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## Development of sucking patterns in preterm infants

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# Sucking patterns in fullterm infants from birth to ten weeks of age

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## Abstract

**Objective** Coordinating sucking, swallowing and breathing to achieve effective sucking is a complex process and even though sucking is essential for nutrition, little is known about sucking patterns after birth. Our objective was to study sucking patterns in healthy fullterm infants and to describe the age-specific variations.

**Method** We studied the sucking patterns of 30 healthy, fullterm infants longitudinally from two or three days after birth to 10 weeks of age. During this time we recorded five to seven feeding episodes that we assessed off-line with the Neonatal Oral-Motor Assessment Scale (NOMAS).

**Results** We found a normal sucking pattern on the second or third day after birth in 27 out of 30 infants. During the following weeks we found abnormal sucking patterns in 23 out of 171 feeding episodes (14 %) and normal patterns in 148 episodes (86%). Altogether, between 38 and 50 weeks' postmenstrual age (ten weeks after birth), 10 infants displayed a deviating, arrhythmical sucking pattern. Dysfunctional sucking patterns and problems of coordinating sucking, swallowing and breathing did not occur. Birthweight, gestational age, type of labour and gender did not influence sucking patterns. Arrhythmical sucking was seen more often in bottle-fed infants.

**Conclusion** Our study demonstrated that practically all healthy fullterm infants started off with a normal sucking pattern soon after birth. One third of the infants displayed one or more deviating episodes up to the age of ten weeks. Apart from bottle-feeding, no other factors were found that influenced sucking patterns.

## Introduction

The ability to suckle at the breast or suck from a bottle is of vital importance to newborns. Sucking and swallowing in combination with a sound gastrointestinal system enables infants to take in food and grow. Coordinating sucking, swallowing and breathing requires complex neural mechanisms. Feeding difficulties during the neonatal period could be the first indication that an infant has neurological problems.

Healthy fullterm infants that are developing normally during the neonatal period can also be expected to have normal, mature sucking patterns from birth onward. A normal sucking pattern is defined as a continuous burst pattern of more than ten sucks per burst with only brief pauses in between the bursts, and with swallows and respirations occurring during the sucking bursts in a sequential pattern <sup>1-4</sup>. The normal developmental course of sucking and swallowing during the first months of life after fullterm birth is characterised by increased rates of sucking and swallowing, longer bursts of sucking and larger volumes per suck (5). An assessment tool to analyse sucking patterns in both breast-feeding and bottle-feeding is the non-invasive Neonatal Oral-Motor Assessment Scale (NOMAS) <sup>6</sup>. The tool contains checklists for feeding behaviour and provides an analysis of, and diagnoses, sucking patterns by assessing the oral-motor components of the tongue and jaw during neonatal sucking. The tool is suitable for infants up to the age of 10 weeks post term. As yet, sucking patterns have not been assessed longitudinally, using the NOMAS, in term born infants during the first ten weeks after birth. Therefore the aim of the longitudinal study presented here was to describe the sucking patterns and its variations in healthy, fullterm infants during the first months after birth. A related question was whether we could identify factors that might influence normal sucking in a normal infant population.

## Methods

Thirty healthy, fullterm infants (18 boys and 12 girls) were selected through midwifery practices and maternity courses, and notices in the media. The criteria for inclusion were a gestational age ranging from 37 to 42 weeks and no complications during neonatal development. Low birth weights were allowed. Infants that had been exposed to drugs and alcohol during gestation, infants with congenital defects or infants that had been seriously ill during their first ten weeks after birth were not included in our study. Twenty-four infants were born vaginally (including one vacuum extraction) and six were delivered by caesarean section. Twenty-eight infants were appropriate for gestational age and had birth weights of more than 2500

grams. Two infants born at 37+4 weeks were small for gestational age (< P10). All the infants had an Apgar score of  $\geq 8$  at 5 minutes. Seventeen infants (51%) were breast-fed from birth up to ten weeks of age, while nine (27%) were bottle-fed. The mothers of four infants (13%) switched from breast-feeding to bottle-feeding after two to eight weeks. The study commenced after permission was granted by the medical and ethical review committee of the University Hospital of Groningen, the Netherlands, and informed parental consent had been obtained.

