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ORAL FEEDING SKILLS OF PREMATURE INFANTS

by
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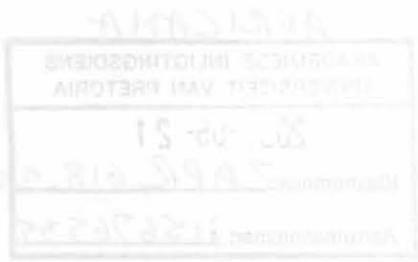
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SUMMARY

ORAL FEEDING SKILLS IN PREMATURE INFANTS

by

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Early intervention is a rapid-growing, comprehensive science. The premature infant forms a significant part of the population who requires early intervention services from the speech-language therapist. Oral feeding problems represent a large part of the unique set of problems which premature infants experience. A lack of information in the literature was identified in terms of: firstly, the comprehensive description of oral feeding skills in premature infants and secondly, a comprehensive evaluation tool which would enable the researcher to describe these oral feeding skills.

The aim of this study was to describe the oral feeding skills of the premature infant during bottle- and cup-feeding. The different effects of the two feeding methods on the physiological status of the subjects were also examined.

The study comprises a theoretical and an empirical section. The theoretical section purports a literature review. Information obtained from recent literature on the premature infant with his/her specific problems as well as the on the mechanism of the whole swallowing process forms the underpinning of the empirical study. The empirical study comprises two phases. The first phase



purports the development and design of a comprehensive oral feeding evaluation tool, namely, the “Feeding Evaluation Form for At-Risk Infants” (FEFARI). The second phase was executed by applying the FEFARI to 42 premature infants of four different gestational ages (34-37 weeks), to enable the researcher to describe all aspects involved in oral feeding in premature infants. A descriptive research design was used, as the oral feeding skills of the subjects had to be observed in their natural conditions. Information regarding the risk factors for feeding problems, the state and behaviour of the subjects and the non-nutritional and nutritional sucking skills during bottle- and cup-feeding, was obtained with the FEFARI. This information is described, discussed, analysed and interpreted according to the aims of this research project.

The results of this study prove the FEFARI to be invaluable for the description of the oral feeding skills of premature infants. The information obtained with the FEFARI is also valuable for the planning of appropriate, effective and accountable oral feeding therapy for premature infants.

These findings have important implications for the management of oral feeding of premature infants. This study encourages the early involvement of the speech-language therapist/feeding specialist with the premature infant in the NICU. Further research is recommended to expand and support the findings of this study.

KEY WORDS:

Premature infant, NICU, oral feeding skills, nutritional sucking, non-nutritional sucking, swallowing, feeding problems, high risk factors, speech-language therapist, feeding specialist.



OPSOMMING

ORALE VOEDINGS VAARDIGHEDE IN PREMATURE BABAS

deur

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Vroeë intervensie is 'n snel groeiende, omvangryke vakgebied. Die premature baba maak 'n beduidende deel uit van die populasie wat vroeë intervensie gelewer deur die spraak-taal terapeut, benodig. Orale voedingsprobleme maak 'n groot deel uit van die unieke probleme wat die premature baba ervaar. 'n Leemte is in die literatuur geïdentifiseer in terme van: eerstens, die omvattende beskrywing van die orale vaardighede van die premature baba en tweedens, 'n omvattende evaluasieinstrument wat die navorser in staat sal stel om die voedingsvaardighede te beskryf.

Die doel van die studie was om die orale voedingsvaardighede van die premature baba te beskryf tydens bottel- en koppievoeding. Die verskillende uitwerking van die twee voedingsmetodes op die proefpersone se fisiologiese toestand is ook ondersoek.

Die studie bestaan uit 'n teoretiese en 'n empiriese gedeelte. Die teoretiese gedeelte bevat 'n literatuuroorsig. Inligting verkry uit resente literatuur oor die premature baba met sy spesifieke probleme, sowel as die meganisme van die

slukproses, dien as begroning van die empiriese ondersoek. Die empiriese ondersoek bestaan uit twee fases. Die eerste fase behels die ontwerp en ontwikkeling van 'n omvattende orale voedingsevaluasie-instrument, naamlik die "Feeding Evaluation Form for At-Risk Infants" (FEFARI). Die tweede fase bestaan uit die toepassing van die FEFARI op 42 premature babas van 4 verskillende gestasie-ouderdomme (34-37 weke) om die navorser in staat te stel om alle aspekte wat met orale voeding van die premature baba te make het, te kan beskryf. 'n Beskrywende navorsingsontwerp is gebruik aangesien die proefpersone se voedingsgedrag in 'n natuurlike omgewing waargeneem moes word. Inligting met betrekking tot die risikofaktore vir voedingsprobleme, die toestand en gedrag van die proefpersone, die nie-nutrisionele sowel as die nutrisionele suigvaardighede tydens bottel- en koppievoeding is met behulp van die FEFARI versamel. Hierdie inligting is na aanleiding van die navorsingsdoelstellings bespreek, ontleed en geïnterpreteer.

Die resultate van die studie toon dat die FEFARI waardevol was vir die beskrywing van die orale voedingsvaardighede van die premature beba. Die inligting verkry van die FEFARI kan ook sinvol aangewend word om 'n toepaslike, effektiewe en verantwoordbare voedingsterapie vir premature babas te beplan.

Die bevindinge hou belangrike implikasies in vir die hantering van orale voeding in premature babas. Die studie moedig ook betrokkenheid van die spraak-taal terapeut/voedingspesialis by die premature baba in die neonatale eenheid so spoedig moontlik, aan. Verdere navorsing word aanbeveel ter uitbreiding en bevestiging van hierdie navorsingsresultate.

SLEUTELWOORDE:

premature baba, neonatale eenheid (NICU), orale voedingsvaardighede, nutrisionele suig, nie-nutrisionele suig, sluk, voedingsprobleme, hoë risiko faktore, spraak-taal terapeut, voedingspesialis.

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CHAPTER 1

ORIENTATION AND STATEMENT OF PROBLEM

Aim: To provide an overview of the problem related to the evaluation of feeding skills in premature infants, in order to serve as a rationale for the study. A solution is proposed, important concepts are defined and the organisation of the chapters is presented.

1.1 INTRODUCTION

Although early intervention is a relatively new discipline, it is a well-recognised field today. Early intervention is usually provided to infants from 0-3 years of age with or at-risk for developmental problems. The United States of America recognises the importance of early intervention with appropriate legislation. The general belief is that the sooner the intervention can be provided, the better the outcome will be (Rossetti, 1998). Early intervention in the Neonatal Intensive Care Unit (NICU) was found not only to be effective, but the developmental outcome of the premature infants also improved significantly due to intervention (Hyde & Jonkey, 1994).

There are certain factors that may place an infant at risk for developmental delays and/or difficulties. These factors, whether they are biological, established or of environmental origin, can influence the infant any time from conception up to well after birth. Due to improved medical technology, currently more infants with biological risk factors survive (Rossetti, 1996; Widerstrom, Mowder & Sandall, 1997). Once the risk factors are identified, comprehensive assessment of the developmental areas can be done and appropriate intervention can be implemented to prevent or minimise any developmental delays which could have

resulted from these risk factors (McCarton, Wallace & Bennet, 1995; Rossetti, 1986, 1998; Sweeney, 1985; Widerstrom et al., 1997)

Premature infants form a recognised high-risk group who require early intervention services. The number of infants in this group is also on the increase, due to improved and more sophisticated medical technology and procedures (Bazyk, 1990; Rossetti, 1986; Oehler, Thompson & Gustafsen, 1996). The survival rate of premature infants has increased considerably in the last decade. This is especially true for the number of infants born between 23 and 25 weeks gestational age (Lau & Hurst, 1999). In South Africa the same phenomenon is experienced. The percentage of infants born with low birth weights, who survive, has increased from 2% (in earlier years) to 18.8 % in 1998 and 15.8 % in 1999 (De Witt, Naudè & Pistorius, 2000). This is not only as a result of improved medical care but can also be attributed to the implementation of the new national health policy, which attempts to provide free medical care for all infants and young children (under the age of six years) in state hospitals. Health care professionals working in neonatal intensive care units, accordingly have a bigger responsibility to manage this increased number of patients effectively.

1. 2 STATEMENT OF PROBLEM

The preterm infant is at risk for many problems, medically as well as developmentally (Bennett, 1995; Jacobson & Shubat, 1991; McCarton et al., 1995). One of the first and more serious problems experienced by preterm and low-birthweight infants, are **feeding problems**. Feeding difficulties make up a major proportion of the problems that arise from prematurity (Bu'Lock, Woolridge & Baum, 1990). Oral feeding of these infants has therefore become a critical concern (Lau & Hurst, 1999). The medical complications that these infants may suffer may also contribute to further feeding problems (Arvedson & Brodsky, 1993; Creger, 1995; Vergara, 1993; Wolf & Glass, 1991). On the other hand,

feeding and swallowing problems can complicate medical management, resulting in prolonged hospitalisation (Comrie & Helm, 1997). There has recently been a tendency to discharge infants earlier, so that the need to intervene and to equip parents for home care management has increased accordingly (Alper & Manno, 1996). Feeding problems do not only imply sucking and swallowing difficulties, but also include aspects such as the cardio-respiratory status (pneumonia, oxygen desaturation, apnea and bradycardia), neuromotor maturity and the state and behaviour of the infant (Lau & Hurst, 1999; Vergara, 1993). Due to their immature nervous systems, premature and sick infants (NICU candidates) are particularly vulnerable to adverse conditions and stress. Inappropriate intervention in the NICU can have life-threatening consequences and traditional therapies may be harmful. The provision of safe and effective therapy to these fragile patients, who require intensive care, implies an advanced level of competency and judgement – beyond that of standard training (Hyde & Jonkey, 1994). Jolley, McClelland, & Mosesso-Rousseau, (1995) also state that the rising number of surviving infants in the NICU created the need for a more detailed assessment of the feeding and swallowing skills of these infants. Effective, accountable therapy in the NICU can only be implemented when appropriate, comprehensive assessment of the infant has taken place. This implies that specially designed assessment procedures are needed to assess the premature infant as a whole, as well as to determine specific areas of need.

Team members involved with the treatment of the NICU patient, including the speech–language pathologist/feeding specialist, should undergo specialised training, study and practice, which includes a clear understanding of neonatal medical conditions and treatment procedures to ensure effective accountable service delivery (Hunter, Mullen & Dallas, 1994, Hyde & Jonkey, 1994). The composition of professionals in the team varies depending on the setting. Infants in neonatal intensive care units, have complicated problems and the professionals who have to address their feeding problems, work in a complex setting. It is therefore important that the professionals and the parents in the NICU setting should work together as a team. The team involved in the management of the

infant in the NICU should include as basic members: the family, nurses (who are the primary feeders) and physicians (e.g. neonatologist, who is the primary physician). Other members who need to be included are ophthalmologists, radiologists, gastro-enterologists, paediatric surgeons and paediatric orthopaedic surgeons, as well as developmental specialists. The last-mentioned group may include any or all of the following: speech-language therapists, occupational therapists, physical therapists, social workers, psychologists and nutritionists (Comrie & Helm, 1997; Lau & Hurst, 1999; Lefton-Greif & Arvedson 1997; Sheahan & Brockway, 1994).

Although some experts like Lau & Hurst (1999) support an interdisciplinary approach, Lefton-Greif & Arvedson (1997) recommend a transdisciplinary approach in the NICU, primarily because of concerns regarding the infant's fragile medical status. Which kind of team approach to follow in the NICU is a complex decision. Regarding the feeding specialist and the primary feeder, the infant can be managed in a transdisciplinary fashion. On the other hand, in terms of medical care, the physicians have to be in control and it is clear that the feeding specialist cannot work in a transdisciplinary capacity. An inter- and even multidisciplinary approach may therefore be more appropriate in the NICU. The paediatric swallowing team comprises several disciplines that share knowledge and interest in overlapping functions that involve multiple anatomic and physiologic systems.

The feeding specialist in the NICU assists in the diagnoses of feeding and swallowing problems, and works with the parents and nurses to establish appropriate feeding guidelines. The infant's status is monitored for improvement in, or regression of, oral feeding skills. The feeding/swallowing specialist usually has professional credentials in speech-language therapy or occupational therapy (Lefton-Greif & Arvedson, 1997). The speech-language therapist plays an active role in the NICU (Alper & Manno, 1996). On the one hand, he/she concentrates on **early communication aspects** and, on the other hand, functions as **feeding specialist**. The purpose of early communication is to tune in to the infants and to provide the appropriate stimulation at the right time (Billeaud, 1993). As feeding

specialist, the speech-language therapist's role is multifaceted and may include the following functions:

- Performing of oral stimulation (Dunn, Van Kleeck & Rossetti, 1993; Sweeney, 1985),
- Reducing tactile defensiveness in and around the infant's mouth (Morris, 1989; Vergara, 1993),
- Providing information to all the team members on the benefits of non-nutritional sucking for infants who are being tubefed (Creger, 1995; Dunn et al., 1993; Morris, 1989; Premji & Paes, 2000; Sheahan & Brockway, 1994),
- Recognising the infant's stress signals (Hussey, 1988)
- Reducing interactional demands on the infant by controlling the NICU environment during feeding (Rossetti, 1998).
- Being responsible for the safe and efficient transfer of non-oral feeding to oral feeding in the preterm infant (Comrie & Helm, 1997; Creger, 1993; Harris, 1986; Mandich & Ritchie, 1996). This implies that the infant must be able to feed safely by breast, bottle or cup. Comprehensive evaluation of the premature infant's state, behaviour, oral-motor and feeding skills is needed to plan safe and accountable intervention.

Cupfeeding, instead of bottle-feeding, of premature infants as an interim method of feeding, until the infant can feed from the breast, is advised by the World Health Organization (WHO, 1989). According to the WHO, breastfeeding is to be promoted in South Africa (as for all infants born in developing countries), because breast milk is more beneficial to the infant than formula milk, it is cheaper and no sterilisation facilities or practices are needed. Bottle-feeding in many rural communities may lead to many problems which may adversely affect the health and nutritional status of infants, such as access to portable, safe water, maintenance of proper sanitation and adequate literacy to prepare the infant

formula according to prescribed guidelines (Olayinka, Oni, Mbajorgu, 2000). This results in poor weight gain and the infants become undernourished which is highly undesirable in this period of rapid brain growth. Furthermore, unsterilised utensils can cause gastro-intestinal infections, which can be life threatening to the young infant. Bottle-feeding in the hospital should be discouraged to avoid nipple confusion in the infant and to avoid the infant becoming accustomed to the shape of the artificial teat and the taste of formula milk and thereafter refusing the breast. Hospitals following the principles advocated by the WHO's and the United Nations Children's Fund's "ten steps to successful breastfeeding", have been awarded the title of "baby friendly hospital" since the early 1990s (Lau & Hurst, 1999). In such hospitals expressed breast milk is requested from mothers of small infants soon after birth. In the local NICU the breast milk is presented with a cup. Boo, Puah & Lye (2000) found that one of the three factors which were significantly associated with the survival of extremely low birthweight infants was the used of expressed breast milk to these infants.

Recently, the issue of whether HIV positive mothers should breastfeed is debated. A study in Zimbabwe found that infants who were exclusively breastfed were at highest risk of mother to child transmission (MTCT) of HIV-1, within the first 3 months. They found breastfed infants four times more at risk of MTCT of HIV-1, than formula-only fed infants (Olayinka et al., 2000). A study conducted in Durban, South Africa, found that exclusive breastfeeding for 6 months reduced the risk of HIV transmission by 44%, compared with mixed feeding (Bobat, 2000). The general consensus though, is that HIV infected mothers should be advised about the risks and benefits of breast feeding for infants, in order to make an informed choice to breastfeed or not (Bobat, 2000; Olayinka et al., 2000). Should their choice be to breastfeed, the breastfeeding should be made as safe as possible and all encouragement to do so exclusively for 6 months should be given.

The question as to why so much emphasis is placed on effective oral feeding in infants, arises. *Firstly*, the sufficient growth of infants is primarily a function of

adequate nutritional intake. The ability to take in that which is needed for adequate weight gain, is the first step in a feeding programme. Most hospitals use a specific weight as a discharge criterion (Comrie & Helm, 1997). Adequate nutritional intake depends on the infant's ability to feed by bottle, cup or breast safely and successfully. It is therefore important to help the preterm infant to transfer to successful oral feeding as soon as possible, so that he/she can be discharged from hospital. The sooner the infant can be discharged, the sooner the parent-infant relationship can be built in normal domestic circumstances. It can also benefit the parents or state hospitals financially to have the infant discharged a few days earlier (Bernbaum & Hoffman-Williamson, 1991; Gaebler & Hanzlik, 1995; Mattes et al., 1994).

Secondly, food is a very important aspect of people's lives. Feeding is not only life-sustaining but has psychological, cultural and symbolic significance. We entertain, celebrate and "treat" each other with food. When a mother is unable to feed her baby, it elicits feelings of concern, anxiety, frustration, resentment, anger and despair. Feelings of inadequacy, incompetence and being worthless as a mother and woman, are common in mothers of infants with feeding problems (Jaffe, 1989; Ramsey, Gisel & Bounty, 1993; Ramsey & Gisel, 1996; Rosenthal, Sheppard & Lotze, 1995). Ramsey & Gisel (1996) also found that early feeding impairment might trigger maladaptive interactional patterns between infants and their mothers/caregivers. Jaffe (1989) and Rosenthal et al. (1995) agree that feeding problems can negatively influence bonding and communication between mother and infant. Thus, it is of the utmost importance to intervene as soon as possible when infants experience feeding problems. It is clear that feeding therapy is an important aspect of early intervention. Accountable intervention should be preceded by comprehensive evaluation.

Comrie & Helm (1997) state that there is an increasing need to identify and evaluate feeding and swallowing difficulties in the NICU, to provide intervention strategies and to prepare families or caregivers for discharge. Jolley et al., (1995) suggest that a more detailed, thus a comprehensive feeding assessment of

premature infants' feeding skills is needed to enable the feeding specialist to plan **appropriate, effective** and **accountable** intervention. A thorough understanding of all aspects of sucking, swallowing and breathing patterns of the premature infant, the general characteristics and medical condition of premature infants and a comprehensive evaluation tool is needed for the appropriate management of feeding difficulties of these premature infants (Vergara, 1993). Cherney (1994) and Rosenthal et al. (1995) emphasize the fact that assessment of all phases of swallowing should be included when evaluating infants' feeding abilities.

Researchers from many disciplines (DeMonterice, Meier, Engstrom, Crichton & Mangurten, 1992) have studied sucking in full-term and preterm infants. Although various aspects of sucking, swallowing and breathing patterns of the full-term infant during bottle- and breastfeeding have been described in the literature, limited information is available on the sucking, swallowing and breathing patterns of the premature infant during bottle-, breast- and cupfeeding (Shivpuri, Martin, Carlo & Fanaroff, 1983; Rosen, Glaze & Frost, 1984). In this regard, Mandich & Ritchie (1996) feel strongly that the characteristics of the sucking and swallowing patterns of infants who experience apnea need to be described in more detail. More specifically, limited research has been conducted on sucking behaviour as a component of feeding abilities and therefore as regulator of nutritional intake and growth (Casaer, Daniels, Devlieger, De Cock & Eggermont, 1982). Furthermore, limited research has been conducted on the oral-motor patterns used by premature infants for sucking and swallowing. Sucking patterns are usually studied in terms of rhythm used during sucking (Braun & Palmer, 1985; Ramsey & Gisel, 1996), the intra-oral pressure on the teats, or the movement of the jaw whilst sucking (DeMonterice et al., 1992). Palmer, Crawley & Blanco (1993:28), stated "Poor feeding patterns have not, however, been well described or defined. Clinical observations of feeding difficulties have traditionally been described as "weak suck, poor suck", and "difficulty in coordinating suck, swallow, and breathing." DeMontrice et al. (1992) feel that further research is needed to define the maturational patterns of sucking, swallowing and breathing co-ordination in

preterm infants. Herman (1991) found that many failure-to-thrive (FTT) infants had mild oral-motor dysfunction, which often goes unrecognised until years later when the child is referred for malnutrition and with a history of difficulty to feed. If the feeding problem as mentioned had been identified and managed earlier, complications could have been avoided. For intervention to be effective, the problem must be defined adequately (Bu'Lock et al., 1990). **It can therefore be concluded that a need exists to describe the oral feeding skills, as well as their maturational patterns, in the premature infant in a comprehensive and holistic way.**

According to Bu'Lock et al. (1990), feeding skills can be adequately defined by careful history taking, examination of the infant in combination with observation of the mother feeding the infant. Examination can also be carried out according to feeding assessment scales. A number of feeding scales have been developed, e.g. "The Neonatal Oral-Motor Scale" (Braun & Palmer, 1985), "The Behavioural Assessment Scale of Oral Function in Feeding" (Stratton, 1981), "The Prespeech Assessment Scale" (Morris, 1987), "Behavioural Assessment Scale of Oral Functions" (Stratton, 1981), "RIC Clinical Evaluation of Dysphagia: Pediatrics" (Cherney, 1994) and Jelm's (1990) "Oral Motor Feeding Rating Scale". The use of the above-mentioned scales poses certain limitations on the comprehensive evaluation and description of the feeding skills of the premature infant. Most of these scales only assess the oral phase of swallowing. Swallowing (deglutition), however, occurs in four phases, namely the oral preparatory, oral, pharyngeal and oesophageal phases. This is rarely recognised in the existing evaluation procedures. The "RIC Clinical Evaluation of Dysphagia: Pediatrics" (Cherney, 1994) does include all four phases of swallowing and provides norms from birth to 24 months. The biggest portion of this evaluation protocol, however, evaluates the ability to manage solids, semisolids and chewing and is therefore not relevant for describing the feeding patterns of preterm infants.

As discussed earlier, feeding of premature infants involves many aspects other than sucking. The preterm infant may experience very specific feeding problems (Arvedson & Brodsky, 1993; Creger, 1995; Vergara, 1993; Wolf & Glass, 1991). The above-mentioned scales also do not consider the physiological or cardiorespiratory responses of the infant to oral feeding, detailed assessment of nutritional and non-nutritional feeding, the interaction between infant and caregiver and the effectiveness of this interaction during oral feeding. It appears that no single comprehensive feeding evaluation scale for the premature population currently exists (Vergara, 1993).

It can be concluded that, although research has been conducted and oral feeding scales have been designed to assess infants' feeding skills, they appear to describe and evaluate the oral feeding skills of premature infants only to a limited degree. The question arises: **which tool or evaluation form can be used to enable the researcher to comprehensively evaluate and describe oral feeding skills of the premature infant?**

1.3 AIM OF STUDY

The aim of this study is to comprehensively describe the oral feeding skills and feeding associated behaviour of the premature infant during bottle- and cup-feeding (Figure 1.1). This comprehensive evaluation will provide the feeding specialist with guidelines for appropriate feeding intervention. This study further aims to contribute to a solution to the problem of inadequate infant feeding assessment scales for premature and other at-risk infants. Part of the solution will be to design a safe, reliable and comprehensive procedure for the evaluation and description of an infant's oral feeding skills whilst bottle-, breast-, or cupfeeding. The comprehensive evaluation will have a holistic approach, which means that aspects such as physiological status, medical status and feeding skills will all be

considered. The result of the interaction between these aspects will ultimately determine the oral feeding ability of the infant as illustrated in Figure 1.1.

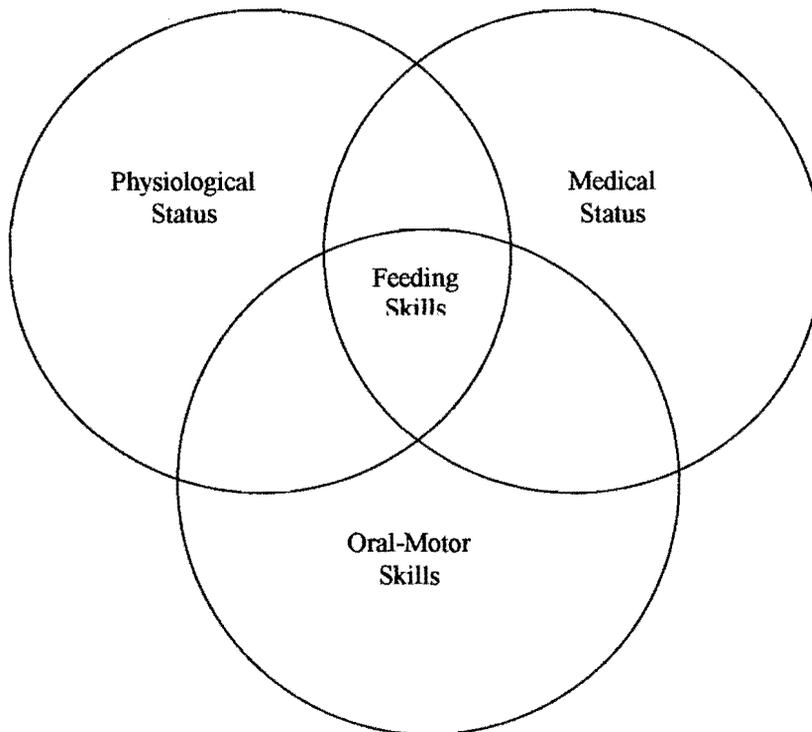


Figure 1.1 The interaction of aspects determining the feeding skills of the premature infant.

This comprehensive evaluation will provide the feeding specialist with adequate information to plan the safest, most effective and efficient feeding therapy. Comprehensive evaluation of the infant's feeding abilities is a prerequisite for appropriate, accountable management of oral feeding (Lau & Hurst, 1999).

1.4 DESCRIPTION OF TERMINOLOGY

The terms used in this study are clarified below by providing brief descriptions:

1.4.1 PREMATURE/PRETERM INFANT

A premature infant is an infant born at or before 36 weeks of gestation. Prematurity is divided into three groups according to the degree of prematurity, *Mild prematurity* refers to infants born between 35 and 36 weeks gestational age, *moderate prematurity* refers to infants born between 31 and 34 weeks gestational age and *extreme prematurity* refers to infants born between 24 and 30 weeks gestational age. In the USA, premature deliveries account for 5% of all live deliveries (Rossetti, 1996). At the Pretoria Academic Hospital the percentage of preterm deliveries appears to be in the vicinity of 15% (De Witt et al., 2000).

1.4.2 ORAL FEEDING SKILLS

An infant needs certain skills to enable him/her to take in fluids through his/her mouth (orally) as against by a nasogastric tube. These skills include the ability to extract fluid from the teat or cup by sucking, to co-ordinate sucking, swallowing and breathing efficiently and safely, and to swallow the fluid without aspirating, or experiencing stress or discomfort in doing so (Rosenthal et al., 1995).

1.4.3 AT-RISK FACTORS

Any factor that interferes with the infant's ability to develop according to known patterns and developmental sequences or to interact with the environment in a normal manner, is termed a risk factor. An infant who is exposed to such factor/s is said to be at-risk for developmental delay (any kind of developmental; communication, feeding, motor, etc.). These factors could be biological or environmental in nature or an established factor (Rossetti, 1996)

1.4.4 FEEDING SPECIALIST

The term feeding specialist used in this study refers to the professional person involved with the management of feeding problems. This professional person may be a speech-language therapist, an occupational therapist or a physiotherapist, but must have received specialised training in the assessment of and intervention in oral feeding problems (Hunter et al., 1994; Hyde & Jonkey, 1994).

1.4.5 DEGLUTITION

Deglutition is commonly known as swallowing and can be defined as the semi-automatic motor action of the muscles of the respiratory and gastro-intestinal tracts that propels food from the oral cavity to the stomach (Miller, 1986; Rosenthal et al., 1995).

1.4.6 ABBREVIATIONS

NICU:	Neonatal intensive care unit
VLBW/LBW:	Very low birth weight/low birth weight
SGA/AGA:	Small for gestational age/Appropriate for gestational age
RDS:	Respiratory distress syndrome
HIE:	Hypoxic Ischemic encephalopathy
NNS:	Non- nutritional/nutritive sucking
NS:	Nutritional/nutritive sucking
WHO:	World Health Organisation

1.5 CHAPTER OUTLAY

This thesis contains six chapters and a brief description of each chapter follows.

1.5.1 CHAPTER 1

A general introduction to the problems encountered in the evaluation and management of the feeding skills of the premature infant and the role of the speech-language therapist is provided to serve as a rationale for this study. A solution is proposed, terminology is explained and a chapter outlay is provided.

1.5.2 CHAPTER 2

The general characteristics of the premature infant; the risk factors leading to developmental delays and feeding problems; the medical complications common in premature infants and the influence thereof on the feeding abilities and behaviour of infants are discussed. This forms part of the theoretical underpinning for the evaluation of the feeding skills of the premature infant, as proposed by this study.

1.5.3 CHAPTER 3

This chapter provides an overview of the mechanics of the sucking and swallowing process in infants, the phases of deglutition (swallowing), the development of feeding skills in infants and the specific feeding problems of premature infants. This information will expand on the basis upon which the design of a comprehensive evaluation procedure for premature infants is based.

1.5.4 CHAPTER 4

The research methodology of this study is presented in this chapter. The study is divided into two phases. The first phase comprising the development of the evaluation form and a pilot study, is described. The second phase is discussed in terms of the aims, research design and the selection criteria of the subjects that

were followed. Reliability and validity of this study are discussed briefly. A description of the material and apparatus as well as the data collection and analysis procedures used to execute each of the phases of this study is provided.

1.5.5 CHAPTER 5

The results of the study and the discussion thereof are presented. Figures and tables are used to illustrate the results. These results are discussed according to the aims and with reference to the relevant literature. Patterns and developmental trends in the feeding skills of premature infants in their different gestational ages and their ability to cope with bottle and cup feedings are identified and discussed.

1.5.6 CHAPTER 6

The implications of the results on clinical practice and further research are discussed. Conclusions are drawn, a critical evaluation of the study is done and recommendations for further research are made.

1.6 CONCLUSION

Premature infants experience many serious problems and oral feeding problems forms a major part of it. According to a literature review, it is concluded that a need to comprehensively describe the oral feeding skills of premature infants exists. Furthermore, a need for a comprehensive evaluation tool was identified to make the description of the oral feeding skill of premature infant in a holistic way, possible.

1.7 SUMMARY

Chapter one describes the role of the speech-language therapist as feeding specialist, the importance of effective oral feeding to the premature infant and the limitations posed by the literature and existing feeding scales on the feeding specialist in fulfilling this role. The need for a comprehensive evaluation procedure/tool to enable the speech-language therapist to provide accountable, effective service delivery regarding feeding problems is motivated. A description of the terminology used in the study is provided as well as an outlay of the chapters.

CHAPTER 2

THE PREMATURE INFANT IN THE NEONATAL UNIT

Aim: To provide an overview of the characteristics of premature infants and to develop an understanding of how risk factors and medical complications can affect their developmental outcome in general and more specifically their feeding abilities.

2.1 INTRODUCTION

A growing number of infants survive premature birth due to advanced technology and medical care. This phenomenon created a need for specialised and appropriate intervention to avoid the developmental delays that these infants are at risk of. According to Widerstrom et al. (1997), the increasing number of premature infants is causing a major public health problem, contributing to a rise in infant mortality and children with disabilities.

Premature infants experience unique problems, which are very different from the problems that full-term infants may display. Feeding difficulties are a major part of these problems. The service provided by the speech-language therapist / feeding specialist for the feeding problems that premature infants experience is part of the specialised care needed by these infants. However, the speech-language therapist is at present not necessarily equipped or adequately trained to render this service (Rossetti, 1986).

According to Hunter et al. (1994), in order to provide safe and effective evaluation and intervention in the NICU, four essential components of knowledge and skill

need to be acquired, namely: *firstly*, a strong medical foundation, *secondly*, a familiarity with the relevant technology and terminology in the NICU, *thirdly*, an awareness of the pathophysiology of individual diseases in the premature infant and *finally*, an understanding of the basic medical management of the infants in the NICU. The information presented in this chapter is an attempt to familiarise the reader with the premature infant and the aspects surrounding these infants, and to provide an overview of the requirements to work with this population, as formulated by Hunter et al. (1994).

2.2 PREMATURE INFANTS

A discussion of premature infants in terms of who they are, what their appearance is like and how they behave, follows. This will provide a knowledge framework for the discussion of the feeding skills and feeding problems of the premature infant.

2.2.1 DESCRIPTION OF POPULATION

An infant born before 37 weeks gestational age, or one month before the estimated date of delivery, is considered to be a premature or preterm infant (Rossetti, 1996). A further distinction is made by dividing these infants into groups according to the degree of prematurity: *mild prematurity* refers to infants born between 35 and 36 weeks gestational age; *moderate prematurity* refers to infants born between 31 and 34 weeks gestational age and *extreme prematurity* refers to infants born between 24 and 30 weeks gestational age (Rossetti, 1996). Prematurity and low birth weight (LBW) are still considered to be the greatest birth complications and accounted for 11% (preterm) and 7% (LBW) of live births in the USA in 1992 (McCarton et al., 1995). Due to improved and more sophisticated technology and medical procedures, more and more moderate and extreme premature infants with birth weights of below 2 500 g (LBW) and 1 500 g (VLBW),

survive the neonatal intensive care unit (NICU) (Bazyk, 1990; Oehler et al., 1996; Rossetti, 1986; Sweeney, 1985).

In South Africa the same phenomenon is experienced, maybe even more so, because an increased number of infants are being born in hospitals as a result of the implementation of the new primary health care plan which provides free medical care for all infants and young children (De Witt, 1999). At the Pretoria Academic Hospital's Maternity section only approximately 2% of all infants born previously, were LBW infants, compared to 16,8% in 1997, 18,8% in 1998 and 15,8% in 1999. The neonatal mortality decreased from 26,1/1000 in 1997 to 13/1000 in 1998 to 11/1000 in 1999 (De Witt et al., 2000). These numbers reflect the vast growth of the NICU population and by implication the growing need for appropriate early intervention strategies.

The preterm and/or small for gestational age (SGA) infant is at risk for a number of medical and developmental problems, including feeding disorders (Widerstrom et al., 1997). As a general statement of risk, the following parameter can be used: The younger the preterm infant is and the lower his/her weight, the higher the risk of long-term sequelae. The fact that the frequency of premature infants is increasing necessitates knowledge of the characteristics of this population.

2.2.2 CHARACTERISTICS OF THE PREMATURE INFANT

The premature infant displays a unique set of characteristics, which differ from those of the full-term infant and therefore need special consideration. The preterm infant is not yet adapted to extra-uterine life. He or she cannot regulate their body temperature or manage sensory input. The motor system is not ready for gravitation and living in an unrestricted environment (Sheahan & Brockway, 1994).

Clinical experience has proven that women are not always certain about the expected time of delivery and the degree of prematurity may therefore be unknown. If the feeding specialist knows what a premature infant looks like and how they behave and respond, it should be possible to clinically identify such an infant and know what behaviour and abilities to expect from such an infant. That should enable him/her to plan appropriate and effective evaluation and intervention strategies. The ways in which premature infants differ in appearance and behaviour from full-term infants, are set out below:

2.2.2.1 General Appearance

The premature infant is different in appearance from the normal full-term infant. The premature infant is very small and has very little body fat. Their skin therefore appears to be wrinkled, making them look like the elderly (Vergara, 1993). Their heads are characteristically flat bilaterally, but the shape usually changes to the normal shape by 2-3 years of age. Their ears are soft and pliable. In the extremely premature infant the pinnae are flat and shapeless (Vergara, 1993). The tongue seems to be small in the oral cavity and tends to be in an elevated position to stabilise itself (Morris & Klein, 1987). The skin appears transparent and thin at first and becomes cracked and peeled later (Sweeney, 1985). Extremely premature infants have no lanugo (the fine hair that covers the body of a newborn) (Sweeney, 1985). They exhibit a very weak cry or may be unable to cry at all (Witt & Rusk, 1993). The feeding specialist should be able to recognise these features, set appropriate expectations and take appropriate precautions in managing such infants.

2.2.2.2 Physiological / Autonomic State

This state involves the respiratory status, heart rate, thermo-regulation and digestive system of the premature infant (Sheahan & Brockway, 1994). They often experience apnea; as Mandich & Ritchie (1996) put it, they forget to

breathe. Of importance to the feeding specialist is the fact that feeding apnea occurs even more often than sleep apnea (Dreier, Casaer, Devlieger & Eggermont, 1979; Garg, Kurzner, Bautista & Keens, 1989; Rosen et al., 1984). This is an important fact that should be included in a comprehensive evaluation of the feeding skills of the premature infant, as the feeding specialist should closely monitor the infant's breathing during feeding intervention.

Hunger cycles and regular feeding rhythms only develop after 35 weeks gestational age (Morris & Klein, 1987; Vergara, 1993). This has implications regarding the realistic stage at which the feeding specialist should introduce oral feeding intervention, because satiety inhibits sucking (Morris & Klein, 1987). In other words, if the infant is not hungry, he or she is not going to suck well.

When the infant is able to achieve physiologic homeostasis, he or she is healthy enough to organise his/her other states and is by implication ready to feed orally. The physiologic homeostasis can easily be disturbed because the brain of the premature infant is still immature and sensitive to stimulation. The neurological system is therefore more vulnerable to excessive, inappropriate stimulation. The feeding specialist should endeavour to avoid this scenario. This can be done by knowing and recognising the stress signals which involve the physiologic state. As soon as a stress signal is identified, intervention should be terminated.

Some of the stress signals involving the physiological system are: apnea (during sleep and feeding); tachypnea; irregular or shallow breathing; change of heart rate: brady- or tachycardia; fall in saturation levels; colour change (especially around the mouth); visceral responses, e.g. vomiting; sneezing, yawning, hiccups, grunting and mottling of the skin (Billeaud, 1993; Creger, 1995; Hussey, 1988; Morris & Klein, 1987; Sheahan & Brockway, 1994; Witt & Rusk, 1993). A comprehensive assessment of feeding skill and feeding associated behaviour should include the observation of these stress signals.

2.2.2.3 Neurological Status

Neurodevelopment follows a predictable sequence. A detailed discussion of the overall neurodevelopment of the premature infant is not within the scope of this study and only a brief discussion, concentrating on the development of oral-motor, sucking and swallowing skills will be presented. Knowledge of infant neurodevelopment should enable the feeding specialist to estimate the developmental age of an infant, which skills to expect and to efficiently and realistically apply feeding therapy. Sucking, even non-nutritional sucking (NNS), is disorganised at 27-28 weeks, but becomes more organised by 30 weeks. The co-ordination between sucking, swallowing and breathing will, however, only improve from 34-35 weeks (Glass & Wolf, 1994). Sucking is also weak and insufficient before 35 weeks gestational age (Vergara, 1993). Introduction of safe and efficient oral feeding can therefore not occur before at least 34 weeks.

Further neurological behaviour that will give an indication of gestational age is the following: A reflexive smile appears from 30 weeks (Hunter, 1993), while other primary reflexes may still be absent, reduced or inconsistent (Creger, 1995) until approximately 36 weeks gestational age when all primary reflexes can be elicited (Glass & Wolf, 1994). The development of the primary reflexes progresses in a cephalocaudal direction (from head to feet) (Creger, 1995). In other words, the lower down the reflexes are located that can be elicited, the older the infant is and the more ready to feed orally. Premature infants can easily become neurologically overloaded, because they have a low sensory threshold (Witt & Rusk, 1993). Sensory overload can have serious consequences, e.g. intra-cranial haemorrhage (Semmler, 1989). They react to sensory overload with stress signals, which can manifest themselves in any system of the infant, e.g. motor, state, physiological or neurological (Creger, 1995). The feeding specialist should be mindful of these facts, be skilled in reading these signs and should in no way contribute to an infant's stress (Rossetti, 1996). Further neurological risk signs that the feeding

specialist should be aware of are: that the infant may be jittery, or have hyperactive reflexes (Creger, 1995; Hussey, 1988; Sheahan & Brockway, 1994).

Should the premature infant experience any stress during feeding intervention, that session should be terminated so as not to contribute to stress in the premature infant.

2.2.2.4 Motor System

Knowledge of the motor system and its development also enables the feeding specialist to estimate a premature infant's gestational age (if it is unknown) and to make the necessary changes in the handling and expectations of the infant.

The motor system of the premature infant is generally not ready for gravitation or living in an unrestricted environment (Semmler, 1989). These infants are usually very hypotonic. The severity of the hypotonia is related to the degree of prematurity – the younger the infant the more hypotonic he/she will be (Hunter, 1993; Sheahan & Brockway, 1994; Witt & Rusk, 1994). After 30 weeks gestational age, the tonus will improve in a caudocephalic direction (from legs to head) – the opposite as that of reflex development (Creger, 1995; Hunter, 1993; Sheahan & Brockway, 1994). The level of hypotonia can give the feeding specialist an indication of the age and readiness for oral feeding.

The extremities of premature infants are typically postured in extension and abduction (Sheahan & Brockway, 1994), as the preterm infant lacks flexor tone and the strength to counterbalance the extension which is favoured by gravity (Morris & Klein, 1987; Vergara, 1993). Gravity also limits arm and leg movement (Morris & Klein, 1987). The premature infant displays extreme headlag when pulled into a sitting position and is unable to maintain head alignment with the trunk (Creger, 1995; Witt & Rusk, 1993). The implication for the feeding specialist is that the positioning of premature infants when giving feeding therapy should be

carefully considered. They should be swaddled with their arms forward and head control should be applied to keep the head and trunk in alignment, thereby avoiding headlag, as this is the most favourable position for deglutition (Morris, 1989).

The infants who have to be maintained on a ventilator for a prolonged period, display hyperextension of the neck, scapular elevation, retraction of the shoulders and the upper extremities, and arching of the trunk with immobility of the pelvis (Sheahan & Brockway, 1994). This body posture is unfavourable for efficient feeding (Lau & Hurst, 1999; Morris & Klein, 1987). The tubes and wires of the monitors complicate the environment in which the premature infant moves (Morris & Klein, 1987). Opportunities for motor movement and its development are therefore limited. When they do begin to move, the movements are spasmodic and jerky, but become more purposeful and smooth by 36 weeks gestational age. Their movements will, however, never be as good by 40 weeks gestational age as those of the full-term infant (Creger, 1995; Sheahan & Brockway, 1994). Special consideration should be given to the positioning of the infant who has been on a ventilator, during feeding.

Active movements can also contribute to instability of the autonomic (physiologic) system (Sheahan & Brockway, 1994). Such movements should be avoided during feeding as part of the attempt to reduce any stress. Stress signals involving the motor system that the feeding specialist must recognise, are: Frantic movements, finger splaying, straightening of the arms, arching, stiffening, hyperextension of the body, facial grimacing, covering the face or eyes with the hand (saluting), squirming or pushing away (Billeaud, 1993; Creger, 1995; Hussey, 1988; Sheahan & Brockway, 1994; Witt & Rusk, 1993).

2.2.2.5 State / Attention

State is defined as the level of consciousness or alertness and the environmental interaction of the premature infant. Attention is the ability to assume and maintain an alert state (Creger, 1995). According to Rossetti (1996), an alert state is a prerequisite for communication interaction as well as oral feeding.

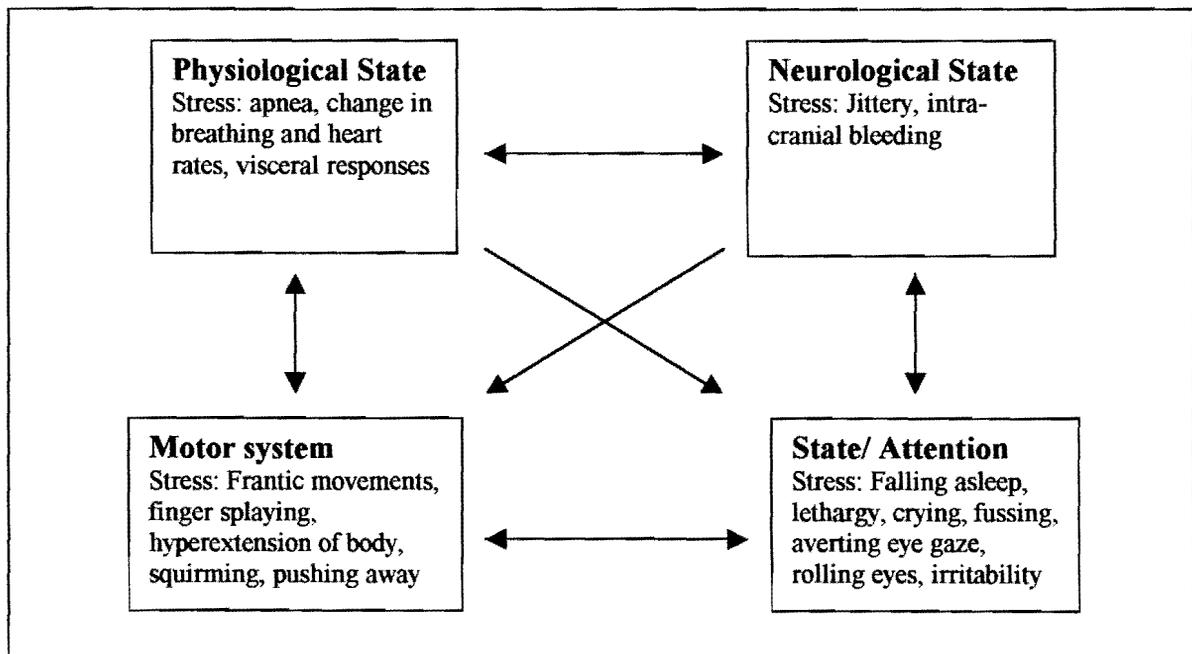
The sleep state predominates before 30 weeks gestational age. Regular sleep-awake cycles only begin around 34 weeks, but even when the premature infant reaches 40 weeks gestational age, he/she exhibits less predictable sleep-wake cycles than the full-term infant (Creger, 1995; Hunter, 1993; Witt & Rusk, 1993). The premature infant finds it difficult to maintain an alert state (Als, Duffy & McAnulty, 1988; Creger, 1995; Witt & Rusk, 1993). Sucking behaviour is known to be better when the infant is awake (Sheahan & Brockway, 1994; Geertsma, Hyan, Jeffrey, Pelletier & Reiter, 1985; Vergara, 1993). Mandich & Ritchie (1996) state that a quiet and alert state is a prerequisite for efficient sucking.

