How does non-nutritive sucking support infant feeding?

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ABSTRACT

Fifty - nine premature infants participated in a randomized controlled study to determine the effectiveness of non-nutritive sucking (NNS). It was predicted that NNS would not accelerate the development of full oral feeding or early language skills as sometimes perceived in practice. However, it was predicted that using NNS as a strategy to support parents to identify and respond to early communication and oral readiness signs would increase confidence in infant management and enable quicker discharge home.

Infants were aged 26 - 35 weeks gestation. Infants with no significant difficulties were randomly assigned to one of three groups; Group 1, NNS pre-tube feeding (n = 19); Group 2, NNS on onset of tube feeding (n = 20) and Group 3, Control (n = 20). Follow – up occurred at 6 months. There were no significant differences with number of days to full oral feeding between the groups receiving NNS and the Control group, χ_2 (2, n = 59) = 4.33, p = .115. A significant difference in number of days in hospital between the Control group and the other two groups was found χ_2 (2, n = 59) = 7.678, p = .022. Significant changes were noted with the development of more normal sucking patterns in Groups 1 – 3. At 6 months, there were no significant differences in receptive (χ_2 (1, n = 56) =

.117, p = .732) or expressive language skills (χ_2 (1, n = 56) = .000, p = 1.0) between all groups. NNS had no significant impact on the transition to full oral feeding or later language development. There was a significant difference in the number of days in hospital between the Control group and the other two groups which involved parents in identification of early communication signs. Possible reasons for this change and future directions are discussed.

Key words: *non-nutritive sucking; full oral feeding; oral readiness; early communication*

HIGHLIGHTS

- We examined using non-nutritive sucking (NNS) with premature infants.
- We predicted that using NNS would not accelerate the development of full oral feeding.
- We predicted that NNS would not accelerate development of early language skills.
- We predicted parent training to identify pre-verbal skills using NNS would decrease time in hospital.

1. INTRODUCTION

This paper considers using non-nutritive sucking (NNS) to support transition to full oral feeding for infants. There are many methods of administering NNS in the literature and these are often a prescribed programme of oral –motor and sensory exercises implemented by a health care professional which do not involve parents (Barlow, Finan & Lee, 2008; Boiron, Da Nobrega & Roux, 2007; Fucile, Gisel & McFarland, 2011; Hwang, Vergana & Lin, 2010; Pimenta, Moreira & Rocha, 2008; Rocha & Lopes Moreira, 2006; Gaebler & Hanzlik, 1996). The focus of this study is from a speech and language therapy and nursing perspective, and it recognises the benefits that NNS can have. It is novel as it concentrates on training parents to use NNS in its simplest form as a tool to guide the infant to a state for effective early feeding. Therefore, the main focus of this study is about understanding the importance of an infant's early communication as well as exploring how NNS is effective. This approach fits well within the Developmental Care model of interpreting the infant's needs (Als, 1986). Some of the literature published about NNS suggests that it can hasten oral feeding skills, and also have benefits in overall oral-motor development (Barlow, Finan & Lee, 2008; Boiron, Da Nobrega & Roux, 2007; Fucile, Gisel & McFarland, 2011; Hwang, Vergana & Lin, 2010; Pimenta, Moreira & Rocha, 2008; Rocha & Lopes Moreira, 2006; Gaebler & Hanzlik, 1996). Indeed, Boiron, Da Nobrega & Roux (2007) state that "*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.*" (p 439).This study explores the impact of NNS when parents are trained to use it. It makes the hypothesis that the identification of infant states and early communication is the strategy that can help infant development rather than using a pacifier to stimulate oral motor movements. Culturally, there

is an anecdotal assumption that oral motor stimulation will have automatic nutritive, non-nutritive and communication benefits.

