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Long-term oral sensitivity and feeding skills of low-risk pre-term infants

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Abstract

This study examined the oral sensitivity and feeding skills of low-risk pre-term infants at 11–17 months corrected age. Twenty pre-term infants (PT) born between 32 and 37 weeks at birth without any medical comorbidities were assessed. All of this PT group received supplemental nasogastric (NG) tube feeds during their birth-stay in hospital. A matched control group of 10 healthy full-term infants (FT) was also assessed. Oral sensitivity and feeding skills were assessed during a typical mealtime using the Royal Children's Hospital Oral Sensitivity Checklist (OSC) and the Pre-Speech Assessment Scale (PSAS). Results demonstrated that, at 11–17 months corrected age, the PT group displayed significantly more behaviours suggestive of altered oral sensitivity and facial defensiveness, and a trend of more delayed feeding development than the FT group. Further, results demonstrated that, relative to the FT group, pre-term infants who received greater than 3 weeks of NG feeding (PT > 3NG) displayed significantly more facial defensive behaviour, and displayed significant delays across more aspects of their feeding development than pre-term infants who received less than 2 weeks of NG feeding (PT < 2NG). The information from this preliminary study suggests that low-risk pre-term infants, particularly those who receive supplemental NG feeding for greater than 3 weeks, may be at risk for displaying long-term altered oral sensitivity and facial defensiveness, as well as feeding delays. These observations warrant further investigation on this topic.

Keywords: Pre-term; Oral sensitivity; Feeding; Nasogastric tube

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1. Introduction

1.1. Background

To date, there has been little information in the literature regarding the long-term feeding and oral sensitivity skills of pre-term (PT) infants. Of the literature that is available regarding this issue, most has focused on the outcomes of high-risk pre-term infants, aged less than 32 weeks gestational age and/or presenting with severe medical comorbidities affecting the oral, pharyngeal, cardiac, respiratory, gastrointestinal, or neurological systems. Many of these infants present with dysphagia and may be at risk of aspiration, thus requiring long periods of non-oral feeding until they mature sufficiently and their primary medical conditions improve enough to allow oral feeding to be attempted [1–7]. Several studies suggest that this group of high-risk pre-term infants often display long-term feeding difficulties beyond the neonatal period [7–9]. However, very little literature has focused on the feeding and oral sensitivity outcomes of lower-risk pre-term infants, who are born relatively more mature and present without medical sequelae.

Pre-term infants who are born after 32 weeks gestational age without any severe medical comorbidities generally do not present with dysphagia, and are usually able to commence oral feeds soon after birth [1–5]. However, most of this group display difficulty meeting their full nutritional and caloric needs through oral feeding alone in the weeks prior to their term date [1–5]. It is suggested that this difficulty is largely due to their poor nutritional and energy reserves, as well as immaturity of the neurological and muscular systems, which results in low endurance levels for feeding [1–5,10]. Consequently, the majority of low-risk pre-term infants generally require at least some degree of short-term artificial dietary supplementation to augment oral feeds. This is usually accomplished through supplemental tube-feeding [1–5,10–14].

Nasogastric (NG) feeding is the most commonly used form of tube-feeding [15]. Nasogastric feeding has an advantage over many other forms of tube-feeding, in that no anaesthesia or surgery is required for the insertion of the feeding tube, and in that the tube does not obstruct the oral cavity. For this reason, NG feeding is often the initial method of tube-feeding used with pre-term infants who display either dysphagia or difficulty meeting their full dietary needs orally [1–3,6,7,10,13,14,16]. However, despite the widespread use of this form of tube-feeding, it remains uncertain whether exposure to NG feeding in infants may impact on later oral sensitivity and feeding. While it has been reported that the immediate side-effects of NG feeding can include the presence of pharyngeal irritation and discomfort, as well as irritation of the mucosa of the oesophagus and stomach [6,7,10,15,16], limited information is available regarding the long-term outcomes for infants who receive NG feeding, in terms of oral sensitivity and feeding development. The information that is currently available regarding this issue is almost entirely based on anecdotal evidence, such as the subjective clinical observations of authors, and is confounded by the comorbidities of the infants studied.

There have been many anecdotal reports in the literature that suggest that exposure to NG feeding in infants may affect oral sensitivity [1–3,6,7,10,12,16]. Specifically, it has been suggested that the adverse stimulation caused by NG feeding may contribute to some children becoming hypersensitive to some forms of oral stimulation, leading to discomfort and rejection of new sensory stimuli [1–3,6,10,12,16]. It has also been suggested that, over time, the continued presence of adverse stimulation from the NG tube may actually contribute to some children becoming desensitised/hyposensitive to stimulation in the oral and pharyngeal regions, possibly leading to delayed triggering of the swallow mechanism and aspiration [1–3,6,12]. However, as little systematic research has been undertaken in this area, it remains unclear what proportion of low-risk pre-term infants who have been exposed to NG feeding are affected by either of these conditions.

