THE IMPACT OF A SENSORY DEVELOPMENTAL CARE PROGRAMME FOR VERY LOW BIRTH WEIGHT PRETERM INFANTS IN THE NEONATAL INTENSIVE CARE UNIT

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DECLARATION

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OPSOMMING

AGTERGROND

Dit is bekend dat vroeggebore babas met ’n baie lae geboortemassa ’n hoër insidensie van ontwikkelings-, gedrags- en mediese agterstande en verskeie leerprobleme toon teen die tyd dat hulle skoolgaande ouderdom bereik. Kommer bestaan ook oor die omgewingseffek van die neonatale intensiewe sorgeenheid op die sensoriese ontwikkeling van die vroeggebore baba en hoe dit tot bogenoemde agterstande kan bydra. Daar is verskillende benaderings wat daarop aanspraak maak dat hulle die probleem kan oplos, met kangaroemoedersorg (‘kangaroo mother care’) en ontwikkelingsorg (‘developmental care’) wat in die literatuur uitgesonder is as besonders belowend. Met die aanvang van hierdie studie was daar nog geen empiriese studies in die literatuur gerapporteer wat enige aansprake van hierdie benaderings bevestig het nie. Daar was dus ’n behoefte vir ’n empiries-nagevorsde program wat prakties in die neonatale intensiewe eenheid toegepas kon word met die oog op die vermindering van omgewingstressors ten opsigte van die vroeggebore baba se sensoriese sisteme.

DOEL

Die doel met die studie was om die invloed te bepaal van ’n Sensoriese Ontwikkelingsorgprogram (‘Sensory Developmental Care Programme’), wat ’n spesifieke kangaroemoedersorg-protokol insluit, op die sensoriese ontwikkeling van die vroeggebore baba met ”n baie lae geboortemassa tot en met die ouderdom van 18 maande (gekorrigeerde ouderdom).

METODOLOGIE

’n Ewekansig-gekontroleerde studie is uitgevoer. Die studiesteekproef het bestaan uit 89 vroeggebore babas met ’n baie lae geboortemassa wat in ’n periode van 24 maande toegelaat is tot die neonatale eenheid van Tygerberg Hospitaal in Kaapstad, Suid-Afrika. Die babas is gewerf op grond van sekere kriteria en is dan daarna ewekansig aan een van twee groepe toegeken: 1) die intervensiegroep het sorg ontvang volgens die Sensoriese Ontwikkelingsorgprogram vir 10 dae; en 2) die kontrolegroep het ook vir 10 dae die standaardsorg van die eenheid ontvang. Die intervensiegroep het uit 45 babas bestaan, van wie 22 die studie voltooi het, terwyl

die kontrolegroep uit 44 babas bestaan het van wie 20 die studie voltooi het. Beide studiegroepe is opgevolg op 6, 12 en 18 maande (gekorrigeerde ouderdom), by welke geleentheid die Sensoriese Funksietoets vir Babas ('Test of Sensory Functions in Infants') telkens toegepas is vir die assessering van sensoriese ontwikkeling. Op 18 maande (gekorrigeerde ouderdom) is 'n assessering met die Griffiths Ontwikkelingskaal ook gedoen om funksies in die ander ontwikkelingsareas van die babas te bepaal. Toetsresultate is geanaliseer met behulp van herhaalde ANOVA-metings en die Bonferoni t-prosedure om die effek van die Sensoriese Ontwikkelingsorgprogram op die sensoriese ontwikkeling van die babas tot en met 18 maande (gekorrigeerde ouderdom) te bepaal.

RESULTATE

Die resultate van die vergelyking van die prestasie van beide groepe (groep-effek), gemeet met behulp van die Sensoriese Funksietoets vir Babas, is van groot belang vir hierdie studie. Die intervensiegroep het betekenisvol verskil op die totale telling ($p<0.00$), sowel as op die volgende vier van die vyf subtoets-tellings: respons op diepdruk ('tactile deep pressure') ($p<0.03$); motoriese aanpassingsreaksies ($p<0.03$); visuele tas-integrasie ($p<0.00$); en respons op vestibulêre stimulasie ($p<0.01$).

GEVOLGTREKKING

Die resultate van die studie dui aan dat die babas in die intervensiegroep baat gevind het by die Sensoriese Ontwikkelingsorgprogram met betrekking tot hul sensoriese funksies tot en met die ouderdom van 18 maande (gekorrigeerde ouderdom). Die Sensoriese Ontwikkelingsorgprogram het geblyk prakties sowel as suksesvol te wees met betrekking tot sy doel. Die Program sou daarom met vrug in ander neonatale intensiewe sorgeenhede aangewend kon word.

ABSTRACT

BACKGROUND

Premature infants of very low birth weight are known to be inclined to developmental, medical, behavioural and various learning deficiencies by the time they reach school-going age. Concerns have been raised about the effect of the neonatal intensive care unit environment on the sensory development of the premature infant and how this could contribute to these deficiencies. Various approaches claim to address this problem, of which kangaroo mother care and developmental care have in the literature been singled out as particularly promising. However, at the commencement of this study no empirical studies had been reported in the literature to confirm any of the claims of these approaches. Therefore, a need existed for an empirically researched programme that could be practically applied in the neonatal intensive care unit with a view to reducing environmental stressors regarding the sensory systems of the premature infant.

AIM

The aim of this study was to determine the influence of a Sensory Developmental Care Programme, which incorporated a specific kangaroo mother care protocol, on the sensory development of the very low birth weight premature infant, up to the age of 18 months (corrected age).

METHODOLOGY

A randomised controlled study was conducted. The study sample consisted of 89 very low birth weight premature infants, admitted during a 24-month period to the neonatal care unit at Tygerberg Hospital in Cape Town, South Africa. The infants were recruited by means of certain criteria and then randomly assigned to one of two groups: 1) the intervention group was cared for according to the Sensory Developmental Care Programme for ten recorded days; and 2) the control group that received the standard care of the unit, also for ten days. The intervention group consisted of 45 infants of whom 22 completed the study, while the control group consisted of 44 infants of whom 20 completed the study. Both study groups were followed up at six, 12 and 18 months (corrected age) when the Test of Sensory Functions in Infants was used to do a sensory developmental assessment. At 18 months (corrected age) a Griffiths Developmental Scale assessment was also conducted to determine function in other areas of development. Test results were analysed using repeated measures of ANOVA, and the Bonferoni *t* procedure to determine the effect that the Sensory Developmental Care Programme had on the sensory development of the infant up to 18 months (corrected age).

RESULTS

The results of the comparison of the performance of both groups (group effect), measured by the Test of Sensory Functions in Infants are of great importance to this study. The intervention group had a significant difference on the total score ($p<0.00$), as well as on the following four of the five sub-tests scores: reactivity to tactile deep pressure ($p<0.03$); adaptive motor functions ($p<0.03$); visual-tactile integration ($p<0.00$); and reactivity to vestibular stimulation ($p<0.01$).

CONCLUSION

The results of this study signify that the infants in the intervention group benefited from the Sensory Developmental Care Programme concerning their sensory functions up to the age of 18 months (corrected age). The Sensory Developmental Care Programme was demonstrated to be both practical and successful in terms of its aims. The Programme could therefore be fruitfully utilised in other neonatal intensive care units.

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ACRONYMS

AIDS	Acquired immunodeficiency syndrome
CMV	Cytomegalovirus
CNS	Central nervous system
ELBW	Extremely low birth weight
HIV	Human immunodeficiency virus
KC	Kangaroo care
KMC	Kangaroo mother care
LBW	Low birth weight
MRC	Medical Research Council
NICU	Neonatal intensive Care Unit
NIDCAP	Newborn Individualized Developmental Care and Assessment Program
REM	Rapid eye movements
SDCP	Sensory Developmental Care Programme
SI	Sensory integration
TSFI	Test of Sensory Function in Infants
VLBW	Very low birth weight
WHO	World Health Organisation

CHAPTER ONE

INTRODUCTION, PROBLEM STATEMENT AND AIM OF STUDY

1.1 INTRODUCTION

The survival and development of premature infants has recurrently been the subject of research and discussion. Initially, attention given to the improvement of antenatal care focused on advancement in neonatal medicine to increase the survival of premature infants (Als, Duffy and McAnulty, 1996; Hunter, 2005). After this, neuro-developmental outcome studies focused on the major disabilities, such as mental retardation, cerebral palsy, hearing loss, blindness and epilepsy (Bennett, 2002). Due to more refined assessment techniques and improved survival rates an increase in neuro-developmental problems was noticed. These included learning disabilities, low-average intelligent quotient scores, attention deficit hyperactivity disorder, neuro-psychological deficits, visual motor integration problems, language delays, behavioural difficulties and sensory-regulatory disorders (Aylward, 2005; Bennett, 2002; McCormick, 1997). Concerns were raised with regard to the influence of the Neonatal Intensive Care Unit (NICU) environment with its constant noise, bright lights and sleep interruptions caused by medical procedures and harsh handling and positioning in the incubator. At the time of premature birth the foetal brain is in a critical period of rapid maturation and the impact of the environment of the NICU could activate the premature infant’s immature central nervous system, which in turn could inhibit the development of neuronal pathways and interfere with their full differentiation (Als, Lawhorn, Duffy, McAnulty, Gibes-Grossman and Blickman, 1994; Bennett, 2002; McLennan, Gilles and Neff, 1983). VandenBerg (2007) refers to the fact that several researchers had documented the immensely different sensory exposures experienced by the infants in the NICU compared to those of a full-term healthy newborn taken home after birth.

Research by Wiener, Long, DeGangi and Battaile (1996) on the sensory processing of premature infants demonstrated that prematurely born infants who were tested on the Test of Sensory Functions in Infants (TSFI) scored lower on sensory processing at six, 12 and 18 months (corrected age) than their full-term counterparts. A study done by Holditch-Davids (1992) pointed out that 25 to 35 percent of preterm infants exhibited developmental, medical, behavioural or learning problems by the time they reached school-going age. This information is supported by the work of McCormick, Workman-Daniels and Brooks-Gunn (1996), who state that 50 percent of infants with very low birth weight (VLBW) required special educational services by the time they had reached the age of eight years, while 15 percent had repeated at least one grade in school.

Several intervention approaches to enhance the care and development of premature infants in the NICU have been developed. Feldman and Eidelman (1998) critically assessed some of these approaches and found that they had not been well researched and the applications were non-specific and vague. They drew attention to the controversy regarding the benefits (adequate sensory stimulation of the right system at the right time) and possible risks (under- or over-stimulation of the sensory systems at the wrong time) that intervention programmes pose to preterm infants. Therefore, they suggested more research on intervention programmes (Wolke, 1998). One of these programmes with sufficient potential to warrant further investigation was kangaroo mother care (KMC) (Weller and Feldman, 2003; White-Traut, 2004).

KMC has become popular in recent years after comparative studies indicated significant short-term advantages when applied to VLBW preterm infants (Feldman and Eidelman, 2003; Gale, Franc and Lund, 1993; Ludington-Hoe, Nguyen, Swinth and Satyshur, 2000). However, no research had been done on the long-term sensory development of VLBW preterm infants who underwent KMC. Thus, more research on the subject was justified.

Another intervention approach to enhance the care and development of VLBW premature infants in the NICU and which focuses on the interaction between the infant’s neuro-developmental needs and the environment, is Developmental Care (see description in 2.7) (Ashbaugh, Leick-Rude and Kilbride, 1999; Kenner and McGrath, 2004; Sizun and Westrup, 2004). Kleberg, Westrup, Stjernqvist and Langercrantz (2002) tested a similar approach, which they called the Newborn Individualized Developmental Care and Assessment Program (NIDCAP) (see description in 2.7). Their study showed better cognitive development at the age of 12 months by those infants who had been cared for by NIDCAP. Unfortunately the validity of their study was compromised by a small sample size (Westrup, Böhm, Langercrantz and Stjernqvist, 2004). Other authors found insufficient evidence to support NIDCAP and suggested more research in this regard (Jacobs, Sokol and Ohlsson, 2002).

KMC and developmental care seemed to be complementary approaches that could be practically and successfully integrated into an approach to improve the sensory function of VLBW preterm infants in the NICU. As will be seen in Chapter 3, a “Sensory Developmental Care Programme” (SDCP) was developed by the researcher, which includes components of both approaches. If the successful application of this integrated approach could be demonstrated in the Western Cape, South Africa, it could be assumed that many other preterm infants under similar conditions could benefit from it.

The situation in the Western Cape is specifically challenging in respect of the treatment of preterm infants. Very low birth weight infants comprise only one percent in developed countries, whereas the incidence is between three and four percent in South Africa (Altuncu, Kavuncuoglu, Gökmirza, Albayrak and Arduc, 2006). A considerably higher incidence of these categories of infants born in the Western Cape is reflected in the relevant statistics. In the Western Cape the statistics show that between 18 percent of babies are LBW and four to six percent are VLBW (MRC Unit, 2006).This situation is associated with the low socio-economic conditions of many residents in this area. The need for meaningful interventions in the Western Cape was therefore not only higher, but also had to be applicable in a situation where public health care was under-funded. The question of significant interventions under such circumstances triggered this research.

1.2 PROBLEM STATEMENT

Due to better technology, survival rates of VLBW infants increased significantly over the last five to ten years and studies demonstrated that the environment of the NICU could contribute to some of the problems experienced when the infants grow up and enter school. Although many studies had focused on the impact of developmental care, KMC or NICU environmental control in isolation, the effect of a comprehensive sensory programme that included elements of developmental care, KMC and NICU environmental control had, at the time of this study, not yet been established for the VLBW preterm infant.

1.3 PURPOSE OF THE STUDY

1.3.1 Aim of the study

The aim of the study was to determine the influence of the use of a Sensory Developmental Care Programme (SDCP), which incorporates a specific KMC protocol, on the sensory development of VLBW preterm infants up to the age of 18 months (corrected age).

1.3.2 Hypothesis

Null hypothesis (Ho): The Sensory Developmental Care Programme for the VLBW preterm infant would not improve the sensory function of the infant.

Alternative hypothesis (Ha): The Sensory Developmental Care Programme for the VLBW preterm infant would improve the sensory function of the infant.

1.3.3 Objectives

The objectives to reach the goal of this study were the following:

1. To ascertain from the literature the most appropriate (most advantageous) environment to be used in the NICU.

2. To design a programme that incorporated: (i) developmental care principles; (ii) an optimal and appropriate NICU environment; (iii) a particular structured KMC regime; and (iv) a sensory intervention strategy based on developmental norms that included appropriate tactile and vestibular input.

3. To apply the designed Sensory Developmental Care Programme (SDCP) to a group of VLBW preterm infants and compare their results with a similar group that had not received the intervention.

4. To evaluate the infants' sensory function on the Test of Sensory Function in Infants (TSFI) (DeGangi and Greenspan, 1989) at six, 12 and 18 months (corrected age).

5. To determine whether the SDCP had an influence on the infants' mental development as tested on the Griffiths Mental Development Scale (Griffiths, 1996) at 18 months (corrected age).

These objectives would be reached in the following manner: VLBW preterm infants were randomly assigned to one of two groups. KMC (skin-to-skin) was practised in an unstructured manner for four hours per day by mothers and their infants in the control group. The SDCP was applied to the intervention group. Infants in both groups were followed up and tested on the TSFI at six, 12 and 18 months (corrected age), and on the Griffiths Scale at 18 months (corrected age). The statistical analysis of the data and the results are also discussed in this thesis.

1.4 DEFINITION OF CONCEPTS

The following is a clarification of the concepts used in this study:

Control group is the group of infants that had received the standardised care of the hospital together with four hours unstructured KMC per day.

Developmental care refers to a method of care used on VLBW preterm infants in the NICU and focuses on the interaction between the infant's neuro-developmental needs and the environment (Ashbaugh et al, 1999).

Gestational age is the age of the foetus after conception and is usually presented in weeks.

Griffiths Mental and Developmental Scales for Babies – Revised: Birth to two is a standardised test battery to assess five areas of development from birth to 24 months. It does not test the sensory functions of the infant.

Intervention group is the group of infants who had been exposed to SDCP.

Kangaroo care (KC) is one component of kangaroo mother care (KMC), namely, the positioning of the infant chest-to-chest and skin-to-skin between the mother’s breasts in an upright position.

Kangaroo mother care (KMC) is a method of caring for and nursing the preterm infant in a supportive environment. It has three components: (i) the skin-to-skin position; (ii) nutrition (breastfeeding); and (iii) early discharge and follow-up. In this thesis KMC and KC are used interchangeably to refer to the skin-to-skin positioning of the infant. As KMC is the term commonly used in South Africa and KMC position is used to refer to the skin-to-skin positioning of the infant, KMC is also used in this thesis to refer to what may be reported elsewhere in the literature as kangaroo care (KC) or skin-to-skin holding.

Low birth weight (LBW) is a birth weight of less than 2500 g. A further classification is generally made in the category of birth weights, namely (Hunter, 2005):

1. *Low birth weight (LBW)* is between 1500 g and 2499 g.

2. *Very low birth weight (VLBW)* is between 1000 g and 1499 g.

3. *Extremely low birth weight (ELBW)* is < 1000 g.

Neonatal Intensive Care Unit (NICU) is a highly specialised hospital unit equipped and designed to care for preterm or critically ill infants immediately after birth (Hunter, 2005).

Sensory Developmental Care Programme (SDCP) is a course of action developed by the researcher, based on sensory integration, KMC and developmental care as described above and designed to optimise the perception of sensation by the senses in a manner that is commensurate with the stages of neurological formation.

Sensory Integration (SI) is ‘the capacity of the central nervous system to integrate information from the various senses to enable the person to interact with the world’ (DeGangi, 2000:282).

Study sample refers to the group of preterm infants recruited for this study and who had completed the tests at 18 months (corrected age). The study sample consisted of an intervention group and a control group.

Test of Sensory Functions in Infants (TSFI) is a standardised test to assess the sensory functions of the infant between three and 18 months (DeGangi and Greenspan, 1989).

1.5 OUTLINE OF THE THESIS

The thesis consists of six chapters, arranged as follows:

Chapter 1 gives a brief introduction to the study. Some matters that arise in the literature, and which prompted the present study, are discussed. The problem statement is given, as well as the aim, hypothesis and objectives of the study. Finally a number of concepts are defined.

Chapter 2 deals with the relevant literature concerning prematurity, sensory development and integration, kangaroo mother care, developmental care, other intervention programmes, the neonatal intensive care unit and testing procedures.

Chapter 3 deals with the design of the randomised controlled trial, as well as the methods of conducting the study. A detailed description of the intervention programme is included in this chapter.

Chapter 4 comprises a summary of the demographic and anthropometric profile of mothers and infants in the study sample.

Chapter 5 contains the analysis of the research results and an assessment of its relevance.