Establishing successful oral feeding for premature infants is challenging due to neurological immaturity, inconsistent physiological stability and limited ability to demonstrate non-verbal communication (Harding, 2009; Hanson & Landmesser, 2003). Mis-interpretation of pre-feeding and oral readiness behaviours can interrupt the introduction of effective feeding (Pickler, Best & Reyna, 2006; McGrath & Medoff-Cooper, 2002). Oral feeding success in premature infants is associated with the increased development of the [quiet alert] state using NNS (Pickler, Best & Reyna, 2006; McGrath & Medoff-Cooper, 2002; White-Traut, Nelson & Salvestrini, 2002). Non-nutritive sucking (NNS) and nutritive sucking (NS) are used as indicators of an infant's oral-motor status and behavioural state (Mizuno & Ueda, 2006; Amaizu, Shulman & Schandler, 2008; Bingham, Ashikaya & Abbasi, 2010). Nutritive sucking is the process of obtaining nutrition with a rate of one suck per second, whereas NNS occurs at two sucks per second in the absence of milk (Wolff, 1959). Many NNS programmes focus on 12 - 15 minutes of intensive oral motor work completed by a researcher (Barlow, Finan & Lee, 2008; Boiron, Da Nobrega & Roux, 2007; Fucile, Gisel & McFarland, 2011; Hwang, Vergana & Lin, 2010; Pimenta, Moreira & Rocha, 2008; Rocha & Lopes Moreira, 2006). The notion that NNS will facilitate development of NS through strengthening of the muscles or neurological stimulation dominates these approaches with use of an oral-motor programme (Barlow, Finan & Lee, 2008; Boiron, Da Nobrega & Roux, 2007; Fucile, Gisel & McFarland, 2011; Hwang, Vergana & Lin, 2010; Pimenta, Moreira & Rocha, 2008; Rocha & Lopes Moreira, 2006; Gaebler & Hanzlik, 1996) (Figure 2). This is an interesting idea given that neurological research highlights that activation sites for both nutritive and non nutritive oral motor skills are distinct (Jean,

2001; Martin, Goodyear & Gat, 2001; Bennett, Van Lieshout & Pelletier, 2009; Perry, Anderson & Lean, 2002). It is however possible to develop NNS abilities, but not be able to progress onto NS (Harding, Frank, Dungu & Colton, 2012). Some papers focus on using NNS to involve parents in recognizing infant communication (Harding, 2009; Mizuno & Ueda, 2006; Harding, Frank, Dungu & Colton, 2012), to calm infants with neurodisability (Harding, Frank, Dungu & Colton, 2012; Coker-Bolt, Jarrad, Woodward & Merrill, 2012) and to develop the [quiet alert] state for oral feeding (Pickler, Best & Reyna, 2006; McGrath & Medoff-Cooper, 2002; White-Traut, Nelson & Salvestrini, 2002). One directly refutes the idea that NNS can facilitate NS, suggesting that work on swallowing rather than sucking is more beneficial due to the earlier development of swallowing (Lau & Smith, 2012).

- *Put Figure 2 about here –*

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The following study predicted that NNS provided by parents would support improved carer interpretation of infant non-verbal signals of oral readiness but not decrease the time to achieve full oral feeding. In contrast to perceived link between nutritive, non-nutritive and language development through oral-motor work, this study also predicted that NNS would have no impact on the transition to full oral feeding or later language development. At times, there are difficulties with establishing parent- infant bonding, especially when there are medical and / or feeding problems (Als, 1986). In this context, NNS is seen as a way of supporting the parents to develop interaction with the infant and to develop an awareness of early infant pre-verbal communication (Harding, Frank, Dungu & Colton, 2012).

2. METHODS

2.1 Subjects

Infants included in the study were born between 26 - 35 weeks gestation and were recruited from a Level 1 inner city neonatal unit (level 2 at onset of study) for this randomized non-blinded controlled study. Infants were excluded if they were identified as having congenital disorders, intraventricular haemorraghes III or IV, severe respiratory problems or necrotizing enterocolitis. Sixty - eight parents were invited to consider involving their infants in the study , and 60 agreed to participate (Figure 1).One left the study before completing any intervention, so 59 participated. Ethical approval was gained from the NHS committee at the Royal Free Hospital, London. Parents were informed of the study with relevant information, and informed signed consent was obtained.

2.2 Setting & Procedure

A computer generated randomization assigned infants to one of three groups; Group 1, NNS pre onset of tube feeding; Group 2 , NNS on onset of tube feeding and Group 3, in which infants received the usual Developmental Care approach (Control) (Als, 1986)(Table 1).