It has been reported that oral sensitivity issues, particularly hypersensitivity, may develop into a conditioned facial defensiveness [1–3,6,7,12,17]. Facial defensiveness is reported to result from a behavioural conditioning process that is likely to occur if physical or emotional trauma, as may be caused by the process of insertion and presence of a NG tube, occurs to the feeding mechanism during the early stages of central nervous system development [3,6,7,12]. It is suggested that children learn to relate this discomfort with the feeding process, thus developing a conditioned avoidance of food and other oral and facial stimulation, which may persist beyond the existence of the original source of the trauma [3,7,12,17]. Behaviour reported to be associated with facial defensiveness includes the use of avoidance tactics in anticipation of approaching food or contact with the face, such as crying, biting, head turning, gagging, and pushing food away [1–3,6,7,12]. However, despite widespread anecdotal reports of the existence of conditioned facial defensiveness in infants who have received NG feeding, there remains no specific data to report the incidence of this behavioural response in the low-risk pre-term population, or any data regarding the duration over which this defensive behaviour persists following the removal of the feeding tube.

There are many anecdotal reports in the literature that suggest that the use of NG feeding in infants may impact on later feeding skill development [1–7,12,16,17]. These reports suggest that children who have a history of tube-feeding may go on to display delayed oral motor development across a range of specific feeding skills, including sucking, swallowing, biting and chewing [1–7,12,16,17]. However, few reports are available that adjust for the confounding effect of pre-existing dysphagia or other medical conditions that may be present in infants who receive NG feeding. As comorbidities of the respiratory, cardiac, digestive, and neurological systems may all affect feeding outcomes [1–3,7,12], it is difficult when studying a population with these conditions to separate the effects of NG feeding from the effects of the primary medical conditions themselves. Therefore, it remains unclear whether NG feeding has the potential to merely exacerbate existing feeding problems/dysphagia, or whether NG feeding has the potential to negatively affect feeding development in previously non-dysphagic individuals, as occurs in low-risk pre-term infants.

In addition, there is a paucity of information available regarding the association between duration of exposure to NG feeding in infants and their feeding and oral sensitivity outcomes. However, considering that it is possible for some children to undergo temporary supplemental NG feeding, while others receive full NG feeding for months and even years, it cannot be assumed that the impact of NG feeding would be of the same degree in these infants.

Given the limitations of the information currently available regarding the long-term oral sensitivity and feeding skills of low-risk pre-term infants, or the association between duration of NG feeding and later oral sensitivity and feeding skills in this population, it is clear that further systematic investigation is needed.

1.2. Aims

The current descriptive study was designed to assess the oral sensitivity (i.e. sensitivity of the palate, gums, tongue, lips, and face in relation to touch, taste, and texture) and feeding development (e.g. sucking, chewing, biting, and swallowing) of pre-term infants born after 32 weeks gestational age, who had no comorbidities that may affect feeding outcomes. Infants were assessed at 11–17 months corrected age to allow an assessment of long-term oral sensitivity and feeding outcomes.

Two specific aims were investigated: (a) to ascertain any significant differences between the oral sensitivity and feeding development of pre-term and full-term (FT) infants with no medical conditions at the same corrected age, and (b) to examine any significant differences between the oral sensitivity and feeding development of pre-term infants who received shorter durations of NG feeding and those who received longer durations of NG feeding.

2. Method

2.1. Participants

Two main groups of infants were recruited for the study: low-risk pre-term infants and a matched control group of full-term infants. Exclusion criteria for both groups included any history of structural lesions to the swallowing mechanism, as well as any history of respiratory, cardiac, gastro-intestinal, or neurological conditions. In this way, only infants void of any known medical conditions that may affect feeding were included.

Candidates for the PT group were recruited from a database of infants who were admitted during their birth-stay to the Royal Women's Hospital (Brisbane), a tertiary neonatal facility with 1100 admissions per year. Inclusion criteria included a gestational age >32 weeks and < 37 weeks at birth, and a corrected age of 11–17 months at the time of assessment. One hundred and fifty-two infants were identified from the hospital database as meeting the selection criteria. Of these potential participants, 73 lived outside a 50-km radius of the hospital and were excluded from the study on this basis. The remaining 79 potential participants were sent an information letter, which was followed up by a phone call from the researchers. Thirty-four families were able to be contacted by telephone during the study; the families of 10 children declined and the families of 24 children agreed to participate. Of the 24, 4 were later omitted due to exclusion criteria diagnosed subsequent to the neonatal period. Biographical details of the 20 pre-term infants included in the study are outlined in Table 1.