Chapter 6 is a summary of the study and its limitations, followed by a conclusion, and finally recommendations concerning the implementation of the intervention programme.

CHAPTER TWO

LITERATURE REVIEW

2.1 INTRODUCTION

This review presents recent information, theories and research results that relate to: causes of preterm labour; sensory development and integration; the neonatal intensive care unit (NICU) and intervention programmes in the NICU, including kangaroo mother care (KMC) and developmental care; and the assessment scales used in this study.

2.2 FACTORS ASSOCIATED WITH PRETERM LABOUR AND THE EFFECT ON FOETAL DEVELOPMENT

The foetus develops within the intrauterine environment, which is mostly determined by maternal variables. Respiratory and nutritive support of the foetus is influenced by the mother’s metabolic, cardiovascular and environmental state. The foetus does not have the ability to adapt to stress or to modify its surroundings and therefore the prenatal environment exerts a tremendous influence on the development and further well-being of the foetus (Joffe and Wright, 2002). Already in 1992 Brooks-Gunn, Gross, Kraemer, Spiker and Shapiro found that biological and environmental factors or the socio-economic status of the mother could affect the mental and psychosocial development of the premature (VLBW) infant in the form of major or minor neuro-sensory deficits and cognitive delays.

The discussion below highlights certain factors of maternal health and environment and their potential effect on the development of the foetus.

2.2.1 Maternal health factors contributing to prematurity

Maternal diseases such as gestational diabetes mellitus (GDM), thyroid disease, phenylketonuria (PKU), renal disease, neurological disorders (epilepsy, multiple sclerosis and myasthenia gravis), systemic lupus erythematosus, heart disease and respiratory disease (asthma and cystic fibrosis) during pregnancy can affect the development of the foetus and cause prematurity and low birth weight (LBW). Other maternal medical conditions such as pre-eclampsia, hypertension, urinary tract infection and intrauterine infections and bleeding can also lead to premature birth (Joffe and Wright, 2002; Lissauer and Fanaroff, 2006; Odendaal, Steyn, Norman, Kirsten, Smith and Theron, 1995).

Another cause of preterm delivery is infection of pregnant women with the human immunodeficiency virus (HIV), which can also be transmitted to the foetus. A study by Martin, Boyer, Hammill, Peavy and Platzker (1997) concluded that infants born to HIV-positive mothers exhibited a high prematurity and LBW rate and the chances of prematurity were higher in infants who were infected with HIV. Since then, more studies have found that the use of highly active antiretroviral therapy (HAART) during pregnancy also increased the risk of prematurity (Townsend, Tookey, Cortina-Borja and Peckham, 2006; Grosch-Woerner, Puch, Maier, Niehues and Notheis, 2008).

Results of the National Sero-Prevalence Survey of women attending public antenatal clinics in South Africa in 2002 showed that 26.5 percent of these women were infected by HIV. Statistics released in 2006 by the National Department of Health in South Africa reveals that nearly one in three pregnant women (29 percent) were infected then. That was an increase of 2.5 percent since 2002.

An infant born to an HIV-infected mother was one of the criteria of exclusion in this study, as it was unclear whether an HIV-positive status could act as a confounding variable.

2.2.2 Maternal socio-economic status and the effect of prematurity

Parker, Greer and Zuckerman (1988) demonstrated that poverty doubled the risk of prematurity and slower development in early childhood. Infants in these conditions are more readily exposed to risks like medical illnesses, parental stress and depression, and have little social support. For example, in the antenatal period infants are exposed to viruses that are associated with a lower socio-economic status, such as cytomegalovirus (CMV). It was found that maternal drug abuse, malnutrition and intrauterine infections could also result in preterm birth, LBW and other insults to the developing nervous system (Egbuonu and Stratfield, 1982; Joffe and Wright, 2002; Lissauer and Fanaroff, 2006; Fike, 2007). Associations between maternal smoking during pregnancy and low economic status were confirmed in studies by Delpisheh, Kelly, Rizwan and Brabin (2006). Such children exposed to both biological and environmental risk factors have been termed as being in ‘double jeopardy’ for developmental delays (Brooks-Gunn et al, 1992).

Escalona (1982) conducted a study of the early cognitive and psychosocial development of predominantly poor and non-white infants and their families living in the Bronx, New York, from birth to age three and a half years. The majority of the group was doubly at risk on the basis of prematurity and low socio-economic background. It was found that by 28 months and thereafter a severe decline in cognitive status was associated with social class. Serious maladjustment not associated with social class also added to impoverished cognitive development. The results of the study therefore suggested that environmental deficits and stressors affected the cognitive and psychosocial development of full-term and premature infants, with the premature infants being even more vulnerable.

Epidemiological studies showed that poor maternal education, young maternal age, single parenthood and poverty are all associated with low birth weight. The level of maternal education could also play a role in the organisation of the home environment, the maternal child-rearing practices and beliefs, as well as maternal interactions. All these factors can directly influence infant’s cognitive function (Brooks-Gunn et al, 1992).

Most of the residential areas in the Western Cape from which the sample for our study was drawn are characterised by poverty, violence, more than two generations or more families sharing a dwelling, poor health and hygienic conditions and young, mostly single mothers with poor educational backgrounds. The hospital that was used for the purpose of the study is a government hospital where people pay according to their income and where children under the age of five years are treated free of charge. The population from which our study sample was selected thus compares well with the babies in ‘double jeopardy’ (Brooks-Gunn et al, 1992).

2.2.3 Maternal substance abuse related to prematurity

Substance abuse during pregnancy has become a major health concern over the past two decades. Consequences of foetal substance exposure include poor intrauterine growth, prematurity, foetal distress, still births, cerebral infarctions, malformations and neuro-behavioural dysfunction (El-Mohandes, Herman, El-Khorazaty, Katta, White and Grylack, 2003; Fike, 2007).

In the Western Cape alcohol remains the most frequently abused substance (Haker, Kader, Meyers, Fakier, Parry and Flisher, 2008). Shishana, Rehle, Simbayi, Parker, Zuma, Bhana, Connoly, Jooste and Pillay (2005) found that 25 percent of males and six percent of females in the Western Cape consumed alcohol in a hazardous or harmful manner. They also reported that the Western Cape had the second highest prevalence of harmful drinking during pregnancy in South Africa, with one of the highest Foetal Alcohol Spectrum Disorder (FASD) rates in the world. Another Human Sciences Research Council (HSCR) household survey found higher levels of harmful alcohol use among the mixed race communities in the Western Cape (18 percent) relative to Black/ African (11 percent), White (seven percent) and Indian (one percent) (Shishana et al, 2005). In addition, the Western Cape had the second highest prevalence of LBW infants (18 percent) in South Africa for the period 1998 to 2005, according to the *Saving Babies 2003–2005* report (MRC Unit, 2006). These statistics reflect the population in the Western Cape from which the participants for our study were recruited.

Similarly to alcohol abuse, maternal smoking has been associated with foetal growth reduction and preterm labour (Moore and Zaccaro, 2000; Lissauer and Fanaroff, 2006; Fike, 2007). Infants born to smoking mothers weigh an average of 150–250 g less than those of non-smoking mothers. The exact mechanism by which foetal growth is retarded is not entirely clear, but placental dysfunction is one of the problems related to heavy maternal smoking during pregnancy (Egbuonu and Stratfield, 1982; Joffe and Wright, 2002; Lissauer and Fanaroff, 2006; Fike, 2007). A study by Delpisheh et al (2006) on socio-economic status and smoking during pregnancy revealed that 37 percent of mothers classified within the low socio-economic status smoked during pregnancy versus 14 percent classified within the high socio-economic status. It is thus clear that maternal smoking during pregnancy can contribute to prematurity and VLBW and that this is more likely to occur among mothers classified with a lower socio-economic status, as representative of the population from which this study sample was selected.

According to Fike (2007), infants exposed to cocaine also have a high incidence of prematurity and LBW. Studies done by both Benson and Lane (1994) and Arendt, Singer, Angelopoulos, Bass-Busdiecker and Mascia (1998) found that infants exposed to cocaine in uterus experienced sensory-motor deficits up to the age of 18 months.

Joffe and Wright (2002) suggest that poor nutrition and health care of a substance-abusing mother may also affect the growth and development of the foetus and induce preterm labour.

As reported by the HSRC in South Africa, the Western Cape has a high prevalence of substance abuse in the lower socio-economic sequelae, which could have contributed directly to perinatal morbidity, prematurity and VLBW and NICU admission.

2.3 SENSORY DEVELOPMENT AND INTEGRATION

Sensory integration is a theory of brain-behaviour relationships that was defined by Jean Ayres (1972a:11) as the ‘neurological process that organises sensation from one’s own body and from the environment and makes it possible to use the body effectively within the environment.’ Ayres started to investigate the scientific literature in the 1960s and gained a deep respect for the importance of the organism-environment interaction and the vital role it plays in brain development and function (Roley, Blanché and Schaaf, 2001; Parham and Mailloux, 2005). Her motive was to discover the hidden disorders that interfered with learning and behaviour (Fisher, Murray and Bundy, 1991; Roley et al, 2001). In developing her sensory integration theory she worked with the assumptions of neural plasticity, nervous system hierarchy, adaptive behaviour, developmental sequence and inner drive (Fisher et al, 1991; Murray-Slutsky and Paris*,* 2000). Ayres completed six factor-analytical studies between 1965 and 1977 to uncover complex neurological processes that are at the heart of an individual’s daily life performance and participation (Fisher et al, 1991; Parham and Mailloux, 2005).

Ayres (1972a) based her research on the results of studies by Harlow and co-workers in the late 1950s and early 1970s on Rhesus monkeys, which demonstrated the role of the environmental influence on the development of the brain. The baby monkeys were separated from their mothers at birth and thereby deprived of tactile, olfactory, thermal, vestibular, visual and auditory stimulation provided by the mother. This produced profound deficits in social behaviour. More studies on rodents by Diamond, Rozenzweig, Bennett, Linder and Lyon (1972) and Greenough (1975) demonstrated that early postnatal rearing environments exerted a significant influence on the brain and behaviour and could actually change the brain’s cyto-architecture.

During her research, Ayres (1979) found that the brain did not develop in terms of isolated sensory modalities, but that multisensory stimuli were more effective (Ayres, 1979). Blair and Thompson (1995) also researched the process of sensory integration and identified the location, incidence and properties of neurons that respond to multisensory cues. They found that the following neurological structures were involved in the sensory integration process. The brain stem takes charge of the survival functions, like feeding, fleeing, fighting and reproduction. The structure responsible for sleep cycles, arousal and attention and also consciousness is the core of the brain stem and is called the reticular formation. The reticular formation combines the spinal cord with the thalamus, which is the big sensory centre through which all sensory intake travels, with the exception of olfaction. At the back of the brain stem is the cerebellum, which is responsible for co-ordinating muscle tone, balance and body movement. All the sensory pathways, except the olfactory system, go through the limbic system, which is in charge of the emotions. The limbic system and reticular formation work hand-in-hand to modulate the nervous system. The cerebral cortex is the highest level where perceived sensations are interpreted and it enables us to write, speak, make decisions and act accordingly. In order to function well, the cerebral cortex relies on the adequate sensory organisation and management performed by the lower and less complex levels. When the connections between the different parts of the brain work smoothly, sensory integration occurs spontaneously (Bundy, Lane and Murray, 2002). These structures control all of our vital body functions and are largely responsible for meeting the newborn’s essential needs to survive, grow and bond with its caregivers (Eliot, 1999).

More recent studies by Meaney, O’Donnell, Viau, Ghatnagar, Sarrieau and Smythe (1994) examined the mechanisms underlying biological-environmental interactions. Specific neural receptors in certain brain areas of rodents that had been handled, reported an enduring increase in the concentration of gluco-corticoid receptors in the hippocampus of such rats as compared to their counterparts that had not been handled. Gluco-corticoids are hormones produced by the adrenal glands and are secreted in response to stressful stimuli such as maternal separation, lack of physical touch and painful events in the postnatal environment. There is an increase in gluco-corticoid receptors when an organism experiences a stressful situation. Such neural changes however influence the way in which the organism interacts with its environment (Sullivan, Wilson, Feldon, Yee and Meyer, 2006).

The gluco-corticoid in humans that is used to measure levels of stress is cortisol. Progress has recently been made to measure the physiological response of infants to stress by assessing salivary cortisol levels, heart rate and respiratory rate (White-Traut, 2004). Sensory deprivation and maternal separation have been linked to stress-related illness and increased stress responses during the later life of primates (Suomi, 1997). These studies support the theories of Jean Ayres (1972a) on the environmental influence on sensory integration.

The research by Flemming, O’Day and Kreamer (1999) on animals further supports the sensory integration theory. These authors demonstrated that inadequate sensory experiences, like that of a stressed mother handling her infant, affect infant development and behaviour, in utero but also in future generations. This research done on animals compared well with humans. It focused on the dynamic relations between environment, stress, genetics and infant development. Studies like these offer evidence of the continuous plasticity in the mammalian nervous system that is affected largely by the experiences that the organism has with the environment (Roley et al, 2001).

Sensory processing disorders can be seen at different developmental stages. Regulatory problems, which manifest in behavioural regulation and sensory-motor organisation, such as sleeping difficulties, poor self-calming abilities, very low or high activity levels, slowness in attaining motor milestones, too little or too much sensory stimulation and atypical muscle tone are conditions related to deficits during the infancy stage (DeGangi, 2000; Gomez, Baird, Jung, 2004). Therefore, it is important to understand the development of sensory processing in the preterm infant in order to prevent developmental disabilities by applying correct intervention techniques.

In summary, the immature central nervous system (CNS) of the premature infant is competent for protected intrauterine life, but is not adequately developed to adjust to and organise the demands and overwhelming stimuli of the neonatal intensive care unit (NICU) (Hunter, 2005). The risk is thus higher in an inappropriate high-technology environment with continual stimuli that cause insults to the developing brain of the preterm infants, which in turn promote sensory integrative disorders (Gressens, Rogido, Paindaveine and Sola, 2002; Ronca, Fritzsch, Bruce, Alberts, 2008). Therefore, it becomes a priority to reduce avoidable stressors in the NICU and to assist the infant to stay calm and organised.

2.3.1 The sensory systems and their functions

The central nervous system consists of the spinal cord and the brain. It develops in a programmed sequence from the spinal cord to the brain stem and lower brain structures. The sequence continues after birth, as the higher brain areas take control. The four important brain structures mostly involved in sensory integration are: (1) the brain stem; (2) the cerebellum; (3) the diencephalons (which are part of the limbic system and also associated with important structures such as the basal ganglia, hippocampus, amygdale and hypothalamus) and the thalamus; and (4) the cerebrum (Kranowitz, 1998; Sullivan, Wilson, Feldon, Yee and Meyer, 2006). Areas that mature gradually after birth are the cerebellum, basal ganglia (responsible for movement), limbic system (responsible for emotions and memory) and the cerebral cortex (responsible for willed behaviour, conscious experience and rational abilities) (Eliot, 1999).

One of the brain’s properties is adaptability or neuroplasticity. Neurobiologists generally agree that genes programme the sequence of neural development, but Edelman (1992) advocates that the connections shift and reassemble as a result of a dynamic series of events. Therefore, the quality of that development is also shaped by environmental factors. The early information that a child receives from the environment through the sensory systems is an important contributor to the final circuitry of the brain (Hann, 1998; Sullivan et al, 2006). Genes are responsible for the growth and location of axons and dendrites, but once these fibres start linking together to function, each child's unique environmental stimuli reshape and refine the fibres. Hence, the importance of creating the friendliest possible environment is important for optimal neuro-development (Eliot, 1999; Sullivan et al, 2006).

There are different sensory systems, which develop at different stages in utero and after birth. These systems interact with the environment and transport messages to the higher centres of the brain where it is processed to enable responses. A discussion of the development and function of these different systems follows below.

2.3.1.1 The somatosensory system

The somatosensory system is the part of the central nervous system responsible for the sense of touch. Touch has four different sensory abilities, each with its own neural pathway. The four abilities are the sense of touch or coetaneous sensation, sensation of temperature, pain and proprioception (the sense of position and movement of one's body) (Eliot, 1999).

Receptors of the tactile system are mechanoreceptors. The process of neurotransmission starts when mechanical force (light touch, deep pressure, stretch or vibration) is applied to the receptor. Touch, temperature and pain receptors are located in the skin, while the proprioceptive receptors react to input from the skin, the muscles and joints (Bundy, Lane and Murray, 2002). These mechanoreceptors translate the tactile messages along sensory neurons, through the spinal cord to go through the brain stem and thalamus to the somatosensory region of the cerebral cortex (a vertical strip, at the frontmost portion of the parietal lobe) (Eliot, 1999).

Tactile stimuli are the very first stimuli that the embryo responds to about three weeks after conception (Faure and Richardson, 2002). Research has proved that touch sensitivity starts to develop at the lips and the nose (Humphrey, 1969; Short-DeGraff, 1988). The chin, eyelids, arms and the legs follow in sequence. By the twelfth week the whole body surface responds to touch. The top and the back of the head remain insensitive throughout gestation, in order to make the birth process easier. By the third trimester sensory fibres reach the brain stem, where the tactile information gets integrated with other senses, which permits the emergence of more sophisticated reflexes, such as the rooting reflex. At around 20 weeks of development, thalamic axons start forming synapses onto the cortex. This process continues well into the third trimester when the foetus starts to perceive touch experiences. During the later half of gestation, the foetus becomes active and kicks, turns and bumps against the walls of the uterus, providing it with a great deal of somatosensory input (Eliot, 1999).

The sense of touch is the most mature sense at birth and premature infants as young as 25 weeks gestational age exhibit electrical activity, however slow, in the somatosensory cortex in response to touch stimuli (Eliot, 1999). This maturity of the touch sense was already highlighted by Ayres (1972b) in her citation of Harlow's studies of mother-infant attachment in Rhesus monkeys in the 1960s. These studies demonstrated that it was tactile contact rather than nourishment that comforted the infant monkeys and caused them to form social relations with their mothers. That is why most mammal species provide physical contact to their newborn babies, which is vital for growth and development (Eliot, 1999; Jacobs and Schneider, 2001). Diamond et al (1972) also showed that rats that were handled frequently demonstrated a better modulated stress-response system. The changes in the neurochemistry of their brains made them less fearful in new situations. Studies on animals help us to understand the interrelation between the development of the human brain and environmental factors.

Touch is both the first and the largest sensory system to develop in the body. Therefore, researchers have argued that this sense, more than any other, offers the best opportunities for developing the emotional and mental well-being of not only normal young babies, but particularly those born prematurely, as they are deprived of the environmental touch stimulation provided by the uterus (Eliot, 1999, Agarwal, Enzman Hagedorn and Gardner, 2002; Biel and Peske, 2005).