It should also be noted that premature infants are less responsive and vocalise less than full-term infants do. They tend to be irritable and have poor impulse and motor control. A limited ability to organise their behaviour and adapt to the environment, is also exhibited. Thus, difficulty of self-regulation is displayed by premature infants (Als et al., 1988; Witt & Rusk, 1993). Light, sound, temperature and general environmental conditions may also influence the infant's alertness (Becker, Grunwald, Moorman & Stuhr, 1991; Rossetti, 1998). Environmental control becomes even more important in feeding intervention, as part of an attempt to avoid an overload of the premature infant's systems. It is well known that their systems overload quickly and they may then respond with stress signals. Some of the stress signals that involve state and attention are: falling asleep, diffuse sleep state, lethargy, averting of eye gaze, rolling of eyes, irritability, crying and fuzziness (Billeaud, 1993; Creger, 1995; Hussey, 1988; Sheahan & Brockway, 1994; Witt & Rusk, 1993).

An infant struggling to maintain cardiorespiratory homeostasis finds it difficult, if not impossible, to assume an alert state and to interact with the environment. They may rather react with bradycardia, tachycardia, apnea or a decrease in saturation levels (Als, Lawhon, Brown, Gibes, Duffy, McAnulty & Blickman, 1986; Billeaud, 1993; Sheahan & Brockway, 1994). Feeding intervention in such circumstances will be out of the question, - medical conditions are always the first priority and therapeutic intervention secondary (Hunter et al., 1994).

The physiologic system, motor state control and attention do not develop simultaneously as in the full-term infant. The systems therefore do not support or enhance one another, but rather disorganise the behaviour of the premature infant (Creger, 1995). They have to learn self-regulatory skills like postural change, hand-to-mouth action, grasping, sucking, visual locking or hand-clasping to maintain or return to a balanced equilibrium. This in part explains why oral feeding does not come easily and effortlessly to the premature infant.

Homeostasis



(Source: Creger, 1995; Hussey, 1988; Sheahan & Brockway, 1994)

Figure 2.1 Disorganisational potential of systems on each other

All of the states and systems discussed above, influence one another and have the potential to disorganise each other (Figure 2.1). For example, the irritable infant may cry with accompanying frantic movements that causes change in breathing and heart rate, which results in the disturbance of the homeostasis.

2.2.3 CONCLUSION

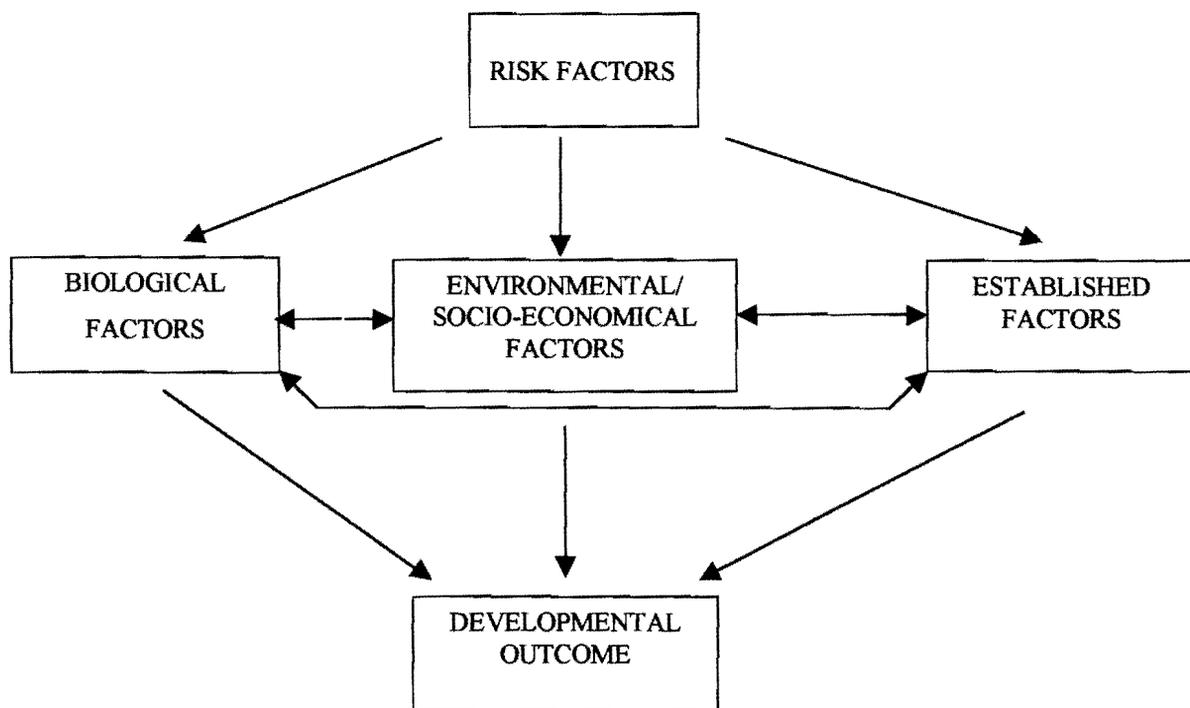
Oral feeding skills in premature infants are influenced by a number of factors. The feeding specialist should have a sound knowledge of the characteristics of the premature infant and the influence that the different states and systems may have on each other, to plan safe and efficient feeding intervention.

2.3 RISK FACTORS FOR DEVELOPMENTAL DISORDERS IN PREMATURE INFANTS

When a premature infant is born, the first question raised is whether he will live or die. As his condition improves, questions about his future and developmental outcome are raised. It is not possible to say with certainty what his/her outcome will be, but the likelihood can be determined. That can be done by establishing which factors have an effect on the premature infant's development (Allen, 1984; Allen & Capute, 1989).

Risk factors can be simply defined as "a prediction of the manifestation of later developmental disability" (Thurman & Widerstrom, 1990:23). The reason for establishing risk factors is to prepare parents for their child's future. The infant's development should be monitored closely and family support be given where necessary, to minimise secondary complications (Allen, 1984; Allen & Capute, 1989).

The risk factors fall into three main groups based on the aetiology, i.e. biological, environmental and established (Aylward, 1990; Kirby, Swanson, Kelleher, Bradley and Casey, 1993; Widerstrom et al., 1997). Rossetti (1996), on the other hand, uses only two main groups in a symptomatological classification system, i.e. *firstly*, Established-Risk and *secondly*, At-Risk (which includes biological and environmental factors). Rossetti (1996) considers a child with known patterns of developmental delay, e.g. Down syndrome, not at risk for these delays, because it is known that certain delays will be present as part of the syndrome. Although Allen (1984) states that it is important to remember that risk does not imply causation, she also mentions that there are conditions that inevitably lead to developmental delays, such as those conditions mentioned as established-risks by Rossetti (1996). Rossetti (1996) also mentions that variations can stem from whether and at which age, these children receive early intervention services. So, in effect, these infants can then also be considered as being at risk of further and/or more serious developmental delays unless they receive early intervention.



(Source: Aylward, 1990; Thurman & Widerstrom, 1990; Vohr, 1991)

Figure 2.2 The relationship between risk factors and developmental outcome

Allen (1984) and Thurman & Widerstrom (1990) also group the factors according to the period of time in which they occur, pre-, peri- and/or postnatally. The discussion of risk factors that follows will be based on the three main categories of involvement or causation of developmental delays: biological, environmental and established. Those groups will then further be discussed according to the period of time in which they occurred. These main factors can also influence each other and further influence the developmental outcome (Figure 2.2). Reference to the relationship between these factors forms part of the discussion that follows.

2.3.1 BIOLOGICAL FACTORS

Biological factors are called medical risk factors by Kirby et al. (1993). A variety of medical conditions can put a premature infant at developmental risk (McCarton et al., 1995). The greater the number of predictor variables, the more accurately a risk status can be assigned to a specific infant (Thurman & Widerstrom, 1990). The Kauai Longitudinal Project did not support this idea and found environmental influences to play a greater role (Aylward, 1990). Traditionally, the developmental outcome of infants with biological risk factors (particularly the LBW infants) has been emphasised and the environmental influences ignored (Aylward, 1990). Regardless of how big the influence on developmental outcome may be, or which influence may have the greatest effect, medical complications/biological factors will influence development and medical follow-up will be necessary in most cases.

The feeding specialist should take note of these factors as part of the medical history in the evaluation of the feeding skills of premature infants, to anticipate possible feeding problems and plan intervention. The influence of biological factors on developmental outcome and feeding skills will be explained in more detail in the following pages, which will be organised from the prenatal period until after birth (postnatally).

2.3.1.1 Prenatal Period

A number of influences can put an infant at risk of developmental delay, namely:

- *Intra-uterine growth retardation (IUGR)*

IUGR refers to the fact that the infant has not grown to his full potential in utero. The infant's weight is inappropriate for its gestational age and falls below the 10th percentile for gestational age on the standard IUG curve (Lubchenco, 1976; Mullen, Coll, Vohr, Muriel & William, 1988). The terms *dismature* or *small for gestational age (SGA)* are also used to refer to this group of infants. If the growth retardation started before 26 weeks gestational age, both the head circumference and weight will fall below the tenth percentile. Restricted head growth is associated with less than optimal neurodevelopmental outcome. It is therefore an important prognostic factor for developmental outcome. If the growth retardation started after 26 weeks, the intelligence of the *dismature* infant may be unaffected. In general, the SGA infants are associated with poorer developmental outcome (Rossetti, 1986; Sweeney, 1985; Thurman & Widerstrom, 1990; Vohr, 1991). They are also poor oral feeders because of their overall weak condition.

Traditionally these infants are introduced to oral feeding later than their appropriate weight for gestational age (AGA) counterparts, because it is general practice in the NICU's to introduce oral feeding based on the weight of the infant (± 1.8 kg), rather than gestational age (Mullen et al., 1988). The literature does not support this viewpoint and uses gestational age as marker to introduce oral feeding (Bazyk, 1990; Merenstein & Gardener, 1989; Sheahan & Brockway, 1994; Vergara, 1993). The reason is that the ability to co-ordinate sucking, swallowing and breathing successfully is seen as a neurobehavioural maturation phenomenon (Semmler, 1989). Adequate neuromuscular co-ordination is a function of gestational age (Bu'Lock et al., 1990). Thus, it can be assumed that gestational age rather than weight effects maturation. Maturation, rather than weight, should therefore be considered when a decision on when to introduce oral

feeding is made. The feeding specialist should know whether an infant of low weight is SGA, but old enough to start sucking safely, or whether he is too young to suck. If the clinical gestational age according to a Ballard or Dubowitz count can not be found in the medical file, knowledge of the appearance and other characteristics of premature infants will give the feeding specialist an indication of the gestational age of the infant. This information should also be included in a comprehensive evaluation of the feeding skills of the premature infant to enable the feeding specialist to plan safe and effective feeding therapy for these vulnerable infants.

If the introduction to oral feeding is delayed in the dismature infant, he becomes prone to some of the complications of prolonged nasogastric feeding. The feeding specialist should endeavour to avoid these consequences. Infants who have received long-term nasogastric feeding experience more problems to transfer to oral feeding; they may become orally hypersensitive, develop aversive behaviour towards oral feeding and eventually become failure-to-thrive (FTT) infants (Bazyk, 1990; Geertsma et al., 1985; Morris, 1989; Merenstein & Gardener, 1989; Palmer et al., 1993; Vergara, 1993).

Another aspect of importance to the feeding specialist is that long-term nasogastric feeding negatively influences the mother-infant relationship, since the nasogastric tube is a constant reminder to the mother that a feeding problem exists and it is unnatural (Morris, 1989). If the mother wishes to breast feed, she might become despondent due to the vast amount of time she has to spend expressing milk and the difficulty of eventually getting the infant "on the breast". The delay in transfer to oral feeding means that the infant has an extended hospital stay which impedes bonding with the mother. It can place a financial burden on the parents as well (Mandich & Ritchie, 1996; Meier & Pugh, 1985).

One of the criteria for transfer to oral feeding is sustained weight gain (Creger, 1993; Mandich & Ritchie, 1996). If the dismature infant still has a very low weight,

he might still be too weak to feed orally and maintain a good weight gain, although he is of an appropriate gestational age to feed orally. The feeding specialist will have to make a decision in consultation with the medical staff as to how soon and often the infant can start with oral feeding in a safe and efficient way.

- *Placental abnormalities*

This may affect the oxygen and/ or nutritional supply to the infant in turn affecting the growth and the neurological development of the infant. Prenatal anoxia can cause anencephaly (Rossetti, 1986; Sweeney, 1985). Neurological problems are one of the main causes of feeding problems (dysphagia) (Arvedson & Brodsky, 1993; McBride & Danner, 1987; Miller, 1986; Rosenthal et al., 1995).

- *Viral infections: **TORCH** group:*

Toxoplasmosis, Others e.g. (a) Syphilis (the mothers should be treated before 18 weeks of pregnancy (Thurman & Widerstrom, 1990), (b) HIV - 80% of the infants who have the HIV virus, contracted the virus via transplacental transfer. These infants may have recurrent bacterial infections, respiratory problems, microcephaly and neurologic abnormalities, 90% experience static or progressive encephalopathy and painful swallowing (odynophagia).

Rubella, Cytomegalovirus, Herpes simplex: All of these viruses can cause neurologic sequelae, psychomotor retardation, microcephaly, learning disabilities, seizures, blindness, a sensory neural hearing loss and hydrocephalus (Creger, 1989; Rossetti, 1986; Sweeney, 1985). Any of these viruses which affect the neurological system, do not only place the infant at risk of developmental delays, but of feeding problems as well.

- *Repeated miscarriage, blood group incompatibilities and unexplained previous foetal or neonatal deaths*

These are other prenatal risk factors for poor developmental outcome (Rossetti, 1986).

It is clear that the health of infant and mother during the prenatal period is already important for the later development of the infant and mother-infant bonding and attachment.

2.3.1.2 Perinatal Period

A number of factors during the birth process and/or in the first week after birth can also jeopardise developmental outcome, e.g.

- *Gestational age*

Prematurity is the number one risk factor for cerebral palsy, with the infants being born before 32 weeks being at the highest risk. This population is also at risk of developmental delays and feeding problems (Bennett, 1995; McBride & Danner, 1987; Rossetti, 1986; Sweeny, 1985). The premature infant is also at risk for medical complications, which will be discussed later. The infant younger than 34 weeks gestational age cannot co-ordinate sucking, swallowing or breathing successfully and is at risk of aspirating the fluid he is consuming, with dangerous consequences. (See par. 2.4 for more detail of the effect on feeding skills.)

- *Hyperbilirubinemia*

Bilirubin is a red bile pigment circulating in the blood. Excessive amounts of bilirubin can lead to central nervous damage (Witt & Rusk, 1993). Low levels of bilirubin in the very premature infant may have subtle effects on learning development. Physiologic hyperbilirubinemia is common in premature infants due to their limited ability to excrete bilirubin from their systems. In maternal foetal blood incompatibility, excessive haemolysis of red blood cells can lead to excessive amounts of bilirubin, which is a leading contributor to neurologic sequelae (Sehna & Palmeri, 1989). Recent prevention techniques have almost eliminated kernicterus, the disease resulting from hyperbilirubinemia. Extreme kernicterus can cause mental retardation, deafness, hypotonia and rigidity choreosis. Psychomotor delays can exist in the absence of overt signs of

kernicterus. If neurological impairment is a result of the hyperbilirubinemia, feeding problems can be expected. Infants with hyperbilirubinemia who receive phototherapy, also tend to be lethargic, which may influence feeding negatively, but it does not necessarily imply long-term feeding problems (Rossetti, 1986; Sheahan & Brockway, 1994; Witt & Rusk, 1993).

- *Metabolic disturbances*, e.g. **hypocalcemia**, **hypoglycaemia**, **metabolic acidosis** (Oehler et al., 1996; Sehnaal & Palmeri, 1989).

Hypocalcemia and **hypoglycaemia** can cause jitteriness and even convulsions. **Hypoglycaemia** can also cause hyperirritability, apnea, cyanosis and irregular respiration. **Acidosis** means the pH in the body is lower than normal (Sheahan & Brockway, 1994). In severe cases it can result in neurologic deficits with associated feeding problems (dysphagia). Although some metabolic disorders are genetic and occur prenatally, others damage the central nervous system after birth (phenylketonuria). If the metabolic disturbances can be detected early enough, developmental sequelae can be prevented or minimised (Allen & Capute, 1989). If the feeding specialist should detect any signs of jitteriness or convulsions, she/he should report it to the medical staff to investigate. If the metabolic condition is known, the feeding specialist should plan evaluation and management accordingly.

- *Respiratory problems*

One of the respiratory problems the premature infant can have, is **respiratory distress syndrome (RDS) or Hyaline membrane disease (HMD)**. This disease most commonly affects the premature infant - 70% of infants born between 28-30 weeks, 60% born before 32 weeks and only 10% of those born between 34-36 weeks develop HMD. Respiratory problems constitute the single largest cause of death in the neonatal period (Rossetti, 1996). The lungs have not developed enough surfactant, a protein that moisturises the lungs to reduce the surface tension. Due to the low surface tension the alveoli collapse during expiration. The infant has to work much harder to reinflate the lungs and needs much higher

energy expenditure. These infants therefore fatigue very quickly, which inhibits their neuromotor and feeding development. HMS can lead to low oxygenation, asphyxia, metabolic acidosis and acute respiratory failure, which can be fatal, unless the infant is mechanically ventilated. The ventilator will provide the lungs with sufficient oxygen at the right pressure to keep the lungs open. Being on a ventilator will delay the premature infant's transfer to oral feeding further and may expose him/her to the complications of long-term nasogastric feeding as discussed earlier (Garg et al., 1988; Vergara, 1993). Feeding problems of infants suffering from cardio-respiratory problems will be discussed in more detail later.

Asphyxia, Anoxia and Hypoxemia are other respiratory complications the premature infant may experience. **Asphyxia** means that the infant experienced a shortage of oxygen as a result of placenta abruptio, prolonged separation of the placenta, or substance abuse. Asphyxia can cause metabolic disturbances or result in an inadequate exchange of oxygen and carbodioxide, which is called **anoxia**. The results of **anoxia** can be non-progressive neurologic deficits, mental retardation and cerebral palsy (spasticity, choreoathetosis and ataxia), deafness and seizures. The impact the anoxia has on the brain is called **hypoxemia**, which leads to Hypoxic Ischemic Encephalopathy (HIE). In severe cases the infant will lapse into a coma. The survivors suffer significant neurologic impairments and associated dysphagia. In moderate cases, they may be lethargic and hypotonic and need short-term ventilation, which may again influence their feeding abilities negatively. They may also develop necrotizing enterocolitis (NEC) or acute renal problems. In mild cases the asphyxia could have occurred immediately before birth. The infant is then born lethargic and later on becomes jittery, hyperalert, irritable and exhibits hyperreflexes (Sweeney, 1985; Sheahan & Brockway, 1994). Feeding problems can also be expected in the mild cases, but more in terms of the influences of state and behaviour on feeding skills. They usually have a more optimistic developmental outcome than severe cases of asphyxia (Sheahan & Brockway, 1994).

- *Cardiovascular problems*

Patent Ductus Arteriosus (PDA). The infants with PDA have less endurance, as they are unable to increase the heart rate to respond to the increased energy demands needed for the extra efforts whilst feeding or moving. The development of their motor and feeding skills are influenced negatively (Sheahan & Brockway, 1994; Sehnaal & Palmeri, 1989).

The efficacy of oral feeding is thus also dependent on the condition of the (premature) infant during and shortly after birth.

2.3.1.3 Postnatal Period / Medical Complications

Although the premature and low birth weight (LBW) infants' survival rates have improved due to improved technology, they are still vulnerable to medical complications as a result of the very treatment that lead to their survival. A variety of medical complications are associated with prematurity (Rossetti, 1996).

- *Bronchopulmonary dysplasia (BPD)*

This is a chronic lung disease related to prematurity, low birth weight and prolonged ventilation. Vohr (1991) states that BPD occurs in 5 - 45% of the premature infants. It can begin as early as 25-26 weeks gestational age. The respiratory tract cilia are destructed by hyperinflation of the lungs during ventilation. Necrosis of the cells of the respiratory epithelium and the cell lining of the alveoli can occur. The oxygen requirements to sustain the lives of these infants may also have deleterious effects on their hearing and vision (as described below Retinopathy of Prematurity), placing them at risk for difficulties in their communication development (Billeaud, 1993). The infants with BPD are very vulnerable to infection during their first year. Recovery is slow and the infants experience a chronic lack of oxygenation, which leads to constant fatigue that will influence their endurance with oral feeding. Rossetti (1996) mentions that it may also cause growth retardation and impair their neuromotor development.

Prolonged hospitalisation negatively effects development of parent-infant relationships, language, feeding and motor skills (Als et al., 1986; Glass & Wolf, 1994; Sheahan & Brockway, 1994; Vohr, 1991).

- *Intraventricular haemorrhage (IVH) and Intracranial haemorrhage (ICH)*

Both conditions are common in infants born under 32 weeks gestational age. Vohr (1991) states that 40% of all low birth weight (LBW) (under 2 500 g) premature infants and Sweeney (1985) says that 50% of the very low birth weight (VLBW) (under 1 500 g) infants develop IVH. The haemorrhage occurs because of the fragile vascular state of the germinal matrix and because of the poorly developed cerebral auto-regulation. Semmler (1989) states that the fluctuation in intra-cranial pressure can be a contributing factor in ICH. The infants with an unstable respiratory status, pneumothorax, swinging blood pressure, or hypoxemia, are at a greater risk of developing IVH. Cellular damage from IVH may occur in areas of the brain causing attention deficits, low or high activity, diminished affect and less skilled motor activity, which may interfere with social interaction (Oehler et al., 1996). The severity of the IVH is related to the incidence of major neurologic abnormalities. Grade I (less than 10% of the ventricle area is bleeding) and grade II (between 10 and 50% of the ventricle area is bleeding) have low long-term risks for neurologic deficits. Grades III and IV (more than 50% of the ventricle area is bleeding) are at high risk for neurologic deficits, hydrocephalus, mental retardation, seizures, deafness or microcephaly (Sheahan & Brockway, 1994; Sweeney, 1985). The neurological impairment suffered by the infant with Intraventricular or Intracranial haemorrhage can cause different degrees of feeding difficulties, which should be evaluated comprehensively to plan effective feeding intervention. It is also believed that excessive handling, movement and stress can trigger ICH (Hunter et al., 1994). It is of the utmost importance that the feeding specialist knows this to avoid being the cause of such serious complications.

- *Periventricular leukomalacia (PVL) follows IVH*

The lesions caused by the bleeding are called PVL and are reduced to cystic cavities. PVL is associated with cerebral palsy, mental retardation, hypertonicity and seizures (Oehler et al., 1996; Sheahan & Brockway, 1994). This means that PVL is also a high risk factor for feeding difficulties.

- *Necrotizing enterocolitis (NEC)*

This is the term used when some of the infant's intestines die because of infection (Thurman & Widerstrom, 1990). NEC is a major complication in the under 2 000 g infant (Sheahan & Brockway, 1994). NEC is a setback in the overall medical progress of an infant and puts him/her under additional stress, which interferes with the neurodevelopment as well as his/her behavioural progress. During the illness the infant with NEC is only on parenteral feeding – no oral feeding is permitted. Depending on the severity of NEC, experience in oral feeding will be delayed. The feeding specialist should therefore be aware that long-term feeding problems can develop unless appropriate intervention is planned.

- *Retinopathy of Prematurity (ROP)*

ROP affects 4% of infants weighing less than 1 000 g (Glass & Wolf, 1993). ROP is the main cause of blindness in premature infants. Oxygen therapy can cause abnormal growth of blood vessels in the immature retina. Most of the abnormal vessels will heal themselves, but in severe cases permanent scar tissue can develop, causing permanent damage. Partial healing can result in night blindness and strabismus (Sheahan & Brockway, 1994; Thurman & Widerstrom, 1990). Glass & Wolf (1993) name blood transfusions, hypo- or hypercarbia, sepsis and light as further possible causes of ROP. The visually impaired infant does not reach out to objects, or manually explore objects, until a much later age than infants with normal vision. Adults tend to talk less to the visually impaired infant, because of a lack of behavioural clues used by the visually impaired infant. The onset of words occur at a later age for the visually impaired than for the normal infant. Bonding and attachment between the infant and the parents are affected

too (Glass & Wolf, 1993). The speech–language therapist should be aware of the impact of Retinopathy of Prematurity on the infant, as it appears that it is a high risk factor for delays in communication development and should therefore be followed up regularly.

In conclusion, it is clear that medical complications play a significant role in the oral feeding skills and developmental outcome of premature infants (Duffy, Als & McAnulty, 1990).

2.3.2 ENVIRONMENTAL / SOCIO-ECONOMIC FACTORS

Numerous factors interfere with normal environmental interaction that can increase the risk of developmental delay (Rossetti, 1996). It has been found that a mother with a low socio-economic status (SES) is more likely to give birth to a premature infant than other mothers (Thurman & Widerstrom, 1990). Aylward (1990) states that cognitive function is the area most influenced by the environment and Vohr (1991) supports this idea by stating that there is a relationship between family socio-economic status and mental development of children. It was found that development differed significantly between the appropriate for gestational age (AGA) infant and the small for gestational age (SGA) infant. SGA refers to infants whose weights fall below the 10th percentile on the growth chart of Lubchenco (1976) (Mullen et al., 1988). The small for gestational age low SES premature infants do not catch up with their development as well as the appropriate for gestational age low SES premature infants do (Vohr, 1991). Traditionally, environmental influences were not monitored well during follow-up sessions, but it has become clear that they are of equal importance as the biological influences (Aylward, 1990). Environmental factors are discussed in the following section in terms of the period in which it may have occurred.

2.3.2.1 Prenatal Period

Environmental factors which can influence the infant in utero are:

- *Maternal nutritional status and health*

Maternal viral infections (e.g. TORCH viruses) can have devastating effects on the infant's nervous system, which may cause feeding problems and developmental delays. Maternal illnesses like hypertension, diabetes and lung disease can compromise nutrient and oxygen supply to the infant and thereby increase his risk of Intra-uterine growth retardation (IUGR), premature delivery and/or poor developmental outcome (Allen & Capute, 1989). Pre-eclampsia is a major contributor to premature births and exposure to X-rays can cause microcephaly. The feeding specialist should take a comprehensive history to fully understand and anticipate problems of the premature infant and to be able to plan effective intervention.

- *Maternal age*

Adolescent mothers, especially under 16 years, are at risk of giving birth to an infant with mental retardation (Rossetti, 1986; Sweeney, 1985; Thurman & Widerstrom, 1990; Wilcox, et al., 1989). Mothers older than 35 years are at greater risk of having an infant with Down's syndrome (Thurman & Widerstrom, 1990).

- *Maternal substance abuse*

If the mother consumes more than 2 fluid ounces of alcohol a day during pregnancy, the infant might display poor motor control, mental retardation, facial dysmorphism, pre- and postnatal growth deficiencies, congenital hip dislocation and attention deficit disorder and be classified as Foetal Alcohol Syndrome (FAS). The risk for the above-mentioned problems can be aggravated if the mother smokes as well. Cocaine abuse may not be such a widespread problem in South Africa, but should be known for its effects, which are: Low birth weight (LBW),

Intra-uterine growth retardation (IUGR), a small head circumference, prematurity and haemorrhagic infarctions. Although Sweeney (1985) mentions that the long-term effect of cocaine is still unknown, the problems associated with LBW, IUGR, etc. are well known. Alcohol and substance abuse can cause congenital anomalies, dysmorphic features and developmental delays. Infants born from addicted mothers tend to have excessive sucking behaviour (Sheahan & Brockway, 1994).

The prenatal environment proves to be an important factor for the oral feeding skills and development of the neonate.

2.3.2.2 Perinatal Period

The environment in which the infant is born may influence the developmental outcome of an infant; for example, if an infant is born before arrival at the hospital, he/she may be at risk for infections. Infections may cause serious illness, which may or may not have long-term effects on the infant. If the infant needed any kind of medical assistance, e.g. suctioning or oxygen, just after birth, the infant is at risk of asphyxia, with all its associated sequelae, as discussed earlier.

2.3.2.3 Postnatal Period

After birth of an infant, several factors can influence his developmental outcome, e.g.:

- *Health care of infant*

Prolonged or chronic hospitalisation heightens the risk for developmental delays and poor parent-child relationships (Sweeney, 1985). Poor nutrition of an infant after hospital discharge can impede development. Unsolved feeding problems in the NICU can cause Failure to thrive (FTT) infants. That is why proper management of feeding problems in the hospital and collaboration with the parents from the earliest days are important.

- *Maternal educational and mental status*

Both play a roll in the level of stimulation, as well as the opportunities for stimulation, that the premature infant will receive (Aylward, 1990; Sweeney, 1985; Vohr, 1991; Wilcox et al., 1989). The quality of the *mother-infant interaction*, competency in parenting roles, poor bonding and the irritable temperament of the premature infant can have a negative influence on the ability of the premature infant to catch up growth and development (Aylward, 1990; Sweeney, 1985). According to Rossetti (1996), the mortality of infants declines with increasing maternal education. This should then also be part of the history when assessing an infant for developmental delays. It might not have a direct influence on the feeding abilities of the infant, but possibly on the nutritional management of the infant.

- *Birth order and Gender*

The infants with a later birth order and male infants are at higher risk of communication developmental delays (Ogletree & Daniels, 1993). Rossetti (1996) states that second-born infants have a lower mortality. Aylward (1990) says that there is evidence that the environmental effects on cognition are stronger in females than in males. Cognition and language are strongly related in the first two years (Rossetti, 1898). The apparent difference in opinion on gender differences may be explained by the fact that males seem to be genetically more prone to language delays, but may be affected less by an unfavourable environment than females.

Thurman & Widerstrom (1990) state that socio-economic status (SES) is the best predictor of later intelligence scores. Aylward (1990) supports this idea by stating that the environment affects cognitive functioning more strongly than motor or neurologic functioning. The relationship between environmental and biological factors is explained by using the “signal-to-noise ratio” analogy. It can be said that the “signal” is the early medical and biological influence on outcome, which is

gradually obscured by the “noise” generated by the environmental influences (Aylward, 1990). Children with both biological and environmental risk factors are considered to be at double hazard for delay (Rossetti, 1996), or sometimes referred to as double jeopardy (Aylward, 1990).

2.3.3 ESTABLISHED / MEDICAL FACTORS

These factors refer to a medical disorder of known aetiology, which has a predictable pattern of developmental performance and is usually described as a syndrome, e.g.: Cornelia de Lange syndrome or Prader Willi syndrome (Allen & Capute, 1989; Aylward, 1990; Vohr, 1991). Other factors are congenital malformations, central nervous system disorders, chromosomal abnormalities, hydrocephaly, microcephaly, genetic/heredity conditions (15-25% of developmental disorders are related to genetic disorders), inborn errors of metabolism, musculoskeletal abnormalities, multiple births, and recurrent neonatal seizures (more than 3 seizures in the neonatal period) (Sweeney, 1985; Thurman & Widerstrom, 1990).

The developmental outcome of these infants is based on a continuum of events rather than on a single biological, social or environmental factor. The continuum begins at the time of conception and may be modified by a complex interaction between biological and environmental factors in the intrauterine climate, the neonatal period and early childhood years (Vohr 1991). Rossetti (1996) does not regard these infants as being at risk, because it is known that developmental delays will arise. But since early intervention still has a positive influence on these children and will better their outcome, even if it won't be normal, it can be argued that they are also at risk – at risk of a poorer outcome without intervention. Thurman & Widerstrom (1990) state that the developmental outcomes of these infants are strongly influenced by the socio-economic circumstances of the child's environment, which may be even stronger than earlier biological events.

Early intervention may or may not contribute to catch up growth and development, but the most important opportunities to recover and catch up have to be provided for the premature infant. Only through a thorough understanding of the premature infant's medical conditions and the developmental risks they display, can effective accountable service be provided to them, with feeding therapy as part of the intervention.

2.4 RISK FACTORS FOR FEEDING PROBLEMS IN PREMATURE INFANTS

Premature infants are not only at risk for developmental delays, but they are also at risk for feeding problems, specific to their circumstances. Premature infants have an overall weak and irritable state, which can decrease the quality of their oral-motor skills and the quantity of their oral intake (Morris & Klein, 1987). The stability of the autonomic, motor and state systems is a prerequisite for oral feeding. So is the maintenance of an awake and alert state, which is problematic for the premature infant. Feeding problems can arise from both neurobehavioural disorganisation and the actual sucking mechanism itself (Hunter, 1993). The feeding specialist must be alert to the following factors that may suggest feeding problems or may influence the oral feeding skills of premature infants.

2.4.1 MEDICAL HISTORY

Aspects from the medical history which should be considered by the feeding specialist when assessing and managing the oral feeding problems of the premature infant, are:

- *Polyhydramnios*

The foetus can swallow amniotic fluid from 16 weeks. If the swallowing of the infant is impaired, the amniotic fluid seems to increase. The excessive amount of

amniotic fluid is called polyhydramnios. This information from a comprehensive history will alert the feeding specialist to the possibility of dysphagia and possible neurological problems, because one of the reasons for a swallowing problem (dysphagia) can be an insult on the CNS. It can also be indicative of a tracheoesophageal fistula (TOF) (Brodsky, 1997), which causes serious feeding problems.

- *Substance abuse*

Cocaine or heroin abuse by the mother causes excessive sucking behaviour in the infant, but the sucking is inefficient. The infants are therefore poor feeders despite their strong sucking pattern (Sheahan & Brockway, 1994).

- *Facial anomalies*

If the premature infant has anomalies like a cleft palate or Pierre Robin sequence, feeding problems normally associated with such an anomaly can be expected.

- *Low birth weight (LBW)*

LBW infants have little body and facial fat. The facial fat must provide the infant with sucking pads in the cheeks which provide stability for the sucking movements. The premature LBW infant has diminished sucking pads. Without this stability, sucking is inefficient and the infant has to spend more energy to consume his oral feeds (Morris & Klein, 1987; Glass & Wolf, 1994). The additional energy expenditure may limit appropriate weight gain. The feeding specialist should constantly, in co-ordination with the medical staff, determine the balance between access to feeding experience and sufficient weight gain. Although Bu'Lock et al. (1990) regard feeding failure to be a result of neuromuscular immaturity rather than a lack of postnatal sucking experience, but sucking experience for the infant who is mature enough to co-ordinate his sucking, swallowing and breathing is very important according to Bazyk (1990) and Vergara (1993).

- *Long hospitalisation*

The hospital routine can have a negative impact on the feeding of the infant, because the infant's biorhythms are ignored in the NICU. The hunger sensation facilitates sucking (Morris & Klein, 1987). If the infant has to be fed at a certain time according to the hospital routine, but he is not hungry yet, poor sucking will be demonstrated (Cagan, 1995). The maintenance of an awake and alert state, with which the premature infant has difficulty, is a prerequisite for oral feeding (Mandich & Ritchie, 1996; Sheahan & Brockway, 1994; Vergara, 1993). If the scheduled feeding time does not correlate with the infant's awake cycle, sucking will be weak and inefficient. In both cases the feed will be administered by tube and valuable sucking experience will be lost. Another factor that places the infant at risk for feeding problems is that hospitalisation implies multiple caregivers with inconsistent feeding techniques (Bernbaum & Hoffman-Williamson, 1991).

A feeding specialist can thus be alerted to possible oral feeding problems by studying a complete medical history of the premature infant.

2.4.2 NEUROLOGICAL FACTORS

Oral feeding skills may be affected by several neurological factors, namely:

- *Immaturity*

The premature infant is not ready to adapt to the extrauterine life and is neurologically not ready to feed orally. Firstly, the co-ordination of sucking, swallowing and breathing only develops after approximately 34 weeks gestational age (Dreier et al., 1979; Bernbaum & Hoffman-Williamson, 1991; Brake, Alfasi & Fleischman, 1988). Secondly, the oral reflexes are diminished or absent (Bernbaum & Hoffman-Williamson, 1991). The gag reflex, which should protect the penetration of foreign objects into the larynx, develops at approximately 35 weeks gestational age. The young infant might not cough when he chokes, but will react with apnea (Loughlin, 1989). The risk of aspiration and apnea exists and

therefore makes oral feeding before 35 weeks unsafe. Thirdly, the premature infant cannot organise and integrate all the stimulation involved in oral feedings (Als et al., 1988). The infant becomes stressed, which disorganises the movements required for oral feeding, with the result that the infant becomes overloaded, refuses to eat, and/or falls asleep. Generally, it should be stated that oral feeding before 34 weeks gestational age will be unsafe and inappropriate for the premature infant (Morris & Klein, 1987; Glass & Wolf, 1994).

- *Insults on the Central Nervous System (CNS)*

This is associated with prematurity and with feeding problems. The infant with a neurologic insult, such as IVH or ICH, is at risk for feeding apnea and should therefore be monitored closely for any sign of feeding apnea so as to avoid hypoxemia (Rosen et al., 1984). In IVH and ICH, the sequelae from the bleeding also have an impact on the neurodevelopmental parameters, of which oral feeding is one. The impact on the feeding involves the motor aspects, oral-motor control and postural control needed for oral feeding. Cerebral palsy (CP) is a frequent outcome of ICH or IVH. Abnormal feeding patterns are often an early marker for potential CP (Hunter, 1993; Glass & Wolf, 1994). Repeated hypoxic incidents may lead to further neurologic damage and may therefore also increasingly affect the oral feeding skills of the infant.

- *Hypotonia*

Premature infants are generally hypotonic and lack postural control in the extensor cervical area. This leads to inadequate stability of the head and neck, needed for oral feeding. The low oral muscle tone causes a poor lipseal on the nipple with leakage of milk at the mouth corners (Bernbaum & Hoffman-Williamson, 1991). Sucking is a flexor skill, but the premature infant tends to be positioned in extension. Extension has a negative influence on sucking and swallowing. The strong extensor tone in the head and neck can also cause cheek retraction, which makes it difficult to maintain lip closure during sucking (Morris & Klein, 1987).

It is clear that neurological factors play a significant role in oral feeding skills. The neurological factors may determine when to introduce oral feeding, as well as the manner in which the management of the problems should be handled.

2.4.3 CARDIORESPIRATORY FACTORS

The degree of respiratory illness and the subsequent medical management of the illness are critical factors in potential feeding difficulties (Glass & Wolf, 1994). Problems with respiration as experienced when an infant has congenital pneumonia, RDS or BPD, limit the co-ordination of sucking, swallowing and breathing because there is less respiratory control. As a result, abnormal sucking patterns may occur. The infant uses short sucking bursts and long pauses (Hunter, 1993; Ramsey & Gisel, 1996). The airflow to the lungs is interrupted every time the infant swallows. The time for breathing is halved during oral feeding. Higher respiratory demands upon the infant are made. In response, the infant may gasp for air, which makes the swallowing inefficient and results in the long pauses before he sucks again. In severe cases, these pauses can become an apnoeic event and even hypoxia can occur (Rosen et al., 1984; Glass & Wolf, 1994).

- *Respiratory Distress Syndrome (RDS)*

The need for extra breathing and frequent fatigue in the infant with RDS was discussed earlier on. Feeding requires even more energy and puts more demands on the respiratory system. These infants experience a low endurance for oral feeding because of the additional oxygen consumption and respiratory reserve that are needed for oral feeding (Bernbaum & Hoffman-Williamson, 1991; Glass & Wolf, 1994).

- *Broncho-Pulmonary Dysplasia (BPD)*

Apart from respiratory problems in the infant with BPD, feeding problems occur very often. Chronic lung disease is a risk factor for feeding problems (Bernbaum &

Hoffman-Williamson, 1991), because motor, tactile and behavioural problems can develop based on the medical interventions that have to be followed for BPD. Garg et al. (1988) found that severe desaturations occurred during feeding of the BPD infant. That could explain why these infants in general have a low endurance, but also for feeding. Infants with BPD are irritable, have poor co-ordination of sucking, swallowing and breathing and may have abnormal oral-motor patterns (Hunter, 1993; Glass & Wolf, 1994). Chronic pulmonary disease leads to poor oral intake that causes low protein energy, resulting in malnutrition. Malnutrition impairs the immunologic response to infections. This can negatively affect the growth of the young central nervous system, which is highly undesirable at this stage of rapid brain growth (Tuchman, 1989). These problems have a negative influence on oral feeding and limit optimal nutritional intake, which in turn lead to poor weight gain (Semmler, 1989; Vohr, 1991; Glass & Wolf, 1994).

- *Mechanical ventilation*

The infant receiving mechanical ventilation is unable to feed orally. Long deprivation of oral feeding limits normal sucking experiences. The sucking reflex is not facilitated and may diminish with time. Prolonged use of endotracheal tubes can cause hyperextension of the head and neck, because that position is used to ensure a more open airway, but the extension position gives little stability for sucking and causes wide jaw excursions. These infants often experience hypersensitivity of the mouth, because of the early negative experiences of intubation. The infant is deprived of the normal pleasurable oral sensations and may develop an aversion towards any oral contact, including feeding (Bernbaum & Hoffman-Williamson, 1991; Glass & Wolf, 1994). The hypersensitivity can also disorganise the early suck-swallow patterns (Morris & Klein, 1987). If sucking is present, abnormal patterns may develop to accommodate the shape and position of the endotracheal tube. The endotracheal tube may also cause damage to the structures of the larynx, causing a possible incomplete protection of the airway during swallowing, which may lead to micro-aspiration (Wolf & Glass, 1994).

- *Heart diseases: VSD, PDA and Cyanotic heart disease.*

These infants are unable to increase their heart rate required for the extra energy expenditure needed for oral feedings. They tire quickly and become tachypneic. They may not arouse to feed and do not have the strength to feed orally. They experience early satiety because of their poor appetite, slow gastric emptying and decreased gastro-intestinal motility. They show poor growth and have a poor nutritional status (Wolf & Glass, 1994).

The feeding specialist has to consider all of these factors carefully when feeding an infant with cardio-respiratory problems.

2.4.4 GASTRO-INTESTINAL FACTORS

Problems in the gastro-intestinal tract of premature infants may influence their oral feeding skills.

- *Gastro-oesophageal reflux (GER)* (Bernbaum & Hoffman-Williamson, 1991)

Infants who often experience regurgitation, associate the unpleasant feeling of GER with feedings and develop an aversive reaction towards oral feedings. In severe cases the infant can develop oesophagitis, which makes it very painful for the infant to swallow and feeds will be refused in an attempt to avoid the pain (Rosenthal et al., 1995; Glass & Wolf, 1994). Micro-aspiration can also occur with GER (Hunter, 1993). If GER is suspected, it has to be medically managed for oral feeding to be optimal.

- *Necrotizing enterocolitis (NEC)*

NEC results in a general weak state of the infant. The infants feed on hyperalimentation (Wolf & Glass, 1994). NEC can cause long-term feeding and behavioural problems (Sehna & Palmeri, 1989). Feeding problems may imply difficulties with the quantity and type of milk that can be tolerated by the intestines as well as problems with the sucking mechanism itself. The cause of the

problematic sucking patterns has to do with the deprivation of the oral sucking experience and the effects of long-term tube feedings in these infants.