All of the pre-term infants recruited received NG feeds during their birth-stay in hospital. Due to the inclusion and exclusion criteria, which ensured that all pre-term infants in the study were >32 weeks gestational age and demonstrated no medical comorbidities, all of the infants also received oral feeds during the birth-stay, with NG

Table 1
Participant demographics for groups and sub-groups

		FT ($n = 10$)	PT ($n = 20$)	PT < 2NG ($n = 10$)	PT >3NG ($n = 10$)
Gender	Male	4	9	5	4
	Female	6	11	5	6
Corrected age at testing	Mean (weeks)	59.2	58.7	58.4	59
	Range (weeks)	48–72	48–71	48–69	49–71
Gestational age at birth	Mean (weeks)	40	33.9	34.6	33.1
	Range (weeks)	39–41	32–36	32–36	32–35
Duration of NG	Mean (days)	0	7.2	6.5	27.9
	Range (days)	0–0	1–42	1–13	21–42
Known developmental delay	Number	0	0	0	0
	Percent	0%	0%	0%	0%
Breast fed at term	Number	9	17	8	9
	Percent	90%	85%	80%	90%
Private hospital cover	Number	4	10	5	5
	Percent	40%	50%	50%	50%

feeds used only as a dietary supplement. For all infants, breast or bottle-feeds were offered first at each feed time, and any remaining feed was given via the NG tube. The hospital from which the participants were recruited has no formal policies regarding the practices of non-nutritive sucking or skin-to-skin contact during NG feeds. None of the mothers of infants in the PT group reported having practiced skin-to-skin contact during NG feeds. Ninety-five percent of the mothers reported having offered their infant a pacifier at some stage during the neonatal period. However, all reported offering the pacifier on an ad hoc basis, rather than limiting its use to feed times, whereby an association between sucking and satiation could be formed.

All of the pre-term infants in the study were taking full-oral feeds at or before term and, thus, no longer required NG supplementation by this time. Infants' post-natal ages were corrected for gestational age at birth for all analyses in the current study. In this way, all infants were classified as being the age they would be if they were born at term.

To examine any association between duration of NG feeding and oral sensitivity and feeding skills, the PT group was sub-divided on the basis of duration of exposure to NG feeds. As there is little evidence in the literature in classifying what is 'long-term' NG feeding, as opposed to 'short-term' NG feeding, it was decided to rank the PT group according to the duration of tube-feeding they had received, and then sub-divide them into two evenly numbered groups. Using this process, one sub-group consisted of 10 infants who had received less than 2-week exposure to NG feeding (PT < 2NG), and the second sub-group consisted of 10 infants who had 3- to 6-week NG feeding exposure (PT >3NG). None of the infants recruited had required between 2 and 3 weeks of NG feeding.

A control group of 10 matched full-term infants was recruited. Inclusion criteria consisted of a gestational age >37 weeks at birth, and an age of 11–17 months at the time of assessment. Candidates for the FT group were recruited from community noticeboards across various childcare centres and playgroup centres within a 50-km radius of the hospital. Twenty-seven families consented to involvement. Ten infants were matched with the PT group for gender and corrected age at the time of assessment. Biographical details of the full-term participants included are outlined in Table 1. None of the FT group had received any form of non-oral feeding.

Statistical testing demonstrated that there was no significant difference between the control group and the two pre-term sub-groups in terms of corrected age at the time of testing ($F = 0.025$, $p < 0.975$). Participants in the control group and the two pre-term sub-groups were also comparable across several other factors that may influence feeding outcomes including diagnosed developmental delays, breast-feeding experience at term, and private health insurance status (see Table 1). Similar percentages of infants in each group had private health cover, with 40% of the FT group covered by private health insurance, compared to 50% of infants in the PT, PT < 2NG, and PT >3NG groups. None of the participants were identified as having any developmental delays. No parent reported that their child had received any form of assessment or therapy from allied health professionals. All parents indicated that their infants had achieved their motor milestones within the normal timeframe. On observation, no child was observed to display any obvious delays in motor skills or social interaction. The mothers of all of the participants indicated that they had intended to breast-feed at the time of their child's birth, and had initiated breast-feeds with their infant. Similar percentages of mothers indicated that they were successfully breast-feeding their infant at term, with 90% of full-term infants receiving breast-feeds at term, compared to 85% of the PT group (80% of the PT < 2NG group, and 90% of the PT >3NG group). The mothers of all of the infants who were not receiving breast-feeds indicated that difficult, painful experiences with breast-feeding were the reason for ceasing breast-feeds. All reported that their infants transitioned to bottle-feeding successfully.