From two or three days after birth to the age of 10 weeks we video recorded the first ten minutes of a feeding episode with the infant in the quiet alert state 7. The second recording was made a week later and subsequently every two weeks until the infants were ten weeks old. All recordings were performed during daytime, mostly at early afternoon. The infant was videoed in profile so that its jaws, the base of the mouth, lips and cheeks were clearly visible. This camera viewpoint is essential for the successful assessment of the infant's feeding behaviour and a prerequisite of the assessment tool. At the time of the recording the infants were all healthy and were fed by either one of the parents. The following details were noted for each feeding episode: breast-feeding or bottle-feeding, the type of milk (i.e. breast milk, or a choice of five formulae without thickening agents), any changes in behavioural state during feeding, and signs of choking, breathlessness, discolouring or stress.

From the ten-minute recording we selected the first two-minute episode of feeding in order to assess the infant's sucking pattern with the NOMAS. The NOMAS suited our research purposes because it is a non-invasive, observational method that takes a number of aspects of sucking and swallowing into account, and it can be used for both breast-feeding and bottle-feeding (6;8). The NOMAS consists of twenty-eight items; fourteen of which relate to movements of the jaws and fourteen to movements of the tongue Table 2. Jaw movements and some tongue movements are scored as observed from the video recordings, and the other tongue movements are scored indirectly from the movements of lips, cheeks and the base of the mouth, as described in the NOMAS manual. The NOMAS distinguishes three sucking patterns: a normal (or mature), a disorganised and a dysfunctional sucking pattern. A normal sucking pattern is characterised as a continuous burst pattern of 10 to 30 sucks per burst with only brief pauses between bursts. Suck, swallow and respiration occur during the sucking bursts in a 1:1:1 sequential pattern. This normal nutritive suck occurs at approximately one half the rate of the non-nutritive suck, that is, one per second (9). An infant that shows a sucking pattern that deviates from this norm is assessed as 'abnormal' and is subsequently classified as disorganised or dysfunctional Table 2. A disorganised sucking pattern refers to a lack of rhythm in the total sucking activity. This means that the infant is unable to coordinate

**Table 2 Neonatal Oral-Motor Assessment Scale (NOMAS (6) 1993 revision** Copyright © 1990/1993 Marjorie Meyer Palmer

**Jaw**

Normal	Disorganization	Dysfunction
<ul style="list-style-type: none"> <li>• consistent degree of jaw depression</li> <li>• rhythmical excursions</li> <li>• spontaneous jaw excursions occur upon tactile presentations of the nipple up to 30 minutes prior to feed</li> <li>• jaw movement occurs at the rate of approximately one per second (1/2 the rate of NNS)</li> <li>• sufficient closure on the nipple during the expression phase to express fluid from the nipple</li> </ul>	<ul style="list-style-type: none"> <li>• inconsistent degree of jaw depression</li> <li>• arrhythmical jaw movements</li> <li>• difficulty initiating movements inability to latch on:                             <ul style="list-style-type: none"> <li>• small, tremor-like start-up movements noted</li> <li>• does not respond to initial cue of nipple until jiggled</li> </ul> </li> <li>• persistence of immature suck pattern beyond appropriate age</li> </ul>	<ul style="list-style-type: none"> <li>• excessively wide excursions that interrupt the intra-oral seal on the nipple</li> <li>• minimal excursions; clenching</li> <li>• asymmetry; lateral jaw deviation</li> <li>• absence of movement (% of time)</li> <li>• lack of rate change between NNS and NS (NNS = 2/sec; NS = 1/sec)</li> </ul>

