**Non-nutritive sucking for infants: what are the issues?**

This article explores the reasons why practitioners use a non-nutritive sucking programme with infants who are developing feeding skills. Non-nutritive sucking is undoubtedly an approach that provides support for a developing infant who is learning to feed, but some of the explanations as to why it is successful and how it relates to nutritive sucking remain unclear.

**Keywords**
premature; feeding; nutritive sucking; non-nutritive sucking; oral readiness


1. Non-nutritive sucking (NNS) is an important part of infant physiological development.
2. NNS does not stimulate nutritive sucking.
3. A new philosophy that accurately defines the role of NNS and how it benefits development of infant feeding is needed.

**Oral readiness**

Oral readiness is one of the important early stages of infant development. It is used as a mechanism for determining the ability of an infant to develop oral feeding skills. Sucking ability, both non-nutritive and nutritive, is often used as an indicator of an infant’s oral-motor status. Signs of oral readiness can also be used to give important information about behavioural states.

A state is a group of characteristic behaviours and physiological changes that occur together in a regular pattern and influence the way an infant responds at any given time. States are divided into sleep and awake states and in each state, an infant responds in a unique and predictable manner. Alertness is an important behavioural state that is linked to an infant’s ability to interact with the environment. It is during the ‘quiet alert’ state that infants are most attentive to important stimuli in their environment, such as voice and nipple presentation. The quiet alert state is often an ideal time for feeding the infant but premature infant alertness is different from that of a term infant.

In term infants, the intensity of sucking is positively correlated with infant responsiveness and the all-important quiet alert state that is necessary for feeding. Greater oral feeding success in premature infants is associated with consistent and increased development of the quiet alert state. Premature infants can achieve a

<table>
<thead>
<tr>
<th>Non-nutritive sucking</th>
<th>Nutritive sucking</th>
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<td>Two sucks per second with no nutrient flow</td>
<td>One suck per second with nutrient flow</td>
</tr>
<tr>
<td>Smaller tongue and laryngeal movements</td>
<td>Greater displacement of the tongue and larynx</td>
</tr>
<tr>
<td>Breastfeeding sucking pressure range = -93.1±28.3mmHg</td>
<td>Breastfeeding sucking pressure range = -77.3±27.0mmHg</td>
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<tr>
<td>Bottle feeding sucking pressure range = -27.5±11.2mmHg</td>
<td>Bottle feeding sucking pressure range = -87.5±28.5mmHg</td>
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**TABLE 1** Comparison of nutritive and non-nutritive sucking.
drowsy or quiet alert state before a feed, but may have difficulty in maintaining this state because of their immaturity, especially in terms of maintaining a stable ‘suck-swallow-breathe’ pattern\textsuperscript{11}. In general, a combination of factors contributes towards feeding success:

- gestational age of the infant
- stability in relation to motor control
- ability to demonstrate consistent physiological behaviours\textsuperscript{10,12}.

Very low birthweight (VLBW, <1,500g) infants are at a higher risk of persistent feeding problems due, in part, to limited energy and nutrient reserves combined with a high basal metabolic rate\textsuperscript{13}. Stability of the suck-swallow-breathe cycle, along with the ability to demonstrate hunger cues, alertness and good health, contribute to the development of oral readiness for the first oral feed.

**Sucking skills: non-nutritive and nutritive sucking**

Infants use two different sorts of sucking: nutritive sucking (NS) and NNS (\textbf{TABLE 1}). NS provides an infant’s nutrition and an important element of NS is the intake of fluid due to the alternation of expression and suction. The process is a complicated interaction involving the lips, cheeks, jaw, tongue, palate, pharynx and larynx in a coordinated way, so that the suck-swallow-breathe cycle can be maintained\textsuperscript{14,15} at a rate of one suck per second, which remains constant during feeding. In contrast, in NNS there is no flow of nutrients and consequently the movement is quicker (two sucks per second) with less jaw excursion. NNS may be used to satisfy an infant’s basic sucking urge or as a state regulatory mechanism\textsuperscript{16}.