- Put Figure 1 about here -

- Put Table 1 about here -

- Put Table 2 about here -

Infants received the intervention once they started to show signs of oral readiness. The target was to engage infants in the programme for a minimum of three times a day until they were taking all of their feeds orally. Parents were encouraged to implement the programme, though if the parents were unable to be present for one of the feeds nursing and therapy staff completed the intervention. Training and on-line verbal

coaching from a speech and language therapist in the identification of key infant behavioral states and responses to these states before the intervention began and on onset of the study (Als, 1986) was provided. For those infants allocated to the NNS pre tube feeding, parents were encouraged to use a pacifier to elicit three sequential sucks and to encourage sequential sucking for a minimum of 5 minutes. Parents were taught how to use NNS to encourage a [quiet alert] state optimal for successful feeding. The same methodology was used for use of NNS on onset of tube feeding. The rationale for using NNS as an intervention to prepare and orientate an infant to a state suitable for feeding was based on the current literature (Gaebler & Hanzlik, 1996; McGrath & Medoff-Cooper, 2002; Pickler, Best & Reyna, 2006; White-Traut, Nelson & Salvestrini, 2002). Outcomes were time taken to achieve full oral feeding, number of days in hospital, type of sucking pattern using the Neonatal Oral Motor Schedule (NOMAS; Meyer-Palmer, 1993), and the average age of gestation for oral feeding. The NOMAS (Meyer-Palmer, 1993) is an assessment tool used to differentiate between disorganized and dysfunctional sucking patterns. Disorganized sucking is frequently demonstrated by premature infants when they begin to feed and is characterized by three five-suck bursts with pauses between suck bursts. Dysfunctional sucking is usually demonstrated by unusual and inconsistent sucking movements rather than immature oral movements. This pattern may be indicative of more serious underlying difficulties (Gewolb, Vice, Schweitzer-Kenny, Taciak & Bosma, 2001; Meyer-Palmer, 1986; Medoff-Cooper, 1991).

Follow up at 6 months identified the number of times infants were re-admitted to hospital, any difficulties arising with oral feeding and receptive and expressive language ratings through discussion with parents using the Pre-School Language Scales (PLS; Boucher & Lewis, 1997).

Analysis of both non-parametric and parametric data used the Statistical Program for Social Sciences software, (version 18.0, SPSS Inc., Chicago, IL, USA).

2.3 Sample size

For infants receiving the usual Developmental Care approach (Als, 1986) in the neonatal unit, the average time from onset of oral trials to full oral feeding was 18.8814 days, with an average gestational age of 35.01. It was calculated that a sample size of 64 infants was required to detect a decrease in the transition time to achieve full oral feeding of up to 7 days with a type 1 error of 0.05, a power of 80. Table 1 and Table 2 show the baseline characteristics of the infant participants recruited to the study. A final total of 60 infants were recruited to the study and 59 completed the intervention offered on the neonatal unit. Gestational ages of the infant participants ranged from 26 to 35 weeks.

2.4 Rater-reliability

A live sample of 10% of infants was blind-assessed between the first author and an independent clinician from another inner - city hospital. Rating involved describing the sucking patterns (referring to the NOMAS; Meyer-Palmer, 1993) and behavioral states (Als, 1986) of a random selection of infants who were about to begin oral feeding or who had attained full oral feeding. Agreement for the sample was 100%.

3. RESULTS

In total, 68 parents of infants were approached and informed about the study. Sixty infants were enrolled and 59 completed the first part of the study. At the six - month follow up, data was gained on 56 infants. Of the infants who did not complete their participation in the study, 2

deteriorated with changes in health and did not progress with the intervention, and 2 moved away from the area.

There were no statistical differences in number of days to achieve full oral feeding between the three groups; Group 1, (n = 19); Group 2, n = 20); Group 3, (n = 20), $\chi_2(2, n = 59) = 4.33$, p = .115 (Kruskal-Wallis Test). Number of days for these three groups ranged from 8 - 50 days with additional outcomes as follows; Group 1 = 19.7 days average; Group 2 = 16.5 days average; Group 3 = 23.9 days average. It is interesting to note that the intervention groups progressed towards oral feeding more quickly than the Control group although the difference was not significant.