2.3.1.2 The vestibular system

The vestibular system is the sense that allows us to experience our body’s movement and the degree of balance. This system tells us if we are moving, in which direction and whether we are upright or not. From birth we need vestibular information as the reference point against which other sensory input is measured. This helps us to orientate ourselves with respect to gravity and our own motion (Murray-Slutsky and Paris, 2000). The vestibular system is responsible for the maintenance of head and body posture, and for movement of the other parts of our bodies, especially the eyes. This allows us to adjust our body’s position and maintain balance and get smoothness of motion (Eliot, 1999).

The receptors for the vestibular sense are situated in the ‘vestibule’ or bony labyrinth of the skull, which houses the inner ear. The inner ear consists of the cochlea (hearing organ), the three semicircular canals and the otolith organs, namely, the saccule and the utricle. The semicircular canals register the speed, force and the direction of head rotation; the saccule detects linear movements; and the utricle perceives head tilts and body changes with respect to gravity (Williamson and Anzalone, 2001; Hain and Helminski, 2007).

The hair cells in the abovementioned structures are the receptors of the vestibular system. The hair cells synapse into the first neuron in the vestibular pathway, where the axons extend to the brain stem to form the vestibular nerve. These fibres synapse on several groups of neurons and send information about balance and motion to the eyes, the motor neurons in the spinal cord and the cerebellum, which integrates and co-ordinates the vestibular information with the visual and tactile senses. Most of the vestibular system’s activity remains below the level of consciousness and only now and again some fibres leading to the cerebral cortex cause conscious perception of movement and position (Eliot, 1999; Hain and Helminski, 2007).

The vestibular and the auditory systems start their simultaneous development five weeks after conception, but the vestibular system progresses much faster than the auditory system. At ten weeks after conception the foetus becomes responsive to movement stimulation in the form of the Moro reflex. The foetus continues to develop more reflex activity and begins to move its eyes reflexively in response to its head position by 12 weeks (Hunter, 2005). By 20 weeks of gestation, the vestibular apparatus has reached its full size and shape the pathways to the eyes and spinal cord have begun to myelinate and the whole system functions at a very high level (Eliot, 1999; Faure and Richardson, 2002).

The vestibular sense is one of the earliest to mature and to experience sensory input; therefore, it also plays an important role in the organisation of other sensory and motor abilities, which in turn influence the development of the higher emotional and cognitive abilities (Eliot, 1999; Ronca et al, 2008). Murray-Slutsky and Paris (2000) argue that inadequate vestibular processing can be the cause of problems such as lack of self-calming abilities, delayed milestones like rolling, sitting, crawling and walking, an inability to sustain an upright position and proper movements of the eyes that can lead to attention deficits and other visual perceptual problems.

Known as the most mature system next to the somatosensory system at birth (Maurer and Maurer, 1988), it is important that the vestibular system must be appropriately stimulated in the NICU to ensure the integration and development of the other senses together with the motor system, which will eventually have an organising effect on cognitive and emotional growth.

2.3.1.3 The visual system

Unlike some of the other sensory systems, the sense of vision is still poorly developed at the time of birth, because it received so little stimulation in the uterus (Faure and Richardson, 2002). However, visual development begins 22 days after conception with the formation of the eyes (Moore, 1993). By eight weeks the upper and lower eyelid folds form and fuse until the twenty-sixth week of gestation (Gardner and Goldson, 2002). The first optic tissue starts developing at 22 days, and by five weeks the retinal differentiation takes place to form the retina and lens. The retina consists of neurons which divide and migrate. The first layer of neurons to develop is the ganglion cells, formed between six and 20 weeks. By eight weeks the optic nerve begins to form. (Eliot, 1999; VandenBerg, 2007)

During the second trimester the growth can be seen in the visual cortex. All the neurons in the primary visual cortex are formed between 14 and 28 weeks of gestation (Eliot, 1999). The synapses that are involved in motion processing (the ‘where’ pathway) develop first. By four months after birth this pathway has reached its maximum synaptic density. The synapses involved in visual perception (the ‘what’ pathway) follow later and reach their peak at eight months after birth (Burkhalter, 1993). The optic nerve starts myelinating at 32 weeks of gestation and continues until seven months after birth (Broody, 1987).

Eliot (1999) reports on studies done by David Hubel and Torsten Wiesel in the early 1960s, in which they deprived monkeys and kittens of any visual experience shortly after birth. They found that this deprivation had a profound effect on the structure and function of the visual cortex and made it clear that the early visual experience in these animals’ lives had a long lasting impact on their visual circuitry and perceptual abilities. Eliot (1999) further reports on more research done by Hubel and Wiesel on whether there was a critical period for visual experience in early development and how long it lasted. This time they deprived kittens of visual experience three months after birth and found that the deprivation was not devastating. They came to the conclusion that the brain needed experience to wire up during the pruning period, when the initial promiscuous synaptic contacts were being refined. Therefore, once the pruning period is over, the cortex cannot be drastically rewired. With this in mind, it is possible that early visual experience shapes an infant’s skill of observation, spatial perception, hand-eye co-ordination and level of arousal.

This gives rise to concern about the visual environment of the NICU to which the premature infant is exposed to after birth. Therefore, it was of great importance to this study to implement the most beneficial and functional lighting environment in the NICU in order to enhance the preterm infants’ development (see discussions in sections 2.4.1.5 and 3.6.2.1).

2.3.1.4 The auditory system

The neural structures underlying hearing develops early in utero and starts functioning about 12 weeks before birth (Faure and Richardson, 2002; Parham and Mailloux, 2005). By the time the infant is born its sense of hearing is quite advanced and it can differentiate between basic sounds. The maturing of the auditory system is gradual and auditory skills, together with the mastery of language, continue to improve over an extended period (Eliot, 1999).

The auditory system starts developing four weeks after conception, when the octocysts on either side of the embryo’s head emerge and the cochlea start to develop between five and ten weeks. The hair cells in the cochlea mature between ten and 20 weeks of gestation and start to form synapses with the first neurons of the auditory system. The auditory nerve, cochlear nuclei and the superior olive are shaped by six weeks after conception. By 13 weeks the higher brain stem auditory centres emerge. Although cortical neurons only form later, the auditory cortex is one of the first areas of the cerebral cortex to mature and the third trimester of pregnancy is the most critical period for this development to take place (Hunter, 2005). Myelination in the auditory system starts quite early and by birth the lower neuronal relay tracts are nearly fully myelinated, while the higher relay tracts myelinate more gradually (Moore, 1993).

Based on research done with ultrasound, foetuses respond to sound at 23 weeks of development. Studies by DeCasper and Fifer (1980) and DeCasper and Spence (1986) suggested that foetuses and neonates exhibited auditory memory when sound stimuli were played towards the mother’s abdomen. Sound discrimination however develops later during the third trimester (Eliot, 1999).

Studies on the types of auditory input received by foetuses in the womb demonstrated that lower frequency sounds, male voices and most importantly, the mother’s voice and her other body sounds, like her heartbeat, blood flow, breathing and stomach noises, were best transmitted and tolerated by the foetus (Gagnon, 1989; De Casper and Fifer, 1980; DeCasper and Spence, 1986).

Some researchers have raised concerns about the dangers of excessive noise exposure during pregnancy and in the NICU in the case of premature birth. Research done on animals has shown that loud noise can lead to a degree of permanent hearing loss (Gerhardt, 1990). The period of greatest sensitivity is just after the onset of hearing, and in humans that period begins at 25 weeks of gestation and extends to a few months after birth. Lickliter (2000) reports on more animal studies that support a connection between atypical patterns of early sensory experience and disruption of early perceptual and behavioural development. Such studies point out the vulnerability of the auditory system of the prematurely born infant in the NICU as it lacks the shielding of its mother’s body and is exposed to loud, prolonged chaotic environmental noise (Gorski, 1991; Hunter, 2005).

2.3.1.5 The olfactory system

The sense of smell plays a powerful role in our lives. Odour goes hand-in-hand with appetite and the selection of food. It also plays an essential role in social interaction and to a remarkable degree in parent-infant bonding. The primary olfactory areas in the cortex are well developed by birth and newborns rely more heavily on it than later in life (Eliot, 1999; Schaal, Hummel and Soussignan, 2004).

The olfactory system starts forming at five weeks after conception. By 11 weeks the olfactory epithelia are abundant and quite mature, but they start to function much later, when their biochemical development is complete. The foetus starts to smell by 28 weeks after conception. In a study of premature infants it was found that the infant only started to show a reaction to different odours after 28 weeks of gestation. The foetus’s olfactory abilities improve rapidly during the third trimester of pregnancy (Moore, 1993; Sarnat, 1978; Schaal et al, 2004).

After birth the young infant orients to the smell of its mother and her milk. Early olfactory images of the newborn are therefore very crucial in the development of the olfactory system. These images depend on the amount of early contact between parent and infant (Schaal et al, 2004). Looking at the preterm infant in the NICU, there is little direct contact between the mother and her baby while it is cared for in an incubator (Eliot, 1999; Gardner and Goldson, 2002).

2.3.1.6 The gustatory system

The ability to taste also starts early during pregnancy and becomes functional during the third trimester of gestation, where it gets a considerable amount of stimulation in the womb (Eliot, 1999).

The first taste buds on the tongue of the foetus emerge eight weeks after conception and by 13 weeks taste buds are formed throughout the mouth and communication starts with the nerves. This coincides with the time when the foetus begins to suck and swallow (Moore, 1993).

A foetus's taste experience in the womb may influence its later behaviour relating to food preferences, as well as bonding and finding comfort with its mother, as it recognises the flavours in her milk (Tatzer, Schubert, Timischl and Simbruner, 1985; Rosenstein and Oster, 1988)

The early taste experience of an infant plays a role in survival as well as the emotional growth and development of the infant. In the NICU, where the premature infants are being cared for, they are mostly fed by a naso-gastric tube and seldom experience the taste of milk. In contrast, they rather often taste the reflux of milk and medication, which leaves a negative imprint in the development of their gustatory systems (Eliot, 1999; Gardner and Goldson, 2002).

2.3.2 The role of the uterus in providing a balanced sensory experience

After conception the foetus is exposed to the constant vestibular, tactile, proprioceptive, olfactory and gustatory sensory stimulation in the uterus (White-Traut et al, 1994). There is however minimum visual and auditory input.

In utero, maternal movements, diurnal cycles and amniotic fluid create gentle oscillating movements providing vestibular stimulation to the foetus. Before birth the foetus is protected in the dark, comfortable, warm environment of the uterus, which provides confinement and at the same time stimulates the tactile and proprioceptive systems as it moves around in this environment (Hunter, 2005). While in utero the foetus's gustatory and olfactory systems are constantly stimulated by the smells and tastes that reach it through the placenta. This may be a way by which the infant monitors the intrauterine environment (Tatzer et al, 1985; Rosenstein and Oster, 1988; Gardner and Goldson, 2002).

The visual and auditory systems are minimally stimulated in utero. The environment is dark and occasionally the foetus is exposed to a very dim spectrum of red light.

The auditory system of the foetus is exposed to the biologic sounds and muffled environmental noises (Eliot, 1999; Gardner and Goldson, 2002; Hunter, 2005).

This ideal sensory environment exists for the full term of the foetus in the uterus. Thereafter the sensory environment of the newborn generally continues to provide the newly born with boundaries, as mothers usually contain them by various methods, such as swaddling (Faure and Richardson 2002). The infant is also exposed to rocking movements, which provide them with the necessary vestibular input to calm them down. Breast milk is readily available if the mother breastfeeds. They usually also sleep in a quiet, calm and dimmed-light environment (Faure and Richardson, 2002; Neser, 2006).

Under normal circumstances the full-term newborn infant experiences a sensory environment that is much more appropriate for its normal development than that of the premature infant in the NICU.

2.4 THE NEONATAL INTENSIVE CARE UNIT

The NICU is often home to the first three months of the premature infant's life. Gardner and Goldson (2002) described the NICU environment as both sensory deprived and sensory bombarded. Researchers such as McCormick (1997) started to focus on the psychological development and the quality of life of very low birth weight (VLBW) and extremely low birth weight (ELBW) children, who were cared for in the NICU (Wolke, 1998). Gressens et al (2002) describe the impact of practices in the NICU on the developing brain. They found that this environment might cause insults to the developing brain and could lead to maladapted behaviour and poor developmental outcomes.

The NICU environment can be profoundly stress provoking for the premature infant and may provide inappropriate stimuli for the optimal sensory development of the infant (White-Traut et al, 1994; Hunter, 2005; Lowman, Stone and Cole, 2006). As already indicated the sensory systems develop in a certain order and get the right stimulation at the right time while in the mother's womb. Sensory development starts with the tactile system, followed by the vestibular, gustatory, olfactory, auditory, and finally, the visual system. Unfortunately there seems to be a 'mismatch', as Als (1986) called it, between the development of the infant's sensory systems and the inherent necessities of the NICU environment (McCormick, 1989; Hunter, 2005). The way in which White-Traut et al (1994) demonstrated the inconsistencies between development and stimulation in the NICU is depicted in Figure 2.1.

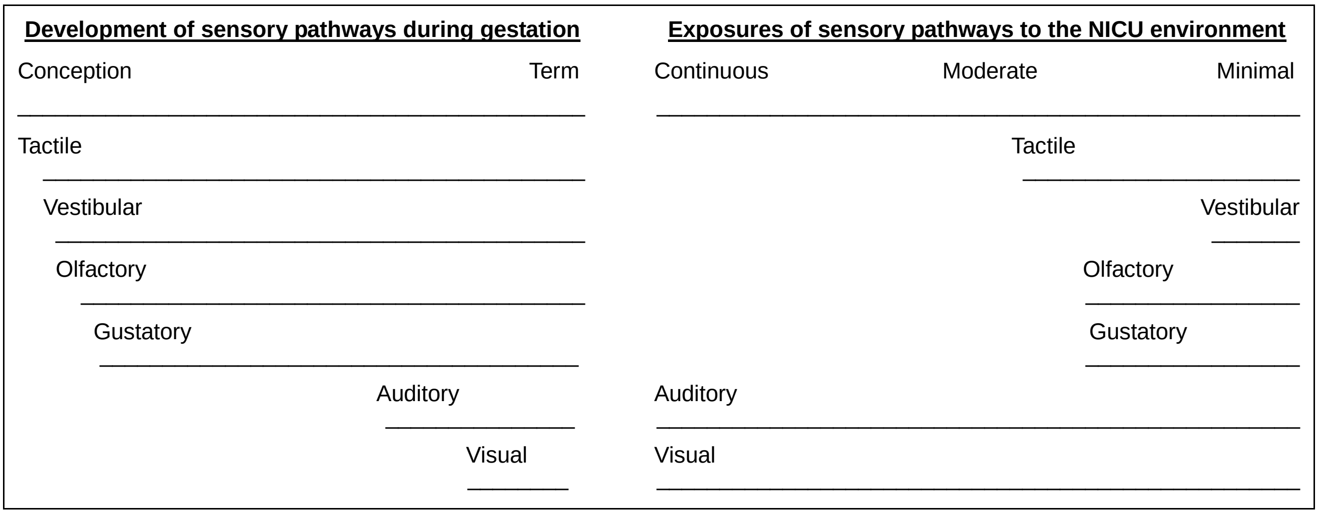

Figure 2.1 Hypothetical comparison of sensory pathway development to sensory exposure in the NICU[1]

The comparison in Figure 2.1 illustrates how the two senses that are the least mature (visual and auditory) are the most stimulated in the NICU. On the other hand, the tactile and vestibular senses, which are the more mature systems, are least stimulated. The tactile sense is often stimulated with unpleasant stimuli that are associated with pain. The development of the olfactory and gustatory senses is also more advanced than the stimuli provided in the NICU.

Improvement in medical science and technology increased the survival rate of younger, smaller and sicker infants. Concerns about the long-term effects of the NICU on the central nervous system of preterm infants resulted in studies and caregiving practices that emphasise developmental concerns (Als et al, 1996; Gardner and Goldson, 2002; Gressens et al, 2002; Hunter, 2005). The results and recommendations will be discussed in section 2.4.1 and 2.5.

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[1] White-Traut et al, 1994:396

2.4.1 The impact of the NICU environment on the sensory systems of the preterm infant

2.4.1.1 The somatosensory system (tactile and proprioception)

The sense of touch is highly developed and stimulated in utero and therefore the very immature preterm infant is very sensitive to touch (Gardner and Goldson, 2002). The stimulation in utero consists of a smooth and wet environment (the amniotic fluid) with constant proprioceptive input imposed by the uterus walls and the foetus's own body (Hunter, 2005).

In contrast with the warm, stimulating intrauterine environment, the environment of the NICU primarily consists of uncomfortable and painful handling during medical and nursing procedures (Gardner and Goldson; 2002; Gressens et al, 2002). These procedures can be prolonged and stressful for the infant and negative physiological responses such as blood pressure changes, alteration in cerebral blood flow, hypoxia and other stress behaviours can be provoked (Long, Philip and Lucey, 1980; Gorski, Hole, Leonard and Martin, 1983; Gressens et al, 2002; Sullivan et al, 2006). Frequent handling (as much as 23 times in 24 hours, according to Altimier (2007)) can disrupt the infants' state regulation and sleep deprivation can contribute to weight loss (Appleton, 1997). These infants can develop a touch aversion reaction that is associated with human touch. The touch aversion reaction can, according to Sullivan et al (2006), be stored as early emotional memories. Frequent touch may elicit stress-related signals like crying and squirming in the infant when touched and can also lead to energy deprivation and associated slower growth and development (Gardner and Goldson, 2002).

Anand and Hickey (1987) found that pain pathways are myelinated in the foetus during the second and third trimesters. Due to the immature CNS and the late myelination of pain fibres in the neonate, there was great controversy on whether the neonates perceived and remembered pain (Agarwal et al, 2002; Jorgensen, 1999). Stevens, Johnston, Franck, Petryshen, Jack and Foster (1999) found that an average of 134 painful procedures were done on 124 preterm infants with gestational ages of 27 to 31 weeks during the first two weeks of their lives. Most of the painful interventions included blood sampling by heel sticks and endotracheal suctioning.

Cignacco, Hamers, Stoffel, Van Lingen, Gessler, McDougall and Nells (2006) revealed increasing evidence that the CNS was much more mature than previously thought. According to these authors, a number of studies disclosed that repeated and sustained pain could have a long-term effect on the neurological and behaviour-orientated development of the neonate. With this in mind strategies for stress reduction in order to promote the unimpeded development and well-being of the neonate are currently some of the most important issues in neonatal intensive care (Cignacco et al, 2006). These strategies focus, among others on the concept of developmental care and new approaches to pain management (Agarwal et al 2002; Sizun, Ansquer, Browne, Tordjman and Morin, 2002; Als et al 1996). Recently pain management has become an important issue in neonatal intensive care to promote unimpeded development and the well-being of the neonate (Cignacco et al 2006).