Tongue and laryngeal movements are distinctly different between NS and NNS\textsuperscript{4}. NNS comprises bursts of tongue movements followed by brief pauses. NS involves significantly greater displacement and excursion in both the anterior and posterior areas of the tongue compared to NNS. Hyoid bone movement during NNS is smaller than the angle of movement recorded in NS. Miller and Kang\textsuperscript{11} describe NNS as being an important foundation skill for NS, but yet their article does not discuss or consider the different neurological origins of the two different types of sucking.

As well as differences in tongue and laryngeal movements, sucking performance varies between NNS and NS, particularly with regard to differences between breastfed and bottle-fed infants\textsuperscript{17}. Breastfed infants demonstrate a higher NNS than NS pressure, compared to bottle-fed infants who display the opposite pattern. In breastfeeding, little milk is available before the milk ejection reflex occurs. As such, infants essentially perform NNS before the milk ejection reflex exerts an effect. It has been postulated\textsuperscript{11} that breastfed infants have a greater NNS pressure to stimulate the milk ejection reflex in the mother’s breast. These differences in pressure are additional points to ponder when considering the use of NNS.

**Infant development**

Successful and effective feeding is a complex, energetic activity that requires the coordination of a suck-swallow-breathe cycle and respiration is important for sustaining this feeding process\textsuperscript{16}. In the high-risk neonatal population, the suck-swallow-breathe sequence is rarely well-coordinated before 34 weeks’ gestation and the infant needs to increase in maturity to acquire competent feeding skills\textsuperscript{18}. Several important studies have addressed this issue and contributed to the understanding of the nature of NNS and NS.

**Study by Bingham et al\textsuperscript{19}**

In this study, NNS was assessed using a pacifier for up to 10 minutes either just prior to, or on onset of, tube feeding. Fifty-one premature infants born between 25-34 weeks’ gestation with a birthweight range of 1512.3±499.9g were included; the mean gestational age was 32.7±0.1 weeks. Rigorous exclusion criteria were applied: no infant with oral-motor problems, neurological difficulties (congenital or acquired) or those undergoing major procedures were included. The authors indicate that oral feeding was offered around 32 weeks, though not all infants were able to show oral readiness at this stage\textsuperscript{19}. Infants transitioned onto full oral feeding 15.8±6.6 days from initiation of oral feeding (range = 5.0-38.0). Higher NNS organisation scores (ie rhythmic and regular suck waves and sucking bursts) were significantly predictive of a shorter transition to full oral feeding (p<0.05) and more regular suck wave pressure deflections were indicative of more competent oral feeders. NNS changed its pattern over time as the infant matured, with more regular and sequential suck patterns developing. Infants born later also showed a quicker transition to oral feeding. In this study it was suggested that measures of burst organisation and sucking consistency in NNS may be useful predictors of performance.

**Study by Gewolb et al\textsuperscript{20}**

This study comprised 20 preterm infants born between 26-33 weeks of gestation. The mean birthweight was 1,187g (range 740-1,590g) and the mean gestational age was 29.4 weeks (range 26-33 weeks’ postmenstrual age). All infants in the study were bottle-fed. At 32-33 weeks rapid, sequential low amplitude sucking and mouthing activity were evident. Over time and as the infant matured, the suck became slower with one suck per second. It was noted that the percentage sucks became more organised into a sequential pattern with increasing postmenstrual age: below 35 weeks, 73% of sucks were sequential, and above 35 weeks, 85.4% of sucks were sequential. The rate of sucks was approximately 55 per minute at 32 weeks’ postmenstrual age and 65 sucks per minute at 40 weeks’ postmenstrual age. A correlation between increasing sequential suck bursts in relation to postmenstrual age was highly significant.