Gestational age on onset of implementing oral feeding was mainly 34 weeks (45.6%), followed by 35 weeks (38.2 %). On discharge, a variety of feeding methods were adopted (Table 3); the highest number of infants discharged home breast feeding were in Groups 1 & 2.

- Put Table 3 about here –

A significant difference in number of days in hospital between the Control group and the other two groups χ_2 was found; (Group 1, NNS pre tube feed (n = 19) mean rank = 21.74; Group 2 NNS on onset of tube feed, (n = 20) mean rank = 31.00; Group 3 Control, (n = 20) mean rank = 36.85; χ_2 (2, n = 59) = 7.678, p = .022 (Kruskal-Wallis Test). Re-admissions included; Group 1, (n = 1) at 10 days due to poor feeding; Group 2, (n = 1) due to a viral upper respiratory infection; Group 3, (n = 2), due to i) respiratory infection; ii) poor feeding leading to dehydration at 16 days of age.

The Neonatal Oral Motor Schedule scores(NOMAS; Meyer-Palmer, 1993) evaluated normal, disorganized and dysfunctional sucking patterns for all infants pre- group allocation and on onset of full oral feeding. Groups 1 - 3 showed statistically significant increases (Wilcoxon Signed

rank test) in the number of normal sucking patterns (Time 1, median = 7, IQR = 5-9; time 2, median = 10, IQR = 10 - 10, $p < .001$). All groups showed significant decreases of disorganised features of sucking as they matured (Time 1, median = 7, IQR = 5 – 9; time 2, medium = 0, IQR = 0 – 0, $p < .001$). Infants displayed hardly any dysfunctional features of sucking.

- Put Table 4 about here -

Receptive and expressive language scores were evaluated 6 months post discharge using the Pre-School Language Scales (PLS; Boucher & Lewis, 1997). The follow –up data was collected from 56 participants (Figure 1). There were no significant differences in PLS receptive and expressive language scores across the three groups (Group 1, n = 19; Group 2, n = 20; Group 3, n = 20;). For receptive language, χ_2 (1, n = 56) = .117 , p = . 732(Kruskal-Wallis Test). For expressive language, χ_2 (1, n =56) = 0.00, p = 1.0 (Kruskal-Wallis Test). There was some variability with expressive language, (though this was not significant) between the three randomised groups; Group 1 n = 19, mean rank PLS expressive = 39.34; Group 2, n = 20, mean rank PLS expressive = 37.88; Group 3, n = 20, mean rank PLS expressive = 39.35 (Table 5).

- Put table 5 about here –

Only parents who had had re-admissions in Groups 1 – 3 mentioned that feeding had been challenging at times. All parents who received the interventions within Groups 1and 2 reported that the intervention helped to support their management of the baby. One parent also reported that she had not considered how important communication was in the day to day management of the infant.

4. DISCUSSION

The numbers used in this study are small, but it raises some points that warrant further study. Unlike other studies (Barlow, Finan & Lee, 2008; Boiron, Da Nobrega & Roux, 2007; Fucile, Gisel & McFarland, 2011; Hwang, Vergana & Lin, 2010; Pimenta, Moreira & Rocha, 2008; Rocha & Lopes Moreira, 2006; Amaizu, Shulman & Schanler, 2008) it has shown that NNS does not specifically enable the development of NS skills as there were no significant differences between Groups 1 - 3 in the number of days to achieve oral feeding. All infants in Groups 1 - 3 showed similar variations in normal and disorganized sucking before and on onset of intervention. Maturation of NS skills in terms of type of sucking pattern may have come about through the experience of oral feeding, however small the amount, rather than using NNS. Additionally, NNS did not enable more rapid development of oral skills in relation to language development as there were no significant differences between receptive and expressive language scores for Groups 1-3 at 6 months. Four infants from Groups 1 - 3 were re-admitted during the first 6 months of life with a variety of difficulties that impacted on their feeding. Gestational age of these infants ranged from 29 – 35 weeks; all had unremarkable Apgar scores and none developed persistent feeding problems.