Avory and Glass (1989) raised concerns about the damage done by the harsh and unnatural setting of the nursery environment of the NICU to the survivors' brains. These infants are often connected to ventilators and in need of feeding tubes and other life-saving devices that prohibit them from being caressed and cuddled. Other factors that inhibit self-generated tactile stimulation are: decreased active postural tone and fewer spontaneous movements; restraints to prevent accidental extubation or removal of intraventricular lines; and medication that can produce lethargy and decreased movement (Greger, 1995).

Many NICUs have 'minimal touch' policy to avoid over-stimulation (Eliot, 1999). Added to this policy, the incubator is also not the most infant-friendly environment. In utero the foetus is in a flexed, contained position with boundaries that provide it with proprioceptive feedback during movement, while in the NICU the infant is often placed on a flat mattress without any boundaries. Therefore, it constantly moves around in the incubator looking for boundaries. These movements are exhausting and energy provoking, preventing the infant from applying self-regulation and calming strategies. This can lead to decreased weight gain (Gardner and Goldson, 2002; Altimier, 2007).

Based on the work of Als (1982, 1986), techniques to provide more touch stimulation, like nesting techniques (providing the infant with more boundaries in the incubator to feel secure), KMC and massage have been used and found to be beneficial in terms of weight gain, temperature control, better sleeping patterns, maturation of the lungs and easier breastfeeding.

2.4.1.2 The vestibular system

The vestibular system is the second sensory system to develop. In utero the foetus is in a confined, fluid-filled area with boundaries to support it, yet allowing it the necessary movement. Maternal movement also stimulates the vestibular system of the foetus. As the foetus grows, the space for free movement decreases and physiological flexion increases. The foetus however receives additional vestibular stimulation through the movement of its mother during pregnancy. The foetus finally prepares for birth when it turns with its head pointing downward in order to enter the birth canal (Hunter, 2005).

In the NICU the infant's vestibular experience is inappropriate. It is alternately exposed to vestibular overload by frequent uncontrolled handling (Gottfried and Gaiter, 1985; Gressens et al, 2002; Altimier, 2007) or deprived of any vestibular input as it lies horizontal on a flat mattress in an incubator (Aucott, Donohue, Atkins and Allen, 2002). The stimulation that the infant experiences through some of the caregiving procedures often provokes a startle reflex from the infant, which may have severe and prolonged disruptive effects on the infant's autonomic system (Als et al, 1996; Gressens et al, 2002).

The functioning of the vestibular system must be appropriately and supportively maintained in the NICU. Therefore, this stimulation should simulate as closely as possible that which the preterm infant would experience in utero.

2.4.1.3 The olfactory and gustatory systems

The olfactory and gustatory systems are both functional by the third trimester of foetal development. In utero, however, they are protected from harmful and overwhelming tastes or smells (Eliot, 1999; Schaal et al, 2004).

In the NICU the premature infant is exposed to the odours of open swabs, cleaning chemicals used in incubators and strongly scented toiletries. It is unable to respond by crying or moving away and responds by decreasing its respiratory rate and transient apnoea, and by increasing its heart rate (Gardner and Goldson, 2002; Schaal et al, 2004).

During its stay in the NICU, the infant experiences many unpleasant tastes and painful stimuli around and within the mouth. The taste of medicine and reflux are some of the unpleasant tastes. Prolonged use of oral and naso-gastric tubes, as well as routine endotracheal and oral suction may contribute to hypersensitivity around the mouth, which may result in sucking, swallowing and oral defensive difficulties (Gardner and Goldson, 2002; Schaal et al, 2004).

Schaal et al (2004) state that olfaction is of high significance in the environment of the premature infant and the use of biologic odours from the mother is the most desirable for the infant.

2.4.1.4 The auditory system

The auditory nervous system achieves full function between 25 and 27 weeks of gestation (White-Traut et al*,* 1994; Hunter, 2005). In utero, sound is filtered through bone, tissue and water and thus tends to be of low frequency and intensity (Altimier, 2007). Here the foetus is exposed to its mother’s voice, heartbeat, breathing and other intestinal sounds. This system is thus protected from the overwhelming noise levels outside the womb (Eliot, 1999; Holditch-Davis, 2003; Hunter, 2005).

In the NICU the auditory system receives the most stimulation and can disrupt the preterm infant when it expects it the least. Hearing thresholds in an infant of 28 to 34 weeks gestational age have been reported at 40 decibel (db), in a 35 to 38 week infant at 30 db and in a term infant at 20 db. Sound levels of 50 to 90 decibels and higher have however been recorded in the NICU (Gottfried and Hodgeman, 1984; Weibley, 1989; Altimier, 2007). There is also little difference between the day and night noise levels in the NICU. Sounds of equipment, telephones, monitors, conversation, the opening and closing of doors of incubators are some of the noises generated in the NICU (Gardner and Goldson, 2002; Hunter 2005; Altimier, 2007).

The effects of the noise in the NICU may initiate a startle reflex, which has an effect on the infant’s physiological stability and can elicit apnoea, bradycardia, colour change and oxygen desaturation (Gardner and Goldson, 2002). The immature CNS is not yet integrated enough to habituate to the noise. The noise levels have a disorganising effect on the infant, which can affect sleep states and energy levels (Gardner and Goldson, 2002; Holditch-Davis, 2003). Hunter (2005) mentions the possibility of sensorineural hearing loss due to prolonged exposure to these levels. This may also cause the infant to go into a neurological ‘shut down’, which can cause problems later in infancy, like reduced sensitivity to auditory stimulation and attention, anxiety, or an over-sensitivity to certain types of sounds and sleeping problems due to day-night confusion (DePaul and Chambers, 1995; Philbin, 2000).

The evidence is clear that the NICU with its reported noise levels is detrimental for the development of the preterm infant.

2.4.1.5 The visual system

Vision is the last system to develop anatomically and it only becomes functional during the final trimester of foetal development (Gardner and Goldson, 2002). The development of the visual cortex is however only completed three months after birth (Hunter, 2005). The visual and the auditory systems are the most important systems necessary for human interaction. Research has documented that the infant aged 35 to 36 weeks post conception is stable enough to integrate and organise multisensory stimulation (White-Traut et al, 1994).

Spitzer and Roley (2001) also refer to research by Turkewitz (1994) on the timing of the onset of interaction between the sensory systems. It was found that earlier than normal introduction to visual input could have a negative influence on the processing capabilities of other sensory modalities, specifically auditory attention in premature children. Turkewitz (1994) suggested that auditory attention deficits were due to a sensory threshold mechanism and not to an attentional mechanism. This confirms the proposition by White-Traut et al (1994) on the vital importance of giving the premature infant the right stimulation for the different systems at the right times for sensory integration to emerge and produce the best adaptive response.

The light intensity in the NICU ranges between 60 and 80 foot candles, yet can reach a level of 1000 foot candles with direct daylight window exposure combined with supplemented artificial lighting. This is in contrast to the recommended light intensity of 60 foot candles, and 100 foot candles in the case of procedures (Hunter, 2005). The light intensity may damage the development of the immature visual system; disturb sleep-wake cycles; affect physiological stability; disrupt the release of growth hormone; and can cause damage to the retina. Intense over-stimulation can interfere with the development of visual attention and frequent ‘shut down’ responses can lead to gaze aversion and attention deficits as the infant develops (Gardner and Goldson, 2002).

Another disturbing factor is the frequent fluctuation of light in the NICU where little regard is given to day and night cycles. This inappropriate pattern of stimulation cannot be tolerated by the premature infant’s immature CNS (Gottfried and Gaiter, 1985). Hunter (2005) refers to research done by Peng, Mao, Chen and Chang (2001) that concluded that increased light intensity increased the heart and respiratory rates and decreased oxygen saturation in preterm infants in the NICU, resulting in physiologic instability. Circadian rhythm, which the foetus continuously receives in utero from the mother’s feeding, sleeping and activity patterns, is interrupted when birth occurs prematurely. The bright lights in the NICU, as well as the medical routines throughout the day affect the infant’s circadian rhythm, which again has an effect on the physiological stability. Research on the effect of implemented cycled light in the NICU demonstrated support for the development of circadian rhythms and the growth of the premature infant (Andura, Andrés, Aldana and Revilla, 1995; Brandon, Holditch-Davis and Belyea, 2002).

The visual stimulation in the NICU may be seen as a constant bombardment and overwhelming experience for the premature infant’s immature visual system. Movement stimulation, high noises, bright lights, sleep deprivation and long-term sedation all affect the early visual development. As Stanley and Craven (2004) note, these are misdirected connections and suppressed pathways that can produce long-term alterations in neuro-sensory function. Therefore, it is important to give careful attention to the visual-sensory environment in the NICU in order to prevent damage or delays in the neuro-sensory visual development of the preterm infant.

2.4.1.6 Motor development

Although the focus of the study is mostly on the functioning of the sensory systems, it is necessary to include some information on the motor-development of the infant.

Preterm infants younger than 30 weeks gestational age entering the NICU have incomplete development in muscle tissue, extremity flexor tone, joint structures, skulls and spinal curvatures (Sweeney and Gutierrez, 2002). These immature structures are vulnerable for postural and skeletal malalignment and if strategic positioning is not used constructively during this period, asymmetry and deformity may occur quickly (Hunter, 2005; Sweeney and Gutierrez, 2002).

The effect of gravity on the foetus is minimal in utero. Furthermore, the confined space supports the development of physiological flexion, which is necessary for the development of normal muscle tone and neuromotor function. The environment outside the uterus is not as supportive to enhance physiological flexion. The prone and supine positions in the incubator restrict mobility and can result in abnormalities of muscle tone and normal neurological development. The extensor muscles are favoured more than the flexor muscles, causing a muscle imbalance. This means that the muscle tone develops in a caudocephalic direction instead of the normal cephalocaudal direction. Effects of the caudocephalic development of muscle tone can result in reduction of flexor tone in the lower extremities and an increase in extensor muscle tone of the trunk (Monterosso, Kristjanson, Cole and Evans, 2003). This extensor muscle tone can lead to a dominance of extensor activity in the trunk with extension of the spine, scapular retraction, hyperextension of the neck and trunk and abduction of the shoulders (Hunter, 2005). The development of midline orientation could be affected and scapular retraction may limit the infant’s later ability to sit without support, crawl, reach out and manipulate objects and bearing weight on the forearms. External rotation and wide abduction of the hips with a lack of pelvic elevation in the lower trunk can have a functional effect on the development of the infant’s crawling, walking and sitting patterns (Gardner and Goldson, 2002; Monterosso et al, 2003; Hunter, 2005). Table 2.1 gives an overview of the potential harmful effects of lower extremity alignment in neonates.

Proper therapeutic positioning in prone, supine and side lying in the NICU have been widely suggested to reduce acquired positional deformities (Gardner and Goldson, 2002; Sweeney and Gutierrez, 2002; Hunter, 2005). Although most NICUs worldwide prefer to use the prone position routinely to nurse the premature infant (Gardner and Goldson, 2002), there are benefits within all three positions (Monterosso et al*,* 2003).

Correct strategic positioning of the infant in this study received great priority in the light of the impact that it could have on further motor development of the infant.

Table 2.1 Musculoskeletal consequences and functional limitations from lower extremity malalignment in neonates[2]

Malalignment	Musculoskeletal consequence	Functional limitations
Hyper-extended neck and retracted shoulders	• Shortened neck extensor muscles and excessive cervical lordosis • Shortened scapular adductor muscles	• Interferes with development of head centring and midline in supine • Interferes with development of graded head control in prone and sitting • Difficulty organising posture in supine • Difficulty bringing hands to the midline
‘Frog’ legs	• Shortened hip abductor muscles • Shortened iliotibial band • Increased external tibial tortion	• Interferes with movement transitions out of prone and sitting positions • Interferes with crawling • Prolonged wide-based gait with out-toeing
Reverted feet	• Muscles turning the foot inward are overstretched • Foot alignment is changed due to muscle imbalance	• Pronated foot position in standing • Excessively pronated foot position delays development of a heel-toe gait

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[2] Sweeney and Gutierrez, 2002:64

2.5 INTERVENTION PROGRAMMES

The controversy regarding the merits of providing stimulation to the premature infant has been going on for a few decades (Korner, 1990). This controversy is based on different views of how much and what type of stimulation the preterm infant needs while still in the incubator. As already mentioned, minimal handling was the prescribed regime until the early 1960s. As time went by, behavioural scientists became concerned about possible sensory deprivation. Consequently, a great variety of sensory and social intervention studies followed. The late 1970s saw more studies to research the bombardment of sensory input on the fragile nervous system of the preterm infant (Korner, 1990; Lickliter, 2000; Jones and Kassity, 2001; Hunter, 2005).

Central to this controversy is the question of whether preterm infants suffer from deprivation of sensory stimuli or whether they are overloaded with sensory information that they cannot process properly. This debate has led to opposite recommendations for the type of intervention appropriate for these infants (Feldman and Eidelman, 1998).

Most of the sensory intervention studies on preterm infants did indicate a variety of benefits. However, the kind of stimulation, the purpose of the stimulation, the amount of stimulation, at what post-conceptional age and how frequently the stimulation should be applied, remained contentious issues (Korner, 1990). Lickliter (2000), who studied animal-based research on sensory stimulation in perinatal development concurs with Korner (1990) that the stimulation given to the organism depends on a number of related factors such as the timing of the stimulation relative to the developmental stage of the organism; the amount of stimulation provided or denied the young organism; and the type of sensory stimulation presented.

Feldman and Eidelman (1998) mention some basic methodological concerns surrounding previous intervention studies. Studies often lacked a clear and specific theoretical basis. Hence, authors did not hypothesise regarding the mechanism of development that was either lacking or abnormal in the premature infant. Another theoretical consideration not addressed was whether the reported gains were transitory or stable. This resulted in a lack of longitudinal data. Furthermore, improper randomisation between treatment and control groups led to imbalanced study designs and outcomes.

In the light of the comments raised so far on stimulation programmes for the premature infants the following aspects needed critical consideration before this study could be conducted:

- Knowledge of the different mechanisms of sensory systems and their development;
- Type of stimulation to be provided;
- Amount or denial of stimulation;
- Timing of stimulation;
- Knowledge of interventional care programmes for the preterm infant;
- Effect of implementing a combination of aspects from selected interventional care programmes; and
- Selection of the most appropriate study design with proper randomisation of the intervention and control groups.

A discussion of methods and results of some intervention programmes relevant to this study follows below.

2.5.1 State/arousal considerations for controlled intervention programmes

According to Feldman and Eidelman (1998), Wolff (1996) and Brazelton (1973) were the pioneers on conceptualising state (sleeping and waking cycles) as the instrument for measuring the way in which the infant related to its environment. Table 2.2 presents a clear indication of the behavioural expression of biological processes related to state organisation.

Table 2.2 Behavioural expression of biological processes related to state organisation[3]

State	Characteristics
1. Quiet sleep	Regular breathing, no spontaneous movement, no REM[4], no suck
2. Light sleep	Irregular breathing, no spontaneous movements, REM, occasional sucking movements
3. Transition-drowsy	Dull dazed look, variable activity, delayed response to stimuli
4. Awake-alert	Bright look, focused response to stimuli, minimal spontaneous activity
5. Awake-hyperactive	Fussy vocalising, very reactive to stimuli, startles, increased motor activity, occasional crying
6. Crying	Intense sustained crying, increased motor activity, non-focused response to stimuli

In their study on the development of sleep-wakefulness of the preterm infant, Andura et al (1995) found that it was more difficult to differentiate between the different stages of state organisation in the preterm than full-term infants. However, they concluded that preterm infants (32 weeks gestational age) slept 17.86 hours per day compared with the 14.78 hours of full-term infants in the first month of life. Holditch-Davis (2003) added that preterm infants spent greater time in light and drowsy sleep-states and less in the waking states than the full-term infant.

A major threat to state-organisation of the preterm infant is that of over-stimulation and interference of sleeping states, which occurs mostly during nursing or medical procedures. In response to the amount of handling of preterm infants in the NICU, Peters (1999) concluded that rest periods of less than 60 minutes were insufficient for the preterm infant to complete a normal sleep cycle.

Researchers such as Als et al (1994) suggested that altering state organisation was the underlying mechanism by which intervention affected development in the preterm infant. This means that the role of intervention is not to provide those experiences the

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[3] Feldman and Eidelman, 1998:616

[4] REM – rapid eye movements

infant is deprived of, but to assist the infant to become ready to take in information from its environment, by organising the cycles of wakefulness and rest.

The importance of these studies for intervention programmes is that preterm infants spend 70 percent of the day in the sleeping state; sleeping patterns can be indicative of the maturity level of the central nervous system of the preterm infant; and preterm infants need rest periods of at least 60 minutes between care procedures or interventions.

Korner (1990), as well as White-Traut et al (1994) used stimulatory intervention programmes that increased the alertness of the premature infant. Other studies like Ludington-Hoe and Swinth, (1996) promoted KMC, which increased the amount of quiet sleep during and after a period of KMC. According to the model of Als (1986), the immaturity of the sensory systems of preterm infants prevents them from state regulation and their responses to sensory stimuli can interfere with their development. Becker, Grunwald, Moorman and Stuhr (1991) used Als's model (1986) to provide a programme to facilitate self-regulation by reducing environmental sound and light, as well as clustering care, thus enabling the infant to sleep for longer periods. Slevin, Farrington, Duffy, Dally and Murphy (2000) assessed the possibility of altering the NICU environment by introducing a quiet period and measuring its effect on the infant's physiological and behavioural responses. The changes made in the environment were associated with a reduced median in diastolic blood pressure and mean arterial pressure, as well as a decrease in the infant's movements and an increase of quiet sleep states. These studies and their results showed that the preterm infant's systems could not integrate the abundance of environmental stimuli in the NICU. As a result, intervention programmes aimed at the reduction of stimulation and the facilitation of self-regulation and state regulation has since become more popular.

2.5.2 Sensory-enriched intervention programmes

Sensory-enriched programmes assume that preterm infants suffer from sensory deprivation that limits their physiological and mental development. According to Feldman and Eidelman (1998), these programmes are mainly based on the maternal deprivation literature of Harlow (1958) and of Piaget's (1952) hypothesis that sensory-motor intelligence serves as the foundation of cognitive development. This implies that missed experiences at specific points in development may have irreversible effects on later growth.

Weller and Feldman (2003) discuss the role of cholecystokinin and opioids in emotional regulation of the infant receiving maternal touch. After combining the results from research on humans, rats and sheep, they came to the conclusion that touch in the postnatal period provided the conditions to promote self-regulation and alleviate potential risk factor-induced emotion dysregulation.

