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What are the issues with non-nutritive sucking for babies?

This article is an exploration of the reasons why practitioners use non-nutritive sucking (NNS) with infants who are developing feeding skills. It is undoubtedly an approach that provides support for the developing infant who is learning to feed, but some of the arguments as to why it is successful and how it links to nutritive sucking remain unclear. An overview of the range of arguments is presented here.

Introduction

Feeding is an intimate time where there are many opportunities for interaction between the mother and the baby as well as learning and developing new skills (1; 2). Infant feeding provides an opportunity and framework for the development of social interaction and language learning (3; 4). For premature infants, the development of feeding can be a complex process due to a variety of factors due to neurological immaturity, inconsistent physiological stability and limited ability to demonstrate non-verbal communication (5).Sucking, both nutritive and non-nutritive, is vital in the early development of the infant (6). It is important for receiving nutrition, of providing stability in distress and also a means of exploring the environment (2; 6).

Oral readiness

Oral readiness is one of the important early stages of baby development and is used as a mechanism for determining the ability of an infant to develop feeding orally (7). Sucking ability both non-nutritively and nutritively is often used as an indicator of an infant's oro-motor status and can also be used to give important information about behavioural states alongside oral readiness signs (8). Alertness is an important behavioural state that is linked to an infant's ability to interact with the environment (9).Premature infant alertness is different from a term infant's. In term infants, the intensity of the sucking is positively correlated with infant responsiveness and the important *quiet alert* state necessary for feeding (10). Greater oral feeding success in premature infants is associated with the consistent and increased development of the *quiet alert* state (10;11). Premature infants can achieve the *drowsy* or *quiet alert* state before a feed, but have difficulties in maintaining this because of the other problems they may have due to immaturity, such as maintaining a stable suck-swallow –breathe pattern (12). A combination of factors contribute towards feeding success; one is the gestational age of the infant and his or her stability in relation to motor control, physiologic status and general ability to demonstrate behaviours (10;12). Infants born with a very low birth weight (l,500g <) 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 (13). Stability of the suck-swallow-breathe cycle, along with the ability to demonstrate hunger cues, alertness and good health all 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 which are; nutritive sucking (NS) and non-nutritive sucking (NNS). Nutritive sucking is the process of obtaining nutrition with a rate of one suck per second, and it remains constant during feeding. An important element of NS is the intake of fluid due to the alternation of expression and suction. Suction is the negative intra-oral pressure which occurs when the tongue and jaw become lower and the soft palate closes the naso-pharynx (14; 15). In contrast, NNS is different and involves two sucks per second. No nutrient flow occurs, so the movement is quicker with less jaw excursion; it may be used to satisfy an infant's basic sucking urge or as a state regulatory mechanism (15). It comprises of bursts of tongue movements followed by brief pauses. Lingual and hyoid displacements are distinct between nutritive and non-nutritive sucking (16). Nutritive sucking involves significantly greater displacement and excursion in both the anterior and posterior areas of the tongue compared to non-nutritive sucking. Hyoid movement during NNS is smaller than the angle of movement recorded in NS. The study describes NNS as being an important foundation skill for NS, but does not discuss or consider the different neurological origins of the two different types of sucking.

Apart from the differences already noted in lingual and hyoid movements, sucking pressures differ between NNS and NS, as well as between breast fed and bottle fed infants (17). Breast fed babies demonstrate a higher NNS than NS pressure, compared to bottle fed babies who display the opposite pattern. In terms of sucks per minute, breast fed babies NNS and NS suck patterns are both higher that bottle fed babies (-93.1 ± 28.3 mmHg). Mizuno & Ueda (17) hypothesise that the reason why breast fed babies have higher NNS is that the suck needs to be at a higher pressure to stimulate the milk ejection reflex from a mother's breast. This also helps to stimulate further expression of milk. These differences in pressure are additional reflection points when considering NNS as an approach.