Feeding orally is influenced by many factors (Bingham, Ashikaya & Abbasi, 2010; Wolff, 1959; Medoff-Cooper, 1991). Those who benefit most from NNS for transition to oral feeding are premature babies with no significant medical problems and it seems likely that success is not for the reasons hypothesised by the majority of the studies (Barlow, Finan & Lee, 2008; Boiron, Da Nobrega & Roux, 2007; Fucile, Gisel & McFarland, 2011; Hwang, Vergana & Lin, 2010; Pimenta, Moreira & Rocha, 2008; Rocha & Lopes Moreira, 2006; Gaebler & Hanzlik, 1996). As a premature infant matures, their NS and NNS patterns increase in frequency (Mizuno & Ueda,

2003). This was illustrated in this study with a quicker time to oral feeding with higher gestational age. Developing swallowing through small amounts of NS has been demonstrated as being more effective than NNS (Lau & Smith, 2012). Non-nutritive sucking patterns do not change significantly on onset of NS although NS changes more dramatically (Gewolb, Vice, Schweitzer-Kenny, Taciak & Bosma, 2001; Medoff-Cooper & Rey, 1995).Infants with neurodisability can develop NNS but this does not automatically lead to the development of NS (Harding, Frank, Dungu & Colton, 2012). With normal infant development, NNS patterns remain static but NS patterns change. These two points seem to indicate that the neurological origins of NNS and NS are distinct, and therefore the rationale for using NNS needs careful consideration and re-evaluation (Gewolb, Vice, Schweitzer-Kenny, Taciak & Bosma, 2001; Clark, 2003; Ertekin, 2011; Medoff-Cooper & Rey, 1995).

Using a pacifier prior to or on onset of a tube feed along with verbal coaching from practitioners appears to be effective in supporting parents to understand early communication vital to interpretation of an infant's state. It therefore needs to be considered as a serious strategy to promote parent confidence when developing infant care skills. Use of NNS in an exercise format as described by Fucile, Gisel & McFarland (2011) does not involve any clear evaluation of infant pre-verbal states as such and consequently needs to be explored further in comparison to more informal methods that utilize parent skills in the development of infant feeding.

In this study infants who received the NNS progressed home more quickly although there was no quicker progression to oral feeding or difference in early language development between the three groups. This tentatively suggests that using NNS possibly has some particular benefits for the development of parent confidence in the identification of their

baby's needs. At present, it is difficult to be specific about why the intervention groups spent fewer days in hospital. Further studies could evaluate parent perceptions of infant states both pre-feeding and at other times during the day. Parent perceptions could be compared pre- and post training. Evaluation of parent identification and preparation of [quiet alert] states using NNS or not and time taken to achieve full oral feeding pre- and post training would yield more specific results, particularly if compared with other groups using different methods.

This study appears not to support the literature which suggests that NNS developed through use of an oral-motor programme may lead to the quicker development of NS (Barlow, Finan & Lee, 2008; Boiron, Da Nobrega & Roux, 2007; Fucile, Gisel & McFarland, 2011; Hwang, Vergana & Lin, 2010; Pimenta, Moreira & Rocha, 2008; Rocha & Lopes Moreira, 2006).Further research that compares more traditional exercise approaches with a parent based communication approach as demonstrated in this study is needed (Barlow, Finan & Lee, 2008; Boiron, Da Nobrega & Roux, 2007; Fucile, Gisel & McFarland, 2011; Hwang, Vergana & Lin, 2010; Pimenta, Moreira & Rocha, 2008; Rocha & Lopes Moreira, 2006; Medoff-Cooper & Rey, 1995; Arvedson, Clark, Lazarus, Schooling & Frymark, 2010).

Ethics approval: Ethical approval was gained from the NHS / IRAS committee at the Royal Free Hospital, London.

Acknowledgements: The authors would like to thank the parents and infants who participated, as well as the neo –natal nurses. In addition, thanks are extended to Avril Hollings, Lorna Reid, Val Baby, Vivienne Hewitt, Lorna Reid, Lisa Skinner and Helen Cockerill.