The conclusions of Weller and Feldman (2003) theoretically support the massage therapy intervention programme of Field (1995). She applied her programme to infants with various conditions such as prematurity, HIV and cocaine exposure, and birth to depressed mothers. The results of the programme demonstrated that preterm massage promoted growth and weight gain; organised sleep states better; promoted more social alertness; and organised motor development better. Researchers such as Jones and Kassity (2001), Mainous (2002) and Beachy (2003) support the implementation of massage therapy in the NICU with preterm infants. Other opinions (Gardner and Goldson, 2002; White-Traut, 2004; Hunter, 2005) suggest that massage therapy with the premature infant lacked reference to the specifics of the intervention provided and the application thereof to preterm infants younger than 32 weeks post gestational age. Feldman and Eidelman (1998) raised their concerns about an additional methodological problem of the difference between maternal and non-maternal touch of massage therapy and the lack of long-term sustainable outcomes of such studies. Therefore, massage therapy with the preterm infant should be administered with caution.

Kangaroo mother care, has received favourable recognition as a multisensory intervention programme for preterm infants (Feldman and Eidelman, 1998; Hunter, 2005; DiMenna, 2006). It has the potential to integrate the two different approaches of self-regulatory and stimulatory intervention (Gardner and Goldson, 2002; Ludington-Hoe, Anderson, Swinth, Thompson and Hadeed, 2004) The uniqueness of KMC is that it provides an appropriate balance between the under-stimulated tactile-proprioceptive and the vestibular systems and the overwhelmed visual and auditory systems, which develop later (Feldman and Eidelman, 1998). KMC has been chosen as an intervention approach for this study due to the self-regulatory potential, minimal handling, controlled tactile-proprioceptive and vestibular stimulation, as well as the benefits of early mother-infant bonding.

Feldman and Eidelman (1998) assert that the first sensory modalities to develop in utero (the proprioceptive and vestibular systems) are assumed to provide a better foundation for subsequent sensory development and self-organisation. Korner (1990) conducted several studies on the effects of waterbeds and came to the conclusion that the effects of tactile stimulation on the development of the premature infant were caused by the proprioceptive component of the waterbed and could reduce apnoea and improve sleep. However, she raised concerns about the generalisation of the use of waterbeds for preterm infants, because of the variety and dynamics of different waterbeds available and the diverse effects that they might have on the premature infants. A replication study by Korner (1990), where each baby was used as its own control, indicated that unstable infants did not respond to waterbeds as favourably as the more stable infants and that apnoea could even increase in some cases. Korner (1990) came to the conclusion that in a clinical intervention it was important that the approach be individualised towards the responses of each infant. This viewpoint has been established as the basis of the Neonatal Individualized Developmental Care and Assessment Programme (NIDCAP) (Aucott et al, 2002; VandenBerg, 2007).

Sensory enrichment programmes have been criticised for not taking developmental sequence of sensory systems, as well as the gestational age and level of maturity of the premature infant, into consideration. Therefore, multisensory stimulation programmes could easily be developmentally inappropriate and over-stimulating to the preterm infant, and can have adverse effects on the development of the infant. Intervention programmes for the preterm infant, however, should be implemented with knowledgeable caution.

2.6 KANGAROO MOTHER CARE

Kangaroo Mother Care (KMC) is a method of caring for and nursing the prematurely born infant. It is often described as consisting of three components: kangaroo position, kangaroo nutrition and kangaroo discharge (Kirsten, Bergman and Hann, 2001; Bergh, 2002) (see Figure 2.2). The kangaroo position entails the skin-to-skin holding of the infant. The nappy-clad premature infant is placed in an upright position between the mother's bare breasts, in other words in a chest-to-chest position (Ludington-Hoe and Swinth, 1996; Engler, Ludington-Hoe, Cusson, Adams, Bahnsen, Brumbaugh, Coates, McHargue, Ryan, Settle and Williams, 2002; Feldman and Eidelman, 2003; DiMenna, 2006). Kangaroo nutrition refers to breastfeeding as an integral component of KMC (Bergman, 1998; Kirsten et al, 2001; Bergh, 2002). Infants in KMC are often discharged earlier, with KMC continued at home and with regular follow-up on the well-being and development of the infant (Bergman, 1998; Bergh, 2002). The supportive environment depicted in Figure 2.2 could include the NICU environment that should support the optimal development of the preterm infant and be supportive of the mother and her family to provide optimal care for the infant.

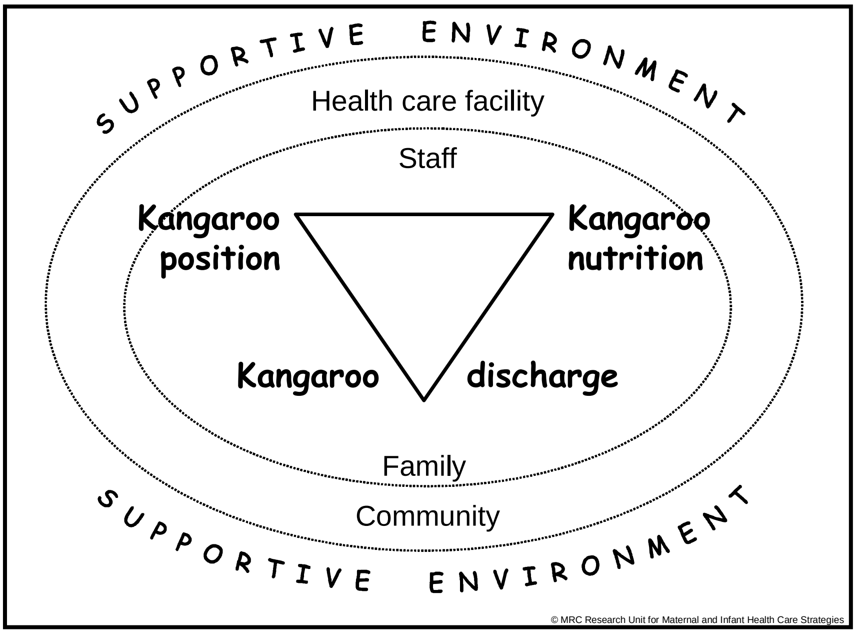

Figure 2.2 Three elements of a KMC programme[5]

Kangaroo Mother Care was introduced in 1979 and initially tested in Bogota, Colombia by Drs Rey and Martinez (Ludington-Hoe, Thompson, Swinth, Hadeed and Anderson, 1994; Kirsten et al, 2001). The reasons for implementing this method of care were overcrowded, understaffed and ill-equipped neonatal intensive care units, high infection and mortality rates of premature infants and poor mother-infant bonding, which led to the abandonment of babies (Gale et al, 1993). Rey and

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[5] Bergh 2002:4

Martinez reported at an international conference in Colombia in 1983 on their results. They highlighted a reduced mortality rate, shorter hospital stay, a decrease in abandonment of infants, better temperature control and more successful breastfeeding (Kirsten et al, 2001; Gardner and Goldson, 2002; Hunter, 2005; Altimier, 2007).

More research especially on the skin-skin component of KMC was done in Europe and the United States (US) during the late 1980s and yielded encouraging results. Physiological benefits such as maintaining skin temperature, respiratory rate, and oxygen saturation within normal limits were some of the results reported. Infants suffering from chronic lung disease showed improved oxygen saturation. Quiet sleep increased, with reduced activity resulting in an improved weight gain (Gale et al, 1993; Bergman, 1998; Aucott et al, 2002; Gardner and Goldson, 2002; Ludington-Hoe et al, 2004). Studies have also shown a reduction in cortisol levels of 60 percent or more of KMC infants compared with infants left in the incubator (Ludington-Hoe, Morgan and Abouelfettoh, 2008). KMC, when practised immediately after birth for six hours, has been found to have a warming and calming effect on newborn infants, subsequently preventing separation distress (Bergman, Linley and Fawcus, 2004).

The importance of physical contact between mothers and their preterm infants, which underlies KMC as a method, was already established through research by Budin in 1907. He observed that mothers who had no physical contact with their preterm infants during their hospitalisation often abandoned their infants (Gale et al, 1993). Kangaroo Mother Care has meanwhile not only been acknowledged as the preferred intervention for decreasing neonatal morbidity and mortality in developing countries, but also has other benefits: (1) it complements good quality care for the preterm infant; (2) it empowers mothers and families to become part of the care team; and (3) it promotes breastfeeding (Charpak, Ruiz, Zupan, Cattaneo, Figueroa, Tessier, Christo, Anderson, Ludington, Mendoza, Mokhachane, Worku, 2005).

The general benefits of breastfeeding, the nutritional component of KMC are well known (Bergman, 1998; Bergh, 2002). A meta-analysis done by Anderson, Johnstone and Remley (1999) highlights the contribution of breastfeeding to neurological development and cognitive ability in particular. Benefits of breastfeeding on cognitive development are both short and long term. A study by Kirsten, Van Zyl, Kirsten and

Thompson (2004) again pointed out the nutritional benefits to the infant after discharge from the KMC unit.

In a recent review article of studies on KMC over the past 25 years, Charpak et al (2005) concluded that those rational bases of KMC that had been clarified established evidence for its effectiveness and safety. However, they stressed the need for more research to define the effectiveness of various components of the intervention more clearly in different settings and for different therapeutic goals. Hence, this current study was aimed at making a contribution in this regard and more specifically with regard to the skin-to skin position.

2.7 DEVELOPMENTAL CARE

Developmental Care is a method of care used for very low birth weight preterm infants in the NICU. The method focuses on the interaction between the infant's neuro-developmental needs and the environment, which includes the family and the health care providers (Aucott et al, 2002; Byers, 2003; Aita and Snider, 2003). The infant's development acts as the basis for the approach of developmental care. The focus of the theory is the interplay of the infant's autonomic, motor, state, attentional-interactive and self-regulatory sub-systems with each other and the environment (Ashbaugh et al, 1999; Aucott et.al, 2002; Beyers, 2003; Aita and Snider, 2003). The implementation of developmentally supportive care practices in the NICUs became popular in the US in the late 1990s.

The synactive organisation of behavioural development as described by Als (1982) serves as the basis from which Developmental Care developed. The theory underlying this process is that there is a hierarchy of dynamic body and attentional systems, which are continuously in interrelationship, allowing the preterm infant to acclimatise to the NICU environment and work towards the ultimate goal of self-regulation (Aita and Snider, 2003; Byers, 2003; Hunter 2005). There are five systems in this model:

1) The autonomic system regularises the physiological stability of the infant.

2) The motor system refers to posture, tone and movements.

3) The state organisation system represents the state from sleep to alertness.

4) The attentional-interactive state relates to the infant’s ability to interact socially, emotionally and cognitively with the environment.

5) The regulatory system involves the behavioural efforts that the infant makes to maintain self-regulation (Aita and Snider, 2003; Byers, 2003; Hunter, 2005).

The spiral diagram in Figure 2.3 illustrates the process of infant’s development and differentiation over time, starting at conception and emerging and expanding developmental capabilities as the foetus grows. The development of each sub-system affects other sub-systems and the integration of the different sub-systems supports the continued differentiation (Als, 1982).

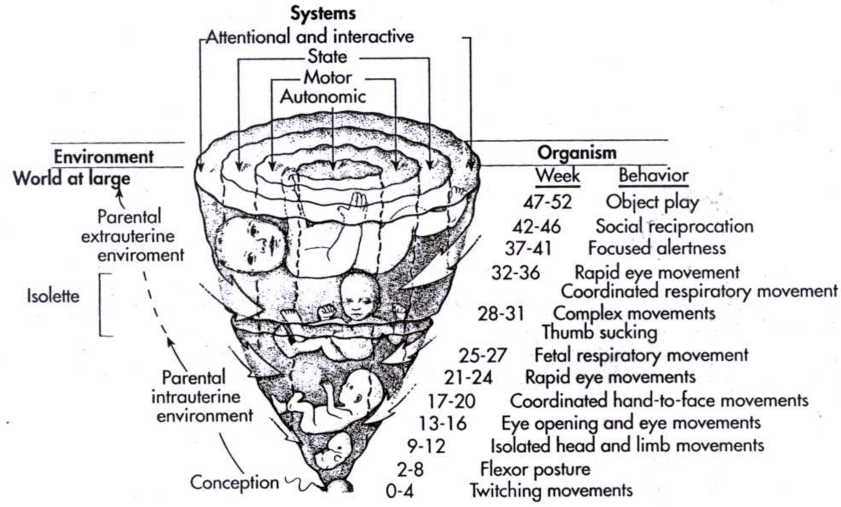

Figure 2.3 Synactive model of organisation and behavioural development[6]

Als (1986) promoted skilled clinical observations of the preterm infant and the environment as a method of assessment, instead of touching the infant. The assessments used by Als (1986) and Miller and Quinn-Hurst (1994) for the developmental care programme were based on careful and systematic observations, using Als’s synactive framework (1982, 1986) to structure these observations, which are intended to provide information about the infant’s neuro-behavioural organisation.

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[6] Als, 1982:284

The researchers analysed signs of stability and instability in the different sub-systems (autonomic, motor, state and attentional-interactional systems) and used the information obtained from the assessment to make recommendations on the modification of the environment and caregiving to minimise the infant’s stress levels (Als, 1986; Miller and Quinn-Hurst, 1994).

After the development of the assessment, further research was conducted and the assessment was expanded to include developmental care practices in the so-called Neonatal Individualized Developmental Care and Assessment Program (NIDCAP).

Several studies were then conducted to evaluate the effect of NIDCAP interventions, by looking at short- and long-term outcomes. Als et al (1994) compared infants receiving routine care with those cared for by NIDCAP intervention and found that the latter group had a decrease in the total number of ventilator days, fewer tube feeding days, shorter hospital stays and discharge at an earlier gestational age. In similar trial by Westrup, Kleberg, von Eichwald, Stjernqvist and Langercrantz (2000), no group differences were found in death, retinopathy of prematurity, weight gain or days on a ventilator. However, the NIDCAP group had fewer days on continuous positive airway pressure (CPAP) and supplemental oxygen and lower gestational age plus chronological age at discharge than the routine care group. Westrup et al (2004) investigated the effects of NIDCAP on the development at preschool age of children born with a gestational age of less than 30 weeks. Although no statistical significant differences could be found on their Intelligence Quotient Scales (IQ), the NIDCAP group showed positive behavioural differences.

Even though many favourable outcomes of developmental care programmes have been reported, Jacobs et al (2002) found that the newborn developmental care and assessment programme was not supported by meta-analyses of the data. Sizun and Westrup (2004) also called for more research on early developmental care practices in the NICU.

NIDCAP has popularised important concepts regarding the need for individual assessment and individualised care for infants and families (Aucott et al, 2002; VandenBerg, 2007). This current study applied some of the elements of developmental care strategies such as management of the environment and simulated utero positioning and kangaroo mother care, which can support preterm sensory neuro-development.

2.8 NEUROPHYSIOLOGICAL DEVELOPMENTAL ASPECTS OF KANGAROO MOTHER CARE AND DEVELOPMENTAL CARE

The premature infant's immature CNS lags behind the term infant and therefore the characteristics in behavioural organisation in the preterm infant are different and the infant needs to be cared for appropriately (Gardner and Goldson, 2002; Hunter, 2005; Altimier, 2007). The ideal NICU environment will support and promote the premature infant's adaptability to extra-uterine life, known as neuro-behavioural organisation (Ludington-Hoe and Swinth, 1996; Altimier, 2007).

Ludington-Hoe and Swinth (1996) used Als's (1986) neuro-behavioural framework discussed in the previous section to investigate research-based linkages between KMC and developmental care. They concluded that KMC was an intervention that met developmental care criteria. Davanzo (2004) reported that skin-to-skin contact, sensory stimulation and better autonomic regulatory control reduced crying and general movements during KMC, with subsequent possible improvement in oxygenation.

The following five dimensions of neuro-behavioural organisation will be discussed next: autonomic, motor, state, attention/interaction and self-regulation. Although they are discussed separately they are nonetheless interdependent, which means that disorganisation in one system affects all other systems (Gardner and Goldson, 2002; Ferber and Makhoul, 2004).

2.8.1 Autonomic neuro-behavioural organisation

The infant first gains control in the autonomic dimension. Physiologically preterm infants react in different ways to environmental stressors. An infant who is autonomically organised is one that can maintain autonomic stability when its environment changes (Ludington-Hoe et al*,* 1994).

The core of an infant's physiological homeostasis is the autonomic-physiological system that regulates the cardio-respiratory functions, temperature and visceral functions (digestion and elimination) (Lawhon and Melzar, 1988). Acolet, Sleath and Whitelaw (1989) found that the KMC position is the ideal environment to support autonomic stability of the preterm infant and encourages basic physiological functions. According to Gale et al (1993) researchers such as Bosque and Ludington-Hoe have pointed out some major improvements in the preterm infant receiving KMC. These improvements include the stabilisation of cardio-respiratory function, where the heart and respiratory rates decrease, an increased oxygenation that results in less bradycardia, fewer and shorter apnoeic episodes, as well as fewer episodes of periodic breathing.

Further research by Ludington-Hoe, Nguyen, Swinth and Satyshur (2000) confirmed that the KMC method prevented the loss of body heat. Rather body warmth is maintained or increased during the application of KMC. Sleep and state stability is also promoted while KMC is in process. Ludington-Hoe is currently investigating the temperature responsiveness of each of the mother's breasts to the skin temperature of the infant (Kennell, 2006).

2.8.2 Motor neuro-behavioural organisation

Muscle tone, posture, quality of movement and presence of reflexes are included in the motoric sub-system (Miller and Quinn-Hurst, 1994). Less control over general movements is associated with younger gestational-aged infants. Any environmental or somatic changes result in overreaction of gross motor movements. General movements consume oxygen and caloric supplies that are needed for growth (Ludington-Hoe et al, 1994). Some of the goals of developmental care for the preterm infant are to minimise unnecessary movements in order to conserve energy and to reduce the infant's overreaction to changes in its environment (Als, 1986).

The KMC position is of major importance in motor regulation. It provides the infant with the upright position, which allows for better pulmonary function and increased oxygenation, thus making breathing easier and reducing agitation and the accompanying jerky movements (Becker, Grunwald, Morrman and Stuhr, 1993). Together with the mother's movement, the upright position also allows for vestibular adaptation. It provides appropriate containment, similar to the contained position of the foetus in utero, which keeps the infant in a flexed position and reduces random motor activity (Taquino and Blackburn, 1994). Protection from increased arousal elements, which have a significant influence on the increased amount of quiet sleep, keeps the infant calm and relaxed (Ludington-Hoe and Swinth*,* 1996).

2.8.3 State neuro-behavioural organisation

‘The state organisation system involves the infant’s ability to display, and to do so with clarity, the different ranges of state from sleep to aroused state. This system is also associated with the infant’s ability to transition between states’ (NANN, 1995:4).