- *Long-term nasogastric feedings*

This can be an early signal of a neurodevelopmental dysfunction (Glass & Wolf, 1994). Although premature infants are initially dependent on nasogastric feeds as they are unable to meet all of their nutritional needs orally, the long-term use of nasogastric feedings may create several problems. These problems are similar to the aversive reactions that may result from endotracheal intubation, as discussed earlier (Bazyk, 1990). Aversive reactions towards oral feeding can develop because of negative associations with unpleasant medical procedures like intubation, sucking procedures and naso- or orogastric tubes being inserted (Bazyk, 1990; Bernbaum & Hoffman-Williamson, 1991). The nasogastric tubes may cause nasal and pharyngeal irritation and provide a negative stimulus every time the infant swallows (Bazyk, 1990; Jaffe, 1989). The hypersensitivity in the oral area can disorganise early sucking-swallowing patterns (Averdson & Brodsky, 1993; Bazyk, 1990; Morris & Klein, 1987; Rosenthal et al., 1995). Breathing patterns may also be altered due to the partial obstruction caused by the tubes in the nasal cavity (Bazyk, 1990; Jaffe, 1989). The aversive behaviour may lead to failure to thrive in more severe cases (Bazyk, 1990; Geertsma et al., 1985; Mandich & Ritchie, 1996). Premature infants are usually fed by nasogastric tubes until they are ready to transfer to the bottle or breast. Although their medical status is good and their weight acceptable, they often do not have the oral-motor skills and co-ordination of sucking, swallowing and breathing to feed effectively. Prolonged use of the nasogastric tube can have negative influences on the development of oral feeding skills (Bazyk, 1990; Mandich & Ritchie, 1996; Morris, 1989; Palmer & Heyman, 1993; Vergara, 1993).

Clinical experience has shown that the period of time spent by many premature infants in the neonatal unit is dependent on the time they need to become successful oral feeders rather than medical reasons. That means that although they are healthy enough to be discharged, they are not able to manage all of their

feeds orally yet. 25% of the infants (\pm 211 per year) in the NICU of the Pretoria Academic Maternity Hospital stayed in hospital for more than 14 days and only 3% of them for more than 60 days in 1998 (De Witt, 1999). Efficient feeding therapy in the NICU can shorten hospital stay. Prolonged hospital stay heightens the risk for developmental delays and poor parent-child relationships (Sweeney, 1985). Earlier discharge from the hospital thus has several advantages. Firstly, it is cost effective, which may be the most important factor from the hospital administrator's point of view, as medical expenses for NICU care are very high (Petryschien, Stevens, Hawkins & Stewart, 1997). Secondly, it has a positive effect on the parent-infant relationship. The mother has the opportunity to care for her infant sooner and bonding is facilitated. Family routines and stimulation of the infant are enhanced which have a positive influence on the developmental outcome of the infant (Aylward, 1990; Vohr, 1991)

2.4.5 ORAL STRUCTURES

Premature infants do not have sucking pads, so that the oral cavity appears to be bigger. The tongues of premature infants appear relatively small (because of the bigger oral cavity), have decreased motility and lack stability for sucking. The tongue is often in an elevated position in an attempt to stabilise it. The jaw exhibits exaggerated excursions, interfering with efficient sucking. The premature infant also has a decreased lipseal and depressed oral reflexes, which complicate oral feeding (Morris & Klein, 1987). The feeding specialist should consider these characteristics when planning feeding intervention.

2.5 CONCLUSION

It is clear that premature infants are different from full-term infants, not only in appearance, but also in the medical conditions and complications that they are prone to and the effects that these can have on their oral feeding abilities and

their developmental outcome. An understanding of the unique characteristics and risk factors that can influence the functioning of the premature infant is vital for the effective and efficient management of their feeding problems. A comprehensive assessment of the premature infant's feeding skills will therefore have to include all aspects discussed in this chapter, either as information collected from the medical history or from direct observation. Only when a thorough assessment of the premature infant as a whole, his medical history and current medical status, state and behaviour, physiological and neurological status and oral-motor skills, has been made, can an appropriate intervention be planned. The requirement of Bu'Lock et al. (1990) to adequately define the premature infant's feeding skills to be able to intervene effectively can be fulfilled in this way.

2.6 SUMMARY

The characteristics of premature infants were described in terms of their general appearance and the different states and systems in which they function. Risk factors for the developmental outcome were examined. The risk factors were divided into three categories, namely biological, environmental and established/medical factors and were discussed according to the period (pre-, peri- or postnatal) in which the factors occurred. The risk factors for feeding problems of premature infants were also discussed. The next chapter will deal with the mechanics of the premature infant's oral feeding skills.

CHAPTER 3

DEGLUTITION IN PREMATURE INFANTS

Aim: To provide an overview of the development of oral structures and feeding skills in normal infants and highlight the functioning of premature infants. The anatomical structures and the nerve supply needed in the feeding process are discussed as well as the different phases of deglutition. This information forms the basis of feeding assessment and intervention.

3.1 INTRODUCTION

Breathing and swallowing are two life-sustaining skills that an infant has to perform soon after birth (Brodsky, 1997). Oral feeding is one of the most complicated developmental tasks a newborn infant is required to master. The physical act of feeding is a complex physiological process. Sucking, swallowing and breathing form the cornerstones of the feeding process (Stevenson & Allaire, 1991; Wolf & Glass, 1991). For swallowing to be physiologically safe and effective, precise co-ordination of the pharyngeal and laryngeal musculature with the airway is required (Brodsky, 1997; Stevenson & Allaire, 1991). Another element of normal swallowing is the acquisition of adequate nutrition (Stevenson & Allaire, 1991) through good oral-motor and sucking skills. The ability of an infant to develop good oral-motor control as part of a well-integrated system depends on various anatomical, physiological, neuromotor, sensori-motor, cognitive and environmental factors (Alexander, 1987). Morris, Miller-Loncar, Landry, Smith & Denson (1999) add to the afore-mentioned, other factors such as gestational age, neurological status, medication, concurrent illnesses and congenital anomalies that may influence the infants' ability to feed orally. Bosma (1993) further states that the manner of arousal towards feeding and the competence in suckle feeding

reflect the infant's general health and neurological status. The premature infant's immature neurological system, abnormal muscle tone, depressed oral reflexes and overall weak and irritable state, result in a decreased quality of oral motor skills and thus reduces the quantity of nutritional intake (Morris & Klein, 1987).

The same multiple anatomical structures needed for oral feeding are primarily needed for respiratory support. These structures are linked, anatomically and functionally, and interact to function in complex ways (Arvedson & Brodsky, 1993; Wolf & Glass, 1991). They also share the same neural supply. This implies that if a problem with any one of these systems is experienced, the others will be involved as well. It is therefore imperative that the **description** and the **comprehensive assessment** of the **feeding skills of premature infants** will take **all** the aspects of **oral feeding** as well as **respiratory status** into consideration.

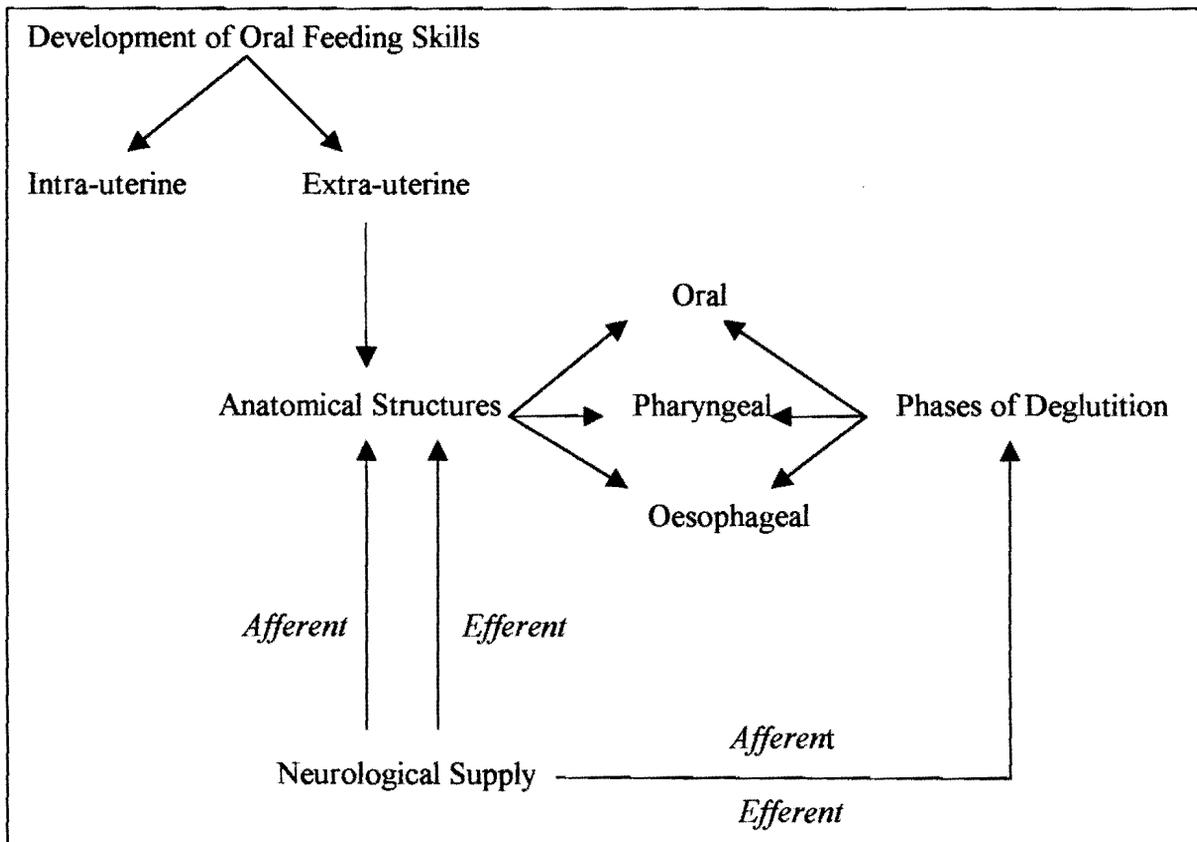


Figure 3.1 Areas of discussion of deglutition in premature infants.

A thorough understanding of the infant's (a) anatomy, embryology and physiology of the upper and lower aerodigestive tracts and related body systems, (b) the central nervous system, (c) the cardio-respiratory system, (d) the gastrointestinal tract and (e) normal development of feeding skills, is therefore needed to appreciate the magnitude of the assessment and management, involved in infants with feeding problems (Arvedson & Lefton-Greif, 1996; Brodsky, 1997; Wolf & Glass, 1991).

3.2 DEVELOPMENT OF ORAL FEEDING SKILLS

Feeding development is a dynamic and interactive process which involves physiological factors, neurodevelopmental progression, respiratory and nutritional status and the effects of body positioning and movement on the upper respiratory tract (Arvedson & Lefton-Greif, 1996). Feeding problems can occur as a result of abnormal development of the mouth or pharynx during the initial development of the embryo (Bosma, 1993). An assessment can then be made on the basis of the difference from what is expected (Arvedson & Lefton-Greif, 1996). The development of oral feeding and the relevant structures will be discussed in two phases, namely the embryological stage (intra-uterine) and after (premature) birth (extra-uterine).

3.2.1 EMBRYOLOGICAL DEVELOPMENT OF ORAL MOTOR SKILLS (INTRA-UTERINE)

The development of the anatomical and neural structures begins in utero. Normal embryological development from conception until birth, as it relates to the dynamic processes of oral-motor functioning, swallowing and respiratory functioning, will be discussed briefly.

26 days after conception, the respiratory and swallowing systems, begin their own path of development (Wolf & Glass, 1991). The tracheoesophageal septum divides into a ventral and dorsal portion. The ventral part develops into the larynx, trachea, bronchi and lungs, the dorsal part into the oesophagus. The branchial arches contribute to the formation of the face, neck, nasal cavities, mouth and larynx. The mandible is one of the first structures to be completed at 4 weeks, the maxilla soon follows and the development of the palate at 5 weeks (Arvedson & Brodsky, 1993).

At 7-8 weeks a mouth opening can be observed and taste buds detected. The oesophagus has reached its relative length (Arvedson & Brodsky, 1993). Breathing movements and jaw opening occur at 10 weeks (Wolf & Glass, 1991). The first motor responses in the pharynx for a pharyngeal swallow have been detected between the 10th and 11th week (Arvedson & Brodsky, 1993; Arvedson & Lefton-Greif 1996). From 10-18 weeks and in the last 3 months the brain tissue is especially susceptible to damage, from toxic substances, nutritional deprivation or disruption of oxygen flow. A spurt in brain growth occurs around 14 weeks (Wolf & Glass, 1991).

The first sucking movements can be detected by 11-12 weeks (Wolf & Glass, 1991). By 12-13 weeks, oral reflexes can be elicited and tongue protrusion begins. There is also response to sound at this age. Swallowing of amniotic fluid has been observed with ultrasound as early as 13 weeks (Arvedson & Lefton-Greif, 1996; Bosma, 1985). The swallowing during this time plays an important role in the balance of the amniotic fluid. Half of the amniotic fluid is swallowed daily (Cherney, 1994; Wolf & Glass, 1991). Dysphagia can be expected if polyhydramnios (excessive amniotic fluid) occurs (Harris, 1986; Kramer & Eicher, 1993.) Polyhydramnios can also occur as a result of a tracheoesophageal fistula (TOF), congenital diaphragmatic hernia (Alper & Manno, 1996) or oesophageal atresia (Wolf & Glass, 1991). Between 15 and 18 weeks more sucking movements occur, which Arvedson & Lefton-Greif (1996) consider to be true

sucking. Wolf & Glass (1991) state that strong gagging occurs at 18 weeks, but Arvedson & Brodsky (1993) are of the opinion that there is only evidence of a gag reflex by 26-27 weeks, while Harris (1986) says that the gag reflex only evolves around 32/33 weeks. Clinical experience has indicated that the gag reflex is weak in most of these infants except in cases where they were exposed to extensive unpleasant procedures, such as recurrent suctioning and intubation. They then usually exhibited hyperactive gag reflexes. It is therefore unreliable to try to estimate a gestational age based upon the maturity of the gag reflex.

Pouting of the lips can be observed at 22 weeks (Hack, Estabrook & Robertson, 1985; Harris, 1986). Life in infants under 24 weeks gestational age, or with a weight of less than 500 g, is unlikely. Significant development in the respiratory and central nervous systems (CNS) occurs between 24 and 32 weeks (Arvedson & Brodsky, 1993).

By 26-28 weeks, single sucking movements and long variable pauses during non-nutritive sucking (NNS) appear (Arvedson & Lefton-Greif, 1996; Cherney, 1994; Harris, 1986; Wolf & Glass, 1991). This is important to know, because if the infant is born at this stage, non-nutritive sucking (NNS) should be encouraged to maintain the natural need and ability to suck and to reap the benefits of NNS until the infant can feed orally. The CNS can be mature enough to direct rhythmic breathing movements and control body temperature (Arvedson & Brodsky, 1993). By 28 weeks, the phasic bite reflex and transverse tongue movements are observed (Arvedson & Brodsky, 1993). A sucking rhythm is present, but the infant becomes exhausted easily as more calories are spent on sucking and swallowing than can be ingested. Rooting is also present, but is of a lesser quality than that of a full-term infant. Breathing and swallowing is not in synchrony yet (Morris & Klein, 1987). During the next 3 weeks, the infant will also begin with mouthing.

3.2.2 DEVELOPMENT OF ORAL MOTOR SKILLS (EXTRA-UTERINE)

A considerable number of infants may survive should they be born at this stage (28-39 weeks) and the development of the oral structures and oral motor functioning continues. These premature infants have to function differently in the environment after birth (extra-uterine) than in a fluid-filled intra-uterine environment, also in regard to their oral motor skills. Their oral motor skills differ from those of the infant who is born at full-term

If the infant was born at 30-32 weeks, his sucking movements during NNS show some intrinsic rhythm (Hack et al., 1985). The NNS will still be weak and will occur less often than in a full-term infant. The organisation of the sucking burst pattern, which is necessary for successful nipple feeding, becomes evident (Arvedson & Lefton-Greif, 1996; Tuchman, 1989; Wolf & Glass, 1991). These sucking bursts are short but stable in length although the pauses may be long and irregular (Arvedson & Brodsky, 1993; Wolf & Glass, 1991). Swallowing occurs before or just after the short sucking burst (Wolf & Glass, 1991). The co-ordination between the sucking, swallowing and breathing also improves (Morris & Klein, 1987).

Between 30 and 34 weeks, white fat forms 8% of the body weight. The presence of white fat is a developmental milestone for normal feeding, because it shows some potential for nutritional reserves. More rooting is noted by 32 weeks (Arvedson & Brodsky, 1993; Morris & Klein, 1987). The gag reflex evolves around 33 weeks (Harris, 1986). This implies that an infant is not equipped to protect his respiratory system effectively before 33 weeks. Oesophageal peristalsis is poorly co-ordinated due to a lack of smooth peristaltic movement (Wolf & Glass, 1991). A significant improvement in oral motor patterns and stronger sucking is seen after 33 weeks (Arvedson & Lefton-Greif, 1996; Morris & Klein, 1987). This implies that an infant may become ready to feed orally from this age onwards. The premature

infant is also maturationally and neurologically better prepared for survival (Morris & Klein, 1987).

From 34 weeks the link between sucking and swallowing becomes better, as well as the co-ordination with breathing (Comrie & Helm, 1997; Dreier et al., 1979), but if any problems arise, apnea may occur (Tuchman, 1989). The initial continuous sucking burst lasts at least 30 seconds (generally closer to 70 seconds) and 30% of their feeding is taken during this time (Wolf & Glass, 1991). An infant with respiratory difficulties will not be able to sustain such a long sucking burst. Gryboski (1969) and Wolf & Glass (1991) are of the opinion that breast-fed infants have better co-ordination of sucking and swallowing than bottle-fed infants. Meier & Pugh (1985) support this idea by stating that infants born at this age may be ready for breastfeeding. Many abnormal or disorganised tongue and jaw movements during sucking still occur up to 34 weeks. This results in poor intake per suck which leads to a longer feeding time (Wolf & Glass, 1991). The WHO (1989) stated that organised oesophageal activities occur if effective sucking can be maintained. Wolf & Glass (1991) state that oesophageal peristalsis is smooth and propagative at 34 weeks gestational age. However, regular breathing is often still disturbed (Bu'Lock et al., 1990). The frequency of respiration reduces because the co-ordination between sucking, swallowing and breathing is not well developed yet and the haemoglobin oxygen saturation levels tend to drop during oral feeding. This has the effect that infants tire more quickly (Wolf & Glass, 1991). It is, therefore, important to monitor the infants on a saturation monitor when oral feeding is introduced and to interrupt oral feeding when necessary, to reduce stress and allow low oxygen levels in the infant to return to baseline values.

The co-ordination between sucking, swallowing and breathing begins to stabilise to the ratio of 1:1:1 and will consistently increase with maturity (Bu'Lock et al., 1990). Arvedson & Brodsky (1993) feel that the suckle and swallowing of these infants may now be developed enough to sustain nutritional needs and adequate

weight gain via the oral route. As the infant matures, more sucking actions per sucking burst occur. Swallowing does not occur simultaneously with sucking, but afterwards. Sucking inhibits swallowing, which is another mechanism to protect the airway (Logan & Bosma, 1967; Gryboski, 1969; Bernbaum et al., 1983; Harris, 1986). At this stage, the sleep-wake cycle emerges and an alert state enhances oral feeding.

By 35-36 weeks, fewer abnormal tongue movements occur, but Bu'Lock, et al. (1990) found that these infants seem to block the hole of the nipple more often at this stage. According to them, mainly mouthing occurs for the first three days. For the next four days, short sucking bursts occur and after that, long deep sucking is observed (Gryboski, 1969). A full-term infant displays almost no abnormal tongue movements (Bu'Lock et al., 1990). Hack et al., (1985) state that as the infant gets older, the tempo of the sucking bursts increase and the frequency of pausing and mouthing decreases. Bottle-feeding can be maintained at this age irrespective of the weight of the infant. Co-ordination between sucking, swallowing and breathing is achieved in most premature infants when they reach 37 weeks gestational age (Bu'Lock et al., 1990). Feeding experience interplays with maturation to improve efficiency of oral feeding (Wolf & Glass, 1991).

Knowledge of the development of sucking and swallowing skills will enable the feeding specialist to assess the oral feeding skills of the premature infant efficiently and to plan appropriate feeding intervention strategies.

The anatomic structures, essential to oral feeding, continue to grow after birth and change their physical relationship to one another, which therefore affects their function. The functional skills depend on the integrity of the anatomic structures. These structures also undergo neurological maturation and experiential learning (Stevenson & Allaire, 1991). The feeding specialist should also have a sound knowledge of these maturational changes to be able to assess and manage premature infants' feeding problems appropriately and safely.

3.3 ANATOMICAL STRUCTURES RELEVANT FOR FEEDING

The aerodigestive tract provides a conduit for passage of both air and food (Cherney, 1994; Wolf & Glass, 1991). The upper aerodigestive tract comprises the oral cavity, pharynx, larynx, trachea and oesophagus. The lower aerodigestive tract comprises the airway; the lungs, and digestive; the stomach and small intestines (Arvedson & Brodsky, 1993).

3.3.1 ORAL CAVITY (LIPS, TONGUE, CHEEKS, PALATE, VELUM, MANDIBLE AND MAXILLA)

The anatomy of the oral structures of a full-term infant is well adapted for sucking. The basic constitution is similar to that of an adult, but the tongue, velum, arytenoid mass and vocal cords of the infant are relatively bigger than the surrounding structures and have a close proximity to each other (Miller, 1986; Stevenson & Allaire, 1991). The premature infant's oral structures also differ from those of the full-term infant. This is briefly set out in Table 3.1 and is fully discussed in the following paragraphs.

Table 3.1. Differences between oral structures of the premature and full-term infant.

Premature infant	Full-term infant
<ul style="list-style-type: none"> ▪ No sucking pads – poor cheek stability ▪ No facial fat ▪ Open lips & jaw at rest ▪ Decreased lip seal ▪ Tongue relatively small for oral cavity ▪ Tongue in elevated position to stabilise ▪ Mandible relatively small – insufficient stability ▪ Palate often high and narrow ▪ Muscles of body and face weak and underdeveloped 	<ul style="list-style-type: none"> ▪ Sucking pads – cheek stability ▪ Facial fat ▪ Closed lips and jaw at rest ▪ Adequate lip seal ▪ Tongue relatively big for oral cavity ▪ Tongue fills cavity, against palate ▪ Mandible normal size – jaw stability ▪ Normal palate ▪ Stronger facial and body muscles

<ul style="list-style-type: none"> ▪ Decreased oral reflexes ▪ Anatomically at sucking disadvantage ▪ Weakened suck 	<ul style="list-style-type: none"> ▪ Intact oral reflexes ▪ Anatomically ready to suck ▪ Strong suck
--	---

(Source: Morris & Klein, 1987; Wolf & Glass, 1991)

The lips and mouth of the premature infant remain in an open position when at rest, in contrast to the full-term infant whose lips and jaw are closed (Wolf & Glass, 1991). The mandible of the premature infant is relatively small for the oral cavity. The position of the neck extensors contributes to a greater amount of jaw opening and reduces stability that would be provided by the flexor tone. This strong extension can cause cheek retraction, which can influence the lipseal (Morris & Klein, 1987).

Premature infants have diminished sucking pads and facial fat, resulting in an increased oral cavity (Wolf & Glass, 1991). Sucking pads are densely compacted masses of fatty tissue within the masseter muscles (Stevenson & Allaire, 1991). These sucking pads stabilise the lateral walls of the oral cavity and decrease the oral cavity in full-term infants (Kramer & Eicher, 1993). The absence of sucking pads and poor lipseal can greatly reduce the mechanical efficiency of sucking (Morris & Klein, 1987).

The tongue of the full-term infant fills the whole oral cavity and rests more anteriorly than in adults. The tongue of the premature infant is relatively small and does not fill the oral cavity (Morris & Klein, 1987; Wolf & Glass, 1991). The oral cavity is relatively bigger because of the diminished sucking pads. The tongue has therefore less stability and moves freely in the mouth or is elevated in an attempt to stabilise it and to oppose the palate. The feeding specialist should have knowledge of this because the nipple can easily be placed under the tongue of the premature infant and inaccurate assessment of sucking, swallowing and the flow rate can be made. The development of normal tongue movements will be

inhibited (Wolf & Glass, 1991). Since the oral cavity is relatively bigger, a very small nipple may not necessarily be needed.

The palates of the premature infants are often high and narrow. That may be due to the fact that the tongue has less constant pressure on the palate, because of the open mouth position tendency in these infants (Wolf & Glass, 1991). NNS may not be implemented regularly when an infant is not ready for nipple feeding yet and less pressure is applied to the palate, as would have occurred in a full-term infant who is exposed to regular nipple feeding. Continuous pressure from oral tracheal tubes, used in infants with BPD, and the lack of contact between the tongue and palate, can also cause a high narrow palate (Wolf & Glass, 1991). The muscles and ligaments of the premature infants are still weak. This has the implication that sucking may be weak and endurance low. The close proximity of the tongue, velum and pharynx to the larynx facilitates nasal breathing (Arvedson & Brodsky, 1993). That implies that if the infant experiences any form of nasal obstruction, feeding may be influenced.

3.3.2 PHARYNGEAL CAVITY (OROPHARYNX, NASOPHARYNX, HYPOPHARYNX)

An understanding of the anatomy of the pharynx is essential for a thorough understanding of the feeding process (Stevenson & Allaire, 1991). There does not seem to be a difference between the anatomy of the pharynx of the premature infant and that of the full-term infant. Development of feeding occurs in a caudal–cephalic direction (Gryboski, 1969). Adequate pharyngeal functioning is needed for adequate oral functioning (Wolf & Glass, 1991). The pharynx consists of 3 muscles, e.g. the superior, medial and inferior constrictors, which are involved in swallowing (Arvedson & Brodsky, 1993). The pharynx can be separated into 3 areas, the oro-, naso- and hypopharynx.

The *oropharynx* extends from the palate (superior) to the base of the tongue (inferior) and includes the valleculae (Stevenson & Allaire, 1991). The position of the velum of the infant is relatively low in the oropharynx, can be in contact with the tongue and is close to the tip of the epiglottis. The epiglottis may even lie over the velum and protects against aspiration by diverting fluids down on both sides of the laryngeal opening (Jolley et al., 1995; Stevenson & Allaire, 1991; Wolf & Glass, 1991). The larynx and hyoid bone are both placed more anterior and superior, and closer to the mandible than those of the adult (Brotsky, 1997; Kramer & Eicher, 1993; Stevenson & Allaire, 1991). The larynx of the infant is on the level of the third cervical vertebra (C₃) whereas that of an adult is at C₇ (Kramer & Eicher, 1993). The high position of the larynx near the base of the tongue diminishes the size of the pharyngeal cavity relatively to that of the adult and it also assists in the closure of the laryngeal vestibule. It is considered to be a natural protection of the airway in infants.

The *nasopharynx* extends from the base of the skull to the roof of the velum (Stevenson & Allaire, 1991). The velum elevates to form a nasopharyngeal closure. This prevents the bolus from entering the nasal cavity. Plaxido & Loughlin (1981) name nasopharyngeal reflux as one of the causes of neonatal apnea. Premature infants tend to be hypotonic (Sheahan & Brockway, 1994). If the hypotonia extends to the muscles in the velum, nasopharyngeal reflux may be a problem in premature infants.

The *hypopharynx* extends from the valleculae to the cricopharyngeus. The larynx opens into the hypopharynx anteriorly (Stevenson & Allaire, 1991). The larynx serves three basic functions, in order of priority, protective (during swallowing), respiration and phonation. The larynx is suspended by suprahyoid muscles from the hyoid bone superiorly and anteriorly. If the head is not in a stable, anterior position, the larynx may not be in a position to protect the airway. Premature infants tend to move their heads backwards into cervical extension, because of dominance of the extension pattern to facilitate respiration and possible tube

placement (Cherney, 1994). That is why positioning of the head and head control later on is so important during oral feeding. Protection of the airway is carried out on three levels: (a) the epiglottis descends forward to close the superior inlet of the larynx, (b) The false vocal cords close and (c) the true vocal folds close (Arvedson & Brodsky, 1993). Infants suck and breathe simultaneously, but during swallowing a brief co-ordinated pause in respiration occurs (Brodsky, 1997). However, the CNS of the premature infant may still be immature, and this co-ordination may then not be well developed yet and feeding problems will be experienced. From this point onwards the respiratory and feeding pathways separate. For the sake of this study, only the feeding pathway, namely the oesophagus, will be discussed further.

3.3.3 OESOPHAGUS

The oesophagus is a muscular tube lined with mucosa, which links the pharyngeal chamber with the stomach. The oesophagus lies in the neck, anterior of the cervical vertebrae, posterior to the trachea and between the cardiac arteries. The recurrent laryngeal nerves are on either side of the oesophagus (Arvedson & Brodsky, 1993). During swallowing food is propelled from the hypopharynx to the stomach. At the superior end, the Cricopharyngeus sphincter or Upper oesophageal sphincter (UES) can be found and at the lower end the gastro-oesophageal sphincter (LES). These two sphincters keep the oesophagus empty between swallows (Arvedson & Brodsky, 1993). The UES and upper third of the oesophagus are composed of striated voluntary muscles and the LES and lower two thirds of the oesophagus, of smooth involuntary muscle (Arvedson & Brodsky, 1993; Wolf & Glass, 1991). The pharynx and oesophagus are the only two organs in the body with striated muscles which are not under voluntary neural control (Arvedson & Brodsky, 1993).

Gryboski (1969) believed that sucking in the premature infant would be inhibited if the peristalsis in the oesophagus were not efficient yet, because development

follows a caudal–cephalic direction. It is thought that the oesophagus is in this way protected until it can handle large boluses. According to Gryboski (1969), peristaltic movements in the oesophagus are only well developed by 37 to 40 weeks gestational age. The WHO (1989), on the other hand, stated that the oesophagus can (at a young age of 34 weeks), be activated and organised if the infant can maintain sucking. It may be true that inefficient peristalsis may inhibit sucking, but it is known from the literature (Arvedson & Brodsky, 1993; Bu'Lock et al., 1990; Comrie & Helm, 1997) and clinical experience that sufficient sucking can occur before 37 weeks gestational age. If it is true that the peristalsis is only efficient a little later, it may explain the high frequency of regurgitation clinically seen in premature infants. They suck efficiently, but because the peristalsis is not well developed yet, the oesophagus overfills and the infant regurgitates. This can be misinterpreted as gastro-oesophageal reflux or vomiting. The fact remain that as the premature infant matures, the peristalsis in the oesophagus becomes more consistent and of higher amplitude (Bosma, 1993), but until it functions efficiently, appropriate management is necessary. Appropriate management can only be carried out after a proper assessment of the oesophageal functioning has been made.

An abnormal oesophagus can have deleterious effects on both the breathing and feeding simultaneously. For example, in the case of a tracheoesophageal fistula (TOF) there is communication between the trachea and the oesophagus and the contents of the oesophagus may spill into the trachea, causing major aspiration. Any mass in the oesophagus can press against the posterior wall of the trachea and compromise breathing (Brodsky, 1997). Oesophageal atresia in an infant can already be suspected in utero if polyhydramnios is detected, because the infant is unable to swallow the amniotic fluid. Hypertrophic stenosis in the oesophagus can cause projectile vomiting. A comprehensive medical and prenatal history should be included in the assessment procedure to plan intervention efficiently.

In conclusion, it may be stated that the anatomical structures of premature infants differ from those of the full-term infant and those of the adult. Abnormalities in these structures may cause feeding difficulties in premature infants.

3.4 NEUROPHYSIOLOGY OF DEGLUTITION

Deglutition or swallowing is a dynamic process. The sensory control of the swallowing process requires widespread involvement. If the CNS is immature, the infant cannot organise or integrate the stimuli that are part of a typical oral feeding environment. The areas from the lips (anterior), the pharynx (posterior), the velopharynx (superior), to the oesophagus (inferior), are involved. Good neural co-ordination of both the cranial and spinal nerve systems is required for efficient swallowing. The peripheral nerves, central nuclei and neural centres are involved, e.g. medulla oblongata, midbrain and cerebellum. The extensive neural network co-ordinates, integrates and determines the sequence of the voluntary and involuntary activities of the swallowing process (Lass et al., 1988). The premature infant's neurological system is still immature. The overall effects of the neural immaturity and the inability to integrate sensory information on the infant's state and behaviour, was described in chapter 2. It can therefore be expected that a process such as feeding, which involves such widespread and integrated neurological participation, will equally be affected by an immature nervous system.

The swallowing centre involves three levels or subsystems which are discussed below.

3.4.1 AFFERENT SYSTEM

The afferent sensory fibres provide the swallowing centre with sensory information for swallowing. Four *cranial nerves*, V₂, VII, IX and X (of which the last two are the most important), synapse with tractus solitarius (NTS) in the *brainstem* and with the adjacent *reticular formation* to provide the sensory information to initiate swallowing (Stevenson & Allaire, 1991; Wolf & Glass, 1991).

Cranial nerve V₂ provides information from the face. It plays an important role in the elicitation of the rooting, suckling and tonic biting reflexes in infants. It provides feedback during sucking and the information from the soft palate facilitates swallowing (Rogers, 1996; Wolf & Glass, 1991). *Cranial nerve VII* provides sensory information (taste) from the anterior two thirds of the tongue and influences sucking behaviour (Wolf & Glass, 1991). Sensory information from the mucosa of the tongue and palate, the soft palate, and pharyngeal folds, is carried by *CN IX* (Rogers, 1996; Wolf & Glass, 1991). Sensory innervations to the lower portions of the pharyngeal wall come from *CN X*. It also carries sensory information from the pharyngeal and laryngeal mucosa, vocal folds and cricothyroideus (Bosma, 1993). It influences swallowing and breathing (Wolf & Glass, 1991). Immaturity of the cranial nerves may have an effect on the oral reflexes and the sensory elicitation of a swallow in premature infants.

It is known that the *reticular formation* controls alertness. The premature infant has problems with maintaining an alert state. If this was due to an immature reticular formation and the reticular formation is also involved with swallowing, it is understandable why feeding problems in premature infants occur and why an alert state facilitates oral feeding. This also illustrates that feeding problems in premature infants are complex and are not merely an inability of the oral structures to perform an activity.

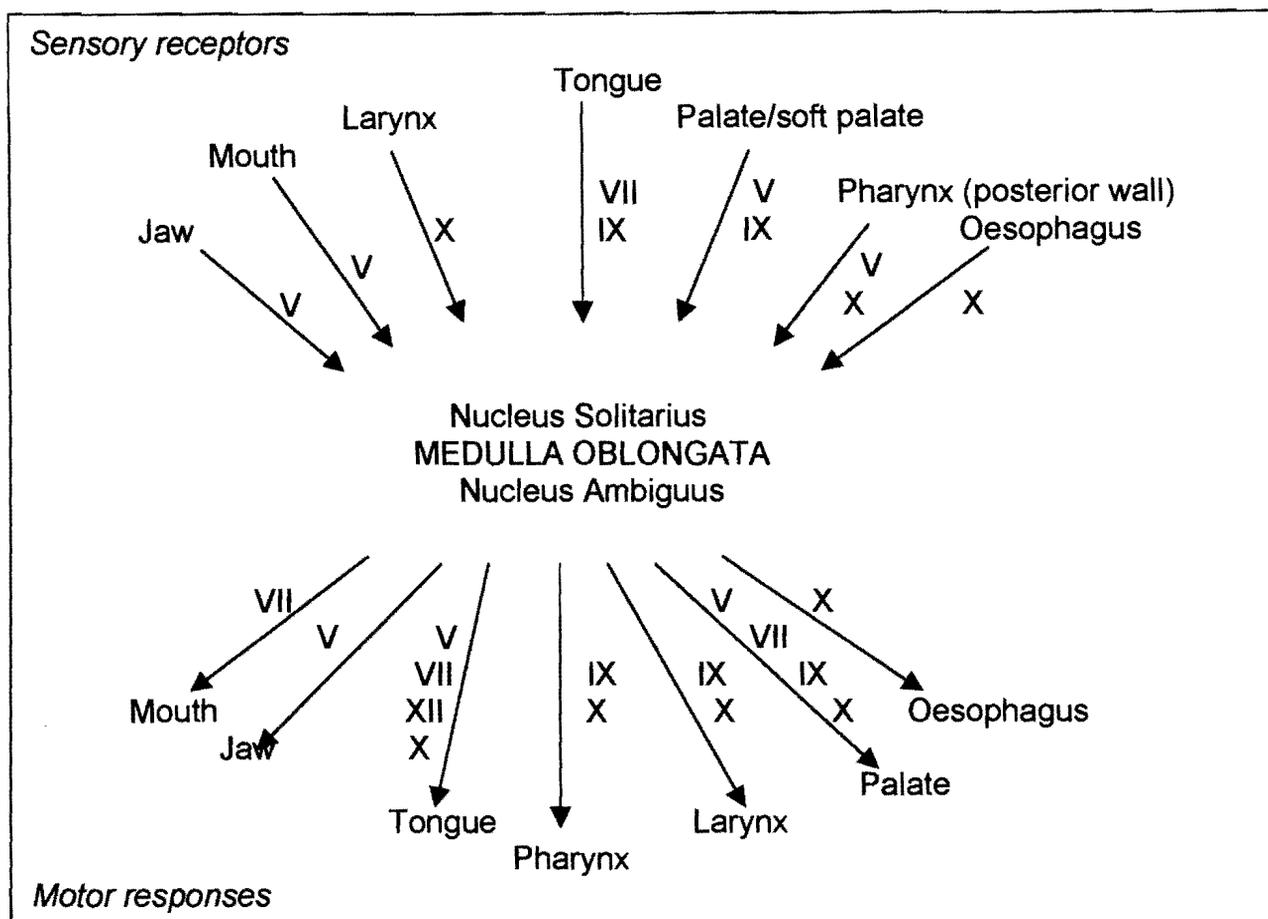
3.4.2 EFFERENT SYSTEM

The efferent motor fibres convey motor commands from the nucleus ambiguus (NA) and the adjacent ventral *reticular formation* and are distributed to *cranial nerves* V₃, VII, IX, X, XII and two of the *cervical peripheral nerves* C₁ -C₃, to supply the oral structures (Wolf & Glass, 1991).

Cranial nerve V₃ is involved with the motor actions of sucking and swallowing. The muscles of the lower jaw help with sucking and palatal elevation and initiate swallowing (Wolf & Glass, 1991). *CN* VII provides the buccinator and stylohyoid muscles involved in sucking and swallowing (Wolf & Glass, 1991). The motor fibres in the soft palate, pharynx, larynx, trachea and oesophagus are provided by *CN* X (Bosma, 1993; Rogers, 1996; Wolf & Glass, 1991) and it is involved with swallowing and breathing (Wolf & Glass, 1991). The dorsal motor nucleus of *CN* X in the *medulla* is responsible for the integration of swallowing, respiration, phonation, emesis and cardiovascular responses (Rogers, 1996). An immature nervous system may have widespread influence on the feeding skills and associated behaviour of a premature infant, as it may affect the motor actions needed for sucking and swallowing. The coordination with breathing may also be compromised by an immature medulla.

3.4.3 ORGANISING LEVEL

An inter-neural network co-ordinates the two systems mentioned above, programmes the whole motor sequence of swallowing and determines the patterns of pharyngeal and oesophageal muscle contractions needed for swallowing (Wolf & Glass, 1991). Figure 3.2 provides a visual representation of the neural network involved in the whole swallowing process.



(Source: Bosma, 1993; Rogers, 1996; Wolf & Glass, 1991)

Figure 3.2 Neural Network for Swallowing

The swallowing centre is situated in the medulla oblongata in the brainstem and modifies all neural input from the pons, limbic and hypothalamic systems, the cerebellum and the frontal cortex (Stevenson & Allaire, 1991; Wolf & Glass, 1991). Centres for respiratory control and feeding are developed simultaneously in the brainstem (Bosma, 1993). This fact may explain why Rosen et al., (1984), Shivpuri et al., (1983) and Solomano (1986) all found that apnea during feeding occurred as often and even more often in premature infants than sleep apnea did, which highlights the importance of including the monitoring of apnea during the assessment and management of feeding skills in these infants. The brainstem integrates and processes different signals from the oropharyngeal fibres and the higher central nervous system and orchestrates the whole swallowing process.

The sensory information received from the receptors of the oral cavity, tongue and pharynx acts as the main trigger for swallowing. In older infants, children and adults, the motor reaction that should follow is determined by the cortex and depends on the size and characteristics of the bolus, the head and neck position and orientation towards gravity (Stevenson & Allaire, 1991). Feeding in the *premature* and very young infants is reflexive, without any supra-bulbar involvement. The older infant develops, through a process of encephalization and experience, the ability to evaluate the physical properties of the food and to manipulate the bolus effectively, and the oral preparatory phase, oral phase and swallowing becomes voluntary.

It is clear that the neurological supply system needed for effective oral feeding is widespread and involves multiple cranial nerves as well as the brainstem for sensory and motor pathways and the organisation of the neural input. As discussed earlier, premature infants have immature neurological systems and problems with oral feeding are therefore to be expected.

3.5 PHASES OF DEGLUTITION (SWALLOWING)

Swallowing or deglutition can be defined as the semi-automatic motor action of the muscles of the respiratory and gastro-intestinal tracts to propel food from the oral cavity to the stomach (Stevenson & Allaire, 1991). It is a physical process which requires the co-ordination of a series of steps. In young infants, it means progression from reflexive oral management, swallowing reflexes and involuntary oesophageal peristalsis, to (as in older children and adults), voluntary oral management, swallowing reflexes and involuntary oesophageal peristalsis. The process involves the autonomic nervous system, striated and smooth muscles as well as sensory input (Rosenthal et al., 1995).

Swallowing occurs in four phases. The anatomical structures and their neural supply will be further described in terms of these phases.

3.5.1 ORAL PREPARATORY PHASE

In this phase, fluids and solid food are prepared into a bolus small enough to swallow safely. In young infants (0-6 months), this phase consists almost exclusively of sucking fluids (Wolf & Glass, 1991). The infants rouse, exhibit a rooting response and start to suckle. Coordination of the tongue, hyoid and mandibular muscles and the lower lip is required. Milk is expressed by rhythmic compressing movements of the tongue against the palate and a negative intra-oral pressure in the oral cavity. This posterior moving, suction-compression wave expresses the bolus towards the pharynx with the medial part of the tongue (Bosma, 1993). If more than one suckle precedes the swallow, a bolus is formed and accumulated in the reservoir between the tongue and velum, or the tongue and valleculae (Stevenson & Allaire, 1991; Kramer & Eicher, 1993; Rosenthal et al., 1995). The soft palate is in a lowered position, helping to prevent a bolus of liquid from entering the pharynx before swallowing. This is accomplished by the contraction of the palatoglossus muscle. The pharynx and larynx are at rest and nasal breathing continues (Arvedson & Brodsky, 1993).

This phase becomes more important as the infant grows older and solid food needs to be chewed before it is swallowed. However, in the case of the premature infant, this phase is very short and forms a close unit with the next phase, namely the oral phase.

3.5.2 ORAL PHASE

The bolus is captured for a moment between the tongue and the velum. In infants it can also be captured in the pharynx, as low as the epiglottis (Logan & Bosma, 1967; Bosma, 1993). The bolus is maintained as a cohesive mass, so the liquid

does not leak into the pharynx prior to the triggering of a swallow (Wolf & Glass, 1991). The tongue grooves to channel the bolus and the medial part of the tongue lifts (due to genioglossus) in a vertical wave movement to project the bolus into the pharynx (Bosma, 1993). The buccal and mandibular muscles also contract and the lips form a tight seal to prevent loss of bolus. The velum lifts to prevent the bolus from entering the nasopharynx (Bosma, Hepburn, Josell & Baker, 1990; Stevenson & Allaire, 1991).

The premature infant's muscles are generally weak, so the contraction of the buccal and mandibular muscles may also be weak. This is also true of the lipseal around the nipple and loss of liquid can be observed in these infants. Nasopharyngeal reflux often occurs in the premature infant, which can lead to apnea (Plaxido & Loughlin, 1981). It has been postulated that this may be one of the reasons that feeding apnea occurs more often in premature infants than sleep apnea. That is why it is important to monitor an infant's physiological functions during oral feeding as well.

The oral motor skills of an infant are represented in the two phases discussed above.