**Tongue**

Normal	Disorganization	Dysfunction
<ul style="list-style-type: none"> <li>• upped tongue configuration (tongue groove) maintained during sucking</li> <li>• extension-elevation-retraction movements occur in anterior-posterior direction</li> <li>• rhythmical movements</li> <li>• movements occur at the rate of one per second</li> <li>• liquid is sucked efficiently into the oro-pharynx for swallow</li> </ul>	<ul style="list-style-type: none"> <li>• excessive protrusion beyond labial border during extension phase of sucking without interruption sucking rhythm</li> <li>• arrhythmical movements</li> <li>• unable to sustain suckle pattern for two minutes due to:                             <ul style="list-style-type: none"> <li>• habituation,</li> <li>• poor respiration,</li> <li>• fatigue</li> </ul> </li> <li>• uncoordinated sucking/ swallowing and respiration which results in nasal flaring, head turning, extraneous movements</li> </ul>	<ul style="list-style-type: none"> <li>• flaccid; flattened with absent tongue groove</li> <li>• retracted; humped and pulled back into oro-pharynx</li> <li>• asymmetry; lateral tongue deviation</li> <li>• excessive protrusion beyond labial border before/after nipple insertion with out and down movement</li> <li>• absence of movement (% of time)</li> </ul>

sucking and swallowing with breathing. A dysfunctional sucking pattern is characterised by abnormal jaw and tongue movements which results in interruption of the feeding process 6.

Previously, we had found that the intra-rater agreement of the NOMAS was 'fair' to 'almost perfect' (with values for Cohen's  $\kappa$  between 0.33 and 0.94), whereas the inter-rater agreement with respect to the diagnosis was 'moderate' to 'substantial' (Cohen's  $\kappa$  between 0.40 and 0.65)(10). For the purpose of the present study eleven Dutch speech and language pathologists, who were certified NOMAS assessors, carried out the assessments. Each recording was assessed by two assessors independently of one another. If they were unable to reach consensus about a particular episode in a recording, it was discussed with all the assessors. Eventually consensus was reached in all cases.

Altogether we analysed 171 episodes in 30 infants, corresponding with a median of 6 episodes (range 4-8) per infant. The results of the repeated assessments of each infant (either normal, disorganised or dysfunctional) were graphically displayed on the time-axis, thus depicting the individual, longitudinal course of normal and abnormal sucking patterns. We checked whether deviating episodes were related to patient characteristics. Finally, we planned to determine whether feeding had been effective, i.e. an intake of at least 10 ml, during the first two minutes of the recording. If possible, we weighed the infants after 2 minutes of breast-feeding, or, in case of bottle-feeding, we measured the residual.