The review by Lehtonen and Martin (2004) mention the six defined behavioural states in full-term newborn infants.The six states are listed in Table 2.2 (see section 2.5.1). A state-organised infant can transition between states appropriately and can reach or withdraw from any state. These behavioural states are immature during early development, but the cyclicity can clearly be observed in the preterm infant (Gardner and Goldstone, 2002; Hunter 2005; Altimier, 2007).

The preterm infant who is over stimulated in the NICU spends 60 to 70 percent of the time in active sleep (Holditch-Davis, 2003). Interventions should increase sleep and promote quiet sleep, where oxygenation is relatively stable. This enables the infant to remain inactive, unresponsive and to conserve energy in order to grow and to maintain a physiological homeostasis (Gardner and Goldson, 2002; Lehtonen and Martin, 2004).

The relationship of KMC and the behavioural states of the preterm infant has been studied and investigated by various researchers. Ludington-Hoe and Swinth (1996) report that Anderson Behavioural State Score results revealed that KMC reduced the amount of time an infant spent in active sleep and increased the amount of time spent in quiet, regular sleep. The quiet regular sleep that needs to be present in infants younger than 32 weeks post-conceptional age has been studied during KMC and documented as appropriate by Yecco (1993). Ludington-Hoe and Swinth (1996) mention how Moeller-Jensen and co-workers found a statistically significant reduction in crying during KMC.

KMC seems to be an important care practice to optimise the sleep cycling of the preterm infant and also fulfils the guidelines of developmental care.

2.8.4 Attention/interaction of neuro-behavioural organisation

Alertness is a fleeting state in preterm infants and it is the state where attention and interaction start. The preterm infant's visual, cortical and central nervous systems are immature and cannot maintain alertness before 38 weeks of gestation (Ludington-Hoe and Swinth, 1996).

Referring to the Synactive Model of Behaviour Organisation proposed by Als (1986) and depicted in Figure 2.3, the attention and interactive system only starts functioning after 37 weeks post conception. This function includes the ability to focus on a message, such as to turn to sounds and look at faces and other objects for a few minutes. The infant exhibits bright-eyed, purposeful interest in its micro-environment and is able to shift attention smoothly from one stimulus to another for brief periods (Hunter, 2005).

By the time the infant has achieved alertness, it becomes cognitively aware of its environment and starts processing information and attention, followed by interaction with its environment. However, it is rare for an infant younger than 40 weeks post conception to respond to maternal input in a way that it encourages more interaction with its environment without giving distress signals like gaze aversion, glassy staring eyes, irritability and crying (Ludington-Hoe and Swinth, 1996; Hunter, 2005).

KMC has an important effect on the sleeping pattern of preterm infants – it protects them from engaging with their environment before they are ready for it at 37 weeks gestational age. KMC however gives the mother confidence and makes her aware of her infant's needs, without having to rely on attentional interaction from the infant.

2.8.5 Self-regulatory neuro-behavioural organisation

Self-regulatory behaviour by the infant is the ability to achieve, maintain, or regain balance and self-organisation in each sub-system as needed, by calming itself through the use of self-consoling behaviours (Hunter, 2005). Some of these behaviours like sucking and bringing hands to the mouth can very easily be done in the KMC position, provided that the infant is placed correctly in flexion with hands to the midline. This position encourages on-demand sucking, which helps with the continuation of breastfeeding (Ludington-Hoe and Swinth, 1996).

In summary, there are many beneficial outcomes for premature infants who are cared for in the KMC position. Such outcomes include increased sleep and less irritability (Messmer, Rodriguez, Adams, Wells-Gentry, Washburn and Zabaleta, 1997), stable physiological parameters (such as heart and respiratory rates) (Feldman and Eidelman, 2003), reduced stress during painful procedures (Johnston, Stevens, Pinelli, Gibbens, Filion and Jack, 2003), increased breastfeeding procedures (Furman, Minich and Hack, 2002) and positive behavioural organisation, development and temperament at one year of age (Ohgi, Fukuda, Moriuchi, Kusumoto, Akiyama, Nugent, Brazelton, Arisawa, Takahashi and Saitoh, 2002).

2.9 DEVELOPMENTAL SCREENING AND TESTING

In this section two different developmental assessments will be discussed, namely, neonatal assessments and developmental assessments applicable for infants. Profiles and tests to determine the sensory development of the infant will also be investigated.

2.9.1 Neonatal assessment

Assessments of preterm infants in the NICU need to be done with the utmost care, with the purpose of the assessment being well considered before administration. Factors to consider during such assessments are the limited tolerance of handling and interaction of the preterm infant and the accuracy of the information if the assessment compromises the infant’s physiologic stability (Miller and Quinn-Hurst, 1994; Hunter, 2005; Lowman, Stone and Cole, 2006). Another aspect to keep in mind is that routine, continual observational assessment can be of more value, because the immature neuro-behavioural organisation of the preterm infant can easily be interpreted as pathology if only tested once (Hunter, 2005). Miller and Quinn-Hurst (1994) reported that researchers like Sweeney (1986) and Field (1990) measured negative physiological changes in the preterm infant after the administration of neurological assessments.

According to Hunter (2005) neonatal assessments that are most popularly used in NICUs are:

- Brazelton Newborn Behavioural Assessment Scale (BNBAS) – healthy infants who can tolerate handling (35–44 week range); this requires certification.

- Naturalistic Observation of Newborn Behaviour (NONB) (NIDCAP level 1) – preterm and term infants too fragile to handle; requires certification.

- Assessment of Preterm Infant Behaviour (APIB) (NIDCAP level 2) – stable preterm infants (>30–32 weeks); requires certification.

Other neonatal assessments used are: NICU Neuro-behavioural Scale (NNNS); Infant Behavioural Assessment (IBA); Neurological Assessment of the Preterm and Full-term newborn Infant (NAPFI); Neonatal Neuro-behavioural Evaluation (NNE); Neuro-behavioural Assessment for Preterm Infants (NAPI); and Neonatal Neurological Examination (NEONEURO) (Miller and Quinn-Hurst, 1994; Hunter, 2005; Lissauer and Fanaroff, 2006; Lowman et al, 2006).

This study was concerned with the sensory development of the infant, therefore none of these assessments were relevant for the purpose of the study. However some of the handling techniques promoted by NIDCAP were incorporated.

2.9.2 Developmental testing for infants

Johnson and Marlow (2006) found that preterm births may have adverse effects on the child’s psychomotor development. The well-documented studies by Aylward (2003) and Wood state that conditions such as visual and hearing impairments, as well as cerebral palsy, have revealed incidences ranging between 15 and 20 percent in the last decade (Johnson and Marlow, 2006; Westrup et al, 2004). An even larger group of approximately 50 to 70 percent of VLBW preterm infants have been documented with low severity dysfunctions, such as learning disabilities, borderline mental retardation, attention deficit/hyperactivity disorders, specific neuropsychological disorders and behavioural problems (Westrup et al, 2004; Johnson and Marlow, 2006; Aylward, 2002; Davis, 2003). Preterm infants are also at greater risk for more long-term behavioural problems, attention deficits, perceptual-motor and visual-spatial problems, which may manifest in 50 to 70 percent of the indicated infants (Aylward, 2002; Davis, 2003; Johnson and Marlow, 2006; Reijneveld, Kleine, van Blaar, Kollee, Verhaak, Verhulst, 2006).

In a later follow-up study Reijneveld et al (2006) found that VLBW infants were more likely to have behavioural and social-emotional problems at school entrance, which could be detrimental for academic functioning. The results of a study to determine the effect of NIDCAP on the development of children of pre-school age who were born prematurely (Westrup et al, 2004) correlate well with the findings of Reijneveld et al (2006). During the assessment Westrup et al (2004) used the following tests batteries to determine their results: the Wechsler Pre-school and Primary Scale of Intelligence – Revised (WPPSI-R) for cognition; the Movement Assessment Battery for Children (Movement ABC) for motor function; the sub-test of the NEPSY test battery for attention and distractibility; and the World Health Organisation’s definitions of impairment, disability and handicap. The research revealed that NIDCAP had a positive impact on behaviour at pre-school age in the sample of infants born very prematurely. However, they experienced problems in recruiting infants and had to conduct their study with less than half the number of subjects required; hence their findings must be interpreted with caution.

Johnson and Marlow (2006) pointed out the need for early outcome monitoring of infants born prematurely. In their review of the standardised developmental assessment tools applicable to infants, they discussed the use of screening tools in comparison with standardised assessment tools. According to their findings, screening tools have little diagnostic utility and preterm infants require more comprehensive and accurate standardised assessment tools to measure their outcomes. Characteristics of a standardised developmental test according to Johnson and Marlow (2006) are as follows: test objectivity; norm-referenced scores; psychometric properties such as a normative sample; reliability and validity; and correct test selection. Standardised developmental tests, most commonly used for infants include:

- Mullen Scale of Early Learning (MSEL);
- Battelle Developmental Inventory II (BDI-II);
- Griffiths Mental Developmental Scales-Revised (Griffiths Scales); and
- Bayley Scales of Infant Development II (BSID-II).

The characteristics of these tests are summarised in Table 2.3.

Table 2.3 Characteristics of the most commonly used standardised developmental tests for infants[7]

Test	Age range	Administration time	Domains assessed	Standardisation years	Sample	Norm-referenced scores	User qualifications
Mullen Scales of Early Learning (MSEL)	Birth through 5 years 8 months	1 year olds: 15 min 3 year olds: 30 min	Gross Motor (≤ 33 months) Fine Motor Visual Reception Receptive Language Expressive Language	1981 – 1986 and 1987 – 1989	1849 USA	Standardised *T* scores (Mean 50, SD 10), percentiles, and age equivalents for each domain. The 4 cognitive sub-scales combine to produce an Early Learning Composite (ELC) standardised score (Mean 100, SD 15), percentile, and age equivalent.	Training and/or experience in clinical assessment of young children.
Battelle Development Inventory II (BDI-II)	Birth to 8 years	1 – 2 h	Personal – Social Adaptive Motor Communication Cognitive (plus sub-domains)	2002 – 2003	2500 USA	Standardised scores for sub-domains (Mean 10, S.D. 3), domains (Mean 100, SD 15), and composite DQ (Mean 100, SD 15), z-scores, percentiles, and age equivalents.	Psychologists and 'Paraprofessionals' (e.g. preschool, primary, special needs teachers).
Griffiths Mental Development Scales – Baby Scales (Griffiths Scales: 0 – 2)	Birth through 23 months	35 – 60 min	Locomotor Personal – Social Hearing and Language Eye and Hand Coordination Performance	(Not stated)	665 UK	Standardises scores for each domain (Sub-quotients, SQ, Mean 100, SD 16), age equivalents, and percentiles. Sub-scale scores combine to provides standardised score (General Quotient, GQ, Mean 100, SD 12), age equivalent, and percentiles for overall functioning.	Psychologists or clinicians with training in developmental assessment. Examiners must undergo a 5-day training course for certification.
Bayley Scales of Infant Development, 2nd Edition (BSID-II)	1 month through 42 months	25 – 60 min	Mental (MDI) Psychomotor (PDI) Test-taking behaviour (BRS)	1991 – 1992	1700 USA	Standardised scores for MDI and PHI (Mean 100, SD 15), percentiles and age equivalents. Percentiles only for BRS.	Professional qualification in individual assessment; experience in testing young children

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[7] Johnson and Marlow (2006:177)

2.9.3 Sensory Development Tests for Infants

Ayres (1972a, 1972b), the ‘parent’ of sensory integration theory (see section 2.3), did not only study the neurological and psychological patterns underlying the process of sensory integration, but she also created a sophisticated series of tests that could assess hidden disabilities (Fisher et al, 1991; Parham and Mailloux, 2005). Initially she developed tests for the sensory integration in older children which led to the publication of the Southern California Sensory Integration Tests (SCSIT). Then more test batteries and profiles were developed, which included items or sub-tests for sensory integrative functions. Tests like the Miller Assessment for Preschoolers (Miller, 1988a), the DeGangi-Berk Test of Sensory Integration (Berk and DeGangi, 1983), the Sensory Profile (Dunn 1999) and the Test of Sensory Function in Infants (DeGangi and Greenspan, 1989) are some of the tests based on her work. The SCSIT however was revised and renamed the Sensory Integration and Praxis Test (SIPT) (Ayers, 1989), which is, in spite of all the other available tests, still regarded as the only set of standardised tests designed specifically for in-depth evaluation of sensory integration (Fisher et al, 1991; Parham and Mailloux, 2005).

The limitations of the initial tests were that they could not be used for infants younger than 24 months. In response to this two standardised instruments were developed to determine the sensory processing abilities of children under the age of two:

1) The Test of Sensory Functions in Infants (TSFI) (DeGangi and Greenspan, 1989); and

2) Infant/Toddler Sensory Profile (Dunn, 2002). This profile consists of a caregiver questionnaire that reflects the following groupings: general, auditory, visual, tactile, vestibular and oral sensory processing. This questionnaire is only available in English and caregivers should be literate in order to read and respond to the questions.

2.9.4 Intervention strategies based on sensory integration

Kranowitz (1998:291–292) explained the term relevance of sensory integration for daily activities in a very meaningful way: ‘[It] is the normal neurological process of taking in information from one’s body and environment through the senses, of organising and unifying this information, and of using it to plan and execute adaptive responses to different challenges in order to learn and function smoothly in daily life.’ Although basic sensory processing has therefore been linked to the development of motor skill, visual-spatial and language abilities, as well as motor planning and emotional stability, it has not been the focus of much research (Wiener, Long, DeGangi and Battaile, 1996; Gomez, Baird and Jung, 2004). Fine and gross motor delays, balance, sequencing and planning of motor tasks, distractibility, sensitivities to touch and movement input, language delays and visual-spatial problems may be present in the pre-school years. At school-going age problems with handwriting, dyslexia, attention deficits and reading disabilities are also related to sensory processing disorders (Wiener et al*,* 1996; Gomez et al, 2004).

Ayres responded (1972a, 1972b; 1979) to the above challenges with the creation of sensory integrative therapy techniques, intervention strategies and equipment to remediate sensory integrative dysfunction in children and to help the child to develop the inner drive through play in order to encourage sensory integration (Fisher et al, 1991). Her therapy techniques were based on the theoretical assumption that the seven senses work together to provide the brain with the information received from stimuli inside and outside the body. This information was processed by the brain to elicit an adaptive response which could be a motor, language or behavioural (emotional/social) response (Spitzer and Roley, 2001). The efficiency with which the CNS regulates, organises and prioritises incoming information, helping us to focus on relevant information in order to respond appropriately to the input, is referred to as sensory modulation (Kranowitz, 1998; Murray-Slutsky and Paris, 2000).

After Ayres, many other expert clinicians further developed and expanded on her sensory intervention theories. Experts like Koomar and Bundy (2002) provided a description of the application of sensory integration procedures for specific types of sensory integrative disorders. Clinicians also adapted sensory integration intervention to approach children with other kinds of problems. Some problems that have been addressed were autism (Mailloux, 2001), developmentally at risk infants (Schaaf and Anzalone, 2001), visual impairment (Roley and Schneck, 2001), cerebral palsy (Blanche and Nakasuji, 2001), environmental deprivation (Cermak, 2001) and fragile X syndrome (Hickman, 2001).

2.10 TESTS USED IN THIS STUDY

The two tests that were used for the purpose of this study are both standardised tests. The Revised Griffiths Mental Developmental Scales (Griffiths, 1996) was used as a developmental test, whereas the TSFI (DeGangi and Greenspan, 1989) was used as a sensory function test. These two tests will be discussed in more detail.

2.10.1 Test of Sensory Functions in Infants

The Test of Sensory Functions in Infants (TSFI) was designed by DeGangi and Greenspan in 1989 as a research and clinical instrument to assess infants with regulatory disorders (for example, sleep disturbances, irritability, colic and intolerance for change), developmental delays, and those who are at risk for sensory processing disorders and learning disorders (for example, high risk premature infants) (Asher, 1996; DeGangi and Greenspan, 1989). The TSFI test was based on the sensory integration theory, as discussed in section 2.9.

Sensory functions form the basis for the development of emotional stability and organised learning behaviour (Greenspan, 1992). Until the TSFI was developed, no objective and standardised instruments were available for occupational therapists to determine infants' sensory functions and they had to rely on their own judgment to decide whether an infant had a sensory deficit and the extent thereof. The development of this instrument made it possible to identify infants with sensory integrative dysfunction and to facilitate early intervention and hence prevent the development of further major deficits (DeGangi and Greenspan, 1989).

2.10.1.1 General description of the test

The description of this 24-item test is based on the work by Asher (1996) and DeGangi and Greenspan (1989). It can be administered to infants, aged four to 18 months. The test measures sensory processing and reactivity in these infants. It includes five sub-tests, which measures five sub-domains of sensory processing and reactivity. The five sub-domains were selected because of the major significance this selection plays in the identification of infants who are at risk for developing learning disabilities.

The test consists of a kit that includes a manual, scoring sheets, small toys and stimulus material.

Purpose of the test

The TSFI presents an objective way to not only identify infants at risk for sensory processing and possible learning deficits, but also to determine the extent to which the problem exists.

Population

The test can be administered on infants between four and 18 months, specifically those infants with a difficult temperament or developmental delays and high-risk premature infants, who may later develop learning problems. For the purpose of the study, the author used the corrected age for the degree of prematurity, although the test administration does not particularly commend anything.

Administration time

It takes approximately 20 to 30 minutes to administer and score the test.

Format

The test is administered individually and requires straightforward interaction with the infant, sitting on the parent's lap, with bare feet and forearms exposed. The therapist touches the child or presents various stimulus materials and then records the child's reactions, using the scoring sheet.

Administrator

The test was designed as a research or clinical evaluation. It may be administered by paediatricians, psychologists, occupational and physical therapists with training and knowledge in the interpretation of test results in the field of sensory development and function.

Description

The test consists of 24 items that provides an overall measure of sensory processing and reactivity. In addition it is divided into five sub-tests, measuring five sub-domains of sensory processing and reactivity. The five sub-tests are:

1) *Reactivity to tactile deep pressure*, which is applied to the arms, hands, stomach, soles of the feet, mouth and total body (the examiner holds the infant against her shoulder).

2) *Adaptive motor functions,* which is the ability of the infant to plan and initiate motor actions when handling the textured toys.

3) *Visual-tactile integration,* which tests the infant’s tolerance when coming into contact with various visually fascinating textured toys.

4) *Ocular-motor control,* which is seen in the way that the infant’s eyes move peripherally and do visual tracking.

5) *Reactivity to vestibular stimulation* is tested by moving the infant in vertical and circular planes, and by holding the infant in the inverted prone and supine body positions.

