategy could be crucial for infants with gestational ages < 28 weeks of gestation and birthweight < 1000 g [1]. Time to independent oral feeding in this subgroup of preterm infants significantly correlates with the length of hospitalization [5,29], and adverse neurodevelopmental outcomes [4,6,7].

Ideally, monitoring of the number of sucks during nutritive sucking should be cost-effective with reusable instruments, minimally invasive, easy to combine with other developmental care practices, and suitable for routine use in neonatal units by bedside nurses and clinicians. This pragmatic approach to monitor nutritive sucking patterns in preterm infants at high risk for prolonged hospitalization could reduce bias in the assessment of readiness to feed orally, promote early attainment of independent oral feeding, and minimize health care costs attributed to the length of hospital stay [2,3]. The IB has many of these characteristics but is still in the early stages of development and not a complete feeding instrument. With this novel system, we can identify preterm infants unable to generate or sustain multiple sucking bursts and thus may signal insufficient suck-swallow-breath coordination. However, we cannot assess suck-swallow-breath coordination directly. Other feeding instruments have the same limitation [30], particularly those that measure non-nutritive sucking. Only sophisticated instruments that measure breathing and swallowing during nutritive sucking generate detailed information on suck-swallow-breath coordination [31], but the use of these type of instruments in daily clinical practice appears burdensome. To increase objectivity in the daily assessment of nutritive sucking, clinicians need to accept indirect measurements of oral feeding performance. Although direct measurements of function are generally preferred, relying on indirect measurements of function is a standard practice in neonatal units. For instance, critical clinical decisions to improve cardiorespiratory function are often made based on changes in heart rate and respiratory rate, both indirect measurements of function.

The main strength of the study is that we analyzed nutritive sucking patterns in preterm infants exclusively. Nutritive sucking patterns at independent oral feeding in preterm infants often differ from those observed in term infants [16,32]. The average number of sucks and sucking rates reported in this study are similar to those reported in other studies using other instruments [3,31]. Another strength is that we performed repeated measures analyses to account for individual variability and postmenstrual age. The main limitations of the study are the small sample size and some of the study procedures used to assess independent oral feeding. By using the IB to assess nutritive sucking patterns, we disregarded information on oral feeding performance during exclusive breastfeeding. Some argue that, before term corrected age, exclusive breastfeeding without bottle feeding of expressed mother's milk may affect the nutrition of preterm infants [33]. However, most international organizations favor breastfeeding over bottle feeding [34]. Also, by not allowing parents to use the IB per study design, we failed to determine the effects of parental involvement on oral feeding performance. Several studies suggest that parental involvement in oral feeding of preterm infants promotes a positive bonding experience and facilitates the attainment of independent oral feeding [35]. These limitations indicate that bottle instrumentation as a method to monitor nutritive sucking will not improve oral feeding performance in neonatal units with substantial parental involvement and high rates of exclusive breastfeeding. Another limitation is that the IB was tested with only one type of commercially available bottle nipples.

In summary, this patient-oriented research may address the problem of subjectivity in the assessment of oral feeding performance and provide clinical evidence to quantify nutritive sucking patterns with the instrumentation of commercially available feeding bottles. Further analyses of sucking burst patterns could improve the determination of readiness for progression to independent oral feeding in preterm infants. Future research is needed with this newly developed instrument to further develop and refine it.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Abbreviations:

IB	instrumented bottle

References

[1]. Walsh MC, Bell EF, Kandefer S, Saha S, Carlo WA, D'Angio CT, et al. , Neonatal outcomes of moderately preterm infants compared to extremely preterm infants, Pediatr. Res 82 (2017) 297–304. [PubMed: 28419085]

[2]. Simpson C, Schanler RJ, Lau C, Early introduction of oral feeding in preterm infants, Pediatrics 110 (2002) 517–522. [PubMed: 12205253]

[3]. Kish MZ, Oral feeding readiness in preterm infants: a concept analysis, Adv. Neonatal Care 13 (2013) 230–237. [PubMed: 23912014]

[4]. Mizuno K, Ueda A, Neonatal feeding performance as a predictor of neurodevelopmental outcome at 18 months, Dev. Med. Child Neurol 47 (2005) 299–304. [PubMed: 15892371]

[5]. American Academy of Pediatrics Committee on F, Newborn, Hospital discharge of the high-risk neonate, Pediatrics 122 (2008) 1119–1126. [PubMed: 18977994]

[6]. Capilouto GJ, Cunningham TJ, Mullineaux DR, Tamilia E, Papadelis C, Giannone PJ, Quantifying neonatal sucking performance: promise of new methods, Semin. Speech Lang 38 (2017) 147–158. [PubMed: 28324904]

[7]. Medoff-Cooper B, Nutritive sucking research: from clinical questions to research answers, J. Perinat. Neonatal Nurs 19 (2005) 265–272. [PubMed: 16106235]

[8]. Gewolb IH, Vice FL, Maturational changes in the rhythms, patterning, and coordination of respiration and swallow during feeding in preterm and term infants, Dev. Med. Child Neurol 48 (2006) 589–594. [PubMed: 16780629]

[9]. Lau C, Development of suck and swallow mechanisms in infants, Ann. Nutr. Metab 66 (Suppl. 5) (2015) 7–14.