## Statistical analysis

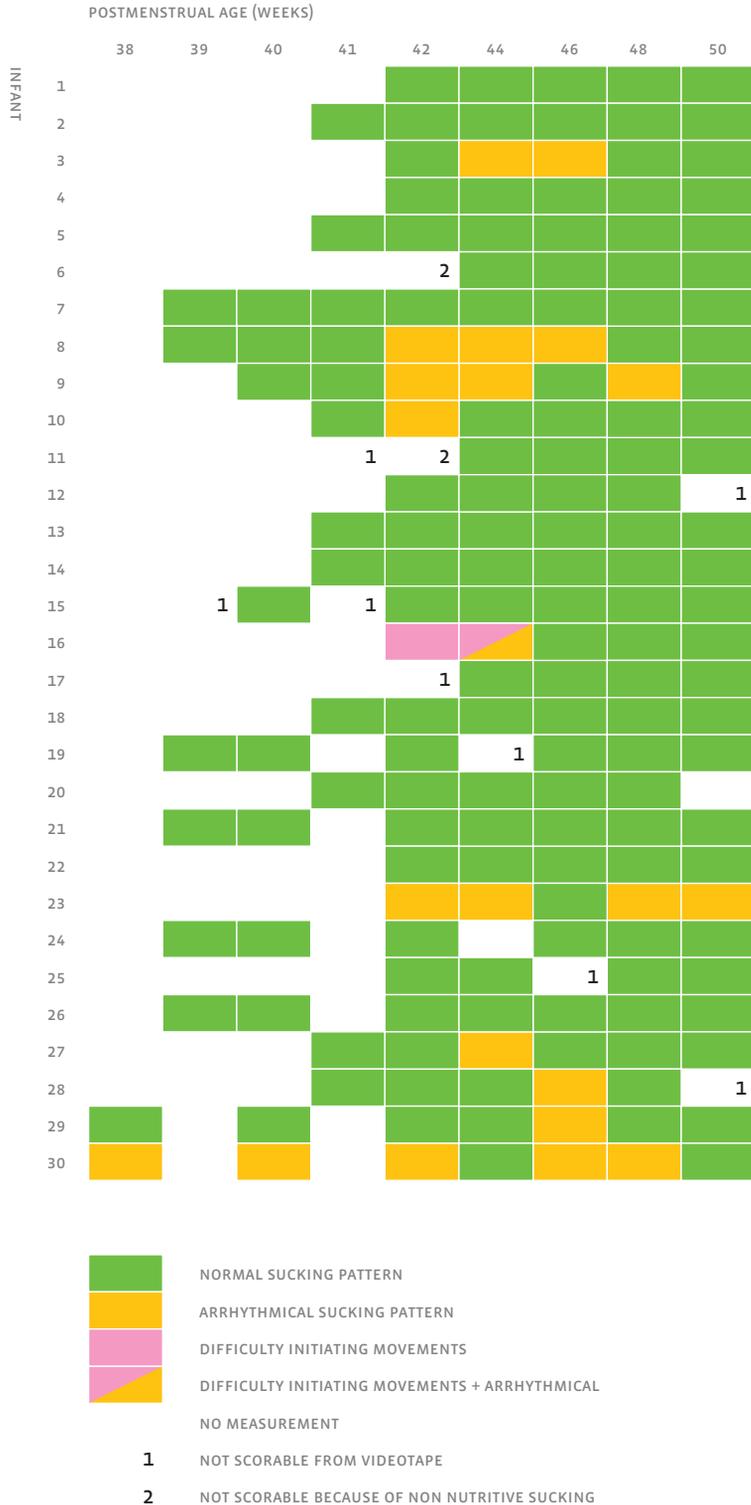
For the statistical analysis of our data we used version 15.0 of the statistical software package spss for Windows. In order to determine whether type of feeding, gestational age, birth weight, gender and type of delivery influenced the sucking pattern, we used the Mann Whitney U and Chi<sup>2</sup>- tests. Probability values of < 0.05 were taken to be significant.

## Results

We found a normal sucking pattern in 27 out of the 30 infants during their first feeding episodes. Out of the 171 episodes we assessed between 38 and 50 weeks' postmenstrual age, 148 (87%) were normal and 23 (13%) deviated from the normal sucking pattern *Figure 1*.

In two thirds of the study group, (20 infants, 67%), we found a normal sucking pattern from the first to the last recorded episode at 10 weeks after birth (*Figure 1*). The 23 abnormal episodes occurred on one or more occasions

**Figure 1 Sucking patterns in term infants** The results of the repeated assessments of each infant, according to the sucking patterns, were graphically displayed on the time-axis, thus depicting individual trajectories.



in a third of the study group, (10 infants, 4 boys and 6 girls). Seven of these 10 infants (70%) showed normal sucking during their first episode at two or three days after birth. Four out of the 10 infants showed abnormal sucking patterns during three or more episodes, two were abnormal during two episodes, and four were only once scored as abnormal. At ten weeks of age all but one of the infants showed a normal sucking pattern.

In accordance with the NOMAS all abnormal episodes were classified as 'disorganised'. Of the possible items in the 'disorganised' category, only two were observed: arrhythmical in 22 episodes (96%) and difficulty initiating movements in one episode (4%). In one instance we found a two-fold deviation in the sucking pattern: both difficulty initiating movements and arrhythmical. A dysfunctional sucking pattern was not found in any of the children during any of the episodes recorded. Details on the results of individual infants are provided in Table 3.