Baby development

Successful and effective feeding is an energetic activity that is complex requiring the coordination of a suck-swallow-breathe cycle with respiration providing an importance source of oxygen to sustain the feeding process (2;6). In the high-risk neonatal population, the suck-swallow-breathe sequence is rarely well coordinated before 34 weeks and the infant needs to increase in maturity to acquire competent feeding skills (18). Bingham et al (19) studied 51 premature infants, born from 25 – 34 weeks gestation with a birth weight range of 1512.3 ± 499.9g. Rigorous exclusion criteria were applied; no infants with oral motor problems, neurological difficulties (congenital or acquired) or those undergoing major procedures were included. Non-nutritive sucking measures were taken just prior to or on onset of tube feeding, and infants were selected when aged on average 32.7± 0.1 weeks' gestational age. The authors indicate that oral feeding was offered around 32 weeks, though not all infants are able to show oral readiness at this stage (20). Infants transitioned onto full oral feeding 15.8 ± 6.6 days (range 5.0 – 38.0) from initiation of oral feeding. Higher NNS organisation scores i.e. 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 compared with those who produced more irregular suck waves. Non-nutritive sucking 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. A discussion point from this study suggests that NNS measures of burst organisation and consistency may be useful predictors of performance. In contrast, Lang et al, (21) measured the intraoral pressure of NS within a population of 91 normal infants' aged 38 weeks gestation to term. An oro-meter was used to detect the pressure changes during sucking. Within this population, variability was noted, even from individual infants during the course of a feed. Infant behaviour was frequently changed during the course of a feed , although overall the number of sucks decreased from a mean of 118 sucks to a mean of 58 sucks from the first two minutes of a feed to the last two. Mean amplitude of the suck wave patterns changed from 7% after 2 minutes to 14% after 6 minutes possibly due to a combination of satiety and tiring. Actual suck intervals and frequency of sucking, i.e. bursts per second did not change during the course of a feed. Both the Bingham et al (19) and Lang et al (21) studies make useful contributions to the nature of NNS and NS.

Gewolb et al (18) studied twenty preterm infants born between 26 – 33 weeks. The mean birth weight of the infants was 1187 g (range 740 – 1590 g). Mean gestational age was 29.4 weeks, the range being 26 – 33 weeks post menstrual age. All infants in the study were bottle fed. At 32 – 33 weeks rapid, sequential low amplitude sucking and mouthing activity was evident. Over time and as the infant matures, the suck becomes slower with one suck per second. Gewolb et al (18) noted that the percentage sucks became more organised into a sequential pattern with increasing post-menstrual age; below 35 weeks, 73% of sucks were sequential, and above 35 weeks, 85.4 % of sucks were sequential; the rate of sucks were approximately 55 per minute at 32 weeks post menstrual age, and 65 sucks per minute at 40 weeks post menstrual age. A correlation between increasing sequential suck bursts in relation to post menstrual age was highly significant.

Whilst 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, and clinically this developmental aspect needs to be a serious consideration in relation to neonatal feeding management (18).Non-nutritive sucking , 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 (i.e. burst organisation and sucking consistency), the shorter the transition to oral feeding will be (19). 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 (5). The following section discusses NNS in more detail and considers its actual benefits.

Non-nutritive sucking

The current literature argues that NNS is beneficial in enabling premature infants to learn how to develop good sucking skills to help develop competent NS (22; 23; 24; 25). Some research argues that NNS should be a specific sensory stimulation and / or oral motor programme that is used to stimulate functional sucking (22;23;24;25) whilst a smaller body of research recommends the use of NNS to enhance oral readiness, reduce pain and provide comfort in medical procedures, reduce reflux, support weight gain or reduce the risk of Sudden Infant Death Syndrome (SIDS)(5;26;27;28).All approaches claim that NNS has benefits, but all provide variable theories to support and justify the use of it as an intervention.