[10]. Lau C, Development of infant oral feeding skills: what do we know? Am. J. Clin. Nutr 103 (2016) 616S–621S. [PubMed: 26791183]

[11]. Philbin MK, Ross ES, The SOFFI Reference Guide: text, algorithms, and appendices: a manualized method for quality bottle-feedings, J. Perinat. Neonatal Nurs 25 (2011) 360–380. [PubMed: 22071621]

[12]. Thoyre SM, Shaker CS, Pridham KF, The early feeding skills assessment for preterm infants, Neonatal Netw. 24 (2005) 7–16.

[13]. Settle M, Francis K, Does the infant-driven feeding method positively impact preterm infant feeding outcomes? Adv. Neonatal Care 19 (2019) 51–55. [PubMed: 30672812]

[14]. Pickler RH, Reyna BA, Wetzel PA, Lewis M, Effect of four approaches to oral feeding progression on clinical outcomes in preterm infants, Nurs. Res. Pract 2015 (2015) 716828. [PubMed: 26000176]

[15]. Brumbaugh JE, Colaizy TT, Saha S, Van Meurs KP, Das A, Walsh MC, et al. , Oral feeding practices and discharge timing for moderately preterm infants, Early Hum. Dev 120 (2018) 46–52. [PubMed: 29654994]

[16]. Wolff PH, The serial organization of sucking in the young infant, Pediatrics 42 (1968) 943–956. [PubMed: 4235770]

[17]. Tamilia E, Taffoni F, Formica D, Ricci L, Schena E, Keller F, et al. , Technological solutions and main indices for the assessment of newborns' nutritive sucking: a review, Sensors (Basel) 14 (2014) 634–658. [PubMed: 24451459]

[18]. Hafstrom M, Kjellmer I, Non-nutritive sucking in the healthy pre-term infant, Early Hum. Dev 60 (2000) 13–24. [PubMed: 11054580]

[19]. Medoff-Cooper B, McGrath JM, Shults J, Feeding patterns of full-term and pre-term infants at forty weeks postconceptional age, J. Dev. Behav. Pediatr 23 (2002) 231–236. [PubMed: 12177569]

[20]. White-Traut R, Rankin K, Lucas R, Shapiro N, Liu L, Medoff-Cooper B, Evaluating sucking maturation using two pressure thresholds, Early Hum. Dev 89 (2013) 833–837. [PubMed: 23972294]

[21]. Lau C, Sheena HR, Shulman RJ, Schanler RJ, Oral feeding in low birth weight infants, J. Pediatr 130 (1997) 561–569. [PubMed: 9108854]

[22]. Capilouto GJ, Cunningham TJ, Objective assessment of a preterm infant's nutritive sucking from initiation of feeding through hospitalization and discharge, Neonatal Intensive Care 29 (2016) 40–45. [PubMed: 28008218]

[23]. Bromiker R, Medoff-Cooper B, Flor-Hirsch H, Kaplan M, Influence of hyperbilirubinemia on neonatal sucking, Early Hum. Dev 99 (2016) 53–56. [PubMed: 27391573]

[24]. Crowe L, Chang A, Wallace K, Instruments for assessing readiness to commence suck feeds in preterm infants: effects on time to establish full oral feeding and duration of hospitalisation, Cochrane Database Syst. Rev (2016) CD005586. [PubMed: 27552522]

[25]. Wang YL, Kuo HC, Wang LY, Ko MJ, Lin BS, Design of wireless multi-parameter monitoring system for oral feeding of premature infants, Med. Biol. Eng. Comput 54 (2016) 1061–1069. [PubMed: 26429347]

[26]. Shivpuri CR, Martin RJ, Carlo WA, Fanaroff AA, Decreased ventilation in preterm infants during oral feeding, J. Pediatr 103 (1983) 285–289. [PubMed: 6875726]

[27]. Longoni L, Provenzi L, Cavallini A, Sacchi D, Scotto di Minico G, Borgatti R, Predictors and outcomes of the Neonatal Oral Motor Assessment Scale (NOMAS) performance: a systematic review, Eur. J. Pediatr 177 (2018) 665–673. [PubMed: 29564628]

[28]. Thoyre SM, Pados BF, Shaker CS, Fuller K, Park J, Psychometric properties of the early feeding skills assessment tool, Adv. Neonatal Care 18 (2018) E13–E23.