This study was approved by the Human Research Ethics Committees of the Royal Women's Hospital and Royal Children's Hospital (Brisbane), and by the University of Queensland. Informed written consent was obtained from the parents of all participants.

2.2. Procedure

Two investigators visited the homes of all participants to conduct the oral sensitivity and feeding assessments during a typical mealtime for the child. Visits were arranged during a main meal, when parents identified that their infant would usually consume solids. All parents confirmed that the mealtime assessed was representative of a typical meal for their child. A Sony TRV 46E video camera recorder was set up on a tripod approximately 2 m from the child's highchair to record the meal. Video recordings of the sessions lasted from approximately 30 min to 1 h, depending on the feeding habits of the child. All assessments were scored from the videotapes by a separate trained clinician, who was experienced in test administration, and blind to the group allocation of the participants.

2.3. Measures

Oral sensitivity was evaluated using the Royal Children's Hospital Oral Sensitivity Checklist (OSC), which was developed for clinical use [18]. The OSC consists of a total of 13 items, divided into two main subtests. The first subtest provided an indication of the child's facial defensiveness, by looking at behavioural responses to approaching facial contact. The second subtest provided more specific information about the child's oral sensitivity, as indicated by their response to stimulation within the oral region. Infants' responses to each of the test items were scored out of a possible six points. One point was taken off the total for each item for the presence of any of six behaviours, suggestive of altered sensitivity (e.g. head turning, gagging, vomiting) [3,6,7,12]. Thus, the lower the score, the more behaviours displayed, and the more altered the response to the sensory input.

Feeding development was evaluated using the first 16 subtests of the Pre-Speech Assessment Scale (PSAS) [19], which provided a means of systematically rating each child's functional feeding abilities. The first 16 subtests of the assessment cover the four main categories of feeding behaviour, sucking, swallowing, and biting and chewing. Each subtest of the PSAS lists a variable number of rankings based on normal developmental milestones. Developmental data for the PSAS were derived from longitudinal data in normal infants, as well as clinical observations of approximately 600 children with early feeding and speech disorders [19].

All group comparisons were performed using non-parametric tests, the Mann–Whitney *U*-test and Kruskal–Wallis test. Alpha level was set at $p < 0.05$ for analysis of the Oral Sensitivity Checklist. A more stringent alpha level of $p < 0.01$ was used for analysis of the Pre-Speech Assessment Scale, as multiple comparisons were undertaken. Due to the data type and the small participant numbers, analysis was completed with recognition that type I error rates would, on occasion, be somewhat higher than the stated *p*-value. As a result, in cases where the statistics for the analysis of the Pre-Speech Assessment Scale did not reach the required significance level ($p < 0.01$), *p*-values of between 0.01 and 0.05 were considered suggestive of significance but not definitive, and will be discussed in the present paper as a statistical trend. This decision is consistent with Davis and Gaito [20], as well as Moore and McCabe [21], who stated that 'there is no sharp border between "significant" and "insignificant", only increasingly strong evidence as the *P*-value decreases' (p. 486).

2.4. Inter-judge reliability

In order to determine inter-judge reliability, 30% of the videotapes were scored by a separate clinician to the primary scorer, who was also blind to the group allocation of the participants. Inter-judge reliability was calculated as the percentage of agreement between the two clinicians across the various subtests of the two assessments. The inter-observer agreement between the clinicians was 96% for the OSC and 93% for the PSAS.

3. Results

3.1. Comparison of FT and PT groups

Comparison across the two subtests of the OSC revealed statistically significant differences between the FT and PT groups in both subtests (see Table 2). Specifically,

Table 2
Comparison of FT and PT groups using the Mann–Whitney test across the subtests of the Oral Sensitivity Checklist

	FT		PT		U	p
	M	S.D.	M	S.D.		
Facial defensiveness	4.00	0.00	3.45	0.89	65	0.037
Oral sensitivity	6.00	0.00	3.60	1.67	15	0.000

the PT group displayed significantly more behaviours suggestive of altered oral sensitivity than the FT group ($p = 0.000$), with all of the infants in the PT group displaying some behaviours suggestive of altered oral sensitivity. Of them, 1 infant displayed hyposensitive behaviours, while the remaining 19 displayed hypersensitive behaviours. The PT group also demonstrated significantly more facial defensive behaviours than the FT group ($p = 0.037$).