Contributors: CH conceived the idea for the project, and LF and VS enabled it to happen. CH took the lead in preparing the manuscript, but LF , VS, KH & NB contributed to its final presentation.

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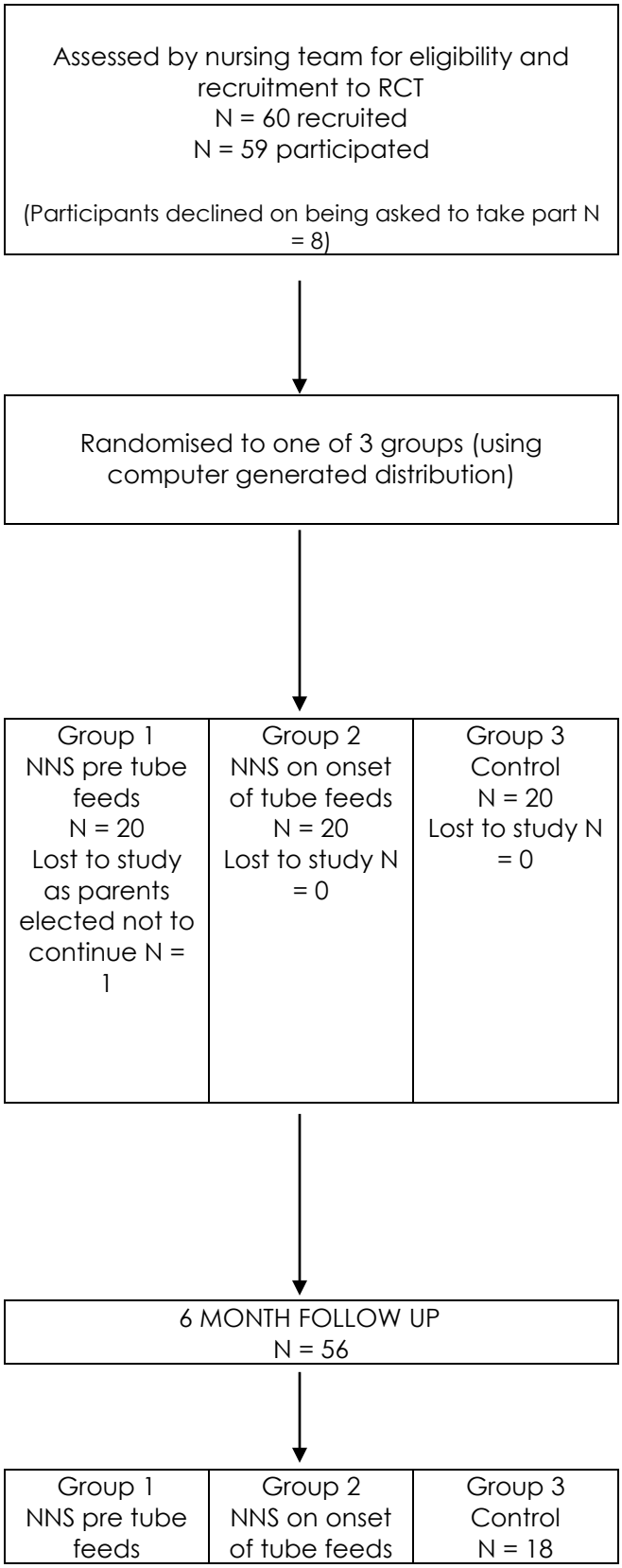
Figure 1: Diagram of the participant allocation procedure



N = 19 Unable to follow up N = 0	N = 19 Unable to follow up as moved away from area N = 1	Unable to follow up as moved away from area N = 2

Figure 2 : Fucile et al (2002) NNS programme

Peri-oral stimulation (Rationale – to improve muscle intractability, strength and orientation reflexes)