[29]. Eichenwald EC, Blackwell M, Lloyd JS, Tran T, Wilker RE, Richardson DK, Inter-neonatal intensive care unit variation in discharge timing: influence of apnea and feeding management, Pediatrics 108 (2001) 928–933. [PubMed: 11581446]

[30]. Griffith TT, Bell AF, White-Traut R, Medoff-Cooper B, Rankin K, Relationship between duration of tube feeding and success of oral feeding in preterm infants, J. Obstet. Gynecol. Neonatal. Nurs 47 (2018) 620–631.

[31]. Chen CT, Wang LY, Wang YL, Lin BS, Quantitative real-time assessment for feeding skill of preterm infants, J. Med. Syst 41 (2017) 95. [PubMed: 28478534]

[32]. Capilouto GJ, Cunningham TJ, Giannone PJ, Grider D, A comparison of the nutritive sucking performance of full term and preterm neonates at hospital discharge: a prospective study, Early Hum. Dev 134 (2019) 26–30. [PubMed: 31128389]

[33]. Meier PP, Engstrom JL, Fleming BA, Streeter PL, Lawrence PB, Estimating milk intake of hospitalized preterm infants who breastfeed, J. Hum. Lact 12 (1996) 21–26. [PubMed: 8715234]

[34]. Guidelines on Optimal Feeding of Low Birth-weight Infants in Low- and Middle-income Countries, (2011) (Geneva).

[35]. Gianni ML, Sannino P, Bezze E, Comito C, Plevani L, Roggero P, et al. , Does parental involvement affect the development of feeding skills in preterm infants? A prospective study, Early Hum. Dev 103 (2016) 123–128. [PubMed: 27591506]

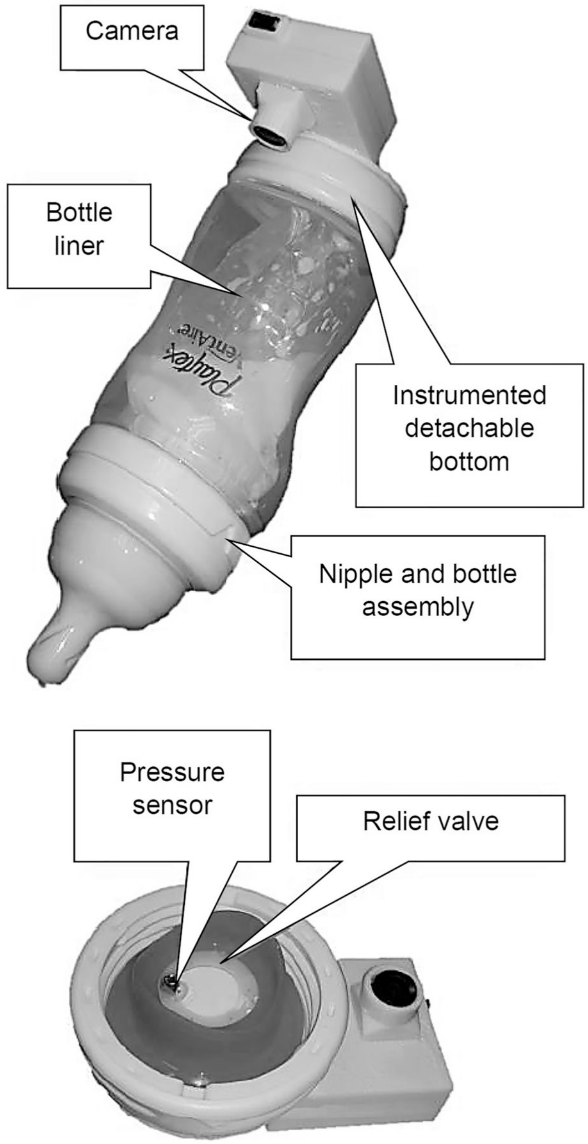

Fig. 1.
Instrumented bottle.