In order to identify factors that might influence normal sucking, we determined whether deviating sucking patterns bore any relation to gestational age, birthweight, gender, type of labour and breast-feeding or bottle-feeding. As far as the type of feeding was concerned we found more arrhythmical episodes in bottle-fed infants than in breast-fed infants. In total, 113 episodes were assessed while on breast-feeding, and 58 while on bottle-feeding. Nineteen abnormal episodes were seen in the case of bottle-feeding in 7 infants and four in the case of breast-feeding in 3 infants. This was significant on an infant level, ( $\text{Chi}^2$ - test-for trend = 5.853,  $p=0.016$ ), on measurement level this was highly significant ( $\text{Chi}^2$ - test = 28.1,  $p<0.001$ ). No other factors were found that influenced the sucking patterns.

We are not able to report reliably on the effectiveness of feeding. In only approximately half of the measurements, it was possible to measure the amount of oral intake during the first two minutes of feeding. This was due to the inability of the caretakers to interrupt feeding after 2 minutes.

## Discussion

Our study showed that sucking is satisfactory for practically all the infants from as early as two to three days after fullterm birth. At ten weeks of age all but one of the infants showed a normal sucking pattern. In two thirds of the infants we found that sucking was completely normal without any abnormality. However, in a third of the infants we found one or more deviating episodes. In these instances disorganization was based mostly on arrhythmical episodes, meaning that one or more bursts of sucking counted less than ten sucking movements. The NOMAS proved to be a sensitive tool to assess deviations in the coordination of sucking, swallowing and breathing. Since sucking, swallowing and breathing at this age are an expression of

**Table 3 Details on deviant episodes**

Infant	Episode in weeks PMA	State	Bursts of sucking	Bottle/Breast
003	44	3	31-12-7-6-3-5-18-15-10-6.	Bottle
003	46	3	13-4-6-26-3-17-3-5:	Bottle
006	43	3	>10 – 18, >20-4-4-3-2-3	Breast
008	42	3	>12-20-11-12-4-4-17.	Bottle
008	44	3	12-20-11-12-4-4-17.	Bottle
008	46	3	46-9-32	Bottle
009	44	3	25-12-4-9-9-15	Bottle
009	46	3	23-14-9-7-4-15-15.	Bottle
009	48	3	>60-5-18-15-7.	Bottle
010	42 (2nd episode recorded)	3 > 2	17-6-3-2-3-3-3-4-3.	Breast
017	42	3	Unable to score	Finger-feeding
017	44	3	Unable to score	Finger-feeding
024	42 (1st episode recorded)	3	1-1-2-1-2-2-2-1-2-9- 1-2-2-2-2-3-6-2-4-4-4-2	Bottle
024	48	3	3-8-16-5-7-6-11-6-18	Bottle
027	44 (3rd episode)	3	43-10-25-11-7-5-5-4-5-11	Breast
029	43 (3rd episode)	2	40-30-15-5-5-14-5	Bottle
029	46	3	29-14-14-8-6-17	Bottle
030	46	3	67-6-5-15-18-4-7	Bottle
031	5	3	54-8-15	Bottle
	7	3	59-10-6-12-20-10	Bottle
	8	3	>40-9-5-6	Bottle
	10	3	53-3-4-4-13-6-15	Bottle
	11	3	77-9-16-9-6-27-2	Bottle