Comparisons of the PT and FT groups on the subtests of the PSAS revealed significant differences or trends on eight of the 16 subtests (see Table 3). The PT group ate significantly less during the meal than FT group ($p = 0.013$), and demonstrated a trend of longer meal duration than the FT group ($p = 0.036$). In addition, in comparison to the FT group, the PT group demonstrated a trend of taking more of their fluid from a bottle rather than transitioning to a cup ($p = 0.036$), less active lip cleaning when taking pureed food from a spoon ($p = 0.037$), more tongue protrusion and loss of food when swallowing semi-solids ($p = 0.016$), and taking fewer sucks of a liquid before

Table 3
Comparison of FT and PT groups using the Mann–Whitney test across the subtests of the Pre-Speech Assessment Scale

	FT		PT		U	p
	M	S.D.	M	S.D.		
Length of time required to eat a meal	2.00	0.00	1.65	0.49	65	0.036*
Approximate amount of food eaten at a meal	3.00	0.00	2.50	0.61	55	0.013**
Types of food eaten by mouth	2.20	0.42	2.00	0.46	82	0.256
Position in which the child is fed	2.10	0.32	2.40	0.68	69	0.120
Sucking: liquids from the bottle or breast	2.00	0.00	1.65	0.49	65	0.036*
Sucking: liquids from a cup	2.00	0.00	2.00	0.73	100	1.000
Sucking: pureed foods from a spoon	3.80	0.42	3.25	0.79	58	0.037*
Swallowing: liquids	2.00	0.00	2.00	0.56	100	1.000
Swallowing: semi-solids	4.40	0.52	3.65	0.93	52	0.016*
Swallowing: solids	2.40	0.52	2.15	0.67	81	0.344
Co-Ordination of sucking, swallowing, and breathing	2.80	0.42	2.15	0.81	55	0.029*
Control of drooling	3.00	0.67	2.75	0.79	83	0.410
Jaw movement in biting	3.60	0.52	2.90	0.97	54	0.032*
Jaw movement in chewing	3.70	0.48	3.00	0.86	52.5	0.024*
Tongue movement during chewing	4.10	0.32	3.70	0.98	78	0.247
Lip movement in chewing	3.90	0.74	3.10	1.33	65	0.110

*$p \leq 0.05$.
**$p \leq 0.01$.

pulling away to swallow or breathe ($p = 0.029$). The PT group also displayed a trend of weaker, less mature jaw movements when biting than the FT group ($p = 0.032$), and weaker, less mature jaw movements when chewing ($p = 0.024$). No other significant differences or trends were observed between the feeding development of these two groups.

3.2. Comparison of FT, PT<2NG, and PT>3NG groups

Comparison across the two subtests of the OSC revealed statistically significant differences between the FT, PT < 2NG, and PT >3NG groups in both subtests (see Table 4). Specifically, significant differences were found between the groups in terms of both oral sensitivity ($p = 0.000$) and facial defensiveness ($p = 0.005$).

Post-hoc analysis revealed statistically significant differences between the oral sensitivity of the FT and PT>3NG groups ($p = 0.000$, $U = 0$) and between the FT and PT < 2NG groups ($p = 0.002$, $U = 15$), indicating that both the PT >3NG and PT < 2NG groups displayed significantly more behaviours suggestive of altered oral sensitivity than the FT group. No significant difference or trend was found between the oral sensitivity of the PT < 2NG and PT >3NG groups.

With regard to facial defensiveness, the PT>3NG group displayed significantly more facial defensive behaviours than both the FT group ($p = 0.005$, $U = 20$) and the PT < 2NG group ($p = 0.036$, $U = 26.5$). No significant difference or trend was found between the facial defensiveness of the FT and PT < 2NG groups.

Comparisons between the FT, PT < 2NG, and PT >3NG groups across the subtests of the PSAS revealed significant differences or trends between the groups on 5 of the 16 subtests (see Table 5). Specifically, significant difference was found between the groups in the strength and maturity of jaw movements when biting ($p = 0.007$). In addition, trends were found between the groups indicating differences in the amount of tongue protrusion and loss of food when swallowing semi-solids ($p = 0.043$), the number of sucks of a liquid taken before pulling away to swallow or breathe ($p = 0.025$), meal duration ($p = 0.033$), and quantity of food consumed during a meal ($p = 0.044$).