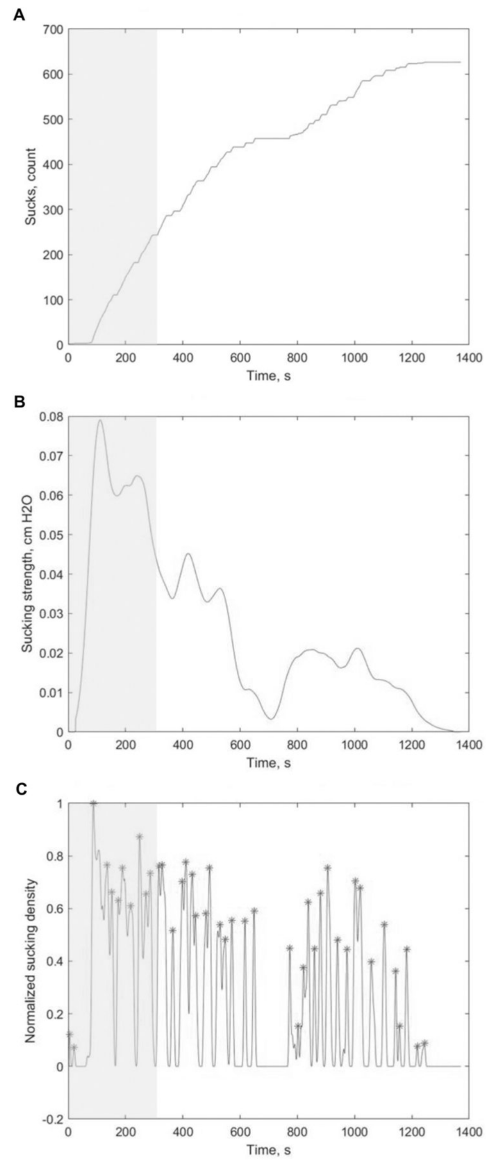

Fig. 2. Nutritive sucking patterns obtained with the IB.

Illustration of the nutritive sucking patterns observed in a characteristic preterm infant. The duration of the entire oral feeding session in seconds is shown on the X-axis. The cumulative number of sucks (A), sucking strength (B), and the number of sucking bursts as normalized sucking density values (C) are shown on the Y-axis. The shadowed areas in panels A, B, and C represent the first 5 min of the oral feeding session. The asterisks in panel C symbolize the number of sucking bursts.

Table 1

Infant demographics and clinical characteristics.

Variables	n = 33
Birth weight in grams, mean (SD)	1182 (385)
Gestational age in weeks, median (IQR)	28 (27–31)
Male sex, %	33
Black race, %	61
Number of feeding sessions with the IB	
1	9
2	18
3	6
Postnatal age in days, median (IQR)	57 (36–77)
Feeding volume administered in ml, median (IQR)	30 (20–40)
Duration of feeding in min, mean (SD)	18 (7)
Number of changes in bottle orientation during a feeding session, median (IQR)	10 (6–15)
Sucking bursts in the first 5 min of oral feeding, median (IQR)	14 (12–16)
Sucking bursts in the first 10 min of oral feeding, median (IQR)	28 (24–32)

Table 2

Repeated measures analysis of nutritive sucking patterns at independent oral feeding.

	Day 1	Day 2	Day 3	p	Variability[a]
	(n = 33)	(n = 24)	(n = 6)		
	Mean ± SE	Mean ± SE	Mean ± SE		
Number of sucks					
Univariate random effects model	740 ± 69	835 ± 76	888 ±133	0.31	57%
Multivariate random effects model[b]	760 ± 76	853 ± 83	897 ±137	0.35	56%
Number of sucking bursts					
Univariate random effects model	54 ± 4	54 ± 4	58 ± 8	0.79	50%
Multivariate random effects model[b]	55 ± 4	55 ± 5	61 ± 8	0.80	54%
Number of sucking bursts in the first 5 min					
Univariate random effects model	14 ± 1	14 ± 1	15 ± 1	0.72	26%
Multivariate random effects model[b]	14 ± 1	14 ± 1	15 ± 2	0.67	27%
Number of bottle orientation changes					
Univariate random effects model	11 ± 1	11 ± 1	9 ± 2	0.61	30%
Multivariate random effects model[b]	10 ± 1	11 ± 1	9 ± 2	0.69	27%
Maximum sucking strength in cmH_2O					
Univariate random effects model	0.10 ± 0.01	0.10 ± 0.01	0.11 ± 0.03	0.87	31%
Multivariate random effects model[b]	0.10 ± 0.01	0.10 ± 0.01	0.11 ± 0.03	0.87	23%
Sucking rate (sucks per second)					
Univariate random effects model	0.7 ± 0.1	0.7 ± 0.1	0.7 ± 0.1	0.62	21%
Multivariate random effects model[b]	0.6 ± 0.1	0.7 ± 0.1	0.7 ± 0.1	0.65	14%

[b]Mean value adjusted for gestational age at birth, birth weight, sex, race, and postmenstrual age.

[a]% of variance attributed to individual variability.