Scoring

The administration and scoring form of the TSFI is used to determine the sub-test scores. The item scores are grouped together for each sub-test and the total is entered on the line designated for each sub-test. These scores are then transferred to the applicable boxes on the front of the form. The total test score is calculated to provide a gross index of sensory delay.

The results of the five sub-tests and the total test classify the infant as normal, at risk or deficient. Scores within the normal range suggest adequate sensory processing and reactivity; while scores in the at risk range denote suspected delays. Scores in the deficient range suggest dysfunction (DeGangi and Greenspan, 1989).

Reliability

Table 2.4 Test-retest reliability coefficients of the TSFI[8]

Sub-test /Total test	Coefficients
Reactivity to tactile deep pressure	0.77
Adaptive motor functions	0.64
Visual-tactile integration	0.84
Ocular-motor control	0.96
Reactivity to vestibular stimulation	0.26
Total test	**0.81**

DeGangi and Greenspan (1989) recommended further research to validate their initial findings, including test-retest reliability studies, using a wider cross section of ages, as well as more extended samples of infants with developmental delays.

Validity

A panel of experts signified that the items represented the behaviours they were designed to measure and the sub-tests represented the overall domain of sensory functioning. Item discrimination and sub-test correlations indicated that they measure sufficiently diverse areas of sensory function. Norm-related validity studies indicated that TSFI measures functions distinct from other developmental tests (Asher, 1996).

2.10.1.2 Development of the test and the relevance of each sub-test

The rationale for the selection of the five sub-domains of the TSFI was that these had a powerful impact on the development of sensory integration in the infant. The tactile and vestibular systems are seen as the co-ordinating centres for sensory functions

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[8] DeGangi and Greenspan, 1989:28; Asher, 1996:91

and they are extremely important for later learning and emotional behaviour (Ayres, 1979; DeGangi and Greenspan, 1989; Kranowitz, 1998; Murray-Slutsky and Paris, 2000; Parham and Mailloux, 2005).

The sense of **touch** (the tactile system), which develops early in infancy, plays a very important role in the planning of motor tasks and the exploration of the environment and body scheme. The two functions of this system are that of protection and discrimination. The tactile protective function is responsible for survival and awareness of the environment and is named the flight or fight system. The flight system refers to avoidance of tactile experiences like refusal of self-care activities such as grooming activities, bathing, dressing and eating. The fight system includes increased motor activity such as irritability including restlessness, anger, tantrums, aggression and emotional distress. The discriminative function is the ability to discriminate between different textures, forms and contours, which lead to **adaptive motor behaviour** and the initiation and planning of movement (Ayres, 1972b; Lederman, 1973; Kranowitz, 1998; Roley et al, 2001; Parham and Mailloux, 2005).

The infant explores, manipulates and performs tasks by using its tactile discriminative function. At the same time it discovers the **visual-spatial** properties of an object or of its environment. The visual-spatial-tactile function is responsible for organisation and orientation of tactile input in time and space. Visual-tactile integration skills form the cornerstones for adaptive-motor functions and early motor-planning (DeGangi and Greenspan, 1989; Mulligan, 1998; Parham, 2002; Parham and Mailloux, 2005).

The **vestibular** system, located at the junction of the two halves of the brain where the neural tracts from all the parts of the brain converge for processing, contributes to communication between the two hemispheres of the brain. The vestibular system therefore assists in spatial orientation of the body and in initiation of exploratory and adaptive movements (DeGangi and Greenspan, 1989; Kranowitz, 1998; Parham, 2002; Parham and Mailloux, 2005). This system is partly responsible for the development of body posture, muscle tone, ocular-motor control, reflex-integration, and equilibrium reactions (Clark, 1985; Williamson and Anzalone, 2001; Hain and Helminski, 2007). It also has a strong influence on language abilities, hand dominance and motor planning (Ayres, 1972b; Murray-Slutsky and Paris, 2000).

Ocular-motor control plays an important role in visual exploration. Ocular movement is closely connected with the vestibular system and can affect the movement function (Ayres, 1972b; Henderson, Pehoski and Murray, 2002).

Twenty-four items were systematically selected from the abovementioned domains. The items that measure reactivity to deep tactile pressure were designed to test the reactions of the tactile protective system, while the visual-tactile-integration sub-tests partially test the reactions of the tactile discriminative system. The visual-tactile-integration test measures an infant's ability to tolerate and visually recognise input from a particular visual-tactile stimulus. As this stimulus is applied to a part of the body, the infant's adaptive motor responses, necessary to plan its action, are also observed. The vestibular system is exposed to vertical, circular and inverted body movement in space to assess the infants' ability to tolerate movement on different planes. Ocular-motor control is measured by the ability of the eyes to lateralise by observing an object in the periphery and to smoothly track a visual target (DeGangi and Greenspan, 1989).

2.10.1.3 The TSFI as instrument in the study to measure sensory developmental outcome

The TSFI proved to be the most appropriate instrument to determine the effect of the Sensory Developmental Care Programme (SDCP) (to be discussed in Chapter 3) on the sensory development of the VLBW preterm infant up to the age of 18 months.

Wiener, Long, DeGangi and Battaile (1996) used the TSFI to determine the differences in sensory processing between normal full-term, full-term with a regulatory disorder, and prematurely born infants. They found that the domain and construct validity as well as the inter-observer reliability validity measure sensory functions in infants. They used as additional measures the Bayley Scales of Infant Development, Mental Scales and the Infant/Toddler Symptom Checklist (Johnson and Marlow 2006; DeGangi, 2000). The results of their study revealed sensory processing disorders of infants with regulatory disorders as well as of prematurely born infants at each of the three age groupings (7–9; 10–12 and 13–18 months). Although they used additional measures they found the TSFI to be reliable and valid to measure sensory functions in infants.

Although the study by Jirikowic, Engel and Deitz (1997) found that the reliability for the total test score of the TSFI was border line, the percentage of agreement for the total test classification categories between test and retest was found to be adequate. The percentage of agreement for sub-test classification categories was low, but they suggested that it was still possible to make stable classification decisions. They suggest that the TSFI scores be interpreted together with other developmental tests.

The two main sensory domains that the test is based on are the tactile and vestibular functions, which are indicative of their importance regarding the development of sensory integration. The tactile and vestibular systems are the two systems that receive the most appropriate input during the process of KMC and developmental care. The sensory developmental care programme (SDCP) used in the study correlates well with the sub-domains that the test covers.

2.10.2 The Griffiths Mental Developmental Scales – Revised: Birth to two years

Ruth Griffiths was an educational psychotherapist who based her Scale of Tests on research that had its origins in her work among mentally handicapped persons before World War 2. During the war her experience as psychologist working among evacuated children prompted her to standardise the scales on a normal baby population. Her first scales were published in 1954 and included those sub-domains (locomotor, personal, social, hearing and speech, eye-hand co-ordination and performance) of development that were significant for intelligence and mental growth. She identified significant trends of development, basic avenues of learning, their interrelationships and their origins. Figure 2.4 illustrates the foundation on which her test scales were built (Griffiths, 1986).

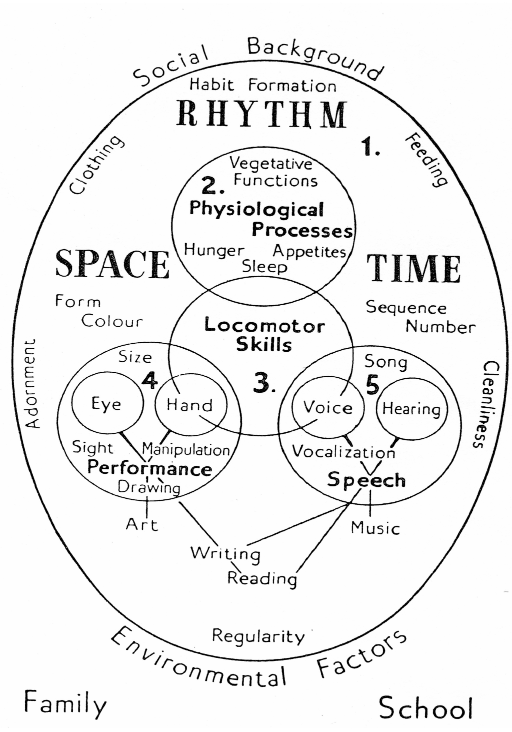

Figure 2.4 Basic avenues of learning[9]

Figure 2.4 depicts the basic avenues of learning and their interrelationships. The earliest adjustment that a baby makes is to adjust to the rhythm of experience at certain times and in certain places. This ability is at the foundation of habit formation. Circle 1 represents the social background in which the child is situated. Circle 2 represents the physiological functions and organic movements. Part of the physiological process are the physical movements of the body, which gradually become more gross and lead to differentiation of movement as locomotor development appears as indicated in circle 3. Circle 4 represents the eye and hand co-ordination. As the hand skills develop the eyes follow and the two areas start working together. At the same time vocalisation starts and the baby begins to listen to sound, whereupon speech development follows as demonstrated in circle 5. All this development takes place in time and space. Performance (circle 4) and speech (circle 5) are the two main aspects of intellectual development and form the basis of formal education, both practical and verbal (Griffiths, 1986).

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[9] Griffiths (1986)

Using this model Griffiths developed the five-scale test, which is presently still in use. The five scales are: locomotor; personal-social; hearing and speech; hand and eye; and performance. In 1996 the test was revised by Michael Huntley to carry out the wish of Dr Griffiths that ‘the work must go on for the benefit of the children’ (Griffiths, 1996:5).

In a survey by the British Psychological Society in 1986 the Griffiths Scales proved to be the most used developmental scale in the United Kingdom (Griffiths, 1986). The test has received worldwide acceptance by paediatricians and psychologists due to its holistic diagnosis based on analysis of the development profile (Griffiths, 1996). Johnson and Marlow (2006) highlighted the properties of the Griffiths Scales and discussed the test as one of the most commonly used and popular standardised tools for assessment in infancy.

2.10.2.1 General description of the test

The Griffiths Scales comprise the ‘Baby Scales’ (birth to 23 months) and the ‘Extended Scales’ (24 months to 8 years). The Griffiths Mental Developmental Scales from birth to two years will be discussed for the purpose of this study only (Griffiths, 1996).

The test consists of five scales that aim at retaining their grade of difficulty for each month of age. There is a total of 276 items for the two-year olds.

Purpose of the scales

The scales measure the rate of mental and motor development in infants and young children.

Population

The scales can be administered on infants and young children from birth to two years.

Administration time

It takes about 50 to 60 minutes to administer and score the scales.

Format

In the text for each item an instruction is given on how the item should be administered. The response the child has to make to succeed is underlined.

Administrator

The test may only be administered by professionals with experience in developmental assessment. Examiner certification requires attendance of a five day training course. Paediatricians and psychologists are trained to administer the scales.

Description

The five domains of functioning that are assessed will be discussed in more detail.

1) Sub-scale A: Locomotor

This scale measures the entire series of developing skills that are necessary to achieve the upright posture, which leads to walking, running, climbing. The sequence of these developing skills is of great importance in the first two years of life, because the rate of progress in this direction is most relevant in assessing the mental level of the infant (Griffiths, 1986).

The 54 items in this scale have been divided into seven categories in periods from birth to two years of age.

2) Sub-scale B: Personal-social

This scale measures the developing abilities that are important for progress in the process of independence and social adaptation. The significance of the mother-child relationship during the first two years of life is important for normal progress in this area. Therefore, the presence and the help of the mother or mother-substitute are essential for a complete assessment on this scale.

This scale consists of 58 items and has been divided into six categories.

3) Sub-scale C: Hearing and language

There are several important stages in this scale that must be taken into consideration. The first stage is that of attention, active listening and early signs of vocalising in response to the mother’s voice.

The child gradually builds up a vocabulary of more complex vocalised sounds and starts to understand the speech of others in the second stage.

The third stage is where the child understands a great deal of what is said by others, but cannot communicate back by means of verbal expression. This is frustrating and often results in tears or temper tantrums. The next stage is the development of word combinations and eventually sentences.

There are 56 items, divided into five categories of development.

4) Sub-scale D: Eye and hand co-ordination

This scale studies the development of the hand and the eye and their gradual co-ordination, which is important for the manipulative skills to grow. The scale starts with a period of attentive looking or visual observance by the child of its immediate spatial environment, after which the child follows movement of objects and people and finally reaches for and grasps objects for further manipulative activities.

This scale has considerable educational implications, as it is associated with the beginning of writing and drawing, which starts with manipulation of pencil and paper.

The scale consists of 54 items that fall into seven categories.

5) Sub-scale E: Performance

The scale is a sequel to the first four scales and the child is now faced with the practical test situation, calling upon ingenuity and readiness to respond. The scale deals with situations that are solved by manual performance and thus similar in some respects to Scale D. Observation followed by association and experimentation are the most important qualities of this scale.

The scale has 54 items, divided into seven categories.

The general quotient is however the piece of information most indicative of the general intellectual ability of the child at certain stages of life.

Scoring

Scores of individual items are written onto a record form. Raw scores for each individual sub-scale are computed by adding the total number of items passed on the sub-scale. The raw-scores of all the sub-scales are added to obtain a total raw score. The raw scores can be converted into three kinds of standard scores: age equivalent, sub-quotient and general quotient and percentile equivalents.

The mean for each sub-quotient is 100 with a standard deviation (S.D.) of 16 points, while the mean for the general quotient is also 100 with a S.D. of 12 points. Two standard deviations under the mean score are classified as a problem area. During an interview with the principal medical officer at the high risk clinic at Tygerberg Hospital and an expert in the field of developmental follow-up studies of the premature infant, she confirmed that the majority of preterm infants in the Western Cape that she had tested on the Griffiths Mental Developmental Scales for Infants had fallen within two standard deviations below the mean of 100 points.

Reliability

Table 2.5 Test-retest reliability coefficient of the Griffiths Mental Developmental Scales from birth to two years[10]

Sub-scale and total scale	Reliability coefficient
Sub-scale A	0.62
Sub-scale B	0.30
Sub-scale C	0.40
Sub-scale D	0.54
Sub-scale E	0.18
Total scale	0.48

Validity

Johnson and Marlow (2006) reported that the scale’s psychometric properties are poorly detailed and with the revision of the scales in 1996, the test-retest reliability is poorer for the first year than the second year. They were also disappointed that no interscorer reliability and validity was provided.

2.10.2.2 Purpose of the Griffith Scales for this study

Despite limitations like poorly detailed psychometric properties and poor test-retest reliability in the first year, the test remains a popular developmental assessment instrument to use for follow-up and research purposes (Johnson and Marlow, 2006).

The consulting paediatrician at the ‘At Risk Clinic’ at Tygerberg Hospital uses the Griffith Scales for the follow-up developmental assessments of preterm infants. For logistics and costs it is considered the most appropriate developmental test to use.

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[10] Huntley in Griffiths, 1996:36

CHAPTER THREE

RESEARCH DESIGN AND METHODOLOGY

3.1 STUDY DESIGN

During the initial planning, a statistician from the Medical Research Council (MRC) suggested that three groups be used in the study which was conducted at two hospitals in the Western Cape using a prospective comparative study design. After completion of the pilot study, the design was changed to a randomised controlled trial at only one site. Figure 3.1 is a flow chart of the chronological course of the study.

<table>
<tr><th colspan="3">PILOT STUDY
Prospective comparative study (3 groups)</th></tr>
<tr><td>Karl Bremer Hospital</td><td colspan="2">Tygerberg Hospital</td></tr>
<tr><td>Group 1</td><td>Group 2</td><td>Group 3</td></tr>
</table>

<table>
<tr><th colspan="2">MAIN STUDY
Randomised controlled trial</th></tr>
<tr><td colspan="2">Tygerberg Hospital</td></tr>
<tr><td>Intervention group (Group 1)
Sensory Development Care Programme (SDCP)</td><td>Control group (Group 2)
Unstructured KMC</td></tr>
<tr><td colspan="2">Follow-up
6 months corrected age (TSFI)
12 months corrected age (TSFI)
18 months corrected age (TSFI and Griffiths)</td></tr>
</table>

Figure 3.1 Chronological course of the study

3.2 PILOT STUDY

A pilot study was deemed necessary to ascertain the viability of the study. This was conducted between July 2001 and September 2002 at two hospitals in the Western Cape according to recommendations by the statistician of the MRC. He further suggested a prospective comparative design for the study, which included three groups. The criteria for inclusion into the three groups were the same as those used for the main study (see 3.4.2), except that the mothers of Group 3 did not expose their infants to any KMC. The occupational therapist at Tygerberg Hospital recruited the participants for Group 2 and Group 3. She also conducted the Sensory Developmental Care Programme (SDCP) (see 3.6.2) with Group 2. The infants in Group 1 were recruited by the Principal Nursing Sister of the KMC unit at Karl Bremer Hospital.

Participants in Group 1 were selected from infants born at Karl Bremer Hospital, where 24-hour KMC was the regime of the hospital at that stage. Mothers were lodged at the hospital, which enabled them to carry their infants' skin-to-skin 24 hours per day.

Participants in Group 2 were selected from infants born at Tygerberg Hospital where infants were exposed to the SDCP.

Group 3 comprised infants born at Tygerberg Hospital, but who were not purposefully exposed to any of the abovementioned interventions.

The pilot study brought the following insights that contributed positively towards the next phase of the investigation. Using two hospitals proved too costly, as the number of participants, as well as follow-up visits, had to be doubled. Karl Bremer Hospital used a different follow-up system for their premature infants than Tygerberg Hospital. Hence, a single participating hospital (Tygerberg) to conduct the study was opted for in order to keep the costs low and to ensure more success with the follow-up visits. The pilot study showed that the correct implementation and structure of the programme within the three groups would become unmanageable to the effect that it would have been very difficult to attend to all the variables, which in turn would compromise the reliability of the results. Variables such as the method of KMC, the training of the different caregivers involved in the programme, as well as environmental control of each group were some of the problems that emerged from the pilot study.

Furthermore, the study design of the pilot project proved to be not quite appropriate for this study. The results following a prospective comparative study usually do not carry the same weight as those of a randomised controlled study. The variables would have been better controlled with a change in research design. Therefore, for the main study, the researcher, after discussions with the statistician, decided to randomly select and assign subjects to an intervention group (Group 1) who then received the SDCP and a control group (Group 2), who only received daily unstructured KMC for four hours. The change in study design were then approved by the Committee of Human Research.

The ten day SDCP (Group 2) at Tygerberg Hospital was well received by the participating mothers and other care givers. However, they felt that the instructions on the handling and positioning of the infants were not clear and specific enough to enable the caregivers on duty to follow exactly the same regime. The SDCP was then revised and adapted (see discussion in section 3.6.2) . Another important point that came to the fore during the pilot study was the necessity to specify the design and fabric used for the KMC top and the nesting cushion (included in the SDCP) to enable equality.