Post-hoc analysis found significant differences between the FT and PT >3NG groups in all 5 subtests listed above. That is, compared to the FT group, the PT >3NG group displayed significantly less mature jaw movements when biting ($p = 0.003$, $U = 13$), significantly more tongue protrusion and loss of food when swallowing semi-solids ($p = 0.010$, $U = 21$), and took significantly fewer sucks of a liquid before pulling away to swallow or breathe ($p = 0.006$, $U = 17$). The PT >3NG group also took significantly

Table 4
Comparison of FT, PT < 2NG, and PT >3NG groups using the Kruskal–Wallis test across subtests of the Oral Sensitivity Checklist

	FT		PT < 2NG		PT > 3NG		χ	p
	M	S.D.	M	S.D.	M	S.D.		
Facial defensiveness	4.00	0.00	3.80	0.63	3.10	0.99	10.44	0.005
Oral sensitivity	6.00	0.00	4.20	1.55	3.00	1.63	17.54	0.000

Table 5
Comparison of FT, PT < 2NG, and PT >3NG groups using the Kruskal–Wallis test across subtests of the Pre-Speech Assessment Scale

	FT		PT < 2NG		PT >3NG		χ	p
	M	S.D.	M	S.D.	M	S.D.		
Length of time required to eat a meal	2.00	0.00	1.80	0.42	1.50	0.53	6.85	0.033*
Approximate amount of food eaten at a meal	3.00	0.00	2.50	0.71	2.50	0.53	6.24	0.044*
Types of food eaten by mouth	2.20	0.42	2.20	0.42	1.80	0.42	5.16	0.076
Position in which the child is fed	2.10	0.32	2.20	0.79	2.60	0.52	4.27	0.118
Sucking: liquids from the bottle or breast	2.00	0.00	1.70	0.48	1.60	0.52	4.68	0.096
Sucking: liquids from a cup	2.00	0.00	2.20	0.79	1.80	0.63	2.32	0.313
Sucking: pureed foods from a spoon	3.80	0.42	3.00	0.94	3.50	0.53	5.80	0.055
Swallowing: liquids	2.00	0.00	2.10	0.74	1.90	0.32	0.97	0.617
Swallowing: semi-solids	4.40	0.52	3.80	0.92	3.50	0.97	6.28	0.043*
Swallowing: solids	2.40	0.52	2.20	0.63	2.10	0.74	0.98	0.613
Co-Ordination of sucking, swallowing, and breathing	2.80	0.42	2.40	0.84	1.90	0.74	7.39	0.025*
Control of drooling	3.00	0.67	2.90	0.99	2.60	0.52	1.87	0.393
Jaw movement in biting	3.60	0.52	3.40	0.84	2.40	0.84	10.07	0.007**
jaw movement in chewing	3.70	0.48	3.10	0.88	2.90	0.88	5.41	0.067
Tongue movement during chewing	4.10	0.32	3.70	0.95	3.70	1.06	1.45	0.484
Lip movement in chewing	3.90	0.74	3.00	1.41	3.20	1.32	2.68	0.262

$^*p \leq 0.05$.
$^{**}p \leq 0.01$.

longer to complete a meal ($p = 0.012$, $U = 25$) and ate significantly less during a meal ($p = 0.012$, $U = 25$) than the FT group.

A statistical trend was found between the FT and PT < 2NG groups in only one subtest. Specifically, the PT < 2NG group displayed a trend of taking longer to complete a meal ($p = 0.030$, $U = 30$) than the FT group. A statistical trend was also found between the PT < 2NG and PT >3NG groups in only one subtest, with the PT >3NG group displaying a trend of less mature jaw movement when biting ($p = 0.019$, $U = 20.5$) than the PT < 2NG group.

4. Discussion

Although the results of the present study are based on small numbers of participants, they provide important preliminary data. Specifically, results demonstrate that, relative to full-term controls, low-risk pre-term infants were found to display continued altered oral sensitivity, facial defensiveness, and delayed feeding development at 11–17 months corrected age. The results also demonstrate that low-risk pre-term infants who received greater than 3 weeks of NG feeding displayed more facial defensive behaviours, and displayed delays across more aspects of feeding development than pre-term infants who received less than 2 weeks of NG feeding. These findings validate the need for further research on this topic.

4.1. Oral sensitivity and facial defensiveness

The assessment of oral sensitivity revealed that both the PT < 2NG and PT > 3NG sub-groups displayed significantly more behaviours suggestive of altered oral sensitivity than the FT group. In fact, all of the pre-term infants in the current study were found to display some form of behaviours suggestive of altered oral sensitivity. This altered sensitivity was displayed as either increased sensitivity or reduced sensitivity, which is consistent with the literature which has suggested that NG feeding may be associated with both oral hypersensitivity [1–3,6,10,12,16] and oral hyposensitivity [1–3,12,16]. In the present study, hypersensitivity was much more common than hyposensitivity in the PT group, as hypersensitive behaviours were observed in 19 of the 20 infants who were examined, compared to only 1 infant who displayed hyposensitive behaviours. Interestingly, the infant who displayed behaviours suggestive of oral hyposensitivity had received the longest duration of NG feeding of all the infants studied. This supports the suggestion by Morris [12] that "as a child adapts or becomes habituated to the sensory presence of the tube, there may also be a habituation to other stimuli on the back of the tongue and pharynx (p. 138)". This issue warrants further investigation.