Non-nutritive sucking in most published studies is largely an oral –motor approach which uses exercises to promote the oral skills necessary to help with feeding and some hint that there may be later language benefits also (22;23;24;25). 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 (29). Swallowing activity involves three distinct areas of the nervous system; i) the peripheral aspect, where all the peripheral sensory and motor events occur; ii) the medullary swallowing centre situated in the nucleus tractus solitarius and the nucleus ambiguous (known as the Central Pattern Generator) and iii) the cerebral cortex and some sub cortical structures connected to the brainstem central pattern generator via corticobulbar pathways (30; 31). The system is complex with cortical activation of swallowing for voluntary and involuntary swallowing being different (30).This has implications for when we ask a child to swallow their saliva or attempt a dry swallow as opposed to observing sequential swallowing during a meal. It subsequently has implications on using NNS to stimulate NS. There are key differences with movements within and aside from eating and drinking; tongue movements in swallowing are slower and more variable than in speech (32). Differences in labial muscle force are noted between cup, straw and non-nutritive labial muscle movement (33). Palatal elevation varies for swallowing and for speech, thus highlighting a contrast in movement types, so use of "ah" to check palatal movement during an oral motor assessment has a questionable value (34). This information suggests that programmes that claim to use NNS to develop NS is neurologically impossible. Aside from the neurological activation, NNS involves muscle stimulation. The origin of oral-motor approaches appears to have been developed from limb rehabilitation therapy with adult acquired disorders populations (30; 35). What has not transferred effectively into discussions and evaluations of oral-motor approaches is that the muscles involved in speech and swallowing are different to limb muscles (35;36). Sciote et al (37) identified that the muscles specifically related to chewing included four different types of myosin heavy chains and have a continuous range of contraction speeds and a high oxidative capacity and are very fatigue resistant. In contrast to limb muscles, there are fewer hybrid fibres and the type I fibres in the masseter muscle are different to type I limb muscle fibres. The tongue muscle fibres are mainly Type IIA in the anterior part of the tongue, and Type I & IM/IIC in the posterior portion of the tongue (38). The muscle fibres relevant for eating and drinking are clearly different and have different properties compared to joint muscles (38). Consequently, if oral motor and swallowing exercises are largely based on limb function rehabilitation approaches, then the outcomes are likely to be variable. Despite these differences, oral-motor exercises are used with children. Babies may receive non-nutritive sucking (NNS) to help them make the transition to oral feeding; "Non-nutritive sucking promotes the coordination of sucking and swallowing, accelerates the maturation of the sucking reflex improves the initiation and duration of the first nutritive sucking," (22; p 439). The notion that NNS enhances sucking maturation as in nutritive sucking development is also supported by other researchers (23; 24) although this approach using NNS to develop NS does not always help infants who have disabilities (27). Arvedson et al, (39) completed a systematic review of the benefits or oral-motor exercises on swallowing skills for preterm infants. Twelve studies were reviewed (39); 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.

Summary

This paper wanted to raise the issue that NNS needs careful evaluation as a clinical tool in relation to expectations of outcomes. It has great benefits for infants, but this author feels that this is due more to the development of infant physiological states associated with oral readiness, learning to interpret infant early communication and infant well-being rather than stimulating the development of nutritive sucking. Other aspects such as differing pressures between the two sucking patterns, differing neurological sites of activation , the fact that NNS could be being stimulated before swallowing skills are established and the different functions of NS and NNS need to be considered. It is important that research integrates more accurate neurological knowledge and concepts into the rationales that support good practice.

2,405 words

Keywords:

Premature; feeding; nutritive sucking; non-nutritive sucking; oral readiness

Key points:

1. Non nutritive sucking is an important part of infant physiological development.
2. Non-nutritive sucking does not stimulate nutritive sucking.
3. A new philosophy that accurately defines what non-nutritive sucking can do and how it benefits baby feeding development is needed.

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Conflict of interest:

None.

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