3.5.3 PHARYNGEAL PHASE

This phase is initiated when swallowing is triggered, when the bolus reaches the anterior faucial arches (Logeman, 1983; Helfreich-Miller, Rector & Straka, 1986). Logan & Bosma (1967) believed that in infants, the bolus can move beyond this point before swallowing is triggered (Wolf & Glass, 1991). Glass & Wolf (1994) support this viewpoint by stating that triggering of the swallow is dependent on the sensory feedback from various areas, namely faucial arches, the uvula, velum, posterior tongue and the pharynx. As the velum elevates for the velopharyngeal closure, the hyoid bone elevates anteriorly and superiorly through the shortening of the thyrohyoid and suprahyoid muscles. The tongue is then pressed posterior-

wards to propel the bolus into the pharynx, thus making the tongue part of the pharyngeal phase (Bosma, 1993). Peristaltic contractions of the posterior and lateral walls of the pharynx descend from the level of C1 (supra pharyngeal constrictors) (Bosma, 1993). The peristaltic wave of the infant, to propel the bolus from the oral cavity to the oesophagus, is similar to that of an adult. The larynx lifts towards the epiglottis to seal off the airway (Bosma, et al., 1990; Brodsky, 1997; Harris, 1986; Stevenson & Allaire, 1991). The infant with a tracheostomy finds this phase difficult because the larynx is often fixed and elevation of the larynx cannot occur (Brodsky, 1997). The epiglottis moves downwards and the true and false vocal cords close (Jolley et al., 1995). The closure of the true vocal cords is the first event to occur in oropharyngeal swallow. A brief co-ordinated stop of respiration is seen as soon as swallowing is initiated (Bosma, 1993; Brodsky, 1997). During suckle feeding respiration is incorporated into the rhythm. Pairs of inspiration and expiration are interposed between swallows. Premature infants tend to omit respiration during the first sucking bursts, which results in feeding apnea. If it continues, hypercapnia and hypoxemia may occur secondary to bradycardia (Bosma, 1993). It is thus important for the feeding specialist to monitor the cardiorespiratory status of the infant closely whilst giving feeding therapy. This can be done by attaching a saturation monitor to the infant.

Minimal spillage into the laryngeal aperture is common in infants because of the laxity of the epiglottis and the large size of the arytenoid cartilage, but this spillage is easily squeezed out of the pharynx with consecutive swallows. Wolf & Glass (1991) wrote that liquid in the laryngeal area is the most effective stimuli to trigger swallowing. If the larynx is not cleared, a cough reflex should be triggered, but premature infants' cough reflexes are not well developed yet and they would rather respond with apnea, or aspiration. The feeding specialist should be aware of this and not be satisfied that an infant is swallowing safely just because he is not coughing. Cervical auscultation is an instrumental help in evaluating the quality of the pharyngeal swallow in premature infants.

In this phase, the motor movement in the pharynx seems to be more prominent, more contractions of the posterior walls occur and the frequency and speed of the peristalsis is higher in the infant (Jolley et al., 1995; Kramer & Eicher, 1993). This phase ends when the bolus reaches the Cricopharyngeal sphincter, which will relax and open to allow the bolus to pass and the airway reopens as the hyoid, larynx, soft palate and tongue return to their resting places (Wolf & Glass, 1991; Helfreich-Miller et al., 1986). The duration of this phase is about 1 second (Rosenthal et al., 1995; Wolf & Glass, 1991).

The pharynx and larynx are richly supplied by chemoreceptors, which are slow adapting stretch/pressure and temperature receptors with the purpose of initiating and modifying swallowing (Wolf & Glass, 1991). The sensory information is conducted by cranial nerves IX (Glossopharyngeus), X (Vagus) and V (Trigeminus) to be integrated by nucleus ambiguus and the Nervi vagus dorsalis (Lass et al., 1988; Wolf & Glass, 1991). The motor nuclei initiate and send the motor information via cranial nerves V, IX, X, XII and the cervical nerves C₁₋₃ to initiate the peristaltic wave (Bosma, 1993). The sensory and motor components are combined and co-ordinated in a centre which probably lies in the medullar reticular formation. This centre also regulates the muscles involved in respiration, which ceases once the swallowing is initiated, so that this phase can be completed uninterrupted (Logan & Bosma, 1967; Helfreich-Miller et al., 1986; Kramer & Eicher, 1993; Lass et al., 1988; Stevenson & Allaire, 1991).

There seems to be a difference of opinion in the literature regarding the number of muscles needed to swallow effectively. Comrie & Helm (1997) state that 20 pairs of muscles and 5 cranial nerves are involved, whereas Glass & Wolf (1994) mention that 26 muscles and six cranial nerves have to be co-ordinated to ensure safe and effective swallowing. Stevenson & Allaire (1991) state that 31 pairs of striated muscles are involved in the whole swallowing process. Whatever the number, it is clear that a vast number of muscles must be used and coordinated to swallow effectively. It follows, therefore, that a premature infant with an

immature neurological system and weak muscles might find co-ordinated swallowing during the pharyngeal phase problematic.

The premature infant is also especially prone to respiratory problems. This phase is very closely involved with breathing and therefore makes it a very important aspect of the premature infant's oral feeding abilities. This phase is often overlooked in the evaluation of the premature infant's oral feeding abilities, if only the oral motor skills are being evaluated. It is crucial that the pharyngeal phases should be included in a comprehensive evaluation of the feeding skills of the premature infant.

3.5.4 OESOPHAGEAL PHASE

This is the final phase in the transfer of nutrients from the oral cavity to the stomach (Wolf & Glass, 1991). It consists of an autonomic peristaltic wave which carries the bolus to the stomach (Brodsky, 1997). Co-ordination and relaxation of two sphincters (superior/rostral: cricopharyngeus and inferior/caudal: gastro-oesophageal) is needed to complete the process: The oesophageal sphincter (or upper oesophageal sphincter/UES) relaxes to let the bolus pass through from the pharynx to the oesophagus (Brodsky, 1997). The sphincter remains open until the whole bolus has reached the oesophagus. It then closes tonically to prevent any reflux back into the pharynx (Glass & Wolf, 1994; Kramer & Eicher, 1993; Jolley et al., 1995). The bolus moves with peristaltic movements of the oesophagus's longitudinal and circular muscles towards the lower gastro-oesophageal sphincter. It also relaxes to allow the bolus to pass through to the stomach and will close immediately after the bolus is through to prevent any reflux, like the cricopharyngeal sphincter, but this time from the stomach into the oesophagus. This phase lasts 8-20 seconds (Stevenson & Allaire, 1991). As the infant matures the phase shortens. The swallowing process is completed at this stage (Logeman, 1983; Rosenthal et al., 1995).

Even though peristalsis in the young infant is present and the sucking has stabilised, accumulation of milk in the oesophagus still occurs. This happens because the peristalsis in the pharynx is faster than the peristalsis in the oesophagus. The rapid successive pharyngeal swallows may result in accumulation of bolus in the oesophagus (Arvedson & Lefton-Greif, 1996). During suckle feeding each pharyngeal swallow briefly inhibits oesophageal peristalsis. Boluses of consecutive swallows may also accumulate in the oesophagus (Bosma, 1993), but usually the oesophagus will empty itself with the last swallow (Kramer, 1989). It might be necessary to give the premature infant extra time between sucking bursts to allow the oesophagus to empty, otherwise overfilling can result in regurgitation, which can be mistaken for reflux.

Sensory feedback from the bolus itself as it progresses through the oesophagus is an important component in the initiation of oesophageal peristalsis (Wolf & Glass, 1991). Sensory and motor neural control of the oesophagus is mainly provided by cranial nerve V (Vagus) and it remains immature in the premature and young infant. That is another reason why gastro-oesophageal reflux (GER) or regurgitation occurs so easily and often in these infants (Gryboski, 1969; Bosma et al., 1990). GER is also commonly seen in cerebral palsy and mentally retarded children. This phase also causes difficulties with feeding in the premature infant and is often neglected in the evaluation of their feeding skills. A comprehensive evaluation of the premature infant's oral feeding skills will be incomplete if the oesophageal phase of deglutition is not included.

3.6 CONCLUSION

The ability of an infant to feed orally efficiently depends partly on the development of intact oral anatomic structures from the embryological stages until well after birth. These structures are linked anatomically and functionally and they share the same neurological supply. The development of effective oral feeding skills of the

premature infant is also dependent on the intact neural supply to the structures involved in feeding and the maturation of the central nervous system. Deglutition or swallowing can be divided into four phases. All these phases pose problems to the premature infant and should be included in a comprehensive evaluation of their feeding skills. Such an evaluation should enable the feeding specialist to describe the oral feeding patterns and oral motor skills of the premature infant in such a way that an appropriate, accountable and, most importantly, a safe therapy strategy can be planned.

3.7 SUMMARY

The development of the oral feeding skills and the anatomical structures needed for oral feeding in the premature infant were discussed. The extent of the neurological supply during deglutition or the total swallowing process, were explained with reference to the sensory and motor pathways, as well as their interaction. Finally, the four phases of deglutition, with special reference to the skills of the premature infant, were described.

CHAPTER 4

METHODOLOGY

Aim: To provide an overview of the research methodology followed in the investigation of the oral feeding skills of the premature infant. The aim and objectives of this research project, the research design, selection criteria, subjects, materials and data collection procedures are also described. The data analysis of the results is explained.

4.1 INTRODUCTION

One of the obvious impediments to research in oral feeding skills in premature infants is the lack of evaluation or assessment instruments with reported reliability and validity (Ottenbacher, Dauck, Grahn, Gevelinger & Hasset, 1985). Construction of such an assessment tool is an evolutionary and dynamic process (Ottenbacher et al., 1985).

This has specific relevance for the feeding evaluation of premature infants, whose feeding patterns have not been well described to date (Palmer et al., 1993). Palmer et al. (1993) developed the Neonatal Oral-Motor Assessment Scale (NOMAS) in an attempt to categorise oral-motor patterns in the premature infants in order to describe these infants' feeding patterns and to establish a good interrater reliability. They unfortunately failed to include aspects such as physiological status of the infants. Skuse, Stevenson, Reilly, App & Mathisen (1995) state that the accurate description of feeding behaviours in young infants requires the development of a system for objective rating of a complex set of interrelated motor skills. For such an assessment system to be of clinical value, it should be reliable and valid. The identification of disorganised or dysfunctional sucking patterns is important to the speech-language therapist, as research has

established the existence of a significant correlation between these disorganised and abnormal sucking patterns in the neonatal period and delays in speech and language at the ages of 30 and 38 months (Braun & Palmer, 1985). Kritzinger (1994) also found that the length of time taken by neonates to transfer from nasogastric feeding to bottle-feeding was the strongest predictor of their communication development.

According to Jolley et al. (1995), the growing population of ill, premature infants in neonatal intensive care units creates a need for more thorough and detailed assessment of their feeding and swallowing abilities. As stated previously, an effective, accountable feeding intervention programme has to be preceded by a comprehensive evaluation.

Glass and Wolf (1994) state that in order to provide effective feeding therapy, the complexity of infant feeding should be understood. The evaluation procedure that needs to precede intervention should therefore enable the feeding specialist to describe the feeding patterns of the premature infant in its widest sense and should provide the information needed to plan intervention strategies. According to Vergara (1993), no comprehensive feeding evaluation instrument which includes all the components of feeding difficulties in the premature infant, is currently available. It is clear that this clinical problem requires research, which can lead to guidelines for the clinical practice which would impact positively on service delivery.

Although limited information is available in the literature regarding the oral feeding skills of premature infants, information in respect of South African premature infants is not readily available. The current study aims to provide a comprehensive description of the feeding skills of this population and is intended to lead to a better understanding of the feeding patterns of these infants.

4.2 AIMS OF STUDY

The **main aim** of this study is to describe the oral feeding skills of premature infants. This will be divided into the following two sub-aims:

4.2.1 SUB-AIM 1

To develop a comprehensive evaluation scale to evaluate the feeding skills of premature infants.

4.2.2 SUB-AIM 2

The application of the evaluation scale in order to describe:

- The characteristics of the subjects, according to subject groups as well as the sample as a whole.
- The oral feeding skills and feeding-associated behaviour of a group of premature infants in terms of:
 - Their non-nutritive sucking skills,
 - Their nutritive sucking skills during bottle- and cupfeeding.
 - The impact of the two feeding methods on the subjects' physiological status.
- And to identify developmental trends.

4.3 RESEARCH DESIGN

The selected research design is discussed, followed by a description of the research phases.

A research design is a scientific arrangement that allows observation and measurement of variables of interest. A qualitative approach is usually followed in

an inquiring process aimed at understanding social and human problems. It is based on human behaviour, observed in a natural setting, with the purpose to describe, explore, explain and interpret information gained from a small sample (Leedy, 1997). This approach is appropriate for describing the feeding behaviour of premature infants in their usual or natural environment.

The choice of the research design is based on the means of collecting and analysing the research data (Leedy, 1997). The descriptive design focuses on a phenomenon. Many research problems in social and behavioural science cannot, according to Huysamen (1994), be investigated by experimental research, but need a descriptive design. For the current study a descriptive design was selected, as the purpose of the research is to *observe* feeding behaviour systematically, to *explore*, *explain* and eventually *interpret* the information. The population should be carefully chosen, clearly defined and specifically delimited to set precise parameters for ensuring discreteness to the population to be observed (Leedy, 1997). Descriptive statistical procedures will be used to analyse the data (Leedy, 1997).

A further advantage of a descriptive design is that the infant's feeding skills can be evaluated under natural conditions.

However, this design also poses some weaknesses. The descriptive design is particularly susceptible to distortion through bias (Leedy, 1997). Firstly, the results rely on the integrity of the researcher to provide accurate and reliable data. The interrater reliability cannot, therefore, be guaranteed. A further problem in South Africa, as in other developing countries, is that there are only a limited number of researchers. This researcher therefore had difficulties in finding available feeding specialists to act as second or third evaluators in the study, to comply with the need for interrater reliability as suggested by Ottenbacher et al. (1985) and Palmer et al. (1993). In order to improve the reliability, a pilot study was conducted to familiarize the researcher with the evaluation form, to identify any

problems in conducting the assessment and to ensure that the items in the evaluation form were formulated clearly and comprehensively.

Because of the nature of this study, the use of a descriptive design is appropriate, since observation and the written recording of data on the compiled evaluation form are the main means of collecting the data.

Finally, the design was applied in a quasi-experimental manner, which implies that neither a control group nor a random sample of subjects, but subjects to which access was possible, were used (Leedy, 1997; Uys, 1987). A sample of convenience or accidental sampling was used in this study, which means that the subjects were chosen as they arrived on the scene (Leedy, 1997). Leedy (1997) states that a sample of convenience may be crude, but can be appropriate if selection criteria are set carefully. Uys (1987) also states that randomised sampling is not always necessary, but that a control mechanism should be used to rule out the influence of extraneous variables. This is accomplished through selection criteria set for the selection of subjects.

4.4 RESEARCH PHASES OF THE STUDY

In order to achieve the two sub-aims of this study, namely to develop a comprehensive evaluation tool and to describe the oral feeding skills of the premature infants, the study was conducted in two research phases, as depicted in Figure 4.1.

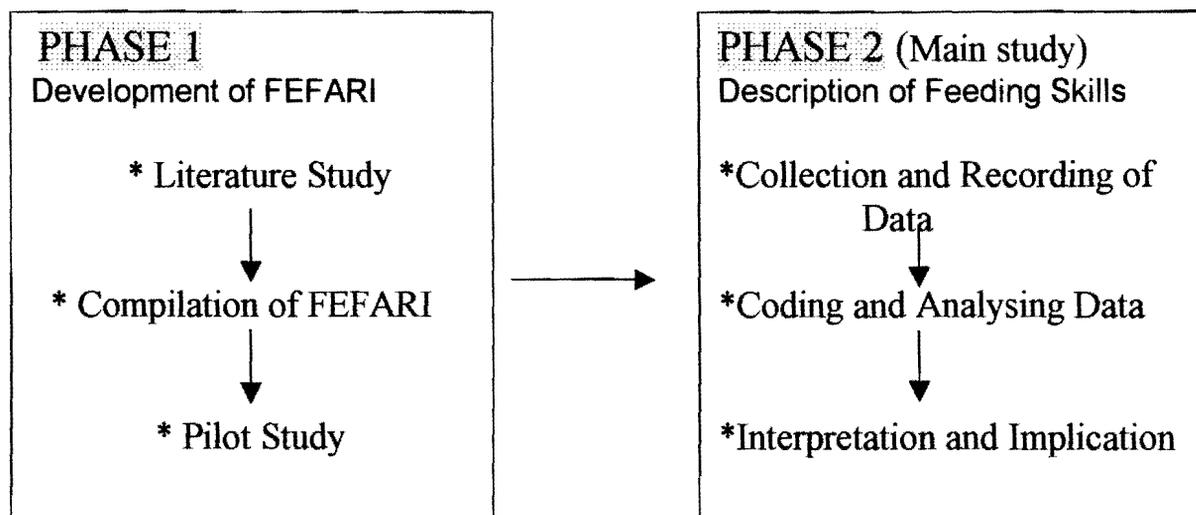


Figure 4.1 Research phases of the study

Phase 1: A comprehensive evaluation tool was developed, namely “The Feeding Evaluation Form for At-Risk Infants” (FEFARI). This was done after an extensive and in-depth literature study had been executed. The application and suitability of the FEFARI was then evaluated by conducting a pilot study.

Phase 2: The feeding skills of the premature infants were described. The appropriate subjects were selected, the data collected, recorded and scored by using the FEFARI. The data was then analysed and interpreted, from which implications could be drawn, which may provide appropriate feeding intervention strategies.

4.4.1 PHASE 1: DEVELOPMENT OF FEEDING EVALUATION INSTRUMENT

In order to achieve the first sub-aim of this study, a comprehensive feeding evaluation instrument for premature infants had to be designed. This process was conducted as follows:

4.4.1.1 Critical Review Of Existing Feeding Scales

The first step was to conduct a literature review to form a theoretical underpinning and gain guidelines for the description and evaluation of the feeding abilities of premature infants. The results of the literature review are given in Table 4.1.

Table 4.1. Critical review of the existing Feeding Scales

Existing scale	Author	Year	Evaluation Area	Norms	Limitations
Neonatal Oral Motor Scale (NOMAS)	Braun & Palmer Palmer, Crawley & Blanco	1985/6 1993	-Nutritive sucking (NS) (Oral phase) -Non-nutritive Sucking (NNS)	Newborn –	-Inappropriate for preterm infants -Only the oral phase assessed -Physiological functioning not assessed -Medical history not taken -Mother-infant communication not assessed.
Behavioral Assessment Scale of Oral Motor Functioning	Stratton	1981	-Nutritive sucking (Oral phase)	Developed For profound-ly retarded children, adolescents and adults	-Inappropriate for preterm infants -Only the oral phase assessed -Physiological functioning not assessed -Medical history not taken -Mother-infant communication not assessed -NNS not assessed
The Prespeech Assessment Scale	Morris & Klein	1987	-Nutritive sucking (Oral phase)	0-24 months	-Inappropriate for preterm infants -Only the oral phase assessed -Physiological functioning not assessed -Medical history not taken -Mother-infant communication not assessed - NNS not assessed
Oral Motor Feeding Scale	Jelm	1990	-NS-oral phase -Different utensils e.g. spoon, straw -Related areas, e.g. Diet, positioning -Notes on respiration phonation, gross and fine motor development	From Birth	- Inappropriate for preterm infants - NNS not assessed -Mother-Infant Communication not assessed - Only the oral phase assessed. - Utensils: spoon, straw, etc. inappropriate
RIC Clinical Evaluation of Dysphagia: Pediatrics	Chemey	1994	-Oral structures, at rest -Oral, Pharyngeal oesophageal phases -Different consistencies -Medical / Feeding History	From Birth	-No norms for preterm -Food consistencies inappropriate -Physiological functioning not assessed

Although various feeding scales exist, they were found to have limitations as they are mainly aimed at the age group from full-term birth and onwards. Furthermore, they evaluate feeding skills with different food textures which are inappropriate for preterm and young infants. Physiological status is not considered and only the oral phase of feeding is evaluated.

As indicated in Table 4.1, a number of feeding scales have been developed, e.g., “The Neonatal Oral-Motor Scale” (Braun & Palmer, 1985), “The Assessment Scale of Oral Function in Feeding” (Stratton, 1981), “The Prespeech Assessment Scale” (Morris, 1982), “Behavioural Assessment Scale of Oral Functions” (Stratton, 1981), “RIC Clinical Evaluation of Dysphagia: Pediatrics” (Cherney, 1994) and Jelm’s (1990) “Oral Motor Feeding Scale”. The use of aforementioned scales poses certain limitations for the comprehensive evaluation and description of the feeding skills of the premature infant, e.g. most of these scales only assess the oral phase of swallowing. Swallowing (deglutition) occurs in four phases, the oral preparatory, oral, pharyngeal and oesophageal phases (Chapter 3 - 3.5). All of these four phases should be included in a comprehensive feeding evaluation. “The RIC Clinical Evaluation Of Dysphagia: Pediatrics” (Cherney, 1994) does include all four phases of swallowing and provides norms from birth (full-term) to 24 months. Unfortunately, no norms for premature infants are available and, furthermore, the biggest portion of the evaluation form, evaluates the ability to manage solids, semisolids and chewing, which is inappropriate for describing the feeding patterns of preterm infants. As discussed in chapter 2, feeding of premature infants involves many aspects other than sucking. The preterm infant experiences very specific feeding problems, (Arvedson & Brodsky, 1993; Creger, 1995; Vergara, 1993; Wolf & Glass, 1991). The above-mentioned scales do not consider the physiological or cardio-respiratory responses of the infant to oral feeding, detailed assessment of nutritional and non-nutritional sucking, the interaction between infant and caregiver and the effectiveness of this interaction during oral feeding. It is important to include these aspects in a comprehensive evaluation of the oral feeding skills of the premature infant to enable the feeding specialist to form a holistic picture of the premature infant and to plan effective,

accountable feeding intervention based on the information obtained from such an evaluation procedure.

It appears that no single comprehensive feeding evaluation scale for the premature population currently exists. Although research has been conducted and oral feeding scales have been designed to assess infants' feeding skills, they appear to describe and evaluate the oral feeding skills of premature infants only to a limited degree. The following question arises: **which tool or evaluation form can be used to enable the researcher to evaluate and comprehensively describe oral feeding skills of the premature infant?** Due to the dearth in the literature, it was deemed necessary to compile a new assessment form for the evaluation of oral feeding skills in premature infants in order to answer to the question asked above.

4.4.1.2 Compilation Of “The Feeding Evaluation Form For At-Risk Infants” (FEFARI) (Appendix A)

A comprehensive evaluation form should enable the user to accurately describe the feeding behaviour of the premature infant. It should also include all important aspects concerning the preterm infant as discussed in earlier chapters. Based on in-depth literature review of the infant feeding process and the premature infant, the following areas need to be included: A full history (medical and feeding) of the infant with accompanying risk factors; clinical observation of the oral structures, anatomically at rest and in function during feeding, which includes the oral, pharyngeal and oesophageal phases of swallowing (Glass & Wolf, 1994; Cherney, 1994; Rosenthal et al., 1995). Apart from the primary swallowing function, aspects like the ability to control behaviour and state, respiration (or breathing pattern), response to tactile input, general neuromotor control, positioning and the control of basic vital functions, during feeding should be considered throughout the evaluation (Glass & Wolf, 1994; Jolley et al., 1995). A system of objective rating and observation of a complex set of oral-motor skills is

needed to accomplish this. The evaluation needs to be reliable and valid to be of clinical value (Skuse et al., 1995). In an attempt to comply with all the previously stated requirements, a comprehensive evaluation form, the FEFARI, was developed (Appendix A.).

The final form of the FEFARI is discussed and the variation used in the pilot study is indicated where appropriate. The following areas of assessment were included in the FEFARI:

.1 Medical History

It is important to determine whether the infant has any risk factors that could compromise his/her feeding skills (Jaffe, 1989; Kramer & Eicher, 1993; Kritzinger, Louw & Hugo, 1995). It was decided to include only those risk factors identified in the literature that can be associated with feeding problems. However, for the *pilot study, all the risk factors for developmental delay were included*. The factors that were finally included, are: prematurity, neurological problems, cranio-facial anomalies, polyhydramnios, placenta abruptio or previa, umbilical cord complications, Meconium aspiration, RDS/BPD, surfactant therapy, asphyxia, mechanical ventilation, cardiovascular condition and intra-ventricular haemorrhage (IVH), TORCH infections, the Apgar count and tube feeding history (Bernbaum & Hoffman-Williamson, 1991; Harris, 1986; Kritzinger et al., 1995; Sheahan & Brockway, 1994). The various risk factors were described in detail in Chapter 2.

.2 Current State and Behaviour

The state and behaviour of the infant at the time of the evaluation is of importance, because factors like hyperbilirubinemia, chronic infections or medication could influence the infant's feeding abilities negatively. Lethargic infants do not perform as well as alert ones (Sheahan & Brockway, 1994; Vergara,

1993). Respiratory problems will also influence their feeding skills negatively. Apnea often occurs in premature infants, but feeding apnea occurs even more often than sleep apnea in the premature infant and is therefore important to include (Dreier et al., 1979; Garg et al., 1988; Rosen et al., 1984). Thus, it is important that a saturation monitor (pulse oximetry) as well as the apnea monitor should be in use while feeding the premature infant.

.3 Physical Examination

A physical examination of the infant is necessary as body positioning, e.g. good alignment of the head and trunk, is a prerequisite for oral feeding (Kramer & Eicher, 1993; Morris & Klein, 1987; Morris, 1989). Bernbaum & Hoffman-Williamson, (1991) and Vergara (1993) support this idea and add that the position whilst feeding is also of importance.

If any hyper/hypotonicity exists, it may affect the feeding skills of the infant and is therefore important for the examiner to take cognisance of.

Dysmorphic features, e.g. cleft palate, Pierre Robin sequence, are marked in this section as well. Any other dysmorphic features may be indicative of a syndrome or sequence. Whether the oral feeding problems or dysphagia, are part of the syndrome or not, may then be established. That information will help the feeding specialist when planning effective intervention.

.4 Oral Feeding History

Information about the current feeding habits is important to help the feeding specialist in determining when the optimum time for the evaluation is, more or less what to expect, which method of feeding should be recommended and which adaptation should be made or special precautions taken (Bernbaum & Hoffman-Williamson, 1991; Jaffe, 1989; Palmer et al., 1993; Sheahan & Brockway, 1994; Vergara, 1993).

.5 Mother-Infant Interaction during Feeding

Feeding time is one of the first communication interactions that the infant and his/her mother share (Billeaud, 1993). The infant communicates his/her hunger and the mother responds to the infant's signals appropriately by presenting the food. Communication between mother and the premature infant can be problematic. It is therefore important that the feeding specialist identifies any problems in this area as soon as possible to ensure appropriate communication development of the premature infant, and to facilitate bonding and attachment between mother and infant. The mother-infant relationship has, as far as known, not previously been included as part of a feeding evaluation, as it traditionally formed part of communication evaluation procedures which did not include the feeding situation. *The form compiled by Kritzinger (1994) for the evaluation of communication skills of neonates was used in the pilot study, but because the form was compiled for full-term neonates, it could not be used for premature infants in the main study.* Communication aspects of caregivers and infants that were included in the FEFARI were selected from the following authors: Bernbaum & Hoffman-Williamson (1991), Harris (1986), Kritzinger, 1994 and Vergara (1993).

.6 Evaluation of the Feeding Process

The evaluation of the feeding process should be done by evaluating the **oral structures at rest**, as well as **during function** (Cherney, 1994; Glass & Wolf, 1994; Morris & Klein, 1987; Wolf & Glass, 1991). The functioning of the oral structures includes *non-nutritive* as well as *nutritive sucking*. Nutritive sucking is assessed in terms of the different phases of swallowing, namely, oral preparatory/oral, pharyngeal and oesophageal phases.

❖ Oral Structures AT REST

Information collected from Bernbaum & Hoffman-Williamson (1991), Jaffe (1989), Merenstein & Gardener (1989), Sheahan & Brockway (1994) and Vergara (1993) was used to determine which items should be included in this section. All structures involved in feeding: the lips, cheeks, jaw palate, velum and tongue, should be evaluated in terms of the anatomical structure, tone, reaction to touch and the appropriate reflexes. Asymmetry and abnormal tone can be an early sign of neurological involvement, as can the absence of certain reflexes (e.g. rooting reflex) or the presence of others (tonic biting reflex). The gag reflex only develops around 34 weeks gestational age and is needed to ensure safe oral feeding. It is therefore important to know whether this reflex has emerged in an infant (Merenstein & Gardener, 1989; Sheahan & Brockway, 1994). Anterior displacement of the reflex, a hypo- or a hyperactive reflex can also affect oral feeding skills (Bernbaum & Hoffman-Williamson, 1991; Palmer et al., 1993; Vergara, 1993). Anatomical deviancies like cleft palate and micrognathia may have substantial influence on the feeding abilities of an infant.

❖ The FUNCTIONING of Oral Structures

The functioning includes both *non-nutritive* and *nutritive sucking* skills.

Firstly, with reference to *non-nutritive sucking (NNS)*: NNS is evaluated by observing the functioning of the lips and tongue, as well as the sucking bursts and rate of movement. The breathing and heart rate before and during NNS are noted and whether stress in the infant increases or decreases while he/she is sucking on the pacifier (Field, Ignatoff, Stringer, Brennan, Greenberg, Widmayer & Anderson, 1982; Lotas & Walden, 1996; Vergara, 1993). Various authors stress the importance of NNS. According to researchers, a few of the positive relationships between NNS and oral-motor functioning are the following: that NNS facilitates sucking movements for oral feeding; it enhances the maturation of the sucking reflex; the muscles needed for oral feeding are being strengthened; and

the disappearance of the sucking reflex due to lack of experience can be prevented (Bernbaum, Pereira, Watkins & Peckham, 1983; Bernbaum & Hoffman-Williamson, 1991; Creger, 1995; Field et al., 1982; Harris, 1986; Mattes et al., 1994; Morris, 1989; Sheahan & Brockway, 1994; Solis, Schutz, McCarty & Stotko, 1989; Vergara, 1993). For the infant under the gestational age of 34 weeks and the older Small for Gestational Age (SGA) infant, NNS is the only way of exercising the oral motor skills and preparing the infant for nutritive sucking. Non-nutritive sucking during tube feeding also enhances general growth and maturation in the premature infant (Bernbaum et al., 1983). The feeding specialist should therefore have knowledge of what the premature infant's NNS abilities are, in order to provide therapy in this area if needed, in preparation of oral feeding. Efficient NNS will also speed up the transfer from tube to oral feeding, which will result in earlier hospital discharge of the infant (Premji & Paes, 2000). This will enhance the mother-infant relationship and is also cost effective (Bazyk, 1990; Lotas & Walden, 1996; Mattes, 1996; Vergara, 1993). Existing scales like the Oral Motor Feeding Rating Scale (Jelm, 1990) and the RIC Clinical Evaluation of Dysphagia: Pediatrics and the RIC Evaluation of Prefeeding skills (Cherney, 1994) do not include the evaluation of NNS. The NOMAS by Palmer, Crawley & Blanco (1993) is the only scale that includes NNS in the evaluation. That is another reason why aspects of NNS were included in the FEFARI (a more comprehensive evaluation form, for the preterm and young at risk infants), to ensure that efficient intervention can be implemented if the need is identified.

Secondly, with regard to *Nutritive sucking (NS)*: This should be evaluated in terms of the oral preparatory/oral, pharyngeal and oesophageal phases of swallowing, to include the whole process of oral feeding. This implies that for the assessment to be comprehensive, the evaluation should be done from the time the food bolus enters the mouth until it reaches the stomach as recommended by Cherney (1993) and Rosenthal et al. (1995).

➤ **Oral preparatory/oral phase**

Existing feeding scales mainly evaluate this phase of swallowing, e.g. the NOMAS (Braun & Palmer, 1986; Palmer, Crawley & Blanco, 1993), the Prespeech Assessment Scale (Morris & Klein, 1987), Behavioral Assessment Scale of Oral Functions in Feeding (Stratton, 1981) and the Oral Motor Feeding Rating Scale (Jelm, 1990). These scales evaluate the oral motor skills with different food textures (thin and thick liquids, pureed and ground solids). Since premature and young infants' diets are restricted to liquids, the greater part of the other scales is therefore inappropriate for the evaluation of young infants' feeding skills. The existing scales, the evaluation forms of RIC and information from other sources (Bernbaum & Hoffman-Williamson, 1991; Vergara, 1993), were useful in the selection of items for this section of the evaluation form in this study. The functioning of the different oral structures, lips, jaw and tongue, is rated in columns as Normal or Deviant. The Deviant column is divided into two columns: Moderate/Disorganized and Severe/Dysfunctional similar to the NOMAS (Palmer et al., 1993). Disorganised sucking refers to a lack of rhythm when sucking actively and dysfunctional refers to an interruption of feeding due to abnormal movements of the tongue and jaw (Palmer et al., 1993). It is expected that the premature infant's skills may be classified as disorganized, as we expect maturation to change oral feeding skills to normal over time with the appropriate stimulation (Gaebler & Hanzlik, 1995). Infants with neurological insults are expected to fall anywhere between disorganized and dysfunctional depending on the severity of the insult. Apart from the functioning of the lips, jaw and tongue, the coordination and rhythm of the sucking and sucking bursts are evaluated as well. The flow rate, bolus formation and timely, coordinated swallowing are also evaluated (Daniëls, Casaer, Devlieger & Eggermont, 1986; Rosenthal et al., 1995).

➤ **Pharyngeal phase**

The pharyngeal phase is evaluated in terms of the elevation of the hyoid bone and larynx, nasopharyngeal reflux and voice quality (Cherney, 1994). The physiological status including the heart rate and breathing rate and whether any stress is experienced by the infant, is also monitored here (Bernbaum & Hoffman-Williamson, 1991; Vergara, 1993). The researcher is of the opinion that problems in this phase are associated with respiratory problems and these should therefore be included in a comprehensive evaluation of the premature infant's feeding skills. Stress symptoms were divided into moderate and severe (Bernbaum & Hoffman-Williamson, 1991; Harris, 1986; Hussey, 1988; Kramer & Eicher, 1993). Premature infants can experience sensory overload very easily, as discussed previously, and stress should therefore be monitored. Feeding apnea occurs more often than sleeping apnea and is therefore important to be monitored (Rosen et al., 1984; Shivpuri et al., 1983; Solomano et al., 1986). Nasopharyngeal reflux can cause apnea in the young infant (Plaxido & Loughlin, 1981). This may influence the sucking of the infant negatively. Apart from the RIC scales (Cherney, 1994), neither of the other feeding scales included the pharyngeal phase and none of them observed the physiological status of the infant during oral feeding, rendering the FEFARI to be more comprehensive.

➤ **Oesophageal phase**

The only aspects of the oesophageal phase that can be clinically observed are: emesis during feeding, projectile vomiting or gastro-oesophageal reflux (GER) and truncal arching (Cherney, 1994; Vergara, 1993). Projectile vomiting can indicate pilorus stenosis, truncal arching is associated with painful swallowing (odynophagia) and GER can cause refusal of oral feeding in the infant because it causes discomfort. Chronic GER can also cause odynophagia (Rosenthal et al., 1995; Wolf & Glass, 1991). Only the RIC Scales (Cherney, 1994) included this phase. The information collected during this phase is also important to plan intervention strategies and was therefore included in the FEFARI.

.7 General Information

The overall feeding time, as well as the reason for ending the feed, need to be recorded. The changes that had a positive outcome on the feeding abilities of the infant should be noted, as well as the changes that had a negative outcome and should therefore be avoided. This information will provide therapy guidelines.

.8 Additional Information

Objective measures can be recorded in this section of the FEFARI. Although these are very useful methods of assessment, which may be necessary to describe aspects of oral feeding and identify problems relevant for the planning of efficient and effective feeding intervention, this kind of high technology is unfortunately often limited in South Africa.

Space is provided on the FEFARI for the description of results of the following instrumental evaluations.

❖ Video Fluoroscopic Evaluation (VFS)

VFS is a valuable, objective method of radiological evaluation of the swallowing process and is widely considered to be the gold standard for identifying aspiration. If a VFS is needed, for instance when aspiration is suspected, the results of the oral, pharyngeal and oesophageal phases can be recorded in this section. Information gained from the VFS can provide the best information to plan effective and safe feeding therapy (Cherney, 1994; Kramer & Eicher, 1993; Rosenthal et al., 1995; Wolf & Glass, 1991). The RIC evaluation form (Cherney, 1994) is the only feeding scale to include VFS.

❖ Pulse Oximetry

The measurement of the saturation levels with pulse oximetry is an objective measurement upon which the feeding can be stopped or delayed until the infant

has recovered to a normal saturation level. The recording of the saturation levels before, during and after feeding in this section of the FEFARI provides the feeding specialist with vital information on feeding apnea, the stress and fatigue levels of the infant. The feeding intervention can thus appropriately be adapted according to the needs of the infant (Bernbaum & Hoffman-Williamson, 1991; Garg et al., 1988; Harris, 1986; Mathew, 1988; Rosen et al., 1984; Vergara, 1993).

❖ **Cervical Auscultation**

Kramer & Eicher (1993) and Vice et al. (1990) consider cervical auscultation as a valuable procedure to provide extra information on the pharyngeal phase of swallowing, since whether a swallow is delayed or absent can be heard by stethoscope. Gurgling sounds can be heard if a partial swallow was performed and bolus residue still exists in the pharynx. The danger of aspiration is possible if the infant is not swallowing effectively. Multiple swallows can also be detected more easily with cervical auscultation. An indication of the suck-swallow-breathing rate can also be gained with cervical auscultation. The information obtained can be notated in this section if the procedure was performed.

.9 Summary of Information

A summary sheet, which can be detached after completion and left in the infant's medical file, is attached to the back of the FEFARI. The main method of feeding is noted here. The overall levels of functioning are recorded for the three phases of swallowing in terms of being adequate (normal); adequate, but with reduced function (mild impairment); interferes with function (moderate impairment) and non-functional (severe impairment). The main problem/s, diagnosis and recommendations are also described. Finally, a space is provided for the signature of the feeding/speech therapist who performed the assessment.

4.4.1.3 Wording and Format

The format of the FEFARI was designed to make it user-friendly for clinicians. The purpose of the assessment is to gain as much information as possible regarding the oral feeding skills of the premature infant. The evaluation format contains descriptions of observations which require judgements to be recorded, thus guiding the feeding specialist to cover all areas of the feeding process and carry out a comprehensive assessment.

On the first page, space is provided for patient information and the date of evaluation. There are subsections for all aspects on which the feeding specialist requires information, as described above. Under each of the first five subsections, involving the history, state and behaviour, etc., a list is given of items that can be marked as No (absent) or Yes (present). The column representing the normal structure/behaviour/functioning is shaded to give the feeding specialist an instant indication of the status of the infant. Next to the “yes” column, a comments column was inserted where the evaluator can make qualitative remarks. The columns under the evaluation of the feeding process are divided into normal and deviant. Again, the column representing the normal is shaded to give an instant view of problem areas. Under the nutritive sucking subsection in the oral preparatory/oral phase, a further distinction in the deviant column was made between moderate /disorganised and severe/dysfunctional. This phase represents all the lip, jaw and tongue movements needed for sucking by the young infant. After this section has been completed, the evaluator can gain an immediate idea of the severity of the problem. The items under each section are listed comprehensively and should enable the feeding specialist to describe the oral-motor skills of the premature infant in terms of functioning and to plan appropriate and safe intervention strategies.

For the purpose of this study, two sets of nutritive sucking subsections were included in the form, one for bottle-feeding and one for cup-feeding. The different

and/or same skills used by the two different methods of feeding can be recorded and compared. This should enable the evaluator to describe the difference in oral-motor behaviour, if present, between these two methods of oral feeding. Numerical values were assigned to feeding behaviour, namely, a number 1 was awarded for normal behaviour/functioning and a 2 for deviant behaviour/functioning. Deviant was further divided into moderate and severe, a 2 was awarded for moderately affected and disorganised behaviour/functioning, and a 3 for severe affected and dysfunctional behaviour. This information will be helpful in determining the degree of the problems and serve as a guide for intervention strategies to be followed.

4.5 PILOT STUDY

A pilot study was carried out as the final step of Phase 1 of the research project. According to Matins, Loubser & Van Wyk (1996), the primary purpose of a pilot study is to detect weaknesses in design and instrumentation. This was therefore adopted as the aim of this pilot study. Guy, Edgeley, Arafat & Allen (1987) also consider the purpose of the pilot study to evaluate the adequacy and clarity of a form. The following sub-aims for the pilot study were formulated to achieve the main aim:

Sub-aim 1: to evaluate the *adequacy and appropriateness* of the evaluation process and the “Feeding evaluation form for at risk infants” (FEFARI). To achieve the first sub-aim the following objectives were formulated:

- To evaluate the applicability of the evaluation form in terms of *relevance* of items included,
- To identify the presence of any misleading or *ambiguous* items,
- To ensure the *clarity* of the terminology,
- To gain an idea of the complexity of items and the ease of *coding*.

- To gain an indication of which strategies might be needed to analyse the data.

Sub-aim 2: to *familiarize* the researcher with the assessment procedure, in an attempt to improve the reliability, since another evaluator was not available for interrater reliability.

4.5.1 SUBJECTS

Five normal, full-term infants without feeding problems were selected to act as subjects for the pilot study. Since no problems concerning these infants' feeding abilities were expected, the researcher could concentrate on the execution of the FEFARI and the realization of the sub-aims of the pilot study without being distracted by actual feeding problems.

4.5.2 PROCEDURE

.1 A research proposal had to be handed in and permission had to be obtained from the Ethical Committee of the Pretoria Academic Hospital to conduct the study. The consent of the Head of the Neonatal Unit of the Pretoria Academic Hospital also had to be obtained before the pilot study could be conducted.

.2 The High Risk Register (Kritzinger, 1994) was used as part of the medical history. The risk register was included because it was considered necessary for a comprehensive evaluation system, to determine whether the infant had any factors that could compromise his development or feeding abilities. The list of risk factors by Kritzinger (1994) was used, as it was a comprehensive set of risk factors that she used in her well-conducted study. Information was collected from the subject's medical file.

.3 The Feeding Evaluation Form for At Risk Infants, (FEFARI) was then used to evaluate their oral feeding skills at their usual feeding time, with their normal method of feeding and drinking milk that they are used to. They were attached to an oximeter to measure saturation levels and a stethoscope was placed for cervical auscultation. The information was then recorded on the FEFARI.

.4 Communication Interaction was assessed using the comprehensive form for the communication skills of neonates which was developed by Kritzinger (1994).

4.5.3 RESULTS OF THE PILOT STUDY

The results of the pilot study are discussed according to the sub-aims.

4.5.3.1 Sub-aim 1 of Pilot Study

The first sub-aim of the pilot study was to evaluate the *adequacy and appropriateness* of the evaluation procedure and the FEFARI. The separate forms for the risk factors by Kritzinger (1994) resulted in a vast amount of extra paperwork. A great number of risk factors applied to developmental delays only and did not affect feeding skills. It was decided to include only the risk factors associated with feeding problems on the FEFARI itself, e.g. Prematurity (length of pregnancy), TORCH infections, Cord collapse/knotted/around the neck, Meconium aspiration, Apgar count, ventilation, Respiratory Distress syndrome (RDS)/Hyaline Membrane Disease (HMD) and Intra Ventricular Haemorrhage (IVH) (Bernbaum & Hoffman-Williamson, 1991; Harris, 1986; Kritzinger, 1995; Sheahan & Brockway, 1994; Vergara, 1993; Wolf & Glass, 1991). These risk factors are also *relevant* as risk factors for developmental delays, which means that these selected factors can still be considered comprehensive enough for also identifying developmental delays in the absence of feeding problems, thus resulting in appropriate and adequate test items.

Hyperbilirubinemia, apnea and stridor were also added to **current state** as these were *relevant* aspects that should be included since they may also influence feeding skills, as discussed in previous chapters (Sheahan & Brockway, 1994; Vergara, 1993).

Mother infant interaction during feeding was added to the FEFARI, including aspects involving the premature infant (Vergara, 1993), as this would improve the *applicability* of the form. For the main study, premature infants will be used and the evaluation of communication skills formulated for full-term infants (Kritzinger, 1994) will therefore be inappropriate. It is nevertheless important to include this aspect because communication of the premature infant can pose problems, as discussed in chapter 2. Items for this section were compiled from information gathered from the literature (Bernbaum & Hoffman-Williamson, 1991, Harris, 1986; Semmler, 1989; Vergara, 1993). No problems with *ambiguity or clarity* were found.

A separate heading for **non-nutritive sucking skills** was added to ease recording for this information. The form had to be adapted to enable the punching in of data in the computer, by providing line numbers etc. for easier *coding*. Normal structures/ behaviour/functioning was awarded a numerical 1, deviant a numerical 2. Where deviant was divided between moderate and severe, the first-mentioned was awarded a numerical 2 and the latter a numerical 3.

After completion of the pilot study, minor modifications to the evaluation form were needed. The results obtained, indicated that the instrument was acceptable and effective in obtaining the data needed for this study.