Amount cc/2 min	Particulars in anamnesis	Particulars concerning episode	Diagnose
30 cc			Arrhythmic
15 cc			Arrhythmic
unknown			Arrhythmic
unknown		Chokes, leaks milk. Hospital nipple.	Arrhythmic
unknown		Chokes, leaks much milk. 'Avent' nipple	Arrhythmic
unknown		Chokes, leaks much milk. 'Avent' nipple	Arrhythmic
20 cc			Arrhythmic
10 cc			Arrhythmic
unknown			Arrhythmic
unknown	Caesarean		Arrhythmic
unknown			Difficulty initiating movements
unknown			Difficulty initiating movements
unknown	Caesarean		Arrhythmic
unknown			Arrhythmic
10 cc	Caesarean		Arrhythmic
10 cc			Arrhythmic
10 cc			Arrhythmic
25 cc	Gemelli, 2155 (<P10), Apgar 9/10. After choking incident on 2e day oxygen was administered briefly		Arrhythmic
24 cc	Gemelli, 2320 gram (<P10), Apgar 8/10 intra-uterine growth retardation.	Scores deviant on 5 episodes	Arrhythmic
10 cc			
20 cc			
23 cc	Drip-fed for a few days.		
25 cc			

**Table 1 Subject Characteristics**

Total	30
Boys / Girls	18 / 12
Gestational age	40 + 1 (37+4 – 42 + 2)
Caesarean section	6
Type of feeding	Breast: 17 infants (57%) Bottle: 9 infants (30%) Both: 4 infants (13%)
Birthweight	3592 (2110 – 4590 gram)
Singleton / Multiple birth	26 / 2

a complex and coordinated function of the central nervous system, we suggested that the NOMAS might also prove to be a sensitive tool to evaluate the neurological condition of infants during this age range.

Our study was unique for its longitudinal design. To our knowledge no other studies have followed sucking patterns during the entire neonatal period up to 10 weeks post term. Most studies of sucking behaviour and sucking patterns in healthy full term infants are based on one or two recordings only 8;11-15. In our study we recorded and examined full term infants from two or three days after birth until they were ten weeks old. Depending on the gestational age this meant that our description of the sucking patterns was based on six or seven feeding episodes. Some aspects that required our special attention were the characteristics of the infants that had one or more deviating episodes, and some differences between breast-feeding and bottle-feeding.

We noticed that in particular bottle-fed infants had an arrhythmical sucking pattern. During breast-feeding there is a naturally occurring surge in milk flow triggered by the milk injection reflex in the lactating mother and under influence of the sucking pressure of the infant . When the infant stops sucking, the flow decreases. During bottle-feeding the flow of milk depends especially on the nipple hole, the thickness of the formula and the internal pressure of the bottle. When the infant stops sucking, the flow remains continuous. Not all infants are capable of adapting their sucking skills to this constant flow 12;16-18. Research has shown, for instance, that infants on bottle-feeding with a commonly used nipple showed greater instability in coordinating sucking, swallowing and breathing and had more perturbation of breathing than breast-fed infants 19.

A limitation of the present study was that both breast-feeding and bottle-feeding was used not equally distributed Table 1 because it proved difficult to include infants whose parents opted for bottle-feeding from birth. Another shortcoming was the impossibility to get exact information about the oral intake in about 50% of the measurements. Although our study group was small, our findings were nevertheless interesting in that they provided new information about sucking patterns during the first 10 weeks after fullterm birth. Our study illustrated that if infants had a normal pattern of sucking from two or three days after birth, they stood a good chance that the further sucking ability would also be uncomplicated, although an incidental deviating episode with arrhythmical sucking was not uncommon.

## **Conclusion**

Out of 30 healthy, fullterm infants 27 displayed a normal sucking pattern at two or three days after birth, i.e. 90%. Up to ten weeks after birth, ten infants sometimes deviated from the normal sucking pattern during a single episode. Almost all displayed the slightest deviation, i.e. an arrhythmical sucking pattern. Six out of these ten infants (20% of the entire group) had more than one deviating episode. Apart from bottle-feeding, no other factors were found that influenced sucking. At the age of ten weeks all infants but one (96%) showed normal sucking patterns.

The coordination of sucking, swallowing and breathing requires complex neural mechanisms. It is reassuring to know that dysfunctional sucking patterns and problems coordinating sucking, swallowing and breathing do not occur in healthy fullterm infants.

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