While the focus of many of these studies is on sucking, it is important to remember that a stable swallow pattern is established earlier than a sucking pattern. Clinically
this developmental aspect needs to be a serious consideration in relation to neonatal feeding management. NNS, in contrast, is described in the literature as an important predictor of how an infant will progress with NS; the higher the NNS organisation score (ie burst organisation and sucking consistency), the shorter the transition to oral feeding will be. However, the contribution that NNS makes towards the development of NS is not clear and needs further critical appraisal in relation to the benefits that can contribute to infant feeding. The following section discusses NNS in more detail and considers its actual benefits.

The benefits of NNS
A wealth of literature argues that NNS is beneficial in that it enables premature infants to acquire good sucking skills, which help them to develop competent NS. Some propose that NNS should be part of a specific sensory stimulation and/or oral-motor programme that is used to stimulate functional sucking. Conclusions from a smaller body of research recommend the use of NNS for a wide range of situations, including:
- Enhancing oral readiness
- Reducing pain and providing comfort in medical procedures
- Reducing reflux
- Reducing the risk of sudden infant death syndrome (SIDS)

All approaches claim that NNS has benefits, yet all provide variable theories to support and justify the use of NNS as an intervention. Most published studies consider NNS as largely an oral-motor approach which uses exercise to promote the oral skills necessary to help with feeding; some studies hint that there may also be later language benefits. Work on oral-motor skills outside of a functional context is considered by some practitioners to be a method of improving oral-motor function both for speech and swallowing. Swallowing activity involves three distinct areas of the nervous system:

1. The peripheral aspect, where all the peripheral sensory and motor events occur
2. The medullary swallowing centre situated in the nucleus tractus solitarius and the nucleus ambiguus (known as the central pattern generator)
3. The cerebral cortex and some subcortical structures connected to the brainstem central pattern generator via corticobulbar pathways. The system is complex and cortical activation of swallowing is different for voluntary and involuntary swallowing. This has implications when a child is asked to swallow its saliva or attempt a dry swallow (non-nutritive activity), as opposed to observing sequential swallowing during a meal (nutritive activity) where two different neurological actions are activated and therefore two different parameters are being assessed.

Differences in labial muscle force are noted between cup, straw and non-nutritive labial muscle movement in older children. In studies of children and adults, evidence suggests that nutritive and non-nutritive activations are distinct from each other. It is inappropriate to make the same assumption about infants, yet it is likely that the neurological connections will be developing in the same way. Indeed, one study has illustrated that it is possible for an infant to achieve a stable NNS pattern, yet be unable to transfer this to NS.

Premature infants and those born with specific needs may participate in a NNS programme to help them make the transition to oral feeding. According to Boiron et al: "Non-nutritive sucking promotes the coordination of sucking and swallowing, accelerates the maturation of the sucking reflex and improves the initiation and duration of the first nutritive sucking." Other researchers support the notion that NNS enhances maturation as in NS development, although an approach using NNS to develop NS does not always help infants who have disabilities. In a systematic review of the benefits of oral-motor exercises on swallowing skills for preterm infants, 12 studies were reviewed and the authors concluded that there were some effects beneficial for the development of oral feeding when NNS programmes are used, although the reasons for success were not clear. There appears to be no evidence to support NNS programmes.

Summary
NNS needs careful evaluation as a clinical tool in relation to expectations of outcomes. It undoubtedly has great benefits for infants, but the actual reason for the success of NNS is not fully understood. It could be that rather than stimulating the development of NS, the success of NNS is due to other reasons, eg the development of infant physiological states associated with oral readiness, learning to interpret infant early communication and infant well-being. There is even less information about the importance of NNS and if it indeed has a specific role with infants who have complex needs. Other aspects between NNS and NS need to be considered further, such as:

- differing pressures between sucking patterns
- differing neurological sites of activation
- the fact that NNS can be stimulated before swallowing skills are established
- the different functions of NS and NNS.

It is important that research integrates early interaction and accurate neurological knowledge into the rationales that support good practice.

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References