4.5.3.2 Sub-aim 2 of Pilot Study

The researcher gained experience in using the FEFARI and was now familiar with the evaluation form and procedure.

4.5.4 VALIDITY AND RELIABILITY

Validity is the attempt to determine whether a measurement tool actually measures what it is presumed to measure (Leedy, 1997). Content validity is one type of validity that is relevant in the compilation of the comprehensive feeding evaluation scale, FEFARI. Content validity is the accuracy with which the instrument measures the factors under study. Reliability means that the information which is gathered with the evaluation form, should not vary as a result of characteristics of the study, e.g. test-retest reliability (Ottenbacher, 1985).

To ensure content validity of the FEFARI, the evaluation form was based on a thorough and in-depth literature review of all aspects involved in the safe oral feeding process of premature infants. The selection of items was also based on the clinical experience of the researcher in managing oral feeding in premature infants in the NICU, for several years. Furthermore, a pilot study was conducted to assess content validity and the results indicated that the items were appropriate.

The research design and the fact that the researcher was the only scorer of the FEFARI, could lead to bias. The reliability can also be compromised by subjective judgment (Leedy, 1997). This was overcome by conducting the pilot study to develop experience in applying the FEFARI. Very specific guidelines for the content and construction of the FEFARI were followed based on extensive literature research. The researcher has years of experience in the assessing and managing of premature infants, which should limit inaccurate recording.

Phase 1 of the study was completed and the second phase could follow. It is discussed below.

4.6 PHASE 2: MAIN STUDY

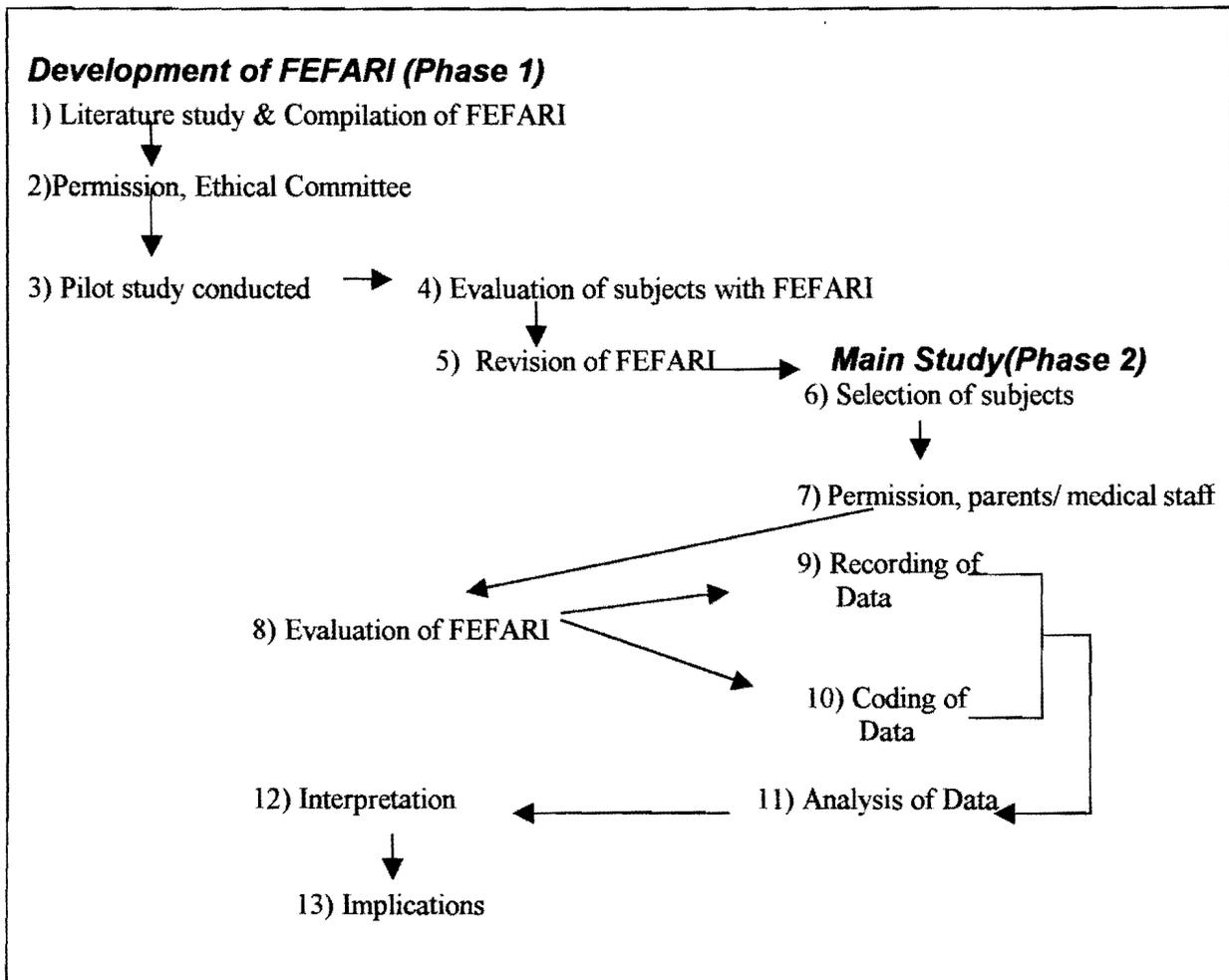


Figure 4.2 Procedures followed in both phases of this study

4.6.1 AIMS

The **main aim** of this study is to describe the oral feeding skills of premature infants. To achieve this, two **sub-aims** were formulated for this study: **Sub-Aim 1** (see par. 4.2) was realised in phase 1.

The main study was thereupon conducted to realise **Sub-Aim 2**, which is:

The application of the evaluation tool in order to describe:

- The characteristics of the subjects, according to subject groups as well as the sample as a whole.
- The oral feeding skills and behaviour of a group of premature infants during bottle- and cupfeeding in terms of:
 - Their non-nutritive sucking skills,
 - Their nutritive sucking skills.
 - The impact of the two feeding methods on the subjects' physiological status.
- And identify developmental trends.
- To identify suitable intervention strategies for different subject groups (Clinical implication)

4.6.2 SUBJECTS

4.6.2.1 Selection Criteria

The integrity of the research can be ensured by setting criteria beforehand and thus making it more trustworthy. By selecting the participants purposefully, more can be learned about the behaviour studied (Leedy, 1997).

The target group for the main study had to comply with the following criteria:

- **Prematurity.** The infants had to be born *prematurely* – On or before 36 weeks gestational age (Rossetti, 1986). The sucking patterns of premature infants are different from the patterns used by full-term infants (Bu'Lock, Woolridge & Baum, 1990) and the purpose of this study is to describe the patterns used by premature infants. The age will be determined with the Ballard score, which will be established by the clinical assistant or paediatrician in the neonatal unit. Clinically it was found that the obstetric dates were unreliable and that the age as determined by the Ballard score was more realistic and reliable to determine the gestational age of an infant (De Witt, 1999)

- **Gestational age** of 34 and 37 weeks. According to Geertsma et al. (1985), oral feeding cannot be expected of infants under the age of 34 weeks. This is firstly, because the gag reflex necessary to protect the airways is not developed sufficiently yet (Harris, 1986; Merenstein & Gardener, 1989; Sheahan & Brockway, 1994; Solis et al., 1989). Secondly, defined periods of sleep-and alertness appear between 34 and 36 weeks and sucking is generally better in the awake state (Geertsma et al., 1985). Mandich & Ritchie (1996) state that factors like the ability to keep a quiet, alert state and organization of behaviour are also necessary for feeding success. Thirdly, the literature also states that the infant under the gestational age of 34 weeks is at risk of aspirating because he is neurologically not equipped to coordinate sucking, swallowing and breathing. By 37 weeks, feeding patterns can be the same as those used by full-term infants (Casaer et al., 1982; Brake, Alfasi & Fleischman, 1988; Braun & Palmer, 1985; Bu'Lock et al., 1990). Lastly, the hunger and thirst cycle is also only noticeable by 35 weeks. Since satiety inhibits sucking (Morris & Klein, 1987) it is advisable to evaluate the infants when they are hungry. No weight restrictions will be made since feeding abilities seem to be more related to gestational age than to weight, as sucking depends on neuromotor maturation and maturation depends on gestational age (Brake et al., 1988; Merenstein & Gardener, 1989; Sheahan & Brockway, 1994; Solis et al., 1989; Vergara, 1993).
- **Neurological intactness:** Subjects had to be neurologically intact, therefore neurologically involved infants were excluded. For instance, infants with intra-ventricular bleeding (IVH) were excluded, as this could cause damage to the central nervous system (Bazyk, 1990) and feeding problems could be a result of neurological involvement rather than immaturity. The aim of this study is the description of the oral feeding skills of the premature infant where problems are due to immaturity only and not to neurogenic dysphagia.

- **Apgar count:** The subject's 5-minute Apgar count must be above 7 to exclude the neurologically involved infants for this study (De Witt, 1999).
- **Medical condition:** The infant must be medically stable, tolerate room air and vital signs must be within normal limits, to limit variables which could have a negative impact on oral feeding skills and behaviour (Braun & Palmer, 1995; Geertsma et al., 1985). This implies that the infant should be medically and physiologically ready for oral feeding (Vergara, 1993). Phototherapy must have been discontinued for at least 24 hours, because hyperbilirubinemia can make the infant lethargic and this may affect his/her sucking behaviour (De Witt, 1999).
- **Feeding method:** The infants must feed from a bottle and a cup, as these are the methods of feeding being investigated in the study and are the methods currently used in "Baby Friendly Hospitals" as well as the Pretoria Academic Hospital.
- **Place of birth:** The subjects must all be patients of the Maternity Hospital of the Pretoria Academic Hospital, as these were the infants for whom consent for the study had been obtained from the Ethical Committee.
- **Gender.** Subjects from both genders were included, as the literature does not make any distinction in feeding skills between the genders (Kritzinger, 1995; Rossetti, 1996; Rosenthal et al., 1995; Glass & Wolf, 1994)
- **Race:** No distinction was made regarding the race of subjects, as no mention of racial differences in terms of feeding skills could be found in the literature. The editors of the journal, Paediatric and Perinatal Epidemiology (2000,14, page 13) further state that race is a social construct and not a biological variable.

4.6.2.2 Selection Procedures

A selection of convenience was made by selecting the first ten infants in each of the age groups: 34, 35, 36 and 37 weeks who met the selection criteria (Leedy, 1997; Uys 1987). Permission had to be obtained from the medical staff of the neonatal unit to evaluate the selected infants. Consent was also obtained from the parents of the infants [Figure 4.2: (points 6,7)]

4.6.2.3 Description of Subjects:

Forty-two (42) premature infants were selected as subjects for the main study. They were patients in the Neonatal Intensive Care Unit (NICU) of the Maternity Hospital of the Pretoria Academic Hospital. Although the hospital is situated in Pretoria, the infants came from various geographical areas.

Four groups were formed according to their gestational age, namely:

- Group 1: 34-weeks gestational age (N=10)
- Group 2: 35-weeks gestational age (N=11),
- Group 3: 36-weeks gestational age (N=11) and
- Group 4: 37-weeks gestational age (N=10) to allow for maturational differences.

The first 10/11 infants of each gestational age group who met the selection criteria, were used.

Table 4.2 provides an overview of the subjects used in the study in terms of their gestational age, birth weight, their current weight as well as their chronological age. It is interesting to note that all of the subjects had a low or very low birth weight. The number of males and females in most groups were virtually equal except in the 37-weeks group, in which about 1/3 were males and 2/3 females. The majority of subjects were black (70%-80%).

Table 4.2. Description of subjects

Gestational age	Group 1 34 weeks N=10		Group 2 35 weeks N=11		Group 3 36 weeks N=11		Group 4 37 weeks N=10	
	Range	Average	Range	Average	Range	Average	Range	Average
Ballard score	31-34 weeks	32.6 weeks	29-35 weeks	32.5 weeks	28-36 weeks	33 weeks	29-36 weeks	34.4 weeks
Birthweight (kg)	1.07-1.65	1.4	1.02-1.46	1.22	1.05-1.91	1.35	1.01-1.85	1.42
Chronological age	1 - 3 weeks	1.5 weeks	1- 6 weeks	2.5 weeks	1- 8 weeks	3 weeks	1- 7 weeks	2.5 weeks
Current weight (kg)	1.16-1.75	1.45	1.07-1.81	1.44	1.34-1.86	1.65	1.32-1.92	1.67

	Number of Subjects	%	Number of Subjects	%	Number of Subjects	%	Number of Subjects	%
Low Birth Weight	4	40	0	0	3	27	5	50
Very Low Birth weight	6	60	11	100	8	73	5	50

Gender	Male 5	Female 5	Male 5	Female 6	Male 6	Female 5	Male 3	Female 7
Race	Black 8	White 2	Black 9	White 2	Black 7	White 4	Black 7	White 3

4.6.3 ETHICAL CONSIDERATIONS

Before this research could be conducted in the hospital setting, a comprehensive research proposal was submitted to, and permission granted by, the Ethical

Committee of the Pretoria Academic Hospital. Aspects as mentioned by Leedy (1997), namely, simple consideration for the patient, openness of the research, respect for the privacy of the patient and avoidance of any harm to the subjects, were considered. Permission to use subjects from the NICU had to be obtained from the head of the neonatal unit as well. After an infant complied with the selection criteria, permission to evaluate the infant had to be obtained from the parents by presenting them with an informed letter of consent. The paediatrician in whose care the infant was, also had to certify that the infant was medically stable enough for the evaluation procedure. As an act of courtesy, the nursing staff's consent was also asked. The feeding time of the ward had to be respected and the availability of a pulse oximeter was needed before the evaluation could proceed.

4.6.4 MATERIALS AND EQUIPMENT

The material and equipment used in the study are summarized in Table 4.3.

A brief overview of the material contained in Table 4.3 is discussed:

- The same nipples generally used in the hospital, were used.
- The same bottles and teats used for oral feeding were used. The hole in the teat should allow for a flow rate of one drop per second. Jain (1987) and Matthew's (1994) found adverse effects on sucking and breathing patterns of infants when a teat with a high flow rate is used for feeding.
- The bottle caps were used as cups for cupfeeding.
- Formula milk or expressed milk, whichever the infant was used to, were used, to limit the possibility of the influence of taste on the sucking behaviour of the infant (Mattes, 1996). Only milk was presented, as it was the only consistency of food that the infants can manage at this age (Rosenthal et al., 1995).
- Feeding Evaluation form for at Risk Infants (FEFARI).

Table 4.3. Material and equipment used in study

	Object	Description	Use
Material	Nipple for Non-Nutritive Sucking (NNS)	Same shape than for Nutritive Sucking	Assessment of NNS skills
	Bottle and nipple	Those provided by hospital. Flow rate: 1 drop/s	Assessment of oral, pharyngeal and oesophageal phases
	Cup	Top of bottle provided by hospital	Assessment of oral, pharyngeal and oesophageal phases
	Milk (formula or expressed breast milk)	Milk that the infant is used to	The only food type used for oral feeding
	FEFARI	Comprehensive feeding evaluation form	Assessment of all aspects of oral feeding
Equipment	Pulse Oximeter	Scientific measuring instrument	Measuring of O ₂ saturation levels and heart rate
	Watch	Watch with a second-hand	Measuring of feeding time and breathing rate
	Stethoscope	Medical instrument for listening to body sounds	Cervical auscultation – listen for swallowing

A brief overview of the equipment mentioned in Table 4.3 is discussed:

- A portable oximeter with fast recording speed and flex probes for the feet, was used to measure the oxygen saturation levels pre-, mid- and post-feeding to give an indication of stress experienced by the infant or possible aspiration. If feeding apnea occurs successively, it might reflect in lower saturation levels as well. Saturation levels of under 90% will be an indication to stop oral feeding until the levels return to baseline values (Bernbaum & Hoffman-Williamson, 1991; Garg et al., 1988; Rosen et al., 1984; Vergara, 1993). The readings pre, mid and post feeding (for NNS and NS) were recorded on the FEFARI.

- A watch indicating seconds, to measure the duration of the feeding and the breaths per minute for breathing rates pre-, mid- and post-feeding, was used.
- A stethoscope was used for cervical auscultation during the evaluation of nutritive sucking. A stethoscope with a small head is placed on the neck, at the level of the larynx, when nutritive sucking is evaluated. The feeding specialist will be listening for pharyngeal sounds accompanying swallowing. Assessment of swallows can be made in terms of a timely or delayed swallow, or multiple swallows. The quality of the swallow can be estimated. The information is recorded under swallowing in the oral phase and further qualitative comments can be made on the FEFARI under a specific heading designated for cervical auscultation (Kramer & Eicher, 1993; Logan & Bosma, 1967, Vice et al., 1990).

4.6.5 DATA COLLECTION PROCEDURES

Arrangements had to be made with the daily nursing staff to do the evaluation at approximately the same time that the feeding usually occurs (Bu'Lock et al., 1990). The infant had to be awake and an oximeter had to be connected near the infant.

The following steps were followed during data collection:

- The medical and oral feeding history of the infant was obtained from the medical file. The infant was then observed for his current state and behaviour, and a physical examination was performed as required by the evaluation form. An evaluation of the oral structures at rest was also made before picking up the infant.
- The infant was placed in a semi-upright flexed position. Shivpuri (1983), Sheppard (1987) and Tuchman (1988) recorded the best saturation levels in premature infants when they were in the semi-upright position. The chest must be partially exposed to observe respiratory movements.

- The flex probe of the oximeter was fitted on the infant's foot. The researcher waited for the infant to calm down before the readings were recorded. The saturation levels were recorded for the duration of the whole feed. The highest and lowest values were recorded (Garg et al., 1988).
- After the baseline breathing and saturation levels were established, the researcher then cradled the infant and presented the pacifier first to evaluate the non-nutritive sucking. This was then notated on the FEFARI.
- The researcher placed the stethoscope in a position for the cervical auscultation. The bottle was then presented and the infant was closely observed for all the test items on the form and the readings on the saturation monitor (oximeter) were notated on the FEFARI.
- After the information was obtained, the infant had a rest period while the researcher recorded the information regarding all the phases of swallowing for bottle-feeding and feeding time on the FEFARI.
- The cap of the bottle was filled with milk for the evaluation of cup feeding. When the infant reached baseline breathing and saturation levels again, the stethoscope was again positioned and the milk presented with the cup. The infant was observed in the same manner and for the same aspects as feeding with the bottle. After the required information had been obtained and recorded, the probe of the oximeter was removed and the infant made comfortable in the bassinet/incubator.
- The mother-infant interaction was evaluated by observing the mother interacting with the infant during feeding and the information was recorded on the FEFARI.
- A maximum of two infants per day were evaluated, to avoid fatigue of the observer (Kritzinger, 1995).
- All of the information was gathered over a period of 12 months, although the majority of subjects (34 of the 42) were evaluated within 6 months.

4.6.6 DATA ANALYSIS AND STATISTICAL PROCEDURES

A discussion of the scoring, recording and statistical procedures used to analyse the data, follows.

4.6.6.1 Data Scoring and Recording

All the data was recorded on the compiled evaluation form (FEFARI). Every line was numbered for coding of the raw data. The responses were given as values: a numerical 1 was awarded if the behaviour/functioning for the item was considered as being normal and a numerical 2 if the behaviour/functioning was considered as a risk factor or deviant. The deviant column in the oral phase was divided into two columns, namely 1) Moderately, disorganized which was awarded a numerical 2 and 2) Severe, dysfunctional column which was awarded a numerical 3. This was done to distinguish between the severities of the problem. Disorganised refers to a lack of rhythm of the total sucking activity and implies that the response is immature and in the process of developing. Dysfunctional refers to an interruption of the feeding process by abnormal movements of the oral structures, which may be indicative of neurological involvement. (Braun & Palmer, 1985)

4.6.6.2 Data Analysis and Data Processing

- After each of the 42 subjects' data was recorded on their own FEFARI form, the data was entered into a computer for the statistical analysis.
- For the analysis of data the following computer programmes were used in the analysing process: The Statistical Analysis System (SAS) computer programming package for descriptive statistics and the frequency distribution. BMDP-Statistical Software Inc for the determination of the T-tests, Wilcoxon and Kruskal-Wallis tests.
- The significance of a phenomenon was determined by the use of the Kruskal-Wallis test, which is especially useful in smaller samples (sample

size greater than 5) and the Wilcoxon test (Steyn, Smit, Du Toit & Strasheim, 1994).

4.7 CONCLUSION

Existing feeding scales demonstrated limitations in their usefulness to describe the oral feeding skills and behaviour of premature infants. The growing number of premature infants specifically in South Africa, created a need for a thorough, detailed assessment tool for the evaluation of their oral feeding skills, to ensure effective, accountable service delivery in the neonatal units. This clinical problem required investigation. A comprehensive evaluation form (FEFARI) was compiled and used in a carefully selected subject group in this study, in an attempt to enable the feeding specialist to describe the oral feeding skills of the premature infant in order to provide some solutions to above-mentioned needs.

4.8 SUMMARY

This chapter described the research methodology which directed this study. It included the aims and sub-aims of the study, and the objectives that were necessary to meet the aims. The research design, subjects, the materials and equipment, and procedures to collect and analyse the data for the main study were described in detail. In this manner, scientific accountability for this study is provided.

CHAPTER 5

RESULTS AND DISCUSSION

Aim: To provide and discuss the results of this study according to the formulated aims. The results are presented in tables and figures and are discussed with the view to explore the factors that may influence the premature infants' oral feeding skills and to identify emerging trends and intervention strategies. The results will be interpreted with reference to the literature.

5.1 INTRODUCTION

The rising number of premature infants in the NICU's has increased the need for effective, accountable management of these infants. One of the aspects of their management purports the management of oral feeding (Jolley et al., 1995; Rossetti, 1986; Widerstrom et al., 1997). Although research has been done on the oral feeding skills of premature infants and feeding scales exist, the available information seems to be fragmented or inappropriate for premature infants, e.g. feeding scales only assess the tongue and jaw movements (Braun & Palmer, 1985; Palmer et al., 1993, Stratton, 1981) and sucking efficacy was measured in terms of the pressure and flow rate (Brake et al., 1988; Casaer et al., 1982; Daniëls et al., 1986; Jain et al., 1987). The need was identified for a comprehensive assessment tool which would enable the feeding specialist to describe the oral feeding skills of the premature infant in order to identify difficulties and to provide intervention strategies.

Sub-aim 1 of the study was fulfilled by developing a comprehensive evaluation tool, namely the "*Feeding Evaluation Form for At-Risk Infants*" (FEFARI), to

enable the clinician to describe the oral feeding skills of the premature infant, which is the **main aim** of this study.

Sub-aim 2 of the study was realized by applying the FEFARI to subjects. The results obtained from the FEFARI will be discussed according to the subheadings, stated in chapter 4, which are the description of:

- The characteristics of the premature infants used in the study
- The oral feeding skills of these premature infants in terms of:
 - Their non-nutritive sucking skills,
 - Their nutritive sucking skills when feeding from a bottle and a cup
 - The impact the different feeding methods have on their physiological status
- The identification of any pattern of skills at a particular gestational age (developmental trends)
- The identification of suitable intervention strategies for different gestational age groups (clinical application).

5.2 PRESENTATION OF RESULTS OBTAINED FROM THE FEFARI

A discussion of the information collected with the FEFARI, according to the subheadings of sub-aim 2, is presented below:

5.2.1 DESCRIPTION OF THE CHARACTERISTICS OF SUBJECTS

The description of subjects follows according to the four subject groups, as well as to the sample as a whole, in terms of their biographical information, medical and feeding history, current state and behaviour and physical status.

5.2.1.1 Biographical Information

Biographical information was obtained from the subjects' medical charts and notated on page 1 of the FEFARI (Appendix A).

A summary of the biographical information of the subjects in terms of gestational age, weight, gender and race is presented in Table 5.1:

Table 5.1. The description of subjects according to each category

		Group 1 N=10	Group 2 N=11	Group 3 N=11	Group 4 N=10	Total Group	Percentage total group
BALLARD SCORE	28-30	0	2	2	1	5	11.90%
	31-33	9	5	3	0	17	40.50%
	34+	1	4	6	9	20	47.60%
BIRTHWEIGHT	1-1.49 kg	5	11	8	5	29	69.00%
	1.5 –1.8 kg	5	0	3	5	13	26.00%
	1.8 kg +	0	0	1	1	2	4.80%
	Mean	1.4 kg	1.22 kg	1.35 kg	1.42 kg		
	SGA	6	9	8	9	32	76.20%
CURRENT WEIGHT (TIME OF EVALUATION)	1 - 1.5 kg	6	6	2	3	17	40.50%
	1.5 –1.8 kg	4	4	6	4	18	42.80%
	1.8 kg +	0	1	3	3	7	16.70%
	Mean	1.45 kg	1.44 kg	1.65 kg	1.67 kg		
GENDER	Male	5	5	6	3	19	46.30%
	Female	5	5	5	7	22	53.70%
RACE	Black	8	9	7	7	31	73.80%
	Coloured	0	1	0	1	2	4.80%
	White	2	1	4	2	9	21.40%

The discussion according to the headings used in the table follows below:

.1 Ballard Score

The Ballard Score awarded to each subject by a paediatrician was used to determine the gestational age of the subjects. Figure 5.1 illustrates the distribution

of the Ballard scores between the subject groups and Figure 5.2 the distribution of the whole subject group.

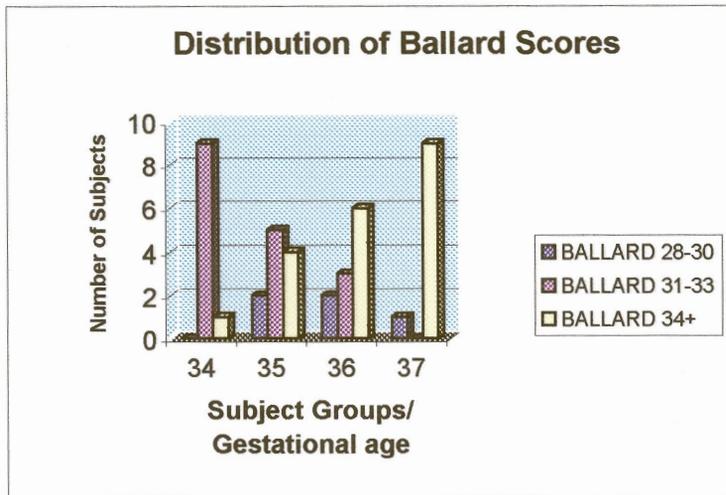


Figure 5.1 Distribution of Ballard scores of the subject groups.

In the two younger age groups, Groups 1 & 2 (34 & 35 weeks gestational age), most of the subjects were born at 31-33 weeks gestational age, thus moderately premature (Rossetti, 1996). Group 1 had no extremely premature subjects (born between 24-30 weeks), but Groups 2 and 3 had two extremely premature infants each. In Groups 3 & 4 (36-37 weeks gestational age), most of the infants were born moderately premature (Rossetti, 1996).

Most of Group 4 (37 weeks gestational age) had a Ballard score of 34+. That implies that most of the 37-weeks group and 47.6% of the total group of subjects (Table 5.1; Figure 5.2) were, according to the literature, mature enough to receive oral feedings from birth (Creger, 1995; Merenstein & Gardener, 1989; Sheahan & Brockway, 1994; Vergara, 1993).

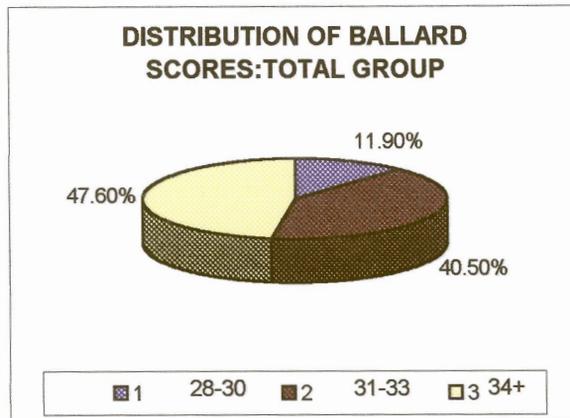


Figure 5.2 Distribution of gestational ages of the total group of subjects.

Only 11.9 % of the total group can be considered as extremely premature. These infants are considered to be medically fragile and are associated with poorer developmental outcome than moderate or mild premature infants (Rossetti, 1998)

. 2 Birthweight

According to Table 5.1, the birth weight of 69% of the total group of infants fell into the 1-1.49 kg span (Very Low Birth Weight/VLBW), with an average of about 1.35 kg. The infants of Groups 1 & 4 (34 and 37 weeks) averaged the highest birth weight (approximately 1.4 kg), followed by 36 weeks (1.35 kg) and 35 weeks (1.22 kg). VLBW infants are considered to have poorer developmental outcome than the LBW infant (Rossetti, 1996). This fact has to be taken into consideration in interpreting the results on feeding skills later on.

According to clinical practices in the Pretoria Academic Hospital's NICU, infants of under 1.8 kg are considered to be unsuitable for oral feeding. A weight criterion is widely used in neonatal units (Brake et al., 1988). Although 47.6% (Figure 5.2) of the total group were mature enough to feed orally at birth, they would probably not have been exposed to any oral feeding experience from birth, as only 4.8% (Figure 5.3) would have met the weight criterion (1 each in the Groups 3 & 4)

(Table 5.1). This is another aspect to consider when interpreting results later on in this chapter.

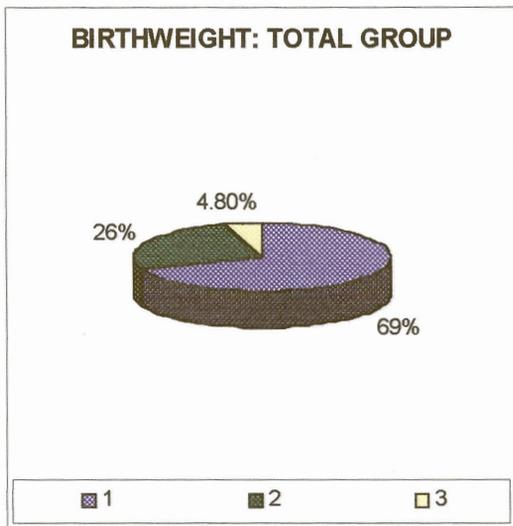


Figure 5.3 Distribution of birth weight for the total group of subjects

Some of the subjects can furthermore be categorised as **Small for Gestational Age (SGA)** also known as dismature. That means that their weight fell below the 10th percentile for their age on the weight chart of Lubchenco (Mullen et al., 1988). 89-90% of the infants in Group 2 & 4 (35 and 37 weeks) and 60% of Group 1 (34 weeks) were SGA (Table 5.1). The percentages of SGA and AGA infants are illustrated in Figure 5.4.

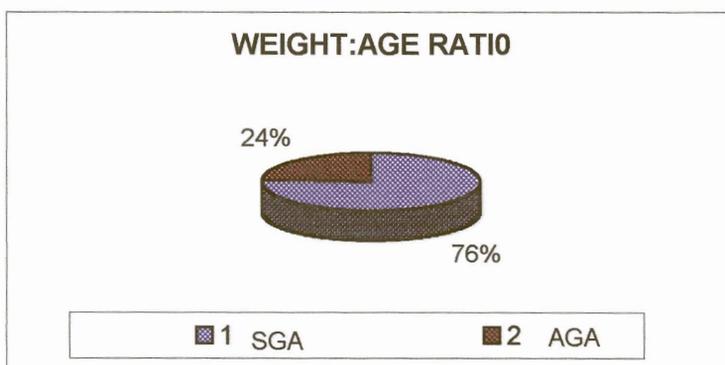


Figure 5.4 The ratio between SGA (Small for Gestational Age) and AGA (Appropriate for Gestational Age) infants of the total group of subjects

Of the total group of subjects, an average of 76.3% were SGA. A high percentage of neonates born in the local maternity hospital could be classified as dismature or SGA infants. Unpublished research which was conducted in a neighbouring hospital, found an indication that black infants scored higher on the Ballard Scores than white infants (De Witt, 1999). This has the implication that, because they are actually younger than the Ballard Score indicates, their low weight may be more appropriate for the lower gestational age. That could explain the difference between SGA and AGA.

. 3 *Current Weight* (at the time of the evaluation)

In the two younger age groups, Groups 1 & 2 (34 & 35 weeks), about 60% of the subjects weighed below 1.5 kg. In Group 3 (36 weeks), 55% weighed 1.5-1.8 kg and 27% over 1.8 kg. Group 4 (37 weeks) had a more or less even distribution between the weight ranges, with 30% weighing over 1.8 kg (Table 5.1). The current-weight distribution between the weight ranges of the whole group is illustrated in Figure 5.5.

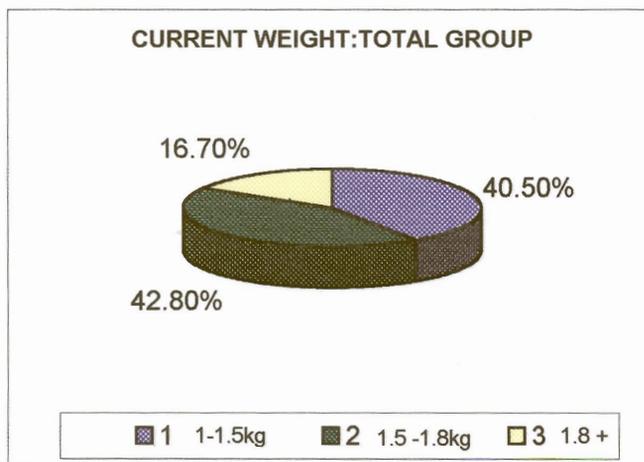


Figure 5.5 Distribution of the current weight for the total group of subjects.

At the time of the assessment, only 16.7% of the subjects would have been considered suitable for oral feeding by the staff in the NICU (using a weight criterion) and 83.3% (40.5% + 42.8%) as unsuitable. It is expected that a high percentage of infants would still receive nasogastric tube feeding, with little

opportunity to gain experience in oral feeding, which may influence the results of oral feeding skills. Brake et al. (1988) and Casaer et al. (1982) stated that feeding efficiency improves with experience, although Bazyk (1990) stated that neuro-maturity played a more significant role than oral motor experience. The result obtained in this study will give an indication of which criterion (weight or maturity) may be the better choice, in deciding when to introduce oral feeding in premature infants.

4 Gender and Race

Slightly more females (54%) than males (46%) participated in the study, illustrated in Figure 5.6. The majority of subjects were black (73.8%) as opposed to 21.4% of white subjects as illustrated in Figure 5.7. A very small percentage (4.8%) of coloured subjects participated in the study and will not be considered as a separate race group.

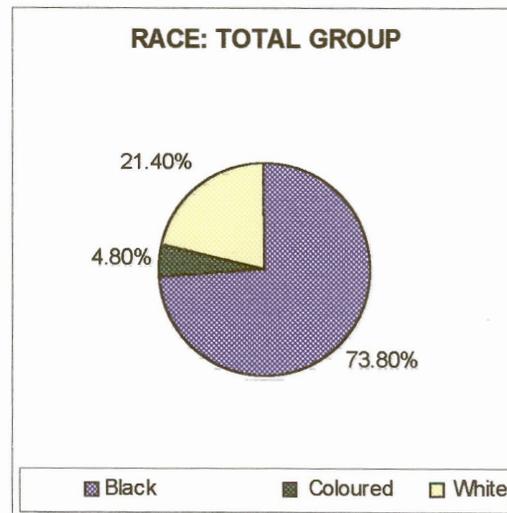
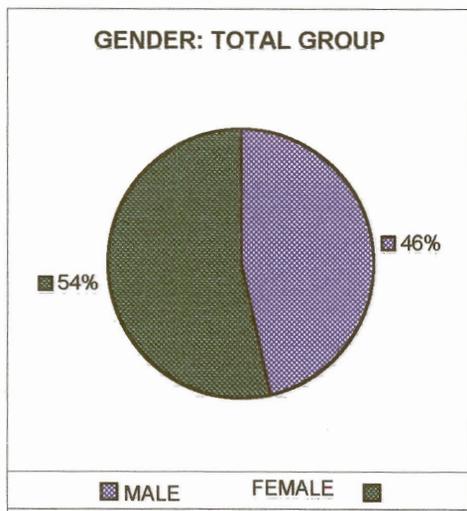


Figure 5.6 Distribution of gender: Total group **Figure 5.7 Distribution of race: Total group**

The literature does not discriminate between the oral feeding skills of different genders or race groups. However, in view of the indication in the unpublished study mentioned above regarding SGA and the fact that the majority of subjects

were black, race has to be taken into consideration in the interpretation of oral feeding skills and/or developmental trends dealt with later in this chapter.

In **conclusion**: the subjects as a whole can be described as moderately premature, born with very low birth weights (VLBW) (the majority had a birth weight of 1-1.49 kg) and three quarters of the cases can also be considered as small for gestational age (SGA). According to a neuro-maturation criterion for readiness to feed orally, 47.6% of the subjects would have been ready *at birth* already, in contrast to the 4.8% by a weight criterion. *At the time of the evaluation*, 60% of the two younger groups (1 & 2) still had a weight below 1.5 kg. Only 16% of the whole group weighed over 1.8 kg and would have been considered ready for oral feeding by a weight criterion, in contrast to 100% using a neuro-maturation criterion as suggested by the literature (Creger, 1995; Vergara, 1993). The distribution between the genders was approximately equal. The subjects consisted of White, Black and Coloured infants, with the majority being Black.

5.2.1.2 Medical History

The information was obtained from the subjects' medical files and notated under heading 1, namely Medical History, on the FEFARI (Appendix A).

A summary of the results is illustrated in Table 5.2. Although ten further factors in addition to those indicated here, are included in the FEFARI, most of them are associated with neurological insults. Infants with possible neurological problems due to e.g. IVH, were excluded from this study, as explained in Chapter 4.

Table 5.2 Number of subjects displaying the most recorded Risk Factors

	Group 1 N=10	Group 2 N=11	Group 3 N=11	Group 4 N=10	TOTAL N=42	Percentage Total group
Prematurity	10	11	11	10	42	100%
BPD	5	4	4	4	17	40.50%
Ventilation	3	3	2	3	11	26.20%
Pneumonia	2	1	1	0	4	9.50%
Cardiovascular	1	2	3	1	7	16.70%
Appgar under 7	3	0	0	1	4	10.80%
Tube feeding	9	8	10	6	33	80.50%
TORCH infection	1	3	0	1	5	11.90%

As suspected from the biographical information, 80.5% of the subjects received tube feedings (Table 5.2), as opposed to only 52.4% (40.5% + 11.9%) who were, according to their neuro-maturity, not ready to receive oral feedings (Figure 5.2) and should therefore have received nasogastric feedings. This percentage (80.5%) correlates with the 83.3% (40.5% + 42.8%) of infants who weighed under 1,8 kg at the time of the evaluation (Figure 5.5). This confirms the fact that weight at present plays a more important role than maturity in determining the method of feeding used in premature infants in the local NICU. The number of subjects who received tube feeding in the different subject groups was: 9 out of 10 in Group 1 (34 weeks); 8 out of 11 in Group 2 (35 weeks); 10 of the 11 in Group 3 (36 weeks); and 6 out of 10 in Group 4 (37 weeks). Although Group 4 had fewer subjects still on nasogastric feeding than the younger groups, these 6 were fewer than expected from a maturational point of view, although still more than expected if weight is considered, as only 3 of these infants weighed over 1.8 kg. It should always be kept in mind that long-term nasogastric feeding may cause considerable complications (see 2.4.4) and was found to be the best predictor for communication delays by Kritzing (1994).

The risk factor that occurred the second most was BPD (40.5%) and had more or less an even distribution amongst the age groups. This correlates with the incidence of 5-45% of premature infants who have BPD mentioned by Vohr

(1991). Difficulties in sustaining oral feeding can be expected from nearly half of the subjects, due to feeding difficulties of infants suffering from BPD (see 2.3.1.3).

Third highest was ventilation with 26.2%, which was also evenly distributed between the age groups. Long-term ventilation can have serious effects on feeding skills, as discussed in Chapter 2 (see 2.4.3). That is why infants who needed ventilation for longer than 2 days were excluded from this study. It is thus not expected to influence the results in this study.

Cardiovascular problems occurred in 16.7% of all subjects, with the most of these subjects from Group 3 (36 weeks), namely 3 out of 11 (27%). This could influence endurance with oral feeding because of the extra energy expenditure needed for oral feeding (Sheahan & Brockway, 1994) and may explain why such a high percentage of them received tube feeding. This fact should be kept in mind when interpreting the results of the 36-weeks group.

TORCH infections were recorded in 11.0% of the subjects, with most of the infants in Group 2 (35 weeks). The infection in all three cases was congenital sepsis and is not expected to have a great influence on the results, as the infants had to be relatively normal and healthy at the time of the evaluation to have been selected for the study. The 1-min Apgar score of less than 7 occurred in 3 of the 10 subjects in Group 1 (34 weeks). The 5-min Apgar score was over 7, so no neurological sequelae are expected to influence the feeding skills. Rossetti (1998) only regards a low Apgar score as indicative of risk *if the second score is lower than the first*. It was furthermore one of the criteria for selection of the subjects as well.

Pneumonia (congenital) occurred in 9.5% of the subjects with the most of these subjects in Group 1 (34 weeks). Pneumonia can have a negative influence on oral feeding as well (see par. 2.4.3). The infants had recovered from the pneumonia at the time of the evaluation and it should not influence the results, but may explain

why most of them (9 out of 10) received tube feeding, apart from their low birth weights. Since most of them were born at 31-33 weeks, long-term effects of tube feeding might not have been well established yet.

In conclusion, it can be stated that long-term nasogastric feeding is the risk factor with the highest incidence in the subjects. BPD and Ventilation occurred second and third most often. The other factors which were displayed, may have contributed in part to the reason why the subjects still received tube feedings. These factors represent high risk factors for feeding problems.

5.2.1.3 Current State and Behaviour

Information was obtained from the bed charts of the infants and entered on page 2 of the FEFARI (Appendix A) under heading 2, namely Current State/Behaviour.

A summary of the factors related to current state and behaviour is presented in Table 5.3.

Table 5.3 Subjects' scoring on items in the STATE AND BEHAVIOUR section of the FEFARI

	Group 1 N=10	Group 2 N=11	Group 3 N=11	Group 4 N=10	TOTAL N=42	Percentage TOTAL GROUP
Not Alert	9	10	8	9	36	85.70%
Lethargic	9	9	8	9	35	83.30%
Medication	4	3	2	2	11	28.20%
Apnea	1	3	0	1	5	11.90%

Most of the subjects were healthy and did not display problems in this section, except that they were lethargic.

Considering the total group of subjects, about 85% of them were not alert, but lethargic at the time of the assessment (Table 5.3). This correlates with the

statement of Creger (1995) that the premature infant has difficulty in maintaining an alert state.

Sucking skills are better when an infant is alert. Mandich & Ritchie (1996) state alertness as a prerequisite for oral feeding. Considerable influence on feeding skills can thus be expected. The assessment was done during the scheduled feeding time of the NICU. The questions can be raised of whether the subjects would have been more alert at a different time as the scheduled feeding time if the subjects' individual sleep-awake cycles were respected and of how facilitative scheduled feeding times are for oral feeding. In a study conducted by Cagan (1995), it was found that 70% of the premature infants suggested that they were ready to feed at a time other than the scheduled feeding time and if they were fed at a time at which they demonstrated feeding readiness behaviour, 18.7% less nasogastric tube feeding was used.

The type of medication that 28,2% of the subjects received is not considered to have any influence on the oral feeding skills (De Witt, 1999). Apnoea did not occur in great numbers, except in Group 2 (35 weeks) (3 out of 11). According to the literature feeding apnoea occurs more often than sleep apnoea (Dreier et al., 1979; Garg et al., 1988; Rosen et al., 1984). Special consideration to this fact should be given, in interpreting results of Group 2 especially, who displayed the highest incidence of sleep apnea.

The conclusion can be drawn that maintenance of an alert state was, at the time of the evaluation, one of the biggest problems for the subjects. It is speculated that this will influence the oral feeding skills of the majority of the subjects

5.2.1.4 Physical Examination

Information gathered from the physical examination performed by the researcher was notated on page 2 under heading 3. Physical Examination on the FEFARI (Appendix A)

The results are summarized in Table 5.4.

Table 5.4 Subjects displaying unfavourable characteristics for oral feeding in the PHYSICAL EXAMINATION section of the FEFARI.

	Group 1 N=10	Group 2 N=11	Group 3 N=11	Group 4 N=10	TOTAL N=42	Percentage TOTAL GROUP
Asymmetrical	0	0	1	2	3	7.10%
Abnormal tone	2	5	1	4	13	31%
Floppy	1	3	2	2	8	19%
Hypertonic	0	1	0	1	2	4.80%
Tone: feeding	1	1	1	3	6	14.30%

Most of the infants displayed a symmetrical body alignment and abnormal tone was observed in approximately a third of the subjects.