In terms of facial defensiveness, no significant difference was found between the responses of the PT < 2NG group and those of the FT group in anticipation of facial contact. However, infants in the PT>3NG group were found to display significantly more facial defensive behaviours than infants in the FT group. This response displayed by infants in the PT>3NG group usually took the form of crying and the use of avoidance tactics, such as head turning and hand waving, in anticipation of facial contact or approaching feeding utensils. The presence of these behaviours supports suggestions in the literature that negative experiences with early feeding may be associated with later conditioned defensive behaviour [1–3,6,7,12,17]. Further, the results of this study suggest that while all pre-term infants who receive NG feeding may be at risk for altered oral sensitivity, those who receive greater than 3 weeks of NG feeding may also be at greater risk of developing a conditioned avoidance of the facial contact associated with feeding. Although limited quantitative data have been reported regarding the association between duration of NG feeding and sensory outcome, the present data suggest that further research is warranted to investigate this possible relationship.

4.2. Feeding

Assessment of feeding development in the current study found statistical differences or trends between infants in the PT group and that of infants in the FT group across numerous aspects of both oral and pharyngeal stages of deglutition. These results are interesting, given that there were no significant differences between the groups in terms of corrected age at the time of testing, and that infants in both groups were comparable in terms of medical and general developmental status, early breast-feeding experience, and private health insurance status. These findings raise the possibility that exposure to NG feeding during the birth-stay in hospital, even if only used to supplement oral feeds, may be associated with later feeding problems. This possibility provides some support to the anecdotal reports by numerous authors that the use of tube-feeding in infants may be associated with poorer feeding skill development [1–7,12,16,17].

Specifically, it has been suggested anecdotally in the literature that prolonged use of feeding tubes may be associated with later problems with swallowing, and the co-ordination of the swallowing and breathing mechanisms [1–3,6,16]. The present study found that, overall, the PT group displayed a statistical trend of poorer skills in both of these areas compared to matched full-term controls. Further, the study found that those pre-term infants in the PT > 3NG group displayed significantly less functional co-ordination of sucking, swallowing, and breathing when drinking than the FT group, as measured by the number of sucks of a liquid taken before stopping to swallow and breathe, as well as less mature skills at swallowing semi-particulate solids. This provides some support to anecdotal reports already in the literature, and suggests that delays in swallowing development and co-ordination may persist over a long-term, until at least 11–17 months corrected age, in low-risk pre-term infants who receive NG feeding during their birth-stay in hospital.

The current study also observed that infants in the PT group displayed a statistical trend of less mature sucking skills than infants in the FT group. This was observed both in sucking of liquids from a cup, and in sucking pureed food from a spoon. Previous research has suggested that pre-term infants who undergo orotracheal intubation (which involves passing a tube through the oral and pharyngeal regions to the trachea for breathing) during the neonatal period are at risk for poorer sucking ability at term and at 3 months corrected age [8]. While the infants in the current study did not receive orotracheal intubation, the present results suggest that early exposure to NG feeding (which also involves passing a tube through the pharyngeal region) may also be associated with poor development of sucking abilities in pre-term infants. Further, the results suggest that low-risk pre-term infants who receive NG feeding during their birth-stay in hospital may be at risk for displaying continued delayed sucking skills until at least 11–17 months corrected age.

The present study also found that infants in the PT > 3NG group displayed significantly weaker and less mature jaw movement when biting than infants in the FT group, and a statistical trend suggesting weaker and less mature jaw movement than the PT < 2NG group. It has been previously reported in the literature that poor jaw control may affect the initial transition to full oral feeding by many pre-term infants who receive NG feeding around birth [10]. However, the current results indicate that poor jaw control may continue to affect feeding ability in low-risk pre-term infants who receive greater than 3 weeks of supplemental NG feeding, well after full oral feeding has been established.

In the present study, it was found that the PT group, as a whole, ate significantly less during the meal than the FT group. Infants in the PT > 3NG group also took significantly longer to complete a meal than infants in the FT group. In light of the high incidence of problems with swallowing, sucking, biting and chewing in this population, it is not unexpected that both a decrease in mealtime completion and an increase in mealtime duration would be observed. In addition, previous research has determined that an increase in meal duration is typically associated with selective or picky eating, such as limited acceptance of certain food types, textures, or temperatures [22]. Therefore, the high incidence of altered oral and facial sensitivity found in the infants studied could also contributing to these mealtime disturbances.

4.3. Limitations of the study

As the current report was based on a small number of infants, it is difficult to speculate whether the infants from this sample are representative of all low-risk pre-term infants. As a result, further research in this area is needed with larger numbers of pre-term infants to confirm findings and to answer remaining questions. Until then, generalisation of results needs to be made with caution.