- Cheeks x 4 (2 minutes)
- Upper lip x 4 (1 minute)
- Lower lip x 4 (1 minute)
- Upper and lower lip curl x 2 each lip (1 minute)
- Upper gum x 2 (1 minute) (rationale = to stimulate swallow & improve suck)
- Lower gum x 2 (1 minute) (rationale = to stimulate swallow & improve suck)
- Internal cheek x 2 each cheek (2 minutes)
- Lateral borders of the tongue x 2 each side (1 minute)
- Mid-blade of the tongue x 4 (1 minute) (rationale = to stimulate swallow & improve suck)
- Elicit a suck with finger (no frequency specified) (1 minute) (rationale = improve suck and soft palate activation)
- Elicit a suck with pacifier (no frequency specified) (3 minutes) (rationale = improve suck and soft palate activation)
- ***TOTAL TIME = 15 minutes***

Tables

Table 1: Baseline characteristics of infants in the three groups

	GROUP 1 ***NNS pre-NGT feeds*** *(n = 19)*	**GROUP 2** ***NNS on onset of NGT feeds*** *(n = 20)*	**GROUP 3** ***Control group*** *(n = 20)*
GA: 26 – 29 wks	5	4	10
GA: 26 – 29 Birth weight range in gms	990 - 1042	1325 - 1420	762 - 1325
GA: 30 – 35 wks	14	16	10
GA: 30 – 35 Birth weight range in gms	1684 - 2053	1480 - 2202	1082 - 2850
GA: 35 – 42 wks	0	0	0
GA: Birth weight range in gms	0	0	0
Sex: Male	12	10	12
Sex: Female	7	10	8

GA = Gestational age
NNS = Non-nutritive sucking
NGT = Nasogastric tube
Gms = grammes

Table 2: Group distributions

	GROUP 1 ***NNS pre-NGT feeds*** *(n = 19)*	**GROUP 2** ***NNS on onset of NGT feeds*** *(n = 20)*	**GROUP 3** ***Control group*** *(n = 20)*
Gender	12 males 7 females	10 males 10 females	8 males 12 females
Gestational age	Mean = 32.53 SD = 2.674	Mean = 31.60 SD = 2.01	Mean = 30.95 SD = 3.137
Birth weight	Mean = 1651.11 SD = 403.124	Mean = 1757.90 SD = 3.4.825	Mean = 167.65 SD = 648.682

Table 3: Type of feeding on discharge

	GROUP 1 ***NNS pre-NGT feeds*** *(n = 19)*	**GROUP 2** ***NNS on onset of NGT feeds*** *(n = 20)*	**GROUP 3** ***Control group*** *(n = 20)*
***N* = breast feeders**	11	14	7
***N* = breast & bottle feeders**	7	6	8
***N* = bottle feeders**	1	0	5
***N* = tube fed + some oral via breast**	0	0	0
***N* = tube fed + some oral via bottle**	0	0	0
***N* = tube fed only**	0	0	0

Table 4: Number of days in hospital and number of readmissions post discharge

Experimental group	***Total number of days in hospital*** ***[Mean /median/mode/SD/ range]***	***Total number of hospital re-admissions 6 months post discharge***
GROUP 1 ***NNS pre-NGT feeds*** *(n = 19)*	Mean = 36.84 Median = 22 Mode = 20 SD = 29.95 9 – 104	1
GROUP 2 ***NNS on onset of NGT feeds*** *(n = 20)*	Mean = 37. 9 Median = 32 Mode = 32 SD = 13.94 23 – 64	1
GROUP 3 ***Control group*** *(n = 20)*	Mean = 54.4 Median = 60.5 Mode = 11 SD = 28.61 11 – 110	2

Table 5: Pre - Language Scales ratings at 6 months

Experimental group	***PLS Receptive Language*** ***(Range 1 – 4)***	***PLS Expressive Language*** ***(Range 1 – 4)***
GROUP 1 ***NNS pre-NGT feeds*** *(n = 19)*	n19 = 4	n17 = 4 n1 = 1 n1 = 1
GROUP 2 ***NNS on onset of NGT feeds*** *(n = 19)*	N19 = 4	n18 = 4 n1 = 1
GROUP 3 ***Control group*** *(n = 18)*	N18 = 4	n15 = 4 n1 = 2 n2 = 2