Nearly half of the subjects in Groups 2 and 4 (35 and 37 weeks) displayed abnormal tone. An average of 31% of the total group of subjects displayed abnormal tone. In both these groups (35 & 37 weeks) approximately half of the abnormal tone could be considered as very floppy and a quarter to be distinctly hypertonic. Sheahan & Brockway (1994) and Witt & Rusk (1993) state that the younger the infant, the more floppy he/she would be. This study did not find that, on the contrary, the age group who least displayed floppiness was the youngest group. The only other factor that both Groups 2 & 4 with more floppy infants have in common is that they both have the highest incidence of SGA infants (table 5.1). There might be a relation between SGA and hypotonicity. It is known from the literature that the SGA infants tend to be in an overall weak state (Vohr, 1991) and they may therefore appear to be more floppy. For the group as a whole 19%

were considered very floppy and 4.8% to be hypertonic. Group 4 (37 weeks) seemed to have the biggest problem with tone whilst feeding, which is contrary to what is expected, as it is believed that tone improves with maturity (Sheahan & Brockway, 1994; Witt & Rusk, 1993). Group 4 is suppose to be the most mature group. Abnormal tone has a negative influence in oral feeding (Morris & Klein, 1987; Morris, 1989)

In conclusion it can be stated that although abnormal tone was displayed in approximately half the subjects in two of the groups, problems with tone generally and during feeding did not have a high occurrence across the group as a whole and therefore the influence on oral feeding skills of the subjects is not expected to be widespread.

5.2.1.5 Oral Feeding History

Information was obtained from the subjects' bed charts and recorded on page 3 under heading 4: Oral Feeding History on the FEFARI (Appendix A).

The subjects received feeding at a scheduled interval of 3 hours and the method of feeding varied. The duration of the feed, (presented in table 5.5), positioning during feeding and endurance depended on the method of feeding applied

Table 5.5 Subjects managing amount of their feed

	Group 1 N=10	Group 2 N=11	Group 3 N=11	Group 4 N=10	TOTAL N=42	Percentage Total group
Endurance						
Whole feed	1	1	4	2	8	19.50%
More than ½	0	1	1	2	4	9.80%
Less than ½	9	9	6	5	29	70.70%

90% of the subjects in the two younger Groups 1 & 2 (34 & 35 weeks) could not finish at least half of their feed orally, but of the 36 weeks group only

approximately 50% of the subjects could **not** finish at least ½ of their feed orally. Although this group (Group 3) had the most subjects (4 out of 11) who could manage their whole feed, it still comprised only ± 36% of the subjects in this group. For the total group, only 19.5% could manage their whole feed orally, which corresponds with the 16.7% who were over 1.8 kg. Only 9.8% of the total group could manage more than half of the feed and 70.7% less than half. Possible explanations for such weak performances can be that the subjects were not exposed to oral feeding experience (Brake et al., 1988; Casaer, 1982), because they were considered unsuitable for oral feeding due to their low birth and current weights. It is possible that, due to staff shortages, nasogastric feeding may have been favoured rather than the time consuming task of introducing oral feeding. On the other hand, they could still be weak and actually have low endurance due to the fact that such a great percentage (76.2%) of them are dismature (table 5.1). Aversive behaviour due to long-term nasogastric feedings and other noxious procedures that these premature infants were exposed to, may have played a significant roll in the subjects' weak performances as well (Bazyk, 1990; Vergara, 1993).

The feeding methods used for the different subject groups, are illustrated in Figure 5.8 and for the group as a whole in Figure 5.9.

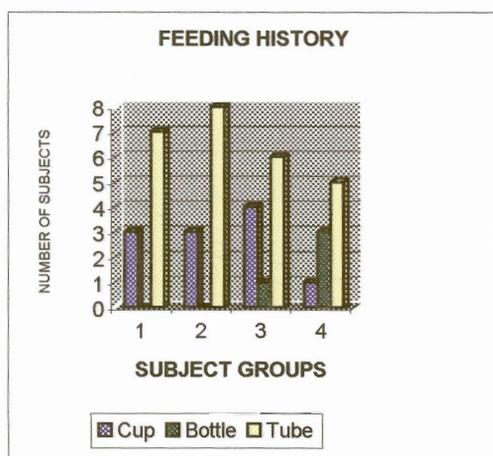


Figure 5.8 Feeding Method for each Age group

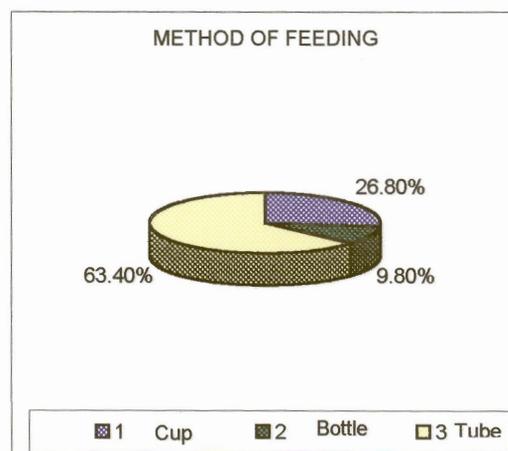


Figure 5.9 Feeding Method for the Total group

From the above, it is clear that approximately 70 % of the subjects of the two younger groups 1 & 2 (34 & 35 weeks) received mainly tube feeding (Figure 5.8). Only one subject in Group 2 weighed over 1.8 kg and \pm 40% over 1.5 kg at the time of the evaluation (Table 5.1). Once again, as was seen in 5.2.1.1, there is a better correlation between tube feeding and weight than gestational age. The rest of the subjects in these two groups received cup feeding, which demonstrates the commitment of the local hospital to meet with the criteria for a "Baby Friendly Hospital". An interesting observation was made in the 37 weeks group, namely, 3 of the 4 subjects who received oral feeding, received bottle instead of cup feeding. An explanation may be that the mothers indicated that breastfeeding was not an option any more, which may be indicative of the problems mothers experience with the slow transfer from tube to oral feeding and the effects thereof on breastfeeding (see 2.3.1.1) (Morris, 1989; Meier & Pugh, 1985; Mandich & Ritchie, 1996).

At the time of the assessment 63.4% of the total group of infants still received nasogastric tube feeding as illustrated in Figure 5.9, although the whole group was mature enough to receive oral feeding according to a maturation criterion.

In conclusion, it can be stated that the subjects had a feeding history of weak oral feeding performances, necessitating nasogastric feeding.

5.2.1.6 Mother-Infant Interaction

This section was included on page 3 in the FEFARI, but due to the great number of mothers who could not be present at the evaluation, results of this section could not be included in this study. Absence of mothers in the NICU is a problem in the local hospital due to many transport problems the parents experience. Kritzinger (1994) found a significant correlation between the number of visits of mothers to their infants in the NICU and communication development of the

infants, as well as transfer to oral feeding. This fact should alert team members involved in the follow up of the infants of this hospital to pay specific attention to communication development.

5.2.1.7 Oral Structures At Rest

Information was gathered by observing the subjects and notating the results on page 4, under heading 6: Evaluation of the Feeding Procedure, of the FEFARI (Appendix A). This subsection was divided into two parts of which “Oral Structure at Rest” was the first part. A summary of the results in this section is presented in Table 5.6.

Table 5.6 Subjects with “abnormal” scores in items of the Oral Structures at Rest subsection of the FEFARI

	Group 1 N=10	Group 2 N=11	Group 3 N=11	Group 4 N=10	TOTAL N=42	Percentage Of total group
LIPS: Open	5	2	1	1	9	21.40%
“ Rooting reflex	7	6	8	7	28	66.70%
Sucking pads	5	2	6	4	17	40.50%
Gag reflex	7	6	8	8	29	72.50%
Biting reflex	4	3	2	4	11	28.20%
High arch	2	4	2	3	11	26.20%
Tongue retracted	2	4	2	3	11	26.20%

The oral structures under observation were the lips, cheeks, jaw, hard- and soft palates and tongue. No problems were generally found with symmetry or tone in these structures, but the oral reflexes seemed to be diminished.

The rooting and gag reflexes appeared to be affected the most in the group as a whole. Not much change with maturation of these reflexes from 34 to 37 weeks (Group 1-4) was observed, on the contrary, the gag reflex score was the lowest in the 36 and 37 weeks groups (Groups 3 & 4). According to the literature, the gag reflex should evolve around 34 weeks (Arvedson & Lefton-Grief, 1996; Logan & Bosma, 1969), but in this study, the subjects with a gestational age of 37 weeks,

still had hypoactive gag reflexes. Approximately 80% of them displayed a hyposensitive gag reflex.

Possible explanations of this fact is that it may partly be due to the fact that the gag reflex is not developed well enough, or that the reflex could have become desensitised due to noxious procedures they have been exposed to over a long period in the NICU. The literature states that the gag reflex is a prerequisite for safe oral feeding (Merenstein & Gardener, 1989, Sheahan & Brockway, 1994), but Arvedson & Lefton-Grief (1996) is of the opinion that no relationship between the presence/absence of the gag reflex and swallowing abilities exists. It can be argued that since oral feeding is supposed to be a neuro-maturation phenomenon and these infants are old enough to feed orally, the gag reflex may not be a prerequisite for oral feeding, thus supporting the opinion of Arvedson & Lefton-Grief (1996). On the other hand, only half of these infants could manage more than half of their oral feeds. Questions can subsequently be raised about the safety of oral feeding in these infants.

The absence or inconsistent rooting reflexes may also be due to desensitisation of the reflex after repetitive noxious procedures, e.g. taping of nasogastric tubes, to which these infants are exposed to in the NICU. The diminished rooting reflexes recorded in this study correlate with the findings of depressed rooting reflexes in the neonates who participated in the study conducted by Kritzinger (1994). It is expected to influence the lip functioning during oral feeding.

The absence of sucking pads in 40.5% of all the subjects did not demonstrate any maturational changes from 34 to the 37 weeks gestational age (Groups 1-4). This may be due to the little body fat that these infants still have, because the majority are still SGA and 83.3% still weighed less than 1.8 kg at the time of the evaluation (Table 5.1). The characteristic of the lips that remain open in the resting position showed a dramatic improvement from Group 1 to 4 (34 weeks to 37 weeks) (Table 5.5) and was mainly observed in Group 1 (34 weeks gestational age).

Morris & Klein (1987) mention this behaviour as characteristic of premature infants. This study found it to be more representative of the moderate and extremely premature infants. In 26.2% of all of the subjects, a high arch and retracted tongue were recorded, with no dramatic differences between the age groups.

In conclusion, it can be stated that although structurally, the main problem may be the absence of sucking pads, diminished oral reflexes seem to occur often in the subjects. The diminished reflexes may have a more serious effect on oral feeding skills of the premature infant than the absence of the sucking pads.

5.2.1.8 Summary Of Characteristics

In summary, the subject groups demonstrated the following characteristics:

- **Group 1** (34 weeks gestational age)

This group has the second lowest average current weight (1.45 kg). All but 1 received tube feeding from birth and at the time of the assessment, 70 % were still being tubefed. The rest all received cup feeding. Of all the groups, they had the most subjects with low Apgar scores and the most subjects with BPD, a history of pneumonia, open lips when at rest and diminished rooting and gag reflexes. It is suspected that they will have the most oral feeding problems.

- **Group 2** (35 weeks gestational age)

They had the lowest average birth weight (1.22 kg), current weight (1.44 kg) and Ballard scores. The second most SGA infants were in this group. They also had the most number of congenital infections, apnea and abnormal tone. Of the 72% who received tube feeding from birth, 70% still received tube feeding at the time

of the assessment. The highest incidence of high arched palate and a retracted tongue were displayed in this group (40% each). According to the number of the risk factors for oral feeding in this group, considerable feeding problems are expected in this group as well.

- **Group 3** (36 weeks gestational age)

All but 1 subject received tube feeding from birth, but at the time of the study, only 54% were still mainly on tube feeding. Of the remaining group who received oral feeding, 36% could manage their whole oral feed. This group had the most subjects (28%) with a history of cardiovascular problems, a diminished rooting reflex (80%), a lack of sucking pads (60%) and 72% demonstrated a hypoactive gag reflex (2nd most). The relatively low number of subjects who received mainly tube feedings at the time of the evaluation, implies that less oral feeding problems can be expected in this group.

- **Group 4** (37 weeks gestational age)

This group had the most SGA infants (90%) and the second most with abnormal body tone (40%). It may be argued that the high incidence of SGA infants in this group may be due to the fact that all the AGA infants in this age group would already have been discharged from the hospital because they had an acceptable weight, contrary to the SGA infants who would still have a low weight. This group may therefore not be representative of 37-week gestational age infants. Three of the four subjects on oral feeding received bottle-feeding, but only 20% could manage the whole feed. The highest incidence of a hypoactive gag reflex was demonstrated in this group (80%). The high percentage of SGA subjects suggests that oral feeding may still be problematic in this group.

These characteristics should be kept in mind when interpreting the results discussed further on.

5.2.2 DESCRIPTION OF ORAL FEEDING SKILLS OF PREMATURE SUBJECTS

The evaluation of the oral feeding skills of the subjects starts on page 4 of the FEFARI (Appendix A) under the heading: Evaluation of the feeding process. The evaluation is done in two parts namely: **Oral structure at rest** (page 4 of the FEFARI) as discussed above and **Functioning of the oral structure** (Page 5 of the FEFARI). The functioning of the oral structures is further divided into the following subheadings: *Non-Nutritive Sucking* (page 5 in FEFARI) and *Nutritive sucking* (page 6 FEFARI)

The Nutritive sucking skills are evaluated according to the four different phases of deglutition, namely the oral-preparatory/oral phase, the pharyngeal phase and the oesophageal phase.

5.2.2.1 Non-Nutritive Sucking (NNS) Skills

The information for this section of the evaluation was obtained by observation and was recorded on page 5 of the FEFARI (Appendix A) under the heading: Non-Nutritive Sucking (NNS). A numerical score of 1 was awarded for normal skill or behaviour, 2 was awarded if the item (skill) was considered moderately abnormal and disorganised. A numerical value of 3 was awarded if the skill was considered severely abnormal and dysfunctional (also see par. 4.4.1.3.).

Generally, it can be stated that the subjects did not experience many problems in this subsection. The younger the group, the fewer difficulties were displayed. The results are summarized in Table 5.7.

Table 5.7 Problems experienced with NNS

GROUP	N=9		N=7		N=10		N=10		N=36			
	Group 1		Group 2		Group 3		Group 4		TOTAL Group			
SCORE	2	3	2	3	2	3	2	3	2		3	
Lips: Pursing	1	1	1	0	0	0	0	2	2	5.50%	3	8.30%
Lips: Closure	1	0	1	0	2	0	5	0	9	25.0%	0	0
Lips: closure sustained	1	1	1	2	4	0	3	2	9	25.0%	5	13.90%
T/elevated tip/retracted	1	1	1	1	2	0	1	1	5	13.90%	3	8.30%
Sucking bursts	1	4	2	2	4	1	4	3	11	30.50%	10	27.8%
Rate of movement	2	0	2	1	1	1	5	2	10	27.80%	2	5.50%

According to Table 5.7, the two younger groups displayed very few problems with NNS, except with weak sucking bursts in 4 out of the 9 (44%) of the subjects in Group 1. Group 3 also had problems with sucking burst, which were prolonged or short, rather than weak. A further 40% of these subjects had difficulty in sustaining lip closure for more than 2 minutes around the pacifier. Group 4 had 3 subjects (30%) who could not sustain the closure for more than 2 minutes and 2 subjects (20%) who could not even sustain it that long. Half of the subjects of Group 4 displayed uncoordinated movements during NNS. It seems that, in the group as a whole, the problems experienced with NNS fall more into the moderately disorganised category than in the severely dysfunctional category.

It is interesting that NNS skills seem to deteriorate with maturation. A possible explanation may be that the sucking reflex may diminish over time if it is not stimulated in the premature infants (Morris, 1989). This has definite service delivery implications for providing sucking experience (Brake et al., 1988). Another explanation may be that since the older group were exposed to bottle-feeding more than the other groups, they were more disorganised with the difference between the sucking rates of NNS and NS. In full-term infants, the adaptation between the two different mechanisms of sucking does not cause any problems.

In conclusion, it can be said that the subjects experienced mild problems with NNS.

5.2.2.2 Nutritive Sucking (NS)

Nutritive sucking during bottle-feeding and cup-feeding was evaluated according to the different phases of deglutition. The information obtained for bottle-feeding was entered on pages 6-8 under the heading: Nutritive Sucking, and for cup-feeding on pages 9-11 under the same heading of the FEFARI (Appendix A).

. 1 Oral Preparatory / Oral Phase

The information regarding this phase was recorded under the subheading: Oral preparatory/oral phase on page 6 for bottle-feeding and on page 9 for cup-feeding of the FEFARI.

The skills of the subjects are discussed according to the different subject groups and the group as a whole. Bottle- and cup-feeding will be compared. The phase will further be discussed according to the structures involved in this phase, namely the lips, jaw and tongue and the triggering of swallowing.

□ Group 1 (34 weeks gestational age)

The problems in both bottle- and cup-feeding can be classified as moderate, disorganised (score: 2), or severe, dysfunctional (score: 3). The results of the oral feeding skills during the oral preparatory/oral phase during bottle- and cup-feeding for this group are summarized in Table 5.8. The mean values for each oral structure and the comparison between the two feeding methods in terms of the p-value and the level of significance are presented in Table 5.9.



Table 5.8 Problems experienced by Group 1 during the oral/oral preparatory phase

Score	GROUP 1: (34 weeks) N=10			
	2		3	
Feeding Method	Bottle	Cup	Bottle	Cup
LIPS / Pursing	0	1	2	1
Closure	1	2	1	1
Maintain	3	6	0	1
Loss of Liquid	0	1	0	3
Movement/ Arrhythmic	5	5	0	4
" / Uncoordinated	7	5	0	2
JAW / Depression	3	6	0	0
" / movement / Arrhythmic	5	7	0	1
" / " / minimal / absent	5	8	0	0
" / " / Lack Rate Change	6	6	0	1
TONGUE /movement / protrusion	0	3	1	0
" / " / elevated / retracted	0	0	1	0
" / " / arrhythmic / weak	4	6	1	3
Sucking bursts	8	6	2	4
Flow rate	7	5	0	1
Bolus formation	2	4	0	0
SWALLOWING/uncoordinated / absent	5	4	0	0
" / delayed / absent	2	3	0	0
" / multiple / no	5	5	0	0
TOTAL	68	90	8	20
2+3	76	110		

The results are discussed according to the information and structure of Table 5.8.

LIPS

Bottle: During bottle-feeding, arrhythmic and uncoordinated movements occurred in 50% and 70% of the cases, respectively.

Cup: During cup-feeding 50% of the subjects displayed arrhythmic movements, 50% uncoordinated movements and an additional 40% no movement of the lips. Moderate loss of liquid in 60% and severe loss in 10% of the cases also occurred during cup-feeding. Arrhythmic and uncoordinated movements were expected (Bu'Lock et al., 1990)

Although subjects seem to display more problems with movement of the lips and loss of liquid during cup-feeding, the difference in the mean score for lips between the two feeding methods, had a p-value of 0.078 and is therefore not statistically significant in this age group (Table 5.9).

Table 5.9 Comparison between bottle- and cup-feeding in Group 1

	Group 1 N=10					
	BOTTLE		CUP		BOTTLE - CUP	
	Mean	SD	Mean	SD	p-Value	Level of significance
Lips	8.4	2.63	10.8	2.46	0.078	None
Jaw	5.9	1.6	7.1	1.45	0.031	5%
Tongue	1	1.7	10.8	1.47	0.219	None
Swallowing	5.4	1.35	5.6	1.07	0.561	None

JAW

Bottle: The problems which occurred the most during bottle-feeding in this age group (Table 5.8) are, arrhythmic movements, minimal excursion and lack of rate change between NNS and NS (about 50% of the subjects in each of the items)

Cup: Additional problems occurred during cup-feeding, namely 60% of the subjects also found it difficult to initiate depression of the jaw, and 20-30% more infants had difficulties with rhythm and movement of the jaw than during bottle-feeding (Table 5.8).

The p-value for the difference in the total jaw score for bottle- and cup-feeding was 0.031 and therefore has a 5% level of significance (Table 5.9). Infants in the 34-weeks age group had **significantly** more problems with jaw movements during cup-feeding.

TONGUE

Bottle: 80% of the subjects experienced problems with prolonged or short sucking bursts and the remaining 20% displayed no sucking bursts. The flow rate was understandably poor. Half of the subjects also demonstrated arrhythmic tongue movements (Table 5.8).

Cup: All subjects experienced problems with sucking bursts, 60% were short and 40% demonstrated no sucking bursts at all. Only 1 subject (10%) had strong rhythmic tongue movement, 60% displayed arrhythmic and 40% very weak movements (Table 5.8). These findings support the statement of Comrie & Helm (1997), that premature infants have limited tongue functioning. According to them, short sucking bursts are an indication of a swallowing dysfunction.

Although the p-value (0.21) for the mean score for tongue movements implies that the difference between bottle- and cup-feeding with regard to the tongue is not statistically significant, rhythmic tongue movements do seem to be better during bottle-feeding (Table 5.9).

SWALLOWING

Bottle: Half of the subjects experienced problems with the coordination of swallowing with breathing. Multiple swallows occurred in half of the subjects and 20% of the subjects had a delayed swallow and 20% slow bolus formation (see Table 5.8).

Cup: The subjects displayed basically the same problems than with bottle-feeding except for bolus formation which was slow in 40% of the subjects (Table 5.8). Swallowing displayed many problems which may tie in with the short sucking bursts as mentioned by Comrie & Helm (1997) and Wolf & Glass (1991).

The difference in swallowing skills between the two feeding method was not statistically significant in Group 1 (see Table 5.9). Thus, in terms of swallowing, the subjects experienced the same kind of problems, whether they were fed by bottle or cup.

In summary, the oral feeding skills during the oral preparatory/oral phase of Group 1 can be described as follows:

Lips could be pursed to initiate feeding, as well as closed and the closure maintained to avoid loss of liquid. This does not support the view of Morris & Klein (1987) that premature infants have a decreased lipseal due to weak oral muscles, resulting in liquid loss. During cup-feeding, however, maintenance of the closure was problematic. Although in this group open lips at rest occurred the most, this fact did not seem to affect the proper closure of the lips in functioning. The movement of the lips were, however, arrhythmic and uncoordinated.

Although the lips could close relatively well, depression of the **jaw** seemed to be problematic (more so for cup-feeding) and mainly minimal excursions could be performed during oral feeding by subjects in this age group. This supports the statement by Wolf & Glass (1991) that abnormal jaw and tongue movements occur at this age. Rhythm and coordination of the jaw were problematic, as well as the maintenance of a rate of 1 suck per second.

Generally, the **tongue** of this age group could form a central groove to direct the bolus in an anterior-posterior movement to the pharynx, but rhythm in this oral structure was also affected and, relating to that, the sucking bursts. These sucking bursts tended to be short or even absent, especially in cup-feeding. Due to the short sucking bursts, the flow rate was poor. This finding supports the statements of Brake et al. (1988) that premature infants suck with less force and that the sucking bursts are short and disorganised. Wolf & Glass (1991) also regarded their sucking bursts as short. This group had the highest number of

subjects with BPD, and therefore supports the view of Wolf & Glass (1991) that infants with respiratory difficulties are unable to sustain long sucking bursts.

The **swallowing** in this age group was uncoordinated and multiple swallows occurred approximately half of the time during both feeding methods. This was the group with the highest incidence of BPD and pneumonia and lowest current weight. The short sucking bursts and multiple swallows may be an attempt by the infants to protect a vulnerable respiratory system, and/or may be due to the lack of strength to perform one effective swallow (Comrie & Helm, 1997). On the other hand, rhythm and coordination during oral feeding are generally problematic, due maybe to the neuro-behavioural immaturity of this age group (Brake et al., 1988; Morris & Klein, 1987).

Although Arvedson & Brodsky (1993) consider the oral feeding skills of this age group as efficient enough to sustain oral feeding needs and a sustained weight, the results of this study imply that not all of these infants are ready for total oral feeding, but may still need partial tube feeding.

It can be stated that although higher scores were recorded over the whole phase for cup-feeding, implying weaker oral feeding skills during cup-feeding, the difference in the mean score for every structure between the two feeding methods was not **statistically significant**, except for **jaw movements** (Table 5.8).

□ **Group 2 (35 weeks gestational age)**

The results for this group are summarized in Table 5.9. A comparison between the mean scores of bottle and cup-feeding, the p-values and level of significance, are presented in Table 5.10.

Table 5.10 Problems experienced by Group 2 during the oral/oral preparatory phase

	Group 2 (35 weeks)			
	2		3	
	Bottle N=10	Cup N=11	Bottle	Cup
LIPS / Pursing	1	2	0	1
Closure	1	3	0	1
Maintain	0	6	1	2
Loss of Liquid	0	6	0	3
Movement / Arrhythmic	3	5	0	4
" / Uncoordinated	3	3	0	3
JAW / Depression	2	7	0	1
" / Movement / Arrhythmic	3	7	0	2
" / " / Minimal / absent	2	8	0	1
" / " / Lack rate change	2	6	0	3
TONGUE / movement / protrusion	3	1	0	3
" / " / Elevated / retracted	0	2	0	1
" / " / Arrhythmic / weak	3	6	0	3
Sucking bursts	8	6	1	5
Flow rate	5	6	0	1
Bolus formation	4	2	0	1
SWALLOWING / uncoordinated / absent	3	5	0	1
" / Delayed / absent	4	2	0	1
" / Multiple / no	3	7	0	1
TOTAL	50	90	2	38
2+3	52	128		

The oral feeding skills in this group can be categorised as moderately disorganised. Sucking bursts in bottle-feeding and jaw movements in cup-feeding were responsible for most of the feeding problems during the oral preparatory/oral phase in this group

The results are discussed according to the information and structure of Table 5.10.

LIPS

Bottle: Good functioning of the lips was generally demonstrated. However, 30% of the subjects experienced problems with coordination and rhythmic movements of the lips (Table 5.10).

Cup: Moderate (in 55% of the subjects) to severe (in 30% of the subjects) liquid loss was a serious problem, as 85% of the subjects experienced liquid loss which may have an impact on their calorie intake. The second biggest problem was the maintenance of lip closure. 55% of the subjects had difficulty in maintaining closure for more than 2 minutes and another 20% could maintain closure for less than 2 minutes. So, although the subjects could open the lips to initiate the feeding, the closure could not be maintained, resulting in liquid loss. Another explanation for liquid loss is that if an infant experiences a bolus as too large, he/she would rather “squirt” it out than risk aspiration due to poor and uncoordinated swallowing which may be present (Comrie & Helm, 1997). Arrhythmic (45% of subjects) and no rhythmic (36% of subjects) movements of the lips were problematic as well. Uncoordinated and weak lip movements each occurred in 27% of the subjects (see Table 5.10).

The p-value for the mean scores of the lip section for the two feeding methods was 0.0078, which means the difference was **highly significant** (1%) in favour of bottle-feeding (see Table 5.11).

Table 5.11. The comparison between bottle- and cup-feeding in Group 2

	Group 2 (35 weeks) N=10					
	BOTTLE		CUP		BOTTLE – CUP	
	Mean	SD	Mean	SD	p-Value	Level of significance
Lips	6.9	1.286	10.8	3.027	0.0078	1%
Jaw	5.1	1.663	7.81	2.316	0.0156	5%
Tongue	9.3	1.494	11.45	3.21	0.0368	5%
Swallowing	5.4	1.429	6.18	2.359	0.560	None

JAW

Bottle: Few problems with jaw movements were displayed. Between 20 and 30% of the subjects had difficulties with rhythmic and coordinated movements, to

change the rate between NNS and NS and to initiate jaw depression (see Table 5.10).

Cup: The main problem was minimal jaw excursion (in 72% of the subjects). Arrhythmic (in 63% of the subjects) or no movements (18% of subjects) of the jaw, difficulty to initiate jaw depression (64%), lack of rate change between NNS and NS (55%), or the total absence of movement (27%), were also displayed (Table 5.10).

The difference between bottle- and cup-feeding is **statistically significant** at a level of 5%, according to the p-value, which is 0.0156 (Table 5.11). This implies that the subjects in this group managed bottle-feeding better than cup-feeding in terms of jaw functioning. The jaw may be naturally more adapted to function effectively around a nipple than with the relatively flat surface of the cup.

TONGUE

Bottle: Sucking bursts were responsible for the most difficulties (90% of the subjects). These sucking bursts were either prolonged (30% of the cases), too short (50% of the cases), or absent (10%). Therefore, the flow rate was poor and the bolus formation slow, as could be expected from the short sucking bursts (see Table 5.10).

Cup: Similar to bottle-feeding sucking bursts were responsible for the majority of problems in cup-feeding - 54% of the subjects displayed short sucking bursts and 45% no bursts at all. Arrhythmic (54% of the cases) or no movements of the tongue (27% of the cases) were observed, resulting in a poor flow rate (in 54% of the subjects) (see Table 5.10).

The difference between bottle- and cup-feeding concerning the tongue is statistically **significant** at a level of 5% in favour of bottle-feeding (p-value:

0.0368) (see Table 5.11). It appears that the tongue is developed to curve and function around a nipple and has difficulty in managing a bolus without it.

SWALLOWING

Bottle: Delayed swallowing was demonstrated in 40% of the subjects. Multiple and incomplete swallows each occurred in 30% of the subjects (see Table 5.10).

Cup: Multiple swallows occurred in 64% of the subjects and uncoordinated swallows in 45% of them (see Table 5.10).

Although multiple swallows occurred twice as often during cup- as during bottle-feeding, the mean score of the whole section of swallowing for both the feeding methods did not differ significantly (see Table 5.11). This implies that individual items in the swallowing section will have to be considered when planning appropriate oral feeding intervention.

In summary, the oral feeding skills of Group 2 during the oral preparatory/oral phase, can be described as follows:

The **lip** functioning during bottle-feeding was good, with pursing of lips to initiate oral feeding, good closure and maintenance of the closure to limit liquid loss. Fewer problems with rhythm and coordination of lip, jaw and tongue movements, as well as swallowing were demonstrated in this group, than in Group 1 (one week younger). The subjects could, however, not maintain closure with the lips around the cup, which resulted in extensive liquid loss, more than in the younger group. Rhythm and coordination generally did not improve with cup-feeding as with bottle-feeding.

Jaw functioning in this group during bottle-feeding can be described as follows: a depression of the jaw to initiate feeding could be executed, it could be

rhythmically moved to suck and these infants had the ability to change the rate of sucking between NNS and NS. During cup-feeding a different picture was observed. These infants could not close the jaw around the cup, minimal excursion inhibited sucking and the rhythm was affected.

The **tongue** formed a central groove, but tented to protrude in the anterior – posterior movement during sucking, especially during cup-feeding. A possible explanation may be that a number of the subjects could now anticipate the feed and the tongue protruded a little to “collect” the milk from the cup. Short sucking bursts were characteristic of this group as well, which correlates with statements of Gryboski (1969) and Bu’Lock (1991), with no improvement in general tongue functioning or swallowing skills from Group 1 (one week younger). Bu’Lock et al. (1990) stated that fewer abnormal tongue movements occur from 35 weeks onwards, but this was not observed in the group used in this study. This group, however, had the subjects with the lowest average birth and current weights and Ballard scores, the second highest incidence of SGA and highest incidence of abnormal tone and apnea. Apart from the fact that they were neuro-behaviourally immature, these infants were expected to be weaker with a lower endurance, which may explain the short sucking bursts and the fact that the swallowing was delayed or multiple swallows performed, due to fatigue.

Multiple **swallows** may have occurred due to the fact that the swallow is ineffective due to the fatigue, or, to protect the airways, extra swallows are performed in attempt to clear the pharynx thoroughly. During cup-feeding swallowing was more uncoordinated, sucking bursts absent and more multiple swallows occurred. A possible explanation may be that sucking facilitates swallowing (Morris & Klein 1987) and sucking in cup-feeding is different because milk can enter the oral cavity by the hand of the feeder and the bolus needs only to be swallowed. The necessary preparation for swallowing may not have taken place. The bolus may also be larger due to the fact that the infant did not have control over the amount of milk entering the oral cavity and multiple swallows may

be used in an attempt to clear the pharynx. If the larger bolus can not be managed by multiple swallows alone, the rest may be expelled to protect the airways, resulting in liquid loss (Comrie & Helm, 1997).

Generally it can be stated that the infants in Group 2 (35 weeks) managed bottle-feeding in the oral preparatory phases **significantly** better than cup-feeding, with the biggest difference in lip performance.

□ **Group 3 (36 weeks gestational age)**

The results are summarized in Table 5.12 and the mean scores, p-values and level of significance are presented in Table 5.13.

Table 5.12 Problems experienced by Group 3 during the oral/oral preparatory phase

Score	Group 3 (36 weeks)			
	2		3	
	Bottle	Cup	Bottle	Cup
LIPS/Pursing	0	5	0	1
Closure	0	3	0	2
Maintain	2	2	0	4
Loss of Liquid	0	5	0	3
Movement/Arrhythmic	1	0	1	5
" / Uncoordinated	2	4	1	2
JAW/Depression	2	6	1	1
" / movement / Arrhythmic	1	3	1	3
" / " / minimal / absent	2	5	0	3
" / " / Lack rate change	1	3	1	3
TONGUE / movement / protrusion	0	1	1	0
" / " / elevated / retracted	2	1	0	1
" / " / arrhythmic / weak	2	4	1	3
Sucking bursts	7	5	1	3
Flow rate	3	4	0	2
Bolus formation	1	2	0	2
SWALLOWING/uncoordinated/absent	4	6	0	1
" / delayed /absent	1	3	0	0
" / multiple / no	2	4	0	0
TOTAL	33	66	8	39
2+3	41	105		

Few problems were experienced during bottle-feeding, except for the sucking bursts which tended to be prolonged rather than short in this age group. Cup-feeding caused generally more problems over all the items.

The results are discussed according to the information and structure of Table 5.12.

LIPS

Bottle: Few problems were demonstrated. Only problems with maintaining of lip closure and incoordination of lip movements were observed in 20% of the subjects in each of the items (see Table 5.12).

Cup: More problems occurred during cup-feeding. Moderate loss of liquid was recorded in 50% of the cases and extensive loss in 30% of the cases, thus compromising calorie intake. The subjects also demonstrated excessive lip pursing in 50% of the cases, closure was weak in 30% of the cases and absent in 20%, which explains the high incidence of loss of liquid. No rhythm could be observed in 50% of the subjects and uncoordinated movements in 40% (Table 5.12).

Lip functioning during bottle-feeding is **significantly** (5%) better than during cup-feeding (see Table 5.13). The lips are naturally adapted to purse for and seal of around a nipple to prevent liquid loss, which is anatomically problematic with cup-feeding.

JAW

Bottle: Two subjects out of the group of 11 had difficulties to initiate jaw depression and performed minimal excursion of the jaw. One subject in each of the following items was also recorded, arrhythmic movement, lack of rate change

between NNS and NS, absence of movement (see Table 5.12). Problems with jaw functioning in this age group are minimal.

Cup: The infants displayed difficulties to initiate jaw depression in 60% of the cases, the excursion of movements during sucking was minimal in half of the cases and absent in 30% of the cases. Arrhythmic movements and lack of rate change between NNS and NS, and absence of movement was recorded in 30% of each of these items (Table 5.12).

The difference between the jaw movements of cup- and bottle-feeding is **highly significant** (level of 1%), with a p-value of 0.0039 (Table 5.13). Jaw movement is thus much better during bottle-feeding.

Table 5.13 Comparison between bottle- and cup-feeding in Group 3

	Group 3 (36 weeks) N= 10					
	BOTTLE		CUP		BOTTLE – CUP	
	Mean	SD	Mean	SD	p-Value	Level of significance
Lips	6.81	1.6	10.8	5.18	0.0283	5%
Jaw	4.82	1.94	8.11	2.369	0.0039	1%
Tongue	8.82	2.272	11.33	3.571	0.0547	None
Swallowing	4.73	1.272	6.33	1.936	0.0313	5%

TONGUE

Bottle: 64% of the subjects experienced problems with sucking bursts - 5 of the 7 subjects demonstrated prolonged bursts whereas 2 of the 7 demonstrated short sucking bursts. This is markedly different from the previous two groups, who mainly had short sucking bursts. The shift to prolonged rather than short may be due to maturation and better coordination of movements and/or it may be due to the fact that this group may have better endurance because they had a higher average current weight, higher Ballard scores and no history of congenital infections, pneumonia or BPD, compared with Group 2. The flow rate was slow in only 27% of the subjects. Difficulties with an elevated tongue tip and arrhythmic

tongue movements were recorded in only 20% of cases in each of the items (see Table 5.12).

Cup: Sucking bursts caused the biggest problems in this subsection as well - 50% of the subjects demonstrated a prolonged or short burst and a further 30% no sucking burst at all, with a resulting poor flow rate (40% of cases) and no flow rate in 20% of the cases. The movement of the tongue was either arrhythmic (40% of cases) or absent (30%) (see Table 5.12).

The mean scores for tongue functioning did not differ significantly in this age group (see Table 5.13). Both feeding methods presented difficulties with sucking bursts, which seemed to be generally prolonged rather than short in this group.

SWALLOWING

Bottle: Uncoordinated swallowing occurred in 40% of the subjects, multiple swallows in 20% and delayed swallows in only 10%. A marked improvement in delayed swallows was observed for this group compared to the previous group. It seems that the rhythmic, anterior-posterior movements of the tongue during longer sucking bursts, facilitated timely swallowing. This links up with the opinion of Morris & Klein (1987) that effective sucking facilitates effective swallowing.

Cup: Uncoordinated swallowing occurred in 60% of the cases, multiple swallows in 40% and delayed swallows in 30%. No real improvement compared to the previous group was observed. The problems in swallowing correlate with the problems in tongue functioning, which again supports the view of Morris & Klein (1987).

The difference in swallowing skills between bottle- and cup-feeding is **statistically significant** at a 5% level (p-value 0.0313), in favour of bottle-feeding. Bottle-feeding appears to be more facilitative for effective swallowing than cup-feeding.

In summary the oral feeding skills of Group 3 during the oral preparatory /oral phase can be described as follows:

Although the rooting reflex was diminished in 80% of the subjects, the **lips** could purse to initiate oral feeding for bottle-feeding very well, but tended to purse excessively for cup-feeding. This implies that the rooting reflex may not influence the ability to initiate bottle-feeding. Morris & Klein (1987) stated that diminished oral reflexes reduce the efficacy of sucking. According to the findings of this study, the rooting reflex may be excluded from this statement. Closure around a nipple to prevent loss of liquid was effective in nipple-feeding, although a few subjects still had difficulty in maintaining this closure for more than 2 minutes. Comrie & Helm (1997) stated that infants rely on sucking pads for support with lip closure. This group, however, had the highest incidence of absent sucking pads (60%), but maintained closure relatively well, with minimal liquid loss. Cup-feeding resulted in weak or absent closure of the lips and moderate to extensive liquid loss was recorded, due to the fact that a seal could not be formed around the cup. The question can be raised of whether sucking pads would have aided lip closure during cup-feeding. If we look at Group 2, the presence or absence of sucking pads does not seem to make a difference, as they were the group with the lowest incidence of absent sucking pads, but had more problems in maintaining a closure. This study, therefore, does not support the above-mentioned statement of Comrie & Helm (1997). The subjects also found it difficult to perform rhythmic and/or coordinated movements with the lips during cup-feeding.

Consistent **jaw** depression to initiate bottle-feeding and normal rhythmic movements to maintain it were evident in this group. Jaw depression was more inconsistent with cup-feeding and minimal to no excursions to maintain the cup-feeding occurred. It may be argued that cup-feeding may be an unnatural method of feeding and that the oral structures are generally less adapted to the form of a cup.

The **tongue** formed a central groove to provide a channel for the bolus to be propelled with rhythmic anterior-posterior movements into the pharynx. During cup-feeding, however, the rhythmic movements were problematic. This may be due to the fact that good lip movements facilitate sucking (Morris & Klein, 1987) and because lip movements were absent and/or arrhythmic, the tongue movements during sucking from a cup were compromised. Inappropriate sucking bursts were still a problem, but shifted more towards prolonged (5-20 sucks per burst) than too short sucking bursts (less than 3 sucks per burst). A possible explanation may be that the shift to prolonged bursts may be due to maturation and better coordination of the tongue movements and/or the fact that the subjects had better endurance, as they had a higher average current weight and Ballard scores and no history of congenital infections. They were thus relatively healthy and strong.

Although **swallowing** was still uncoordinated, there were fewer delayed and multiple swallows for bottle-feeding, while a few more subjects still displaying delayed and multiple swallows during cup-feeding. The improved oral feeding skills demonstrated in this group correlate with the fact that only 54% of them still received mainly nasogastric feeding. Although, according to their good performances with bottle-feeding, this percentage could be higher, the fact that most of the subjects were receiving cup-feeding at the time of the evaluation, which caused more problems, may be the reason why nasogastric feeding was still preferred by the staff.

Group 3 managed bottle-feeding **significantly** better than cup-feeding in the oral preparatory/oral phase, except for tongue functioning, which was similar. So far, this group, as the most mature of the three subject groups, demonstrated the best oral feeding skills.

□ **Group 4 (37 weeks gestational age)**

The results are summarized in Table 5.14. The mean scores for the different oral structures, the p-value for the difference between bottle and cup-feeding and the level of significance are presented in Table 5.15.

This group performed slightly poorer with bottle-feeding than Group 3, which was a week younger. With cup-feeding they performed slightly worse in the numerical 2 scores (moderate/disorganised), but better in the numerical 3 scores (severe/dysfunctional), resulting in an improvement of the total score.

Table 5.14 Problems experienced by Group 4 during the oral/oral preparatory phase

Score	Group 4 (37 weeks) N=10			
	2		3	
	Bottle	Cup	Bottle	Cup
Feeding Method				
LIPS/Pursing				
Closure	1	1	0	1
Maintain	0	3	0	0
Loss of Liquid	1	4	0	4
Movement/Arrhythmic				
" / Uncoordinated	1	5	0	1
	3	4	0	1
	3	3	0	1
JAW/Depression				
" / Movement / Arrhythmic	1	6	0	0
" / " / Minimal / absent	3	4	0	1
" / " / Lack rate change	3	7	0	0
	0	5	1	1
TONGUE / movement / protrusion				
" / " / Elevated / retracted	2	2	0	1
" / " / Arrhythmic / weak	3	2	0	0
Sucking bursts	2	4	1	2
Flow rate	9	7	1	2
Bolus formation	5	7	0	0
SWALLOWING/uncoordinated/absent				
" / Delayed / absent	1	1	0	0
" / Multiple / no	0	1	0	0
	3	2	0	0
TOTAL	42	70	3	15
2+3	45	85		

The results are discussed according to the information and structure of Table 5.14.

LIPS

Bottle: Arrhythmic and uncoordinated movements of the lips were demonstrated in 30% of the subjects, which is slightly worse than Group 3 (see Table 5.14).

Cup: The main problem during cup-feeding was moderate liquid loss in 50% of the cases and an additional 10% exhibited extensive liquid loss. They also had trouble in maintaining the closure for more than 2 minutes (40% of subjects) and for less than 2 minutes (40% of the subjects), which accounts for the extent of liquid loss. Between 30 and 40% of them demonstrated arrhythmic and uncoordinated lip movements (see Table 5.14)

Lip functioning in this age group is **significantly** better during bottle-feeding than during cup-feeding (Table 5.15 – p-value 0.0156; 5% level of significance)

Table 5.15 The comparison between bottle- and cup-feeding in Group 4

	Group 4 (37 weeks) N=9					
	Bottle		Cup		Bottle – cup	
	Mean	SD	Mean	SD	p-Value	Level of significance
Lips	6.9	0.99	1	3.162	0.0156	5%
Jaw	4.9	1.595	6.89	20.88	0.025	5%
Tongue	9.5	1.434	10.67	2.345	0.125	None
Swallowing	4.5	0.972	4.67	0.866	0.312	None

JAW

Bottle: Minimal excursion and arrhythmic movements of the jaw each occurred in 30% of the cases (see Table 5.14).

Cup: 60% of the subjects had difficulty to initiate depression of the jaw. Minimal excursion was demonstrated in 70% of the cases and arrhythmic movements in 40% of the subjects. Half of them did not change sucking rate between NNS and NS (see Table 5.14).

The difference in jaw functioning between bottle- and cup-feeding was statistically **significant** (5%) in favour of bottle-feeding (see Table 5.15).