A second limitation of the present study is related to the nature of the population studied. Specifically, very few pre-term infants do not initially require some supplemental NG feeding to meet caloric and nutritional needs. Therefore, as little is known about the oral sensitivity and feeding outcomes associated with prematurity alone, it has to be acknowledged that it is difficult to fully distinguish the impact of NG feeding on oral sensitivity and feeding development in pre-term infants from any possible unidentified impact of prematurity. Further, given that duration of NG feeding received by pre-term infants is dependant on medical need, and not a factor that can be randomly manipulated, it is not within the scope of this type of study to establish whether exposure to NG feeding and later feeding and oral sensitivity problems are causally related in this population. However, the findings from this study are able to suggest that low-risk pre-term infants who are exposed to longer durations of NG feeding appear to be at risk for more delayed feeding skills and altered oral sensitivity than other low-risk pre-term infants who are exposed to shorted durations of NG feeding. Therefore, further research is warranted with more infants to more precisely establish the nature of this apparent relationship.

4.4. Other factors to be addressed in future research

In general, the results of the current study revealed that the infants in the PT group displayed lower mean scores than the infants in the FT group across all of the feeding subtests. However, statistical trends and/or statistically significant differences were found between the groups in only some, but not all, of the subtests. As very little research has directly examined this area previously, it is difficult to speculate why the pre-term infants displayed greater delays in some areas and not in others. In addition, the possibility exists that greater differences in sensitivity and feeding may have existed between the groups at earlier ages than was assessed in this study. Further research is needed to investigate these issues.

Another factor that needs to be considered in future research is that the pre-term infants studied in the current investigation displayed no significant medical comorbidities. Bazyk [7] reported a significant positive correlation between the length of time an infant takes for the transition from NG to full oral feeding and both, the total number of medical conditions they display, as well as the specific number of cardiac conditions, respiratory conditions, digestive conditions, and certain neurological conditions they have. This indicates that such medical conditions may cause or exacerbate feeding problems in infants receiving NG feeding. Therefore, it is possible that NG feeding may be associated with more negative outcomes in relation to oral sensitivity and feeding development when combined with these medical conditions. Further research needs to be conducted with pre-term infants who demonstrate medical comorbidities to determine if this is the case.

5. Conclusion

To date, there has been limited systematic evidence regarding the long-term oral sensitivity and feeding skills of low-risk pre-term infants, born between 32 and 37 weeks gestational age with no medical comorbidities. This study, however, suggests that this population may be at risk of altered oral sensitivity, facial defensiveness, and delayed feeding development until at least 11–17 months corrected age. The feeding outcomes that low-risk pre-term infants appear to be at greatest risk of include weak, immature jaw movement in biting and in chewing, less active lip cleaning when taking pureed food from a spoon, more tongue protrusion and loss of food when swallowing semi-solids, poor co-ordination of sucking, swallowing, and breathing, delayed transition to drinking from a cup, rather than a bottle, prolonged duration of mealtimes, and reduced amount of food eaten at meals.

In the literature so far, there has also been limited evidence examining the association between duration of exposure to NG feeding and later oral sensitivity and feeding skills in the pre-term population. This study, however, suggests that low-risk pre-term infants who are exposed to greater than 3 weeks of NG feeding may be at greater risk of more adverse reactions to facial contact, and delays across more aspects of feeding development, than pre-term infants who receive less than 2 weeks of NG feeding. Specifically, pre-term infants who receive greater than 3 weeks of NG feeding appear to be at risk for displaying both altered oral sensitivity and general facial defensiveness, as well as weak, immature jaw movement in biting, poor swallowing of semi-solids, poor functional co-ordination of sucking, swallowing, and breathing, prolonged duration of mealtimes, and reduced amount of food eaten at meals. Such preliminary findings suggest that increased duration of supplemental NG feeding during the birth-stay in hospital may be associated with more negative outcomes in feeding development and facial defensiveness at 11–17 months corrected age.

The results of the present study are limited by the small number of infants assessed. However, the findings validate the need to conduct further investigation with larger numbers of pre-term infants. In the clinical setting, there is a need for information regarding the areas where pre-term infants who receive NG feeding may be at risk in relation to oral sensitivity and feeding development. This information will assist in planning service delivery to appropriately anticipate the needs of this population with regards to assessment and treatment. In addition, this information will also assist in guiding the development of early prevention programs for neonates with NG tubes in place. Such programs may be capable of preventing or reducing any avoidable adverse effects on oral sensitivity and feeding development associated with early tube-feeding exposure in this population, as well as the impact such problems may have on infant and parent stress and quality of life.

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