TONGUE

Bottle: Few problems were experienced with anterior-posterior rhythmic movements (20%), but sucking bursts were problematic in 90% of the subjects, two-thirds displayed short and one-third prolonged sucking bursts. Group 3 demonstrated bursts that were more prolonged. It seems that regression to short bursts had taken place. If the fact is taken into account that this is the group with the highest number of small for gestational age infants (90% of the subjects), it correlates with the findings of Mullen et al. (1988) that SGA infants display more feeding problems than their AGA peers. The flow rate was expectedly poor as a result of the short sucking bursts (see Table 5.14).

Cup: Arrhythmic movements occurred in 40% of the subjects. Sucking bursts during cup-feeding were short (70% of cases) or absent (20% of cases), resulting in a poor flow rate (see Table 5.14).

Although arrhythmic movement of the tongue occurred in more subjects during cup-feeding, the sucking bursts during both feeding methods were too short. The difference in the mean score between cup- and bottle-feeding was not statistically significant (see Table 5.15). This implies that the manner in which the tongue shapes around the nipple is facilitative of strong, rhythmic movement, but that the length of the sucking burst is not affected by the feeding method in this subject group.

SWALLOWING

Bottle: Multiple swallows occurred in 30% of the cases (see Table 5.14).

Cup: Relatively few problems were experienced with swallowing - only 20% of the subjects demonstrated multiple swallows (see Table 5.14).

No statistically significant difference between the two feeding methods was found for swallowing (see Table 5.15).

In summary, the oral feeding skills of Group 4 can be described as follows:

The **lips** could purse to initiate bottle- and cup-feeding, close around the nipple and maintain this closure to provide a seal to prevent liquid loss. During cup-feeding, however, the closure and maintenance thereof were more problematic and moderate liquid loss still occurred in half of the subjects. Lip movements still tended to be arrhythmic and uncoordinated in approximately a third of the subjects for both feeding methods. The lip functioning during cup-feeding for this group is better than for Group 3 in the sense that fewer numerical scores of 3 (severely dysfunctional) were awarded to this group for lip functioning.

Jaw depression for bottle-feeding was consistent, but was difficult to initiate in cup-feeding. Arrhythmic movements occurred in approximately a third of subjects for both feeding methods, but twice as many of the subjects demonstrated minimal excursions of the jaw with cup-feeding than with bottle-feeding. The rate of movement was similar to the rate in NNS in half of the cases during cup-feeding, but during bottle-feeding the rate of movement was 1 per second.

All subjects displayed central grooving of the **tongue**. In all of the subjects, the movement of the tongue was symmetrical, but 20% of them demonstrated mild protrusion of the tongue during the anterior-posterior movements. This protrusion did not, however, interfere with function. Another 20-30% demonstrated elevation of the tongue tip, but no retraction of the tongue tip was observed. Arrhythmic movements in the tongue were a problem in 20% of the cases during bottle-feeding and 40% of the cases during cup-feeding. Rhythm seems to be affected

in all of the oral structures involved in this phase. This fact correlates with the literature, which states that arrhythmic movements are problematic in premature infants (Morris & Klein, 1987; Bosma, 1993), although only a few infants in this group displayed it. A more serious problem throughout all groups, is the occurrence of short sucking bursts with associated poor flow rates. This applies to cup- as well as bottle-feeding. Only 10% of the subjects demonstrated appropriate sucking bursts with appropriate pauses during both feeding methods. During bottle-feeding, two-thirds of the subjects demonstrated short bursts and one-third, prolonged bursts. One subject showed no sucking bursts at all. During cup-feeding, 70% displayed short bursts and 2 subjects displayed no bursts at all. It is interesting to note that there seemed to be a shift towards prolonged bursts in Group 3, as it appeared that their oral motor skills improved with maturation but coordination with breathing still needed refinement. Group 4 regressed to short bursts and generally scored poorer than Group 3 in all of the items in this section. A possible explanation may be that this group is the group with the greatest number of SGA infants (90%) and has the highest incidence of abnormal body tone (40%). Mullen et al. (1988) found that SGA full-term infants had more oral feeding problems than AGA full-term infants. The findings in this study correlate with that. This has the implication that weight does play a roll in oral feeding skills (especially sucking bursts) and not only neuro-maturational factors, as stated in the literature (Brake et al., 1988; Creger, 1995; Vergara, 1993). It was speculated earlier that this group may not be representative of 37-weeks gestational age infants in general and oral feeding skills of this group should not be generalized to other AGA 37-week-old infants in the light of the above-mentioned facts.

There was, however, an improvement in swallowing, namely, that the swallows that were performed were more timely and more coordinated than in the previous age group. Multiple swallows also decreased during cup-feeding (Tables 5.12 & 5.14). Swallowing as such may therefore be more associated with neuro-maturity than weight.

. 2 Pharyngeal Phase

The information for this phase was obtained by observation and performing cervical auscultation. The data was recorded under the subheadings: Pharyngeal Phase on page 7 and Cervical Auscultation on page 8 of the FEFARI for bottle-feeding. Data for cup-feeding were recorded under the same headings but on pages 10 and 11, respectively.

The results are summarized in Table 5.16 and visually presented in Figure 5.10.

Table 5.16 Subjects with deviant behaviour during the pharyngeal phase

	Group 1		Group 2		Group 3		Group 4		TOTAL			
	BottleCup		BottleCup		BottleCup		BottleCup		Bottle		Cup	
	N=10	N=10	N=10	N=11	N=11	N=9	N=10	N=9	N=41		N=39	
Voice Quality	2	4	3	2	2	3	5	4	12	29.30%	13	33.30%
Suck-Swallow-Breathing	7	9	6	10	1	5	8	8	22	53.70%	32	82.10%
Naso-pharyngeal reflux	0	0	0	1	0	0	0	0	0	0	1	2.60%

The most problematic aspect of the pharyngeal phase was the coordination of sucking, swallowing and breathing. Discussion of the results according to Table 5.16 follows.

□ Group 1 (34 weeks gestational age)

Bottle: The suck-swallow-breathing (SSB) sequence was associated with stress in 70% of the subjects and gurgly sounds (voice quality) in the pharynx could be detected by cervical auscultation in 20% of the subjects, which correlates with the 20% who displayed delayed swallows (see Table 5.8). This implies that swallowing is not very efficient in a small percentage of the subjects and may explain why half of them used multiple swallows to clear the pharynx (see Table 5.8).

Cup: 90% of the subjects experienced stress with the SSB sequence and gurgly sounds could be detected in 40% of them (see Table 5.16). This correlates with the slow bolus formation which occurred in 40% and/or delayed swallowing which occurred in 30% of the subjects. Swallowing was also ineffective during cup-feeding, as 50% also used multiple swallowing to clear the pharynx. This may explain why so many subjects experienced stress during swallowing. They constantly might have feared that their respiratory system was in danger. The reason why the swallowing at this age is ineffective, uncoordinated and disorganised may be due to their neuro-behavioural immaturity (Brake et al., 1988; Morris & Klein, 1987; Wolf & Glass, 1991).

According to Figure 5.10, more subjects experienced problems with voice quality and the SSB sequence during cup-feeding than during bottle-feeding, although the difference according to the p-value (0.375) of the overall score for the pharyngeal phase is statistically not significant. Aspects will have to be considered in isolation to determine which method of feeding is favoured for that particular group in order to plan appropriate intervention, as the total scores do not provide such information.

□ Group 2 (35 weeks gestational age)

Bottle: The SSB sequence was associated with stress in 60% of the subjects and gurgly sounds were recorded in 30% of the subjects (see Table 5.16), which also correlates with the occurrence of delayed swallows in this group. The stress associated was slightly reduced in comparison to the previous age group and accordingly also the number of multiple swallows (see Tables 5.8 and 5.9).

Cup: From Table 5.16 it is clear that the stress caused by the SSB sequence was observed in 90% of the subjects and the voice quality was marked by gurgly sounds in only 18% of the subjects. The low percentage of gurgly sounds correlates with the low number of subjects (2) who displayed delayed swallows.

The high percentage of related stress (90%) correlates with the high percentage of multiple swallows (70%) that occurred during cup-feeding in this age group. Multiple swallows may be an attempt to clear the pharynx from an incomplete swallow due to neuro-behavioural immaturity. On the other hand, they may feel threatened by a bolus that may possibly be too large and may use multiple swallows to clear away the “danger” and become stressed by the situation. Only one subject demonstrated naso-pharyngeal reflux. Although Plaxico & Loughlin (1981) indicated this as a cause for apnea which needs consideration during feeding management, this study did not find a high incidence of naso-pharyngeal reflux and this was therefore not regarded as a major risk for these infants.

The number of subjects displaying problems with voice quality, the suck-swallow-breathing sequence and naso-pharyngeal reflux during the pharyngeal phase is visually presented in Figure 5.10.

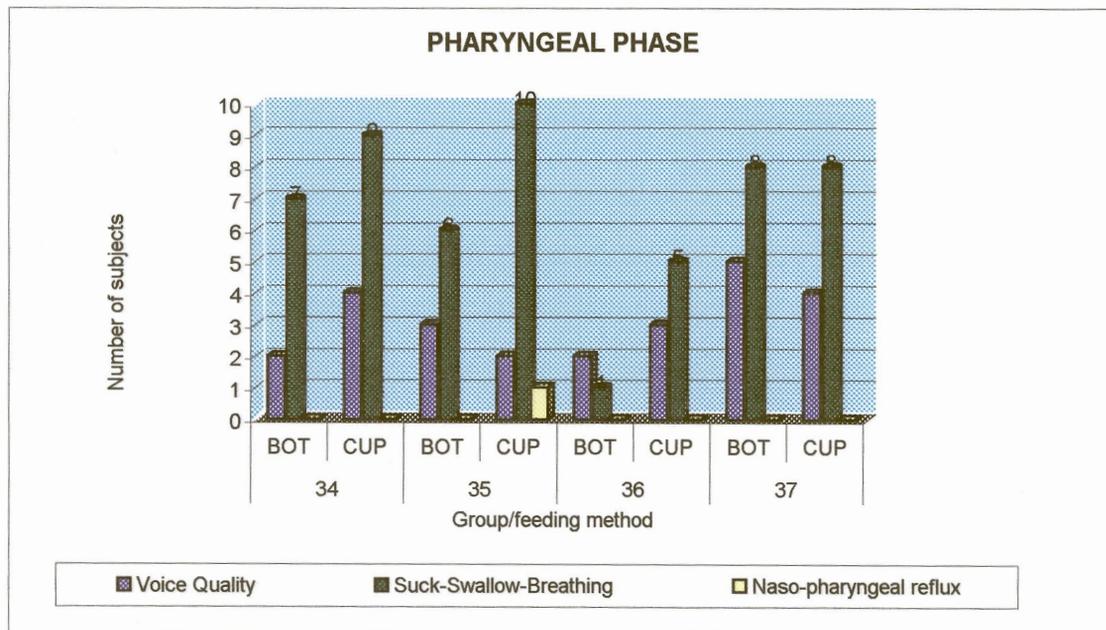


Figure 5.10 Subjects who displayed deviant behaviour during bottle- and cup-feeding in the pharyngeal phase.

According to Figure 5.10, a relative big difference between SSB for bottle- and cup-feeding can be seen in favour of bottle-feeding for age groups 34, 35 and 36 weeks gestational age. Although there was a visible difference for SSB during both feeding methods for Group 2 (35 weeks gestational age), the difference in the total score for performances in the pharyngeal phase was statistically not significant (p -value 0.37), so each aspect will have to be looked at in isolation to determine which feeding method caused the least problems, in order to plan appropriate intervention.

□ **Group 3 (36 weeks gestational age)**

Bottle: Stress was associated with the SSB sequence in only 1 out of the 11 subjects and the voice quality marked with gurgly sounds, in 20% of the subjects, which correlates with the 20% who displayed delayed swallowing. This group generally displayed good performances during the pharyngeal phase, which correlates with the fact that this was the group with the lowest incidence of nasogastric feeding (54%). In the light of the fact that so few problems were experienced in the oral as well as the pharyngeal phases, it could be expected that more subjects in this group should receive oral feedings. The number of subjects who received tube feedings could manage less than half of their feeds according to the feeding history. During the evaluation for this study, 5 of the 11 subjects experienced fatigue after approximately 5 minutes of bottle-feeding and bottle-feeding had to be terminated. It is interesting to note that those infants who tired more easily, were the subjects with the lower weights at the time of the evaluation (1.34; 1.35; 1.55; 1.6 and 1.79 kg, respectively). The weights of the others in the group, who could manage more than half of their feed, varied from 1.6 to 1.81 kg. This implies that although they may be mature enough and have adequate oral feeding skills to feed orally, infants with lower weights do not have the endurance to complete an oral feed.

Cup: Approximately half of the subjects experienced stress with the SSB sequence during cup-feeding and gurgly sounds could be detected in 30% of the subjects. The incidence of stress associated with the SSB sequence correlated with the findings that about 60% of the subjects demonstrated uncoordinated swallowing and 40% used multiple swallowing to clear the pharynx. The presence of gurgly sounds correlated with the 30% of delayed swallows that were recorded. This group still experienced a considerable extent of problems during cup-feeding, contrary to the relative success they experienced with bottle-feeding.

The total score of cup-feeding for the whole subsection does not, however, differ statistically significantly from bottle-feeding, although the differences in two items presented in Figure 5.10 show a marked difference between bottle- and cup-feeding. The same implication as for Groups 1 and 2 applies for this group.

It can be concluded that readiness to feed orally is dependent on the neuro-maturity of an infant, but endurance to complete an oral feeding is related to his/her weight. This has implications for the management of oral feeding in premature infants, namely, that oral feeding may be introduced at the appropriate gestational age (34 weeks) in order to expose the infant to valuable experience in acquiring oral feeding skills. The length of time the infant is exposed to oral feeding will, however, be determined by his/her weight and medical history. This concept ties in with the statement of Wolf & Glass (1991) that experience interplays with maturation to improve the efficacy of oral feeding.

□ **Group 4 (37 weeks gestational age)**

Bottle: 80% of the subjects experienced stress associated with SSB and the voice quality was affected with gurgly sounds in 50% of the cases. This does not correlate with the relative problem-free swallowing found in the oral preparatory/oral phase of this group (see Table 5.14). Multiple swallows were

recorded in 30% of the cases, which may tie in with the occurrence of gurgly sounds. The high incidence of stress may be related to the regression to short sucking bursts in this group. It may be argued that they were uncomfortable with oral feeding due to lack of experience and/or strength, became stressed with the confrontation of a bolus and in an attempt to manage the flow rate and coordinate SSB, reverted to short sucking bursts, as they were more mature to make such adaptations. Brake et al. (1988) stated that oral feeding may improve with experience, as cognitive skills mature. Comrie & Helm (1997) stated that short sucking bursts may be indicative of swallowing dysfunction. This study does not confirm that view in this age group, as their swallowing skills were relatively good (good coordination and timely), although they were executed with associated stress and short sucking bursts were used.

Cup: The same extent of problems were experienced during cup-feeding as in bottle-feeding, although the subjects also performed relatively well with the swallowing items in the oral preparatory/oral phase.

No statistically significant difference between cup- and bottle-feeding was found in this group during this phase, which is also reflected in Figure 5.10. This group, thus experienced the same extent of problems with both feeding methods.

In summary, the oral feeding skill during the pharyngeal phase of all four groups can be described as follows:

All of the subjects demonstrated a laryngeal and hyoid bone elevation when swallowing.

Naso-pharyngeal reflux did not occur in the majority of subjects.

Voice quality was affected due to delayed or inefficient swallowing in approximately a third of the subjects in Groups 1, 2 and 3, and in half of the subjects of Group 4, during both feeding methods.

The SSB sequence was generally stressful (82% of the total group), with the lowest incidence in Group 3, which correlates with the good performance that they displayed in the oral preparatory/oral phase. This may be an indication that oral feeding skills improve with maturity as expected according to the literature (Brake et al., Creger, 1995; 1988; Wolf & Glass, 1991). Group 4, however, was the oldest group but displayed more problems during both the oral preparatory/oral phase and the pharyngeal phase than Group 3. A possible explanation may be that Group 4 had the highest incidence of SGA infants (90%). Mullen et al. (1988) found significant differences in the oral feeding skills of SGA and AGA infants, implying that the oral feeding skills of this group may not be representative of the feeding skills of all 37-week infants and that weight does play a roll in the efficiency of oral feeding skills.

Breathing rate could not be recorded due to practical problems in the unit. The heart rates changed during the course of the feed, but never resulted in bradycardia or tachycardia. The stress symptoms that they experienced will be discussed under Impact on Physiological Status (par. 5.2.2.3).

. 3 Oesophageal Phase

The information was obtained by observation and was recorded under the subsection Oesophageal Phase on page 7 for bottle-feeding and page 10 for cup-feeding in the FEFARI (Appendix A).

A summary of the problems displayed is presented in Table 5.17.

Table 5.17 Subjects who displayed problems during the oesophageal phase.

Feeding method	Group 1		Group 2		Group 3		Group 4		TOTAL			
	Bottle	Cup	Bottle	Cup	Bottle	Cup	Bottle	Cup	Bottle		Cup	
N	10	10	10	11	11	9	10	9	41		39	
Emesis after feed	0	0	1	0	0	0	1	0	2	4.90%	0	0
GER	0	0	0	1	0	0	0	0	0	0	1	2.60%

Very few problems were observed in the subjects during this phase for both feeding methods.

Groups 1-4

Emesis less than 30 minutes after bottle-feeding occurred in only one of the subjects in each of Groups 2 and 4. Gastro-oesophageal reflux (GER) occurred in only one subject, receiving cup-feeding in Group 2 (Table 5.17). Emesis during a feed was not a problem and emesis more than 30 minutes after a feed did not cause any problems either. Projectile vomiting and truncal arching also did not occur in any of the subjects. Although GER occurred, the incidence was very low (Table 5.17). This implies that the oesophageal peristalsis has matured to the extent that boluses could be managed effectively by the esophagus. It therefore does not support the view of Gryboski (1969) that oesophageal peristalsis is only well developed at 37-40 weeks gestational age, but rather supports the statement by the WHO (WHO, 1989) that peristalsis can be activated and organised from 34 weeks.

In conclusion, nutritive sucking in the premature subjects can be summarized as follows; During the oral preparatory/oral phase, uncoordinated and arrhythmic lip, jaw and tongue movements improved with maturity. The lips functioned well in terms of the ability to purse in order to initiate sucking with bottle-feeding, as well as maintaining the closure to prevent liquid loss. Jaw depression was only a problem in Group 1, thereafter the subjects could depress the jaw to effectively initiate bottle-feeding. Minimal excursion of the jaw was mainly a problem in cup-feeding. The tongue formed a central groove but short sucking bursts were displayed in 3 of the 4 groups. Swallowing was generally uncoordinated and delayed. Multiple swallows also occurred. Delayed and multiple swallows improved with maturity.

During the pharyngeal phase, the sucking-swallowing and breathing sequence was associated with stress, but this also seemed to decrease with maturity.

Few problems were experienced during the oesophageal phase.

5.2.2.3 Impact on the Physiological Status

The information was obtained by observation of the stress symptoms and the recording of data from the oximeter (saturation level and heart rate). This was entered in the FEFARI (Appendix A) under the headings **Pharyngeal phase – Stress symptoms**, page 7, and **Pulse Oximetry**, page 8, for bottle-feeding and pages 10 & 11 for cup-feeding.

. 1 Stress Symptoms

The **stress symptoms** were divided into nine moderate and nine severe symptoms. The results of the stress symptoms are summarized in Table 5.18 and visually presented in Figure 5.11. Other symptoms included in the FEFARI which was not displayed by any subject was excluded from Table 5.18.

Table 5.18 Subjects displaying stress symptoms.

Feeding method:	Group 1		Group 2		Group 3		Group 4		TOTAL			
	Bottle	Cup	Bottle	Cup	Bottle	Cup	Bottle	Cup	Bottle		Cup	
Moderate stress:												
Fatigue	2	1	1	2	3	2	0	1	6	14.6%	6	15.4%
Yawning	1	0	0	0	0	0	1	0	2	4.9%	0	0.0%
Hiccups	0	0	1	0	0	0	0	1	1	2.4%	1	2.4%
Flared nostrils	1	0	0	1	0	0	1	0	2	4.9%	1	2.6%
Crying	0	2	0	0	0	4	1	2	1	2.4%	8	20.5%
Averting gaze	1	0	1	0	0	0	0	0	2	4.9%	0	0.0%
Fisting	0	0	0	0	0	0	2	1	2	4.9%	1	2.6%
Severe stress:												
Falling Asleep	2	7	4	4	3	4	5	6	14	34.1%	21	53.8%
Coughing	0	1	1	3	0	0	1	0	2	4.9%	4	10.3%
Choking	2	0	0	1	0	0	0	0	2	4.9%	1	2.6%
Noisy Breathing	2	2	2	2	1	0	4	3	9	22.0%	7	17.9%
Colour change	1	0	0	0	0	0	1	0	2	4.9%	0	0.0%
Chest Retraction	1	2	1	0	0	0	0	0	2	4.9%	2	5.1%
Stridor	1	2	2	0	1	1	2	0	6	14.6%	3	7.7%
Actively refusing feed	4	5	1	2	1	4	1	3	7	17.1%	14	35.9%
TOTAL number	18	22	14	15	9	15	19	17	60		69	

The two symptoms displayed most often in the group as a whole, for bottle- and cup-feeding, fell into the severe category, namely falling asleep and actively refusing the feed.

Figure 5.11 provides a visual presentation of the number of subjects displaying each of the stress symptoms in the gestational age groups of 34, 35, 36 and 37 weeks (Groups 1 – 4). Bottle- and cup-feeding data for each age group is presented separately to provide a visual image of the difference between the two feeding methods.

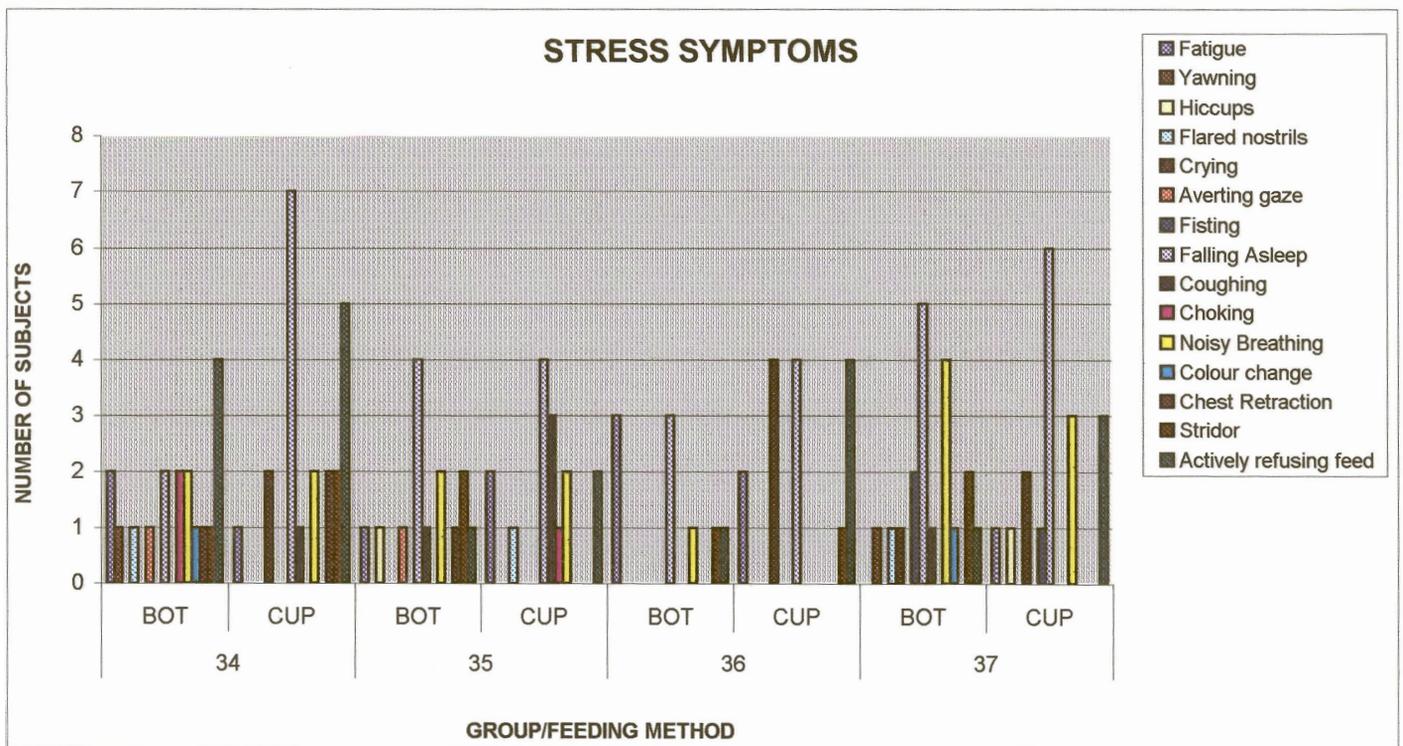


Figure 5.11 The stress symptoms displayed by the different subject groups during bottle and cup-feeding

Information in Table 5.18 and Figure 5.11 will be discussed for each group.

□ **Group 1** (34 weeks gestational age)

Bottle: 40% of the subjects displayed severe stress by actively refusing the nipple after a few minutes of bottle-feeding. 20% of the subjects displayed each of the following symptoms: fatigue, falling asleep, choking and noisy breathing (see Table 5.18). The rest of the symptoms were displayed by either only one, or none of the subjects in this group, as depicted in Figure 5.11.

Cup: 70% of the subjects fell asleep and 50% actively refused the feed after a few minutes of cup-feeding and the feeding had to be terminated (both severe stress symptoms). The only moderate stress symptom that was displayed in more than one subject was crying, which was displayed in 2 of the 10 subjects. Severe stress symptoms were displayed in 20% of the cases in each of the following symptoms: noisy breathing, stridor and chest retraction (see Table 5.18). These symptoms were all related to the respiratory system. This is the group with the highest incidence of BPD (50%) and history of pneumonia (20%) (see Table 5.2). The incidence in these symptoms, however, was not high. A higher number of subjects experienced severe stress with cup-feeding (see Figure 5.11).

□ **Group 2** (35 weeks gestational age)

Bottle: 40% of the subjects fell asleep during the feed and 20% of them displayed each of the following severe symptoms: noisy breathing and stridor (see Table 5.18).

Cup: 40% of the subjects receiving cup-feeding fell asleep, 30% coughed, and 20% displayed each of the following: fatigue, noisy breathing and actively refusing the feed (see Table 5.18).

Similar stress was experienced during both feeding methods, as depicted in Figure 5.11, with the highest incidence in falling asleep for both. This is the group

with the highest incidence of congenital infections (30% - Table 5.2). The implication is that those subjects may still be weak and have poor endurance for oral feeding, reacting to it by falling asleep, which may be considered as severe fatigue.

□ **Group 3** (36 weeks gestational age)

Bottle: 30% of the subjects displayed the moderate symptom of fatigue and 30% the severe symptom of falling asleep.

Cup: Of the moderate symptoms, 40% of the subjects displayed crying and of the severe symptoms, 40% of the subjects displayed each of the following: falling asleep and actively refusing the feed.

A little more stress was experienced during cup-feeding than during bottle-feeding (see Figure 5.11). This group experienced the least stress during bottle-feeding of all groups, and the same during cup-feeding as Group 2 (Total number, Table 5.18). Group 3 also had the least problems with oral feeding skills of all groups and may therefore have experienced the least stress.

□ **Group 4** (37 weeks gestational age)

Bottle: More severe than moderate stress symptoms were displayed, namely, 50% of the subjects fell asleep and 40% had noisy breathing. The moderate symptoms that were displayed were fisting and stridor (20% of the subjects for each of the symptoms). This group displayed the most stress during bottle-feeding of all groups (see Table 5.18). This ties in with the fact that they also experienced more problems generally with oral feeding skills.

Cup: Severe symptoms: 60% of the subjects fell asleep, 30% displayed noisy breathing and another 30% actively refused the feed. Moderate symptoms: 20% started to cry during the feed. This group was a little more stressed than the previous two groups, but not as much as Group 1 (see Table 5.18).

The number of subjects displaying different stress symptoms did not differ significantly for the two feeding methods.

In **summary** it may be stated that the stress symptoms which occurred most in the whole group during *bottle-feeding* were: Falling asleep (34.1%), noisy breathing (22%) and actively refusing the feed (17.1%). Groups 1 and 4 displayed the most stress.

The stress symptoms which occurred most during *cup-feeding* for the group as a whole were: Falling asleep (53.8%), actively refusing the feed (35.9%) and crying (20.5%). Group 1 displayed the most stress. These facts imply that approximately a third of premature infants do not have the strength and endurance to complete an oral feed without experiencing stress, particularly cup-feeding.

. 2 Pulse Oximetry

The **heart rate** changed during the whole feeding process, but never below or above the normal limits for premature infants.

The results of the saturation levels before (pre), during (mid), and after (post), feeding for each group, during bottle and cup-feeding are summarized in Table 5.19.

Table 5.19 The range and average percentages of the saturation levels pre-, mid- and post-feeding during both feeding methods.

Method	Group 1				Group 2				Group 3				Group 4			
	Bottle		Cup		Bottle		Cup		Bottle		Cup		Bottle		Cup	
%	Range	Avg	Range	Avg												
Pre-	92-99	96.4	92-99	96.3	92-99	97	93-99	96	93-99	97.2	96-99	96.1	92-98	96.5	92-98	95.3
Mid-	82-99	93.7	85-98	94.2	83-99	93.9	85-97	92.8	92-99	95.2	86-98	92.5	80-97	89.8	83-97	89.6
Post-	90-99	96.6	92-99	97.4	93-99	96.5	90-98	94.6	94-99	96.9	90-98	94.4	92-98	95.6	91-98	94.1
Number of subjects below 90%	2		1		2		3		0		2		5		5	

The **saturation levels** generally lowered during feedings. During cup-feeding, 40.5% of the subjects' saturation levels fell to beneath 90% compared to the 28.2% during bottle-feeding. The range of the saturation levels and the average percentage did not differ much across the different groups before the feeding started.

The mid-feeding readings differed for different groups and for different feeding methods.

□ Group 1

The difference between bottle- and cup-feeding is marginal in terms of their saturation levels. Only one subject had unfavourable saturation levels (under 90%) during cup-feeding and two subjects during bottle-feeding. Although more obvious differences in the stress symptoms were displayed during the two feeding methods in favour of bottle-feeding for this group, this did not seem to influence the saturation levels. It may be argued that they reacted with stress, e.g. falling asleep or refusing the feed to prevent a drop in saturation levels, thus protecting their oxygen status effectively.

□ **Group 2**

The pre-, mid- and post-feeding readings for bottle- and cup-feeding differed slightly (see Table 5.19). During bottle-feeding the saturation levels of 2 subjects dropped below 90% and during cup-feeding it dropped below 90% in 3 subjects. This group displayed slightly fewer stress symptoms (see Table 5.18) than the previous group, but had slightly more infants with unfavourable saturation levels. This is the group with the lowest birth and current weights and second-most SGA infants (see Table 5.1). A possible explanation may be that they try to maintain feeding a little longer because they are a little more mature, by not reacting to the stress by falling asleep or refusing the feed as soon. However, since they are still weak and the energy demands during feeding are high, the saturation levels in a few infants fall below 90%.

□ **Group 3**

A slightly larger drop in the average saturation levels occurred during cup-feeding (pre-mid = 3.6%) than during bottle-feeding (pre-mid = 2%). Two of the subjects' saturation levels fell beneath 90% during cup-feeding, compared to no subjects during bottle-feeding. This implies that infants in this group could maintain their physiological status slightly better during bottle-feeding. This correlates with the recordings for the oral preparatory/oral phase, which favoured bottle-feeding, as well as and the lower incidence of stress symptoms during bottle-feeding.

□ **Group 4**

This group displayed the biggest fall in saturation levels from the pre-feeding to the mid-feeding situation, namely, 6.7% during bottle-feeding and 5.7% during cup-feeding. Approximately half of the subjects' saturation levels fell beneath 90%, which implies considerable stress and problems with coordination of sucking, swallowing and breathing. This correlates with the fact that this group

experienced more problems with the whole feeding process than the previous group. These problems may be the reason why they were still in the NICU despite their maturity.

In **summary** it can be stated that the range of saturation levels did not vary much between the different gestational ages. No statistically significant differences were found between pre- and mid-, pre- and post-, or post- and mid-feeding values for bottle and cup-feeding. The number of subjects whose saturation levels fell below 90%, were slightly higher for cup-feeding (11) than for bottle-feeding (9). This implies that although the oral feeding skills of relatively healthy premature subjects may not be adequate yet, they are able to protect their oxygen levels during oral feeding.

5.2.2.4 Developmental Trends

The information obtained in the oral-preparatory/oral phase on page 6 under the heading: Nutritive Sucking, Subheading: Oral-preparatory/oral phase of the FEFARI (Appendix A), will be used.

The functioning of the lips, jaw and tongue, as well as swallowing during bottle-feeding will be scrutinized in an attempt to identify any pattern of behaviour and/or to identify any developmental trends. Only the information for bottle-feeding will be used, as it is the natural and the most widely used alternative to breast-feeding.

The problems that were experienced by each group for every oral structure are visually presented in the following Figures: Lip - Figure 5.12, Jaw – Figure 5.13, Tongue – Figure 5.14 and Swallowing – Figure 5.15. Discussion of the results will follow in accordance with to the oral structures.

.1 Lips

The number of subjects in each age group who scored a number 2 or 3 for the different items for lip movements, during bottle-feeding is visually presented in Figure 5.12.

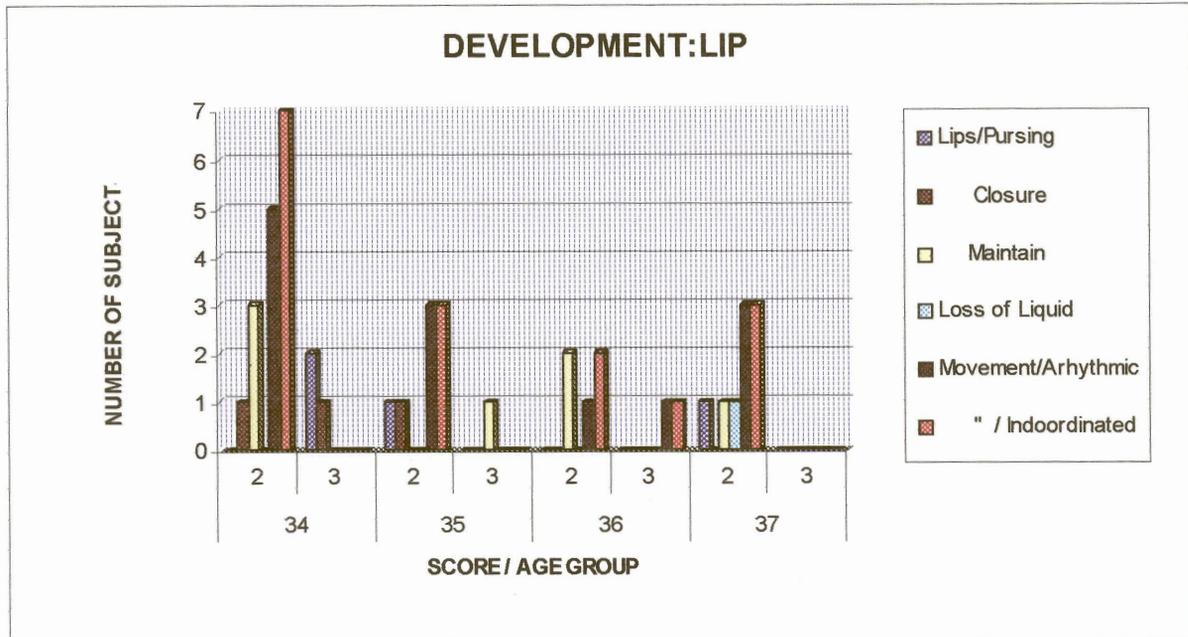


Figure 5.12 The distribution of problem areas in lip functioning for the different groups during bottle-feeding

Uncoordinated lip movements occurred in the highest number of subjects (7) in Group 1 (34 weeks gestational age) (Figure 5.12). The occurrence of uncoordinated lip movements decreased with an increase in gestational age, except for Group 4, but it has already been argued that this particular group may not be representative of other 37-week-old infants. This decrease in occurrence may suggest that coordination improves with maturity, with the biggest improvement between 34 and 35 weeks. This supports the statement of Brake et al. (1988) that premature infants are “unlikely” to feed successfully before 35 weeks gestational age. Arrhythmic movements (Figure 5.12) had the second highest incidence, which also decreased with maturity, except once again, in Group 4. A slight improvement with maturity can also be seen in maintaining the

lip closure (Figure 5.12) and lip pursing to initiate oral feeding. Thus, it may be stated that lip performance improves with maturity.

.2 Jaw

Figure 5.13 visually presents the number of subjects in each age group who scored a 2 or a 3 for different jaw movements.

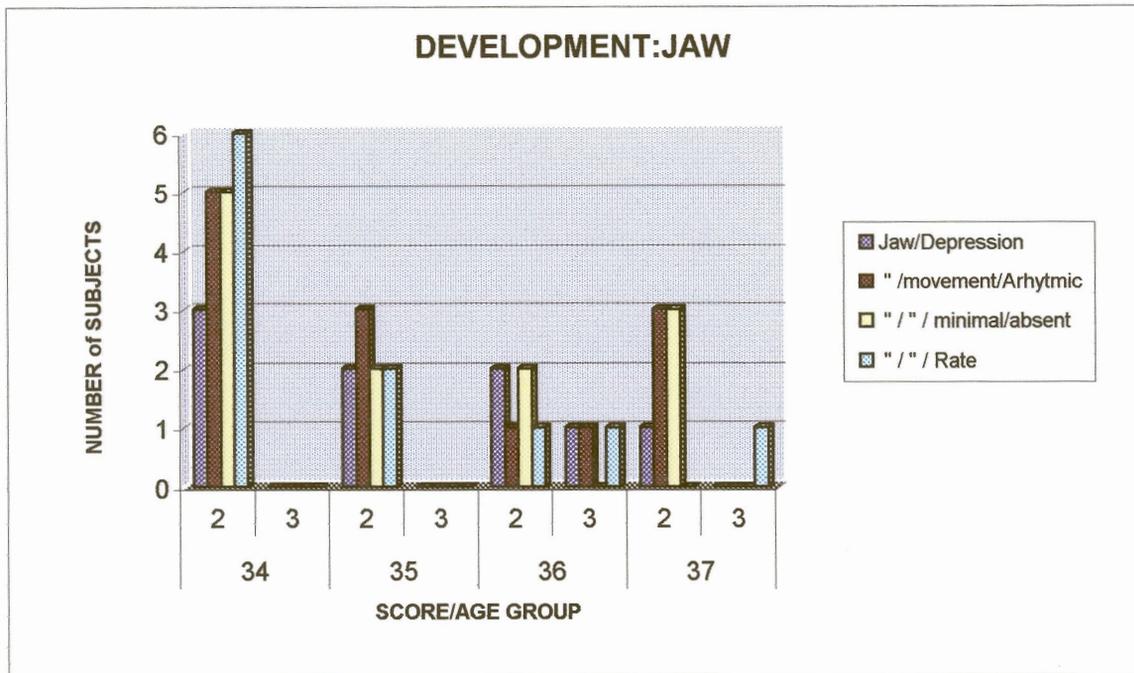


Figure 5.13 The distribution of problems in jaw functioning of the different age groups during bottle-feeding.

The 34 weeks gestational age group (Group 1) displayed the most problems with the change in rate of movement between NNS and NS (Figure 5.13). A marked improvement occurred in the 35 weeks group (6 to 2), after which age only a slight improvement can be observed, according to Figure 5.13. The second highest number of problems displayed by the 34 weeks group was arrhythmic movements of the jaw. According to Figure 5.13, improvement can also be observed, as the number of subjects who had problems decreased from 5 to 3 to 1, except for the 37 weeks group who may not be representative. Minimal movement of the jaw displayed a marked improvement from 34 to 35 weeks (number decreased from 5 to 2). Jaw depression to initiate oral feeding was not a

major problem as only about 20 - 30% of the subjects experienced problems with this item. The marked improvement observed from 34 to 35 weeks gestational age also supports the view of Brake et al. (1988), as mentioned above.

.3 Tongue

The visual presentation of the skills if tongue movements of the subjects, follows:

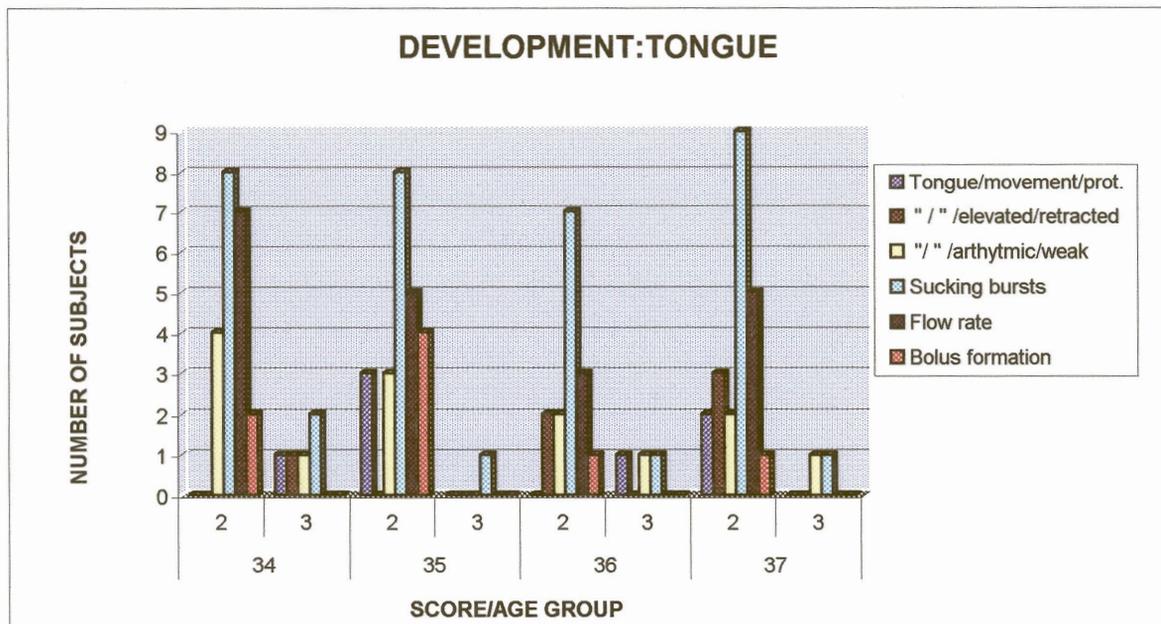


Figure 5.14 The distribution of problems with tongue functioning in different age groups during bottle-feeding.

According to Figure 5.14, inappropriate sucking bursts (prolonged or too short) (numerical score of 2) and/or no sucking bursts (numerical score of 3), were displayed by most subjects and did not change noticeably over the different gestational ages. This implies that development towards appropriate sucking bursts did not occur up to 36/7 weeks gestational age. Morris et al. (1999) found a positive relationship between length of sucking bursts and motor development at 6 months of age. The motor development of premature infants should therefore also be closely monitored and problem areas managed if required. Flow rate indicates that a slight improvement with maturity occurred (except-as expected by now, the 37 week group). Arrhythmic and/or absent movements of the tongue also showed a slight improvement from 34 to 36 weeks gestational age

Apart from sucking bursts, slight improvement in tongue functioning seemed to have occurred with an increase in maturity.

.4 Swallowing

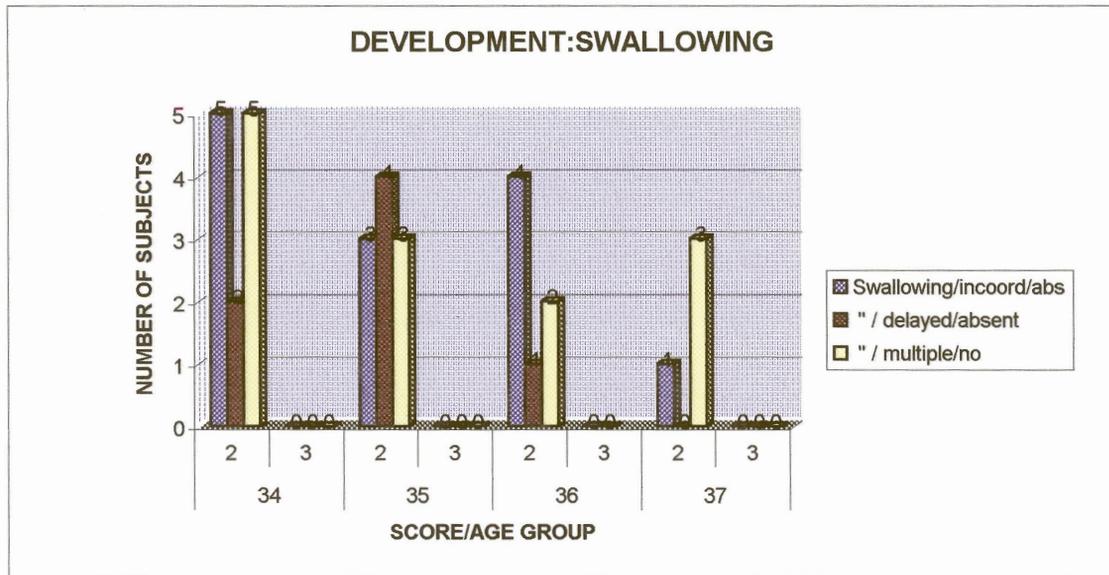


Figure 5.15 The distribution of problems with swallowing in the different age groups during bottle-feeding.

According to Figure 5.15, the coordination of swallowing seemed to be a problem in 30-50% of the subjects until they were 37 weeks gestational age. Group 4 had many problems related to lip, jaw and tongue movements, as well as with stress associated with swallowing. Yet, the ability to coordinate the swallowing seemed to have matured. Multiple swallows indicated a slight improvement from 34 to 36 weeks gestational age. The increase in multiple swallows in the 37-week group was associated with stress as discussed previously. Delayed swallowing varied and did not follow a particular pattern. Thus, according to Figure 5.15, it can be stated that the only aspect which seemed to have improved with maturity, was multiple swallowing.

In **conclusion**, it may be stated that oral motor skills of the subjects improved with maturity. The biggest improvement was observed between 34 and 35 weeks gestational age in terms of the coordination of lip movements, the rate change in jaw movements between NNS and NS, rhythmic movements and normal excursion of the jaw during bottle-feeding. Slight improvements were also observed in the pursing of lips to initiate the feed, the maintenance of the closure, the rhythmic movement of the tongue and the use of multiple swallows by the subjects.

5.3. CONCLUSION

The FEFARI proved to be invaluable for the description of the oral feeding skills of premature infants who served as subjects.

A very high percentage of the subjects used in this study were SGA (76%), and lethargic (83%) at the time of the evaluation. This with the presence of respiratory problems appeared to significantly influence their oral feeding skills. Little problems were experienced with NNS. Subjects in all the gestational age groups investigated generally managed bottle-feeding better than cup-feeding, especially in the oral preparatory/oral phase. The problems which occurred most in this phase, were arrhythmic and uncoordinated movements of the lips, jaw and tongue. Sucking bursts were problematic and multiple swallows were used by the younger groups, until swallowing became more coordinated and effective. During the pharyngeal phase the coordination of sucking, swallowing and breathing caused most of the problems upon which the subjects reacted to with considerable stress. The oral feeding skills of the subjects can be described as disorganised rather than dysfunctional. Oral feeding skills improved with gestational age, but weight played a role as well, as SGA subjects experienced more problems. The information obtained from the FEFARI provided a variety of guidelines for oral feeding intervention strategies.

5.4. SUMMARY

In this chapter, the results were described and discussed according to the sub-aims set out for this study. The results were firstly presented with regard to the description of the characteristics of the subjects and secondly with regard to their oral feeding skills which included both NNS and NS. Nutritive sucking was discussed according to the different phases of swallowing and the impact thereof on the physiological status of the subjects. Developmental trends were identified based upon the results obtained in this study.

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

Aim: To present the general conclusions of this study and to discuss the clinical implications of the results. The study is furthermore critically evaluated and recommendations for further studies are made.

6.1 INTRODUCTION

This study has highlighted the importance of early oral feeding intervention in premature infants which are part of an increasing population of infants/young children who require early intervention (Rossetti, 1996; Oehler et al., 1996; Widerstrom et al., 1997). As part of a team, the speech-language therapist often fulfils the role as the feeding specialist responsible for the successful and speedy transfer from nasogastric to oral feeding.

Early intervention for premature infants already starts in the NICU. This is based on the principle that the sooner intervention is introduced, the better the developmental outcome of the infant (Hyde & Jonkey, 1994; Rossetti 1998). A major proportion of premature infants experience oral feeding problems. This can have serious consequences for the premature infant (Bu'Lock et al., 1990; Lau & Hurst, 1999). Special consideration should be given to the oral feeding skills of the premature infant in the NICU, as the ability to take oral feeds successfully and reaching an acceptable weight (usually 1.8 – 2 kg) are often used as criteria for the discharge of these infants. Earlier discharge of a premature infant has significant advantages, such as: *Financial* – in state hospitals on a tight budget, a few days earlier discharge from a NICU is highly desirable. For infants in the NICU of a private hospital, the financial burden upon parents can be alleviated

substantially by a few days shorter hospital stay. *Psychological* – an earlier discharge enhances the mother-infant relationship and bonding, and the family routine can begin. Furthermore, mothers of infants with feeding problems suffer from a variety of negative feelings, e.g. anxiety, despair and unworthiness, etc., which can be avoided or decreased with appropriate early feeding intervention. *Communication* - a relationship between disorganised neonatal oral motor skills and delays in speech and language development at 30 months of age was found (Brake & Palmer, 1985) and Kritzinger (1994) found that the length of nasogastric tube feeding was a strong predictor of communication development. Early feeding intervention will therefore not only be beneficial for the infant itself, but also for the parents and hospital authorities. Efficient, accountable feeding intervention has to be preceded by a comprehensive, holistic evaluation.

The FEFARI designed for this study therefore included aspects other than only the oral-motor skills of these infants to ensure appropriate evaluation of their feeding skills. It also addressed the need expressed by Jolley et al. (1995) for a detailed assessment of feeding and swallowing abilities of premature infants, which includes aspects such as physiological and cardio-respiratory status as well as nutritive and non-nutritive sucking. Feeding therapy based on the information gathered by such a comprehensive evaluation, and in consultation with other team members in the NICU, is therefore the responsible accountable procedure. The feeding specialist should thus also have specialised knowledge of the premature infant as a whole in addition to all the medical complications that may occur in them (Hyde & Jonkey, 1994).

Since early intervention is still a relatively young discipline and limited information on the oral feeding skills of premature infants exists in the literature, more research in this field is necessary to improve the oral feeding services to this population, as oral feeding skills in these infants play such an important roll in their little lives, as briefly explained previously.

The aim of this study, then, was to describe the oral feeding skills of premature infants, in order to improve the understanding thereof by the feeding specialist. In search of an appropriate evaluation tool which would enable the researcher to do so, the need for a comprehensive evaluation protocol was identified. The FEFARI was designed and successfully applied to 42 premature infants.

Utilising the results obtained in the FEFARI, the oral feeding skills of the subjects could be described. Valuable information regarding the characteristics of the subjects provided insight into and enhanced the understanding of the influences of biological and medical factors on the oral feeding skills of the subjects. The non-nutritive sucking (NNS) skills as well as the nutritive sucking (NS) skills could be described in terms of the lip, jaw and tongue functioning and their effect on the physiological status of these infants. Swallowing skills could be described and associated stress identified to provide the feeding specialist with intervention guidelines. The influence of bottle- and cup-feeding on the physiological status of the subjects could be determined and information on developmental trends during bottle-feeding from 34 to 37 weeks gestational age could be obtained by using the FEFARI. The results were discussed fully in Chapter 5.

This chapter will discuss the conclusions drawn and implications of these results. A critical review of this study is done, followed by recommendations for future research.

6.2 CONCLUSIONS AND IMPLICATIONS

Issues of importance during oral feeding of the subjects, emerged in the results and will be discussed in terms of their theoretical and clinical implications.

6.2.1 CHARACTERISTICS OF THE SUBJECTS

With regard to aspects of the **characteristics** of the subjects, the results raised the following issues:

Gestational age: According to the neuro-maturational criterion of when an infant is ready to feed orally, 47.6% of the subjects were ready *from birth*, as they were at least 34 weeks old, but according to the weight criterion, only 4.8% weighed over 1.8 kg and would have been considered ready. *At the time of the evaluation*, however, all of the subjects would have been neurologically ready to feed orally, but only 16.7% met the weight criterion. According to practices in NICU's (Lau & Hurst, 1999) as well as the local NICU, weight is used to determine the introduction of oral feeding. This implies that these infants were not exposed to oral feeding previously and explains why most of the subjects (80%) still received mainly nasogastric feeding at the time of the evaluation, putting the subjects at risk of the negative effects of long-term tube feeding, as discussed in par 2.4.4. These subjects thus had minimal experience in oral feeding. Experience in oral feeding plays a significant role in the transfer from nasogastric to oral feeding (Brake et al., 1988; Casaer et al., 1982; Wolf & Glass, 1991). The sooner this transfer can occur, the sooner the infant can be discharged. It is therefore clear that introduction of oral feeding should start at the appropriate gestational age of premature infants as advised by the literature (Merenstein & Gardener, 1989; Sheahan & Brockway, 1994; Vergara, 1993).

Weight: About three-quarters of the subjects (76.2%) were SGA, with the highest occurrence in Group 4 (90%). Group 4 experienced significantly more problems during both feeding methods although these subjects were the most mature. The subjects in the other groups with the least endurance to finish their whole feed, also had the lowest weights amongst that particular group. This study therefore also supports the view of Mullen et al. (1988) that SGA infants display more oral feeding problems than AGA infants. Clinically this would imply that although

maturation plays a major role in oral feeding skills, it has become clear during this study that the weight of an infant plays a significant role, contrary to the literature stating that oral feeding is only a neuro-maturational phenomena. A balance should therefore be found between providing the opportunity to suck to gain valuable sucking experience, and sustained weight gain. "The ultimate measure of feeding efficacy is weight gain which reflects the volume taken in, as well as total caloric expenditure" (Wolf & Glass, 1991: 267). Excessive energy expenditure for oral feeding should therefore be avoided, as well as stress, as this could possibly also cause avoidance behaviour and conditioned dysphagia. This implies that the SGA infant should be allowed to gain experience in oral feeding, but that the time of exposure to oral feeding may have to be limited. Other methods of oral stimulation like oral-motor stimulation and NNS may have to be used in a greater degree in SGA infants than in the AGA infants to enhance oral feeding skills and increase the maturation of sucking skills (Bernbaum et al., 1983; Bernbaum & Hoffman-Williamson, 1991; Mattes et al., 1996).

Respiratory Status: 40.5% of the subjects in the whole group suffered from BPD and 16.7% had a cardiovascular condition. These subjects were healthy at the time of the evaluation, but oral feeding experience and endurance to complete the feeds could previously have been affected negatively by the above-mentioned factors. Only 19.5% of the whole group could manage the whole feed at the time of the evaluation, illustrating the possible effect of lack of sucking experience and that the endurance to feed orally was still problematic. During the evaluation with the FEFARI, half of the subjects of Group 4 (the group with the most SGA infants) displayed unfavourable saturation levels, once again demonstrating the problems this group had with oral feeding. Generally, the drop in saturation levels may be due to the uncoordination of sucking, swallowing and breathing. Respiration is ceased every time swallowing occurs. Multiple swallows will therefore result in longer periods of cessation of respiration, which may result in a drop of saturation levels in this group. Approximately one third of the subjects did not have the strength or endurance to complete an oral feed without experiencing severe

stress. This information correlates with the findings of Morris et al. (1999) that respiratory problems contribute greatly to feeding problems in premature infants.

Clinically this implies that SGA infants and/or infants with a history of respiratory problems should be attached to a pulse oximeter so that the saturation levels can be monitored closely during oral feeding for signs of fatigue. The pace of oral feeding and the length of the feeding time can then be adapted according to the needs of these infants. Supplementing oxygen during oral feeding may have to be considered as well. This will ensure a safe and comfortable feeding experience to this group of infants.

It can be concluded that readiness to feed orally may be dependent on the neuro-maturity of the premature infant, but the ability to endure the whole feed is related to the weight and respiratory status of the infant.

State & Behaviour: Most of the subjects were lethargic (85%) at the scheduled time of feeding for their evaluation, which affected oral feeding negatively, especially in terms of endurance to complete a whole feed. The literature is clear that an alert state is a prerequisite for oral feeding (Mandich & Ritchie, 1996), but also recognises that premature infants find it hard to maintain an alert state (Creger, 1995). It can therefore be stated that the subjects were not ready (in terms of the state they were in) to be fed at that particular time, because scheduled feeding times were followed, which may not have correlated with the subjects' natural time to be ready. General practice in NICU's is to feed infants at scheduled feeding times. Cagan (1995) established that a great number of premature infants are ready to feed orally at a time other than the scheduled feeding time. Furthermore, the subjects became stressed during oral feeds and a significant percentage reverted to falling asleep. More subjects fell asleep during cup-feeding than during bottle-feeding.

Clinically, the feeding specialist and staff working in NICU's must therefore know and accommodate these facts and should reconsider the practice of scheduled feeding times and move towards more individual-based feeding needs, as with the individualised developmental programmes (e.g. NIDCAP). Such a change in management may not only lead to improved oral feeding skills of these infants, but may also shorten the time needed to transfer from tube to oral feeding. That may lead to earlier discharge of these infants and hence would be cost-effective intervention.

Although **maturation** plays a major role in oral feeding skills, it has become clear during this study that **weight** and the **medical history** of an infant play an important role in efficient oral feeding as well.

6.2.2 ORAL FEEDING SKILLS

The conclusions and implications with regard to the oral feeding skills are provided below.

6.2.2.1 Non-Nutritive Sucking (NNS)

In conclusion, the NNS skills can be categorised as disorganised and moderately affected, with the most problems occurring with the sucking bursts. NNS skills seemed to deteriorate with maturity in the subjects. A possible explanation may be that sucking may diminish if it is not stimulated (Morris, 1989) and if the infant is often exposed to noxious procedures in and around the oral structures. The fact that NNS skills seemed to deteriorate with maturity in the subjects, highlights the need to provide the opportunity for non-nutritive sucking in the NICU's as early as possible, preferably from birth. The feeding specialist should endeavour to provide the premature infant with appropriate sucking experience. This can further be achieved by training the nursing staff as well as the mothers to provide sufficient NNS opportunities and by informing them about the benefits of NNS. This is

important, not only to avoid the scenario stated by Morris (1989) that infants who once had the ability to suck, may lose it if they are denied the opportunity to do so, but also for all of the many other good reasons found in the literature (Bazyk, 1990; Bernbaum et al., 1983, 1991; Creger, 1995; Lotas & Walden, 1996; Vergara, 1993) as discussed in chapter 4 (4.3.1.2 under .6).

6.2.2.2 Nutritive Sucking (NS)

The conclusions drawn from and implications of the results of NS skills during **bottle- and cup-feeding** will be discussed according to the different phases of deglutition.

Firstly, the *oral preparatory/oral phase*: It can be concluded that the functioning of the oral structures are generally disorganised and oral feeding skills moderately affected in the group as a whole. The most pronounced problems were arrhythmic and uncoordinated movements which were mainly observed in the lips, jaw and tongue. Improvement of rhythm and coordination occurred in the lip and jaw movements with maturity, with the biggest improvement between 34 and 35 weeks gestational age in bottle-feeding. A slight improvement with maturity was displayed from 35 weeks gestational age onwards. The tongue displayed good central grooving from 34 weeks onwards for both feeding methods. The length of the sucking bursts also seemed to increase with maturity. The younger the subjects the more multiple swallows occurred. Oral feeding was the most stressful for the 34-week gestational age-group, whether it was by cup or by bottle. Uncoordinated and arrhythmic movements of the oral structures were problematic in approximately half of the subjects and fatigue was experienced after approximately 5 minutes of oral feeding, but they could sustain good saturation levels.

The clinical implication of these findings is that although 34 weeks gestational age is considered an appropriate age to introduce oral feeding according to the

literature (Arvedson & Brodsky, 1993), oral feeding intervention may have to be provided with great caution at this age. This implies that oral feeding may have to be limited to 5-10 minutes per session to avoid fatigue. The saturation monitors should be used to ensure that the saturation levels stay above 90%. Intervention should be directed towards the facilitation of *rhythm* and *coordination* without causing stress. The advice by Cagan (1995) to feed an infant when he/she gives *clues* that he/she is *ready* to feed, to optimise the learning experience, should also be considered. Even though oral feeding is still problematic at this age (34 weeks), these infants should be exposed to the *experience*, even if it means only the opportunity for NNS, since Casaer et al. (1982) and Brake et al. (1988) found a correlation between feeding efficacy and experience above 34 weeks gestational age. Wolf & Glass (1991), support the importance of experience by stating that experience interplays with maturation to improve efficacy of oral feeding. Further clinical implications according to the information obtained from the FEFARI would be that guidelines are provided for the management for all the age groups, such as the regulation of flow to facilitate appropriate sucking bursts to reduce the possibility of large boluses that may result in multiple swallowing and stress.

Secondly, the *pharyngeal phase*: It can be concluded that most of the problems in this phase occurred with the coordination of sucking, swallowing and breathing. This caused severe stress in the subjects. Swallowing in the subjects of this study can be described as ineffective, uncoordinated and disorganised. Multiple swallows were probably needed because the swallowing was still ineffective. Delayed swallowing is indicative of uncoordinated and disorganised swallowing. The swallowing skills (namely: timely, coordinated swallowing and single swallows), however, improved with maturity. Clinically, this information suggests that oral feeding therapy should be directed at enhancing organization and coordination of swallowing by pacing, for example. The flow can furthermore be regulated to facilitate appropriate sucking bursts and to reduce the possibility of large boluses that will result in multiple swallowing and stress. Ample time should

be allowed for the infant to complete multiple swallows should they still occur, before the next bolus is presented. This should reduce stress experienced in the premature infant during oral feeding and should improve the overall pleasurable experience of oral feeding to these infants. These principles can be applied in the hospital situation as well as in the home environment. Mothers will therefore have to be trained to present oral feedings in the appropriate manner as discussed above.

Lastly, the *oesophageal phase* showed minimal problems in the subjects of this study. This implies that peristalsis of the oesophagus has matured enough to manage the boluses formed by these subjects.

The following statement can be derived from the above-mentioned facts: weight seems to play a roll in the success of sucking skills and sucking bursts, but neuro-maturity plays a bigger role in the competence of swallowing and the functioning of the oesophagus.

Cup-feeding caused more disorganised movements of the lips and jaw, as well as stressful, uncoordinated swallowing, than bottle-feeding in the subjects of this study. The lips and jaw generally functioned significantly better during bottle- than cup-feeding. The smallest difference between bottle- and cup-feeding occurred in Group 1. More stress associated with swallowing was experienced with cup-feeding (82.1% of the total group) than with bottle-feeding (53.7% of the total group) (see Table 5.16). It can thus be concluded that the subjects generally managed bottle-feeding better than cup-feeding.

The clinical implication is that cup-feeding may not be the best method of feeding for premature infants, especially after 35 weeks gestational age. Although the local hospital policy is to present cup-feeding to all premature infants to promote breastfeeding, all premature infants do not end up being breastfed, e.g. a HIV positive mother who chose not put her infant at risk with breastfeeding. Many

practical problems in terms of the availability of the mothers to establish breastfeeding are experienced in the local hospital. The reason for presenting cup-feeding should therefore be considered very carefully when deciding to expose a premature infant to this method of oral feeding. Cup-feeding does not appear to be facilitative for the development of good oral–motor skills associated with sucking and should therefore, as it was intended initially, only be limited to be used as an interim method of oral feeding until breastfeeding can be established. Preterm infants benefit greatly by breast milk even if it is expressed (Boo et al., 2000) and should therefore actively be encouraged. If aggressive attempts to establish breastfeeding have failed, cup-feeding should be terminated in favour of bottle-feeding. If cup-feeding is to be maintained, the mother has to be trained to present the cup appropriately and to provide other stimulation to enhance the transfer to oral feeding (breastfeeding) in order to keep the period of time exposed to cup-feeding to the minimum.

From the afore-going discussion it is clear that the FEFARI designed for and applied in this study, proved to be invaluable in obtaining information that can be used to plan appropriate, effective and accountable intervention strategies for feeding therapy in premature infants in NICU's. It may also be valuable for the use in paediatric wards of hospitals where other infants with feeding problems are treated.

6.2.3 TRAINING OPPORTUNITIES

First of all, the speech-language therapist who wishes to act as feeding specialist in a NICU will have to be trained in all aspects covered by the literature review. He/she will also have to become familiar with the content, application and interpretation of evaluation tools such as the FEFARI and obtain knowledge with regard to various intervention strategies.

The feeding specialist should then be responsible for the training of staff and caregivers or mothers involved with the oral feeding of the premature infants. The nursing staff are involved with these infants 24 hours of the day and are therefore the sensible persons to assist the feeding specialist. The medical staff are important in establishing a clinical gestational age for the infants and are responsible for the medical status of the premature infant. The feeding specialist can and should not work in isolation. Teamwork increases the accountability and quality of the service provided to the premature infant (ASHA, 1991). In-service training of the NICU staff can be provided by the feeding specialist. According to the results obtained in this study, the aspects described below should be included in such training.

Firstly, with regard to the safe **introduction of oral feeding skills**: Knowledge of the appropriate age to introduce oral feeding should be acquired, as well as the insight of the roll that weight can play. The importance of establishing a clinical age is thus crucial in the decision regarding the introduction of oral feeding. The influences of risk factors such as, for example, cardio-respiratory status should be explained, and special precautions to be taken during oral feeding in such cases should be emphasised. Individual needs, e.g. the length of time exposed to oral feeding for each premature infant, should be highlighted. A checklist can be useful to determine readiness of an infant to transfer from nasogastric to oral feedings (Appendix B)

Secondly, for the infant who is not ready to transfer to oral feeding, the training of the nursing and medical staff and the parents regarding the implementation of and the advantages of **NNS** is also very important, as explained previously.

Feeding specialists involved in the NICU should thus act in the capacity of consultant and trainer, as well as actively giving individual therapy regarding more severe or complicated cases. The study thus supports the importance of team

work in the NICU, which should be regarded at all times, and collaboration with each other should be promoted.

Lastly, it can be stated that valuable conclusions were drawn from the results obtained from the FEFARI. The clinical implications provided the feeding specialist with guidelines for appropriate accountable service delivery to premature infants in NICU's.

6.3 CRITICAL EVALUATION OF STUDY

A critical evaluation is necessary to establish the value of this study, and the worth of the clinical implementation thereof, and to guide the planning and execution of further research.

A descriptive research design was chosen for this study, since the behaviour of the subjects was observed and evaluated under natural conditions. Although this design and the scoring which is subjective, can be susceptible to bias, it was controlled, in part, by conducting a pilot study and by the well-considered selection of the items in the FEFARI after an in-depth literature study by the researcher. More raters would have increased the reliability and validity of the study. However, other therapists to act as second and/or third raters were not available at the time of the study. The problem in South Africa, as in other developing countries, is the scarcity of speech-language therapists and, even more, so of feeding specialists. Video-recording could have been helpful with observations of current state and behaviour, oral structures at rest, jaw and lip movements during feeding as well as stress symptoms displayed by the subjects. Aspects such as cervical auscultation for the detection of multiple and/or delayed swallowing and the observation of tongue movements can, however, not be evaluated by video-recording.

Generalization to all premature infants can not be made, as only a small sample size (10 subjects per group) was used in this study (Leedy, 1997) and the group as a whole group was not homogenous in terms of gestational age. The number of subjects in each group was, however, sufficient to establish the statistically significant difference between lip, tongue and jaw movements during the different feeding methods in each group. The study was successful by presenting results which provided an indication of tendencies in oral feeding skills of the subjects and clues for feeding intervention.

A sample of convenience was used. Thus, the first subjects who complied with the selection criteria were selected. The subjects selected by this procedure for Group 4 (37 weeks gestational age) proved not to be representative of healthy AGA premature infants with a gestational age of 37 weeks. They were the only available subjects of that age complying with the selection criteria in the local NICU, and weight was not one of the selection criteria which proved, in this study, to play a roll in oral feeding. AGA infants of this age might already have been discharged from the hospital. The use of a larger sample size, including AGA, by using subjects from other NICU's and possibly already discharged 37-week-old infants, would provide information that could be generalized.

This study was successful in fulfilling its aims, namely to develop a comprehensive holistic evaluation tool (FEFARI) to enable the feeding specialist to describe the oral feeding skills of the premature infant. The inclusion of certain aspects in the FEFARI, such as the medical condition, biographical information (characteristics), cardio-respiratory status, state and behaviour and neuro-maturity, as suggested by Lau & Hurst (1999) and Vergara (1993), in the evaluation of the oral feeding skills of the premature infant, proved to be necessary for the understanding and interpretation of the information gathered, to form a holistic picture of their oral feeding skills. The inclusion of the different phases of swallowing as recommended by Cherney (1994) and Rosenthal et al. (1995), also provided valuable additional information regarding the efficacy of

swallowing in premature infants. The description of their oral feeding skills according to this holistic view enabled the researcher to establish clinical implications, which can be used to plan appropriate, effective and accountable oral feeding intervention for premature infants.

Although the FEFARI appears to be ready to be clinically used in its present form, the inexperienced user of the FEFARI may need some form of training in the application thereof. Alternatively, a brief manual may need to be compiled to accompany the FEFARI to explain definitions and descriptions of the items used in the FEFARI and to provide guidelines for scoring.

The execution of the FEFARI may be time-consuming if the user is unfamiliar with it, and if it is used for the evaluation of both feeding methods. In the clinical situation, though, evaluation of only one method of preference (based on the collaborative decision of team members) is usually needed. The FEFARI was, however, not intended to be a screening tool for a quicker way of evaluation, but as a comprehensive evaluation tool with which intervention could be planned. It will therefore need more time to execute.

The information obtained from the FEFARI, used in this study, also succeeded in supplying an answer for the statement of DeMontrice et al. (1992), that more information about the maturational patterns of oral feeding in premature infants was needed, since a decrease in feeding problems with maturation could be detected with the FEFARI.

This study is also valuable in the light that it is the first study to evaluate oral feeding skills during cup-feeding and the influence thereof on the physiological status of the infant. The FEFARI, once again, was a sensitive tool to provide information on cup-feeding to plan appropriate efficient oral feeding therapy.

Due to circumstances, the mothers of the infants were rarely present in the NICU and could the mother-infant interaction not be evaluated. Valuable information regarding the communication of the premature infants could therefore unfortunately not be collected.

Due to practical circumstances during this study, only the pre-feeding breathing rates could be collected. Information on the influence of bottle- and cup-feeding on the breathing rates during and after oral feeding could unfortunately not be obtained in this study. This information could have been used to ascertain the possible stress levels of the subjects or to provide a possible explanation of how they maintained their saturation levels.

6.4 RECOMMENDATIONS

It is concluded that the design and development of the FEFARI has led to a new clinical tool for the evaluation of the oral feeding skills of premature infants. It does not only provide valuable information on the oral-motor skills of these infants, but also regarding the premature infant as a whole, e.g. the physiological status. However, based on this research, further studies are needed to address the limitations discussed in 6.4. The following recommendations can therefore be made:

6.4.1 RESEARCH RECOMMENDATIONS

In order to generalize the information obtained from the FEFARI, it can be applied to a large sample and to subjects from different geographical areas. The results of such a study may serve as a baseline “norm” for the oral feeding skills of premature infants of different gestational ages and would therefore provide a baseline for identifying abnormal or deviant oral feeding skills. Different evaluators can use the FEFARI to establish interrater reliability. Further research should

therefore endeavour to standardize the FEFARI. It may be necessary to compile a manual for the appropriate and consistent use thereof.

6.4.2 RECOMMENDATIONS WITH REGARD TO THE APPLICATION OF THE FEFARI

The applicability of the FEFARI to other situations, such as breastfeeding, or to other population groups can be evaluated. Application of the FEFARI to other infants with risk factors for feeding problems, e.g. neurologically involved infants, can establish the appropriateness and applicability of the FEFARI for infants other than premature infants. Mandich & Ritchie (1996) stated that a lack of information on oral feeding skills of infants with apnoea exists. Only a few subjects suffered from apnoea in this study, therefore apnoea did not seem to cause problems in this study. The FEFARI can therefore be applied to a subject group with significant apnoea, to determine how apnoea as such may influence the characteristics of the sucking and swallowing patterns of infants who experience apnoea.

A wider variety of age groups can be included to identify at which age oral feeding skills of premature infants match the oral feeding skills of full-term infants. This information may be helpful in planning intervention, and the training and support provided by the parents of these infants. If baseline information is available, the sensitivity of the FEFARI on identifying differences in various population groups can be evaluated.

Further research to obtain information on the mother-Infant communication can be conducted, as this section of the FEFARI could unfortunately not be completed during this study. The influence of the mother-infant interaction on the transfer time to oral feeding can also be studied in order to motivate the active involvement of mothers with their infants in the NICU's.

Further studies can be conducted on SGA infants, firstly, to compare the number of SGA infants born in South Africa (and the incidence of SGA in the local black population) to the number born in other countries, as it appears that a higher number of SGA infants are born locally. There is a correlation between the prevalence of SGA infants and poor socio-economical status (SES). South Africa has a vast number of people suffering from SES and it is expected to reflect in the number of SGA infants. Secondly, the FEFARI can be used to compare the oral feeding skills of SGA and AGA infants. The SGA infants are associated with poorer developmental outcome and more feeding problems due to an overall weak state compared to their AGA counterparts (Mullen et al, 1988; Vohr 1991; Widerstrom et al. 1997). This will imply that a larger number of infants in South Africa may need oral feeding intervention, needing the services of feeding specialists. A desperate need for the training of more feeding specialists may be proved by such information.

6.4.3 RECOMMENDATIONS FOR THE HOSPITAL SETTING

Follow-up studies can be conducted to establish the role of experience and the cost effectiveness of appropriate oral feeding intervention based on the information gathered with the FEFARI. Cost effectiveness in state hospitals is an important issue. The salary of a feeding specialist may have to be weighed against the cost of longer hospital stays of premature infants. Such information may be helpful in establishing new or preserving existing posts for feeding specialists

The influence of the manipulation of the NICU environment (as advocated by Rossetti, 1998) on oral feeding skills can also be studied. This information may have important clinical implications for the oral feeding therapy for premature infants.

6.5 CONCLUSION

Premature infants form an increasing proportion of the population in need of early intervention (Oehler et al., 1996). One of the most serious problems that they experience concerns their feeding. The feeding specialist, as part of a team, has the important task of providing these infants with appropriate, effective and accountable feeding therapy. Comprehensive evaluation of the oral feeding skills of the premature infants is essential for the planning of such therapy. Existing feeding scales pose many limitations. The FEFARI was therefore designed for this study, with the main aim to describe the oral feeding skills of the premature infant and to plan intervention strategies based on the information obtained from the FEFARI. This study thus succeeded in the attempt to provide, firstly, a comprehensive evaluation tool for the oral feeding skills of the premature infant and, secondly, a description of all aspects involved with oral feeding in premature infants. The study also proved to be of great clinical value for the feeding specialist.

The use of the FEFARI and the information obtained from the results of this study will hopefully lead to much needed improved service delivery in terms of feeding intervention to all infants with oral feeding problems.

6.6 SUMMARY

Chapter 6 presents the conclusions drawn from the results on the oral feeding skills of premature infants, of this study. Important clinical implications with regard to service delivery to the premature infant in the NICU, are raised. A critical evaluation of the study was done to identify the contributions and limitations thereof. Finally, recommendations for further studies were made. A general conclusion is reached, namely that premature infants should be introduced to oral feeding as from 34 weeks gestational age, that their weight, physiological and

medical status should be carefully considered when implementing feeding therapy and that bottle-feeding is preferred to cup-feeding in premature infants.

This study concludes by emphasizing the importance of successful oral feeding in premature infants. Should intervention be necessary, a comprehensive evaluation should precede feeding therapy by a thoroughly trained feeding specialist.

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APPENDIXES

APPENDIX A: FEFARI

APPENDIX B: Checklist for Readiness for Oral Feeding



FEEDING EVALUATION FORM FOR AT-RISK INFANTS (FEFARI)

Karina Uys

Patient information

Date of evaluation: _____

Patient number

--	--	--	--	--	--	--	--

 1-7

1

 8

Ballard score: _____ Weeks 9 – 10 Birth weight: _____ 13-15
Current gestational age: _____ weeks 11-12 Current weight: _____ 16-18

1. MEDICAL HISTORY

	1 No	2 Yes	Comment	
1. Prematurity				19
2. Neurological problems				20
3. Craniofacial anomalies				21
4. Feeding problems: family history				22
5. Polyhydramnios				23
6. Placenta abruptio/previa				24
7. Cord prolapse/around neck/knotted				25
8. Meconium aspiration				26
9. RDS/BPD				27
10. Surfactant therapy				28
11. Mechanical ventilation			Days	29
12. Asphyxia				30
13. Pneumonia				31
14. Cardiovascular condition				32
15. IVH				33
16. Apgar - under 7			/1 min /5 min /10 min	34
17. Tube feeding			Days	35
18. Infection:TORCH			E.g.	36



2. CURRENT STATE/BEHAVIOUR

	1 No	2 Yes	Comment	
Quiet				37
Allert				38
Lethargic				39
Medication				40
Hyperbilirubenia				41
Respiratory problems				42
Ventilation dependant				43
Oxygen dependant				44
Dusky spells				45
Pneumonia				46
Stridor				47
Chronic infection				48
Noisy breathing				49
Coughig/choking				50
Trouble breathing during feeds				51
Apnoea				52

3. PHYSICAL EXAMINATION

	1 No	2 Yes	Comment	
Symmetrical				53
Normal tone				54
Hypertonic				55
Very floppy / hypotonic				56
Excessive neck and trunk extensions				57
Dismorphic features:				58
Cleft palate - overt - submucosal				59
Position whilst feeding: -excessively flexed / floppy -neck extension -supine				60



4. ORAL FEEDING HISTORY

		1		2		3	
Duration of feed: in minutes	20 or less		30 - 40		45 or plus		61
Endurance of oral feeding	Manages whole feed		Manages more than half of the feed		Manages less than half of the feed		62
Feeds better when	Alert, eyes open		Less alert, eyes closed		Night-time		63
Feeding position	Reclined		Semi-reclined		Upright		64
Intervals between feeding times	3 hourly		4 hourly		2 hourly		65
Method of feeding	Cup / Breast		Bottle		Nasogastric		66

5. MOTHER-INFANT INTERACTIONS: DURING FEEDING

	1 No	2 Yes	Comment	
MOTHER: Present				67
- Eye contact				68
- Talks to infant				69
- Touches infant				70
- Responds to cues from infant				71
- Secure, confident				72
INFANT: Present				73
- Relaxed/calm				74
- Alert/wakeful				75
- Active				76
OVERALL: Pleasurable interaction				77

	Normal structure/behaviour/functioning
--	--

Abbreviations:

N	Normal	BPM	Breaths per minute
IVH	Intra ventricular haemorrhage	GER	Gastro-esophageal reflux
BPD	Bronchopulmonary dysplasia	T	Toxoplasmosis
RDS	Respiratory Distress Syndrome	O	Other e.g.syphilis
NS	Nutritive Sucking	R	Rubella
NNS	Nonnutritive Sucking	C	Cytomegalovirus
NG	Nasogastric	H	Herpes simplex
OG	Orogastric		



Patient number 1-7

2 8

6. EVALUATION OF FEEDING PROCESS:

➔ ORAL STRUCTURES AT REST

	1	Normal	2	Deviant	
LIPS		- Symmetrical		- Asymmetrical	9
		- Closed		- Open	10
		- Soft		- Retracted	11
Reflex: Rooting		- Eager		- Inconsistent / Hyperactive - Absent	12
Tone		- Normal		- Hypertonic - Hypotonic	13
Reaction in touch		- Normal		- Hypersensitive - Hyposensitive	14
CHEEKS:		- Symmetrical		- Asymmetrical	15
Tone		- Normal		- Hypotonic	16
Sucking pads		- Present		- Absent	17
JAW:		- Symmetrical		- Asymmetrical - Micrognasia	18
Reflex: Biting		- Present		- Absent - Tonic biting reflex	19
PALATE: Hard		- Symmetrical		- Asymmetrical - High arch - Narrow - Cleft	20
VELUM		- Symmetrical		- Asymmetrical - Cleft overt/submucosal	21
Reflex: Gag		- Present		- Absent - Hyperactive - Hypoactive - Anteriorly displaced	22
TONGUE: SHAPE		- Symmetrical		- Asymmetrical	23
		- Rounded tip		- Excessively rounded - Excessively pointed	24
		- Thin, Flat		- Retracted - Elevated	25
Tone		- Normal		- Soft/Hypotonic	26
Size		- Normal		- Macroglossia	27
Reflex: Sucking		- Present		- Absent - Depressed	28
Reflex: Swallowing		- Present		- Absent	29
Reaction to touch		- Normal		- Hypersensitive - Hyposensitive	30



Patient number 1-7

8

➔ **FUNCTIONING OF ORAL STRUCTURES**

6.1 NON-NUTRITIVE SUCKING (NNS)

	1	Normal	2	Moderately disorganised	3	Severely dysfunctional	
LIPS: Pursing:		- Initiates		- Excessive		- Absent	9
Closure:		- Initiates		- Weak		- Absent	10
		- Maintains		- More than 2 min		- Less than 2 min	11
TONGUE movement		- Symmetrical		- Asymmetrical		- Absent	12
		- Anterior - Posterior		- Protrusion - Elevated tip		- Retracted - Very weak	13
Sucking bursts		- Appropriate pauses		- Prolonged pauses		- Absent	14
				-- Short pauses		- Very weak	
Rate of movement		- 2/sec		- Incoordinated		- Absent	15
Stress symptoms		- Absent		- Present			16
During NNS		- No change		- Decreases		- Increases	17

Breathing rate

Baseline	<input type="text"/>	BPM	18-19
During NNS	<input type="text"/>	BPM	20-21

Heart rate

Baseline	<input type="text"/>	Beats/min	22-24
During NNS	<input type="text"/>	Beats/min	25-27



Patient number

							1-7	
							4	8

6.2 NUTRITIVE SUCKING

Bottle 1

	9
--	---

6.2.1. ORAL PREPARATORY/ORAL PHASE

	N o r m a l		D e v i a n t			
	1	2	Moderate Disorganised	3		Severe Dysfunctional
LIPS: Pursing	- Initiates		- Retraction - Excessive		- Absent	9
Closure: Initiates	- Efficient		- Weak		- Absent	10
	Maintains	- Efficient	- More than 2 min		- Less than 2 min	11
Loss of liquid	- Minimal		- Moderate		- Extensive	12
Movement	- Rhythmic		- Disrhythmic		- No rhythm	13
		- Coordinated	- Incoordinated		- Absent	14
JAW: Degree of depression	- Consistent		- Inconsistent - Difficult to initiate		- Atonic biting reflex	15
Movement	- Rhythmic		- Arrhythmic		- Absent	16
		- Normal	- Minimal excursion		- Atonic biting reflex - Absent - Jaw Thrust	17
Rate of movement	- 1/sec		- Lack of rate change between NS-NNS		- Absent	18
TONGUE: Grooving	- Central		- Bulging		- Absent/Flaccid	19
Movement	- Symmetrical		- Asymmetrical		- Absent	20
		- Anterior-posterior	- Protrusion, without interruption of function		- Protrusion-excessive before and after nipple insertion	21
		- Anterior-posterior	- Elevated tongue tip		- Retracted	22
		- Strong: Rhythmic	- Arrhythmic		- Very weak	23
Sucking burst	- Appropriate pauses		- Prolonged (5-20 sucks) - Short (less than 3 sucks)		- No sucking bursts	24
Flow rate	- Sufficient		- Poor		- No flow	25
Bolus Formation	- Efficient		- Slow		- Absent	26
Swallowing	- Coordinated		- Incoordinated		- Absent	27
		- Timely	- Delayed		- Absent	28
		- Once/ Twice	- Multiple		- No swallowing	29



6.2.2 PHARYNGEAL PHASE

	1	Normal	2	Deviant	
Laryngeal/hyoidbone elevation		- Present		- Absent	30
Nasopharyngeal Reflux		- Absent		- Present	31
Voice quality		- Clear		- Gurgly	32
Suck, Swallow Respiratory sequence		- Effortlessly		- Associated with stress	33
Breathing rate: Pre-feeding _____ BPM During-feeding _____ BPM Post feeding _____ BPM		- N(30-80 BPM) - No change		- Tachypnoea - Bradypnoea Difference pre + post ↑10BPM ↓10BPM	34
Heart rate: Pre-feeding _____ Beats/min During-feeding _____ Beats/min Post feeding _____ Beats/min		- Full term 70-170 Beats/min - Preterm 140-160 Beats/min		- Tachycardia - Bradycardia: ↓ 80 beats/min	35

➔ Stress symptoms: Moderate

No 1	Yes 2		
		- Fatigue	36
		- Yawning	37
		- Sneezing	38
		- Hiccupping	39
		- Flared nostrils	40
		- Sweating	41
		- Crying/Fussiness	42
		- Averting gaze	43
		- Fisting of hands	44

➔ Stress symptoms: Severe

No 1	Yes 2		
		- Falling asleep	45
		- Coughing	46
		- Choking	47
		- Vomiting	48
		- Noisy Breathing	49
		- Colour change	50
		- Chest Retraction	51
		- Stridor	52
		- Actively refusing nipple	53

6.2.3. OESOPHAGEAL PHASE

	1 No	2 Yes	Comment	
Emesis: during feeding				54
after feeding (↑ 30 min)				55
after feeding (↓30 min)				56
Projectile vomiting				57
Regurgitation/GER				58
Truncal arching				59



7. GENERAL INFORMATION

Feeding time _____ Minutes

60-61

Reason for ending the feed:

Changes during assessment that had a positive outcome

Changes during assessment that had a negative outcome

8. ADDITIONAL INFORMATION

Instrumental evaluation

8.1 Video fluoroscopic evaluation:

Oral Phase

Pharyngeal phase:

Esophageal phase:

8.2 Pulse Oximetry

Prefeeding	%	62-63
Midfeeding	%	64-65
Postfeeding	%	66-67

8.3 Cervical Auscultation:



Patient number

--	--	--	--	--	--	--

 1-7

5

 8

6.2 NUTRITIVE SUCKING (CONTINUED)

Cup

6.2.1. ORAL PREPARATORY/ORAL PHASE

	Normal		Deviant			
	1	2	Moderate Disorganised	3		Severe Dysfunctional
LIPS: Pursing	- Initiates		- Retraction - Excessive		- Absent	9
Closure: Initiates	- Efficient		- Weak		- Absent	10
	Maintains	- Efficient	- More than 2 min		- Less than 2 min	11
Loss of liquid	- Minimal		- Moderate		- Extensive	12
Movement	- Rhythmic		- Disrhythmic		- No rhythm	13
	- Coordinated		- Incoordinated		- Absent	14
JAW: Degree of depression	- Consistent		- Inconsistent - Difficult to initiate		- Atonic biting reflex	15
Movement	- Rhythmic		- Arrhythmic		- Absent	16
	- Normal		- Minimal excursion		- Atonic biting reflex - Absent - Jaw Thrust	17
Rate of movement	- 1/sec		- Lack of rate change between NS-NNS		- Absent	18
TONGUE: Grooving	- Central		- Bulging		- Absent/Flaccid	19
Movement	- Symmetrical		- Asymmetrical		- Absent	20
	- Anterior-posterior		- Protrusion, without interruption of function		- Protrusion-excessive before and after nipple insertion	21
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FEEDING EVALUATION FORM FOR AT-RISK INFANTS (FEFARI)

Karina Uys

Patient information

Date of evaluation: _____

Gestational age: _____

SUMMARY OF INFORMATION

MAIN METHOD OF FEEDING

BOTTLE

BREAST

CUP

OVERALL FUNCTIONING LEVELS

	ADEQUATELY	ADEQUATE BUT REDUCED FUNCTION	INTERFERES WITH FUNCTION	NON-FUNCTIONAL
Oral phase				
Pharyngeal phase				
Esophageal phase				
Conclusion	Normal	Mild impairment	Moderate impairment	Severe impairment

MAIN PROBLEM/S

DIAGNOSIS

RECOMMENDATIONS

SPEECH THERAPIST



APPENDIX B

Readiness for Transfer to Oral Feeding

	Yes/No
Respiratory: Non-laborious breathing	
Breathing Rate less than 60/min	
O ₂ needs not more than 40%	
Cardiological: Stable	
Gastric: Sufficient bowel sounds	
Tolerate bolus feeds (2-3 hourly)	
Neurological: Gestational age of 34 weeks +	
Swallowing reflex present	
Nutritional: Sustained weight gain	
State & Behaviour: Maintain quiet, alert state	
Signs of endurance	
Communication clues for approach/withdrawal	

Compiled by Karina Uys