The progress of the pilot study was assessed after 14 months of designing, planning and practising the programme. This study was then discontinued and the knowledge gained from that experience was used to redesign the main study.

3.3 SETTING

The most suitable hospital to conduct the study proved to be Tygerberg Hospital. This is a tertiary, referral, level 3, teaching hospital for Stellenbosch University and is situated in the Western Cape.

Infants for the study were recruited from the high care ward. This ward consisted of six small rooms (more or less 10 m^2 each) with three to four incubators in each. One of these rooms was allocated to the participants in the intervention group.

All infants in the study sample were either discharged from hospital or transferred to secondary hospitals after the ten day programme.

3.4 SAMPLING

Simple random sampling was used to allocate infants to the intervention and control groups.

Castle's (1979:27) definition of a 'simple random sample' applies when he denotes it as one 'into which each individual in the population has an equal chance of selection'. Random sampling is a fair and unbiased method to use for the recruitment of subjects and maximises the reliability of research results (Dawson-Saunders and Trapp, 1990).

3.4.1 Determining the size of the research sample

A statistician at the MRC initially determined that 100 infants should be included in the study sample to ensure reliability and validity, with a re-analysis of the results after one year to determine whether ongoing recruitment would be necessary.

During the time that the study was conducted, however, the sample size changed. The following are some of the reasons for this course of events:

- Tygerberg Hospital changed its policies due to the fact that more hospitals in the area (Eersterivier, Conradie and Karl Bremer) opened NICUs and high care wards. Tygerberg Hospital became the hospital where all the at-risk cases were admitted, while all stable infants had to be transferred to one of the other hospitals. Subsequently, the hospital claimed the beds allocated for use in this study for sicker infants when its NICU became too full. This slowed down the research process as the recruitment of infants was dependent upon the availability of beds.

- An increase in the numbers of mothers with a positive HIV status admitted to the NICU and high care wards at Tygerberg Hospital was experienced; whereas the study criteria determined that no infants of mothers with an HIV/AIDS history could be included in the study group.

- The Department of Occupational Therapy, which was responsible for the recruitment of infants and the implementation of the study programme in the hospital, lost some posts during the time. As a result of the bigger workload, the department could no longer continue with the implementation of the programme.
- A reduced pace of recruitment caused the study to become drawn out. Therefore, results have not yet been implemented in the normal programme of the NICU.

A statistician at Stellenbosch University scrutinised the preliminary results in September 2005 and was of the opinion that it qualified for the status of a valid study and that recommendations for their implementation could be made on that basis.

3.4.2 Inclusion criteria for the study population

The inclusion criteria were as follows:

- Premature infants who had a VLBW (900 g to 1350 g) at time of recruitment.
- Infants must have been off the ventilator and well for at least 24 hours prior to recruitment.
- Infants had to be cared for two weeks after admission to the study in the same unit.
- Mothers of infants must have been able to implement KMC at least four hours a day during the two weeks after admission to the study.
- For logistical purposes, only infants coming from the Tygerberg substructure (20 km radius), having a permanent address and whose mothers were proficient in either Afrikaans or English, were included.

3.4.3 Exclusion criteria for the study population

Infants were excluded from recruitment under the following applied conditions:

- Born with congenital abnormalities;

- Regarded by the medical practitioner in charge as unstable;
- Any infections at time of recruitment; and
- Mothers who were confirmed as HIV positive (because of the greater chance of the infants contracting infections).

3.4.4 Random assignment to groups

All infants admitted to the level two high care ward (see section 3.3) were screened by the ward clerk with respect to their weight. Whenever the weight was within the inclusion criteria, the infant was referred to occupational therapy for further assessment regarding the remaining inclusion criteria.

After recruitment, the occupational therapist working in the Paediatrics Department sought informed consent from the mother, by discussing the information and consent document (Appendix A) with her and answering any questions she might have. After a mother had signed the agreement, the infants were alternately assigned to either the intervention (Group 1) or control (Group 2) group by the occupational therapist.

The recruitment of the infants was conducted for 24 months.

3.4.4.1 Intervention group (Group 1)

Infants in the intervention group were cared for according to the SDCP (described in section 3.6.2) for ten recorded days, which stretched over two weeks, Monday to Friday, with a weekend off in between.

3.4.4.2 Control group (Group 2)

The infants who comprised the control group received the standard care of the ward, which excluded the SDCP, except for being allowed to practise unstructured KMC for four hours per day.

3.5 ETHICAL CONSIDERATIONS

The study protocol was submitted for ethical approval to the Committee for Human Research at the Faculty of Health Sciences of Stellenbosch University.

No infant was allowed to participate in the study unless the mother had given informed consent in writing. The anonymity of the subjects had to be assured to ascertain that no confidential information would be shared with anyone except the researcher and her collaborators. The occupational therapist who recruited the infants kept all information of infants safely filed in the Department of Occupational Therapy at Tygerberg Hospital. She only handed the information to the researcher once the TSFI had been performed on the infants at six, 12 and 18 months. Thereafter, the data was sent anonymously to the statistician for analysis. No reports on the study revealed any names of clients involved.

Although the intervention group was exposed to the SDCP, no treatment that had already been part of the normal protocol of the hospital was withheld from the infants in the control group, including unstructured KMC.

The mother whose pictures were used to illustrate some aspects of the intervention also gave written consent to be photographed.

3.6 THE STUDY

The intervention for the two groups differed. Group 2 only received unstructured KMC, while group 1 received the SDCP. The unstructured KMC and SDCP will now be discussed.

3.6.1 Unstructured kangaroo mother care (control group)

The unstructured KMC refers to skin-to-skin contact between the mother and infant that was allowed for the subjects in the control group for four hours per day any time or any way the mother preferred (not using the KMC tops which were issued to the mothers of the infants in the intervention group). It was checked by the nursing assistant allocated for KMC and recorded (see Appendix D2) by the occupational therapist for ten days, spanning two weeks, Monday to Friday, with an unrecorded weekend in between. Only the time spent in unstructured KMC was recorded on a daily basis.

3.6.2 SDCP (intervention group)

The intervention group of infants were cared for according to the SDCP for ten recorded days, spanning two weeks, Monday to Friday, with a weekend off in between. The same occupational therapist who randomly selected the infants for the study also conducted the SDCP.

The SDCP consisted of the following components:

- Maintaining an optimal environment;
- Handling techniques;
- Structured KMC;
- Positioning of the infant in the incubator;
- Vestibular stimulation; and
- Support group for mothers.

The group participation of mothers, the behaviour of infants during a one hour observation period and the time spent in the KMC position were recorded by the occupational therapist on a daily basis (see Appendix D1).

3.6.2.1 Maintaining an optimal environment

The room that was selected for the intervention group was the room furthest from the entrance of the unit and therefore the least exposed to noise.

Care was taken that the following were adhered to and recorded on the daily checklist (Appendix B):

a) Optimal visual environment

The blinds covering the windows were kept closed to prevent too much sunlight coming in the room. Lights were switched off between medical procedures, while receiving blankets were used to partially cover the incubators. All these measures were put into place to reduce the light in the room in order to protect the infant's visual system from overwhelming exposure to light (Stanley and Craven, 2004; Gottfried and Gaiter, 1985; Gardner and Goldson, 2002). Conditions like decreased oxygenation, increased incidences of retinopathy, poorer circadian rhythms, altered sleep patterns and skin changes such as rashes are associated with exposure of the preterm infants to bright lights in the high care ward (Gardner and Goldson, 2002).

b) Optimal auditory environment

No radios were allowed to be switched on in the room. Plastic bins replaced the metal ones to prevent loud unexpected noise when closing the bins. Loud talking at all times and especially during ward rounds were to be curtailed and incubator alarms had to be attended to without delay. These intervention strategies correlate with the guidelines given by Gardner and Goldson (2002) in order to protect the auditory system and prevent other neurological damage (Holditch-Davis, 2003; DePaul and Chambers, 1995; Philbin, 2000).

c) Optimal somatosensory environment

The regulation of the temperature of the incubators were regularly checked and kept between 35 and 36 degrees Celsius. The nesting cushions (see section 3.6.2.4) had to be in place in the incubator all the time, with the infants dressed only in nappies. These additional environmental aspects were deemed necessary in order to provide appropriate somatosensory input to the infant when it was not in KMC (Gardner and Goldson, 2002; Cignacco et al, 2006).

d) Optimal vestibular environment

Two rocking chairs were placed in the room and had to be present for the mothers to use during the day when they did KMC. Slow rhythmic movements enhance the vestibular system (Maurer and Maurer, 1988).

e) Optimal olfactory environment

To keep the odours in the environment as constant as possible, all incubators had to be left open for at least ten minutes after having been cleaned with chemicals. Caregivers were not allowed to use perfume and they had to wait for two minutes after they had washed their hands with soap before handling the infant. The mothers also had to sprinkle a few drops of mother’s milk on their breasts close to the infant’s nose so as to get them used to the smell of the milk (Schaal et al, 2004; Gardner and Goldson, 2002).

f) Optimal gustatory environment

Nasal gastric tube feeding of mother’s milk was encouraged during KMC. This was done to help the infant to associate feeding with being close to its mother and to accelerate independent feeding from the breast (Tatzer et al, 1985; Rosenstein and Oster, 1988).

3.6.2.2 Handling techniques

Specific techniques were used for the handling infants. The three main guidelines of flexion, containment and midline orientation used during the implementation of the handling techniques are widely promoted by developmental care programmes such as NIDCAP (Ludington-Hoe et al*,* 1994; Als, 1986; Taquino and Blackburn, 1994). The somatosensory systems such as the tactile and proprioceptive systems receive deep pressure touch input. This, together with containment of the body parts, has an organising effect on the central nervous system of the infant (Sizun et al, 2002; Als et al, 1996). These handling techniques were applied to medical procedures such as measuring oxygen saturation and temperature performed by medical or nursing staff, as well as caregiving procedures carried out by nurses and mothers such as changing nappies, cleaning, feeding and practising KMC. The occupational therapist provided training sessions with suitable dolls for all the caregivers involved.

Whenever the infant was handled it had to be contained in a flexed position with extremities held in the midline. This was done in sequence as shown below on the next page:

1) The natural position of the infant in the incubator in supine is that of extension with external rotation and abduction of the shoulders and hips.

2) Slowly move the shoulders into a position of internal rotation, adduction and flexion.

3) Place hands on chest in the midline.

4) Use one hand to keep the infant's arms on chest and the other hand to bring its hips to mid-position (internal rotation, adduction and flexion) with its knees in flexion.

5) Move one hand up towards infant's hands on its chest in order to free the other hand. Use the three middle fingers to contain the infant's arms, hips and knees while placing the thumb and little finger behind the infant's thighs for support and to keep its hips in the flexed position. The free hand can now be used for applying various procedures.

When removing the infant from the nesting cushion in order to be placed onto a different surface or into the KMC position, containment as demonstrated in the first five steps had to be done before the following steps could be carried out:

6) Mould the free hand around the back of the infant's head to enhance deep tactile input and containment.

7) Slowly move the arm in behind the infant's back, while supporting the spine

All movements must be done very slowly, applying firm pressure to allow the infant to process and adjust to incoming sensory stimuli. Do not flex the spine excessively.

3.6.2.3 Structured kangaroo mother care

Mothers of the infants in the intervention group were issued with special, tight-fitting cotton Lycra tops (KMC top) for wearing while the baby was in the KMC position, as well as special head caps and disposable nappies for their infants.

The tops were manufactured after consultation with a few other hospitals in the Western Cape and Gauteng that were already promoting KMC. After testing the different tops, the design used by Groote Schuur Hospital was selected, as it could stretch sufficiently and accommodate a more natural position for the infant, namely, that of flexion and midline orientation, similar to the position of the foetus in the womb.

The researcher obtained permission from Groote Schuur Hospital to use their basic pattern. The same cotton Lycra material was used for tops issued to the mothers in the SDCP. Adjustments like adding neck straps, shaping and lengthening the tops were made to provide more comfort for the mothers and improve the infant's safety.

The occupational therapist instructed mothers to use the handling techniques as previously discussed (see section 3.6.2.2). This they first practised with a doll before being allowed to handle their infants.

The mothers had to have the KMC top on with neck straps loosened before starting the transfer process.

The first five phases explain the transfer:

1) The mother stands close to the incubator and applies the previously mentioned handling techniques of containing the infant with the one hand and sliding the other hand in at the back to support the head and the spine.

2) The mother now keeps the infant in the contained, supported position and slowly transfers the infant to her shoulder.

3) The mother contains the infant with one hand, while keeping open the KMC top with her other hand.

4) The mother slowly slides the infant into the KMC top between her breasts, while retaining the infant in the contained position. The mother has to ensure that the infant stays in the flexed, contained position where its hands and knees can be in the midline.

5) After this the neck straps of the KMC top are fastened and the cap put on the infant's head to prevent heat loss.

This process is reversed (phases 5 to 1) when the infant is transferred back to the incubator.

6) Mothers were alerted to the possibility of their infants sagging too much when falling into the deep sleep phase and were shown how to apply upward pressure on their buttocks to ensure that their airway stayed open.

7) This method of KMC was practised by the mothers for at least four hours per day. The duration of an uninterrupted KMC period had to be at least 40 minutes, in order to prevent state (sleeping pattern) disturbances of the infant.

8) The nursing staff was also informed of the specialised KMC method that the mothers of the intervention group followed. This instruction was done by the occupational therapist at the beginning of the study and every month thereafter.

3.6.2.4 Positioning of the infant in the incubator

The infants were positioned in the incubator on a nesting cushion, designed by the researcher. Different mattress options were considered and researched before the final nesting cushion was selected. Some NICUs visited by the researcher used rolled towels and sheets to provide boundaries for the infant in the incubator. This method did not offer the infant the most beneficial tactile environment and flexion and containment of the infant could not always be maintained. Another design was the ‘Snuggle Up’ device for keeping the infants in a contained position (produced by Children’s Medical Ventures, Connecticut, USA, and distributed by Neo Care Medical, SA). Although this device was expensive, it did not provide the infant with the necessary pliable and soft tactile input. Furthermore, it restricted the movement of the infant. A cushion filled with Styrofoam balls and covered with towelling material was used from time to time in the NICU at Tygerberg Hospital fabricated according to a design obtained from a paediatrician in the Netherlands. Queries about the roughness of the towelling material on the infant’s skin, the impact of the noise of the Styrofoam balls during movement on the auditory system of the infant, the possibility of dangerous gasses being exposed by the warming of the Styrofoam balls in the incubator and the lack of an upper boundary were raised by other paediatricians and nursing staff in Tygerberg Hospital.

After having considered the different sleeping devices for premature infants in the incubator the nesting cushion was adapted. The material and also the filling material were selected carefully in order to be pliable and soft to enable the infant to snuggle into the moulded hollow. The nesting cushion had to offer the infant the appropriate tactile and proprioceptive input, while maintaining the position of flexion, midline orientation and containment. The volatiles emitted by the filling material in the cushion were also analysed at the Department of Chemistry of Stellenbosch University and found not to be a health risk for the infant. The cushion is manufactured and distributed by Nurture One, Cape Town, South Africa.

a) Nesting cushion

1) A nesting cushion was provided for each infant.

2) The cushion is equipped with a broad strip of material that stretches from side to side over the width and covers the trunk, legs and buttocks of the infant.

3) This band provides proprioceptive feedback for the infant and contains the infant in a flexed-midline position.

b) Preparing the nesting cushion

1) Remove the existing mattress in the incubator and elevate the incubator by 10 to 20 degrees at the head end.

2) Place nesting cushion on the floor of the incubator.

3) Mould a hollow in the middle of the cushion in preparation for the infant to fit in.

c) Transfer of infant to nesting cushion

1) The infant is transferred to the cushion while being held in a contained position as described under handling techniques (see section 3.6.2.2).

2) When placed in the cushion, the infant's head has to be between the two parallel stitching lines and the body in the prepared hollow.

d) Positioning in supine

1) The infant is placed on its back with the head between the stitched parallel lines and the body in the prepared hollow, while the one hand opens the band and the top hand keeps the infant in a contained position.

2) Mould the cushion to form a boundary at the top for the head and along the sides for the shoulders and arms to stay in the mid-position.

3) Mould the cushion at the bottom to provide a boundary for the legs and feet.

e) Positioning in side-lying

1) Place the infant in the side-lying position, while maintaining flexion and midline orientation.

2) Keep both shoulders in flexion and adduction with scapular protraction, while moulding the cushion to support the position. The infant's hands can get together or the thumb can reach the mouth for self-regulation.

f) Positioning in prone

This position was not recommended unless caregivers in charge (mothers and nursing staff) take special and continuous care of the infant while in this position. A reason for this decision was the possible risk of sudden infant death syndrome (SIDS) as the apnoea monitors in the unit were older and not always reliable. Although the nesting cushion was designed to register an under-mattress apnoea monitor, there were no such monitors available at Tygerberg Hospital. Another reason for this decision was the fact that the infants spent at least four hours per day in the KMC position, which would have similar benefits such as improved oxygenation, improved lung mechanics, decreased energy expenditure, decreased heat loss, decreased gastric reflux and better regulatory interaction for the infant than that of being in the prone position (Gardner and Goldson, 2002).

g) Transporting the infant in the nesting cushion

When the infant was removed from the incubator and transported, other than for KMC, it had to be kept on the cushion in the contained, flexed midline position in order to make the transition less traumatic. The following steps were followed during the procedure:

1) Slip both hands under the cushion in the incubator.

2) Carefully move the mattress out of the incubator.

3) Keep the infant in the contained position.

4) Transport infant in the contained position.

3.6.2.5 Vestibular input

An occupational therapist from the Department of Occupational Therapy at Tygerberg Hospital received training by the researcher on the ten day vestibular stimulation programme.

Mothers, as the primary caregivers of their infants, received a one-hour visit on a daily basis from the occupational therapist during the ten day programme. During this time the mothers had to participate in a seven minute vestibular stimulation programme with their infants in the KMC position.

During the exercises, mothers placed one hand under the buttocks of the infant, while the other hand supported its back. Exercises entailed the following:

1) Slow, rhythmic walking on the spot for two minutes (120 steps);
2) Two minutes of slow, rhythmic, 180 degree rotational, side-to-side movements of the trunk with feet in a stationary position (100 movements from one side to the other);

3) Two minutes of slow rocking on the spot from the left to the right foot and back (120 movements from one side to the other); and

4) One minute of slow, rhythmic forward-and-back rocking (± 30°) while standing (50 movements forward and back).

The counting of steps and movements was done by the occupational therapist to ensure that the group kept the correct pace.

Apart from these exercises, mothers were expected to spend an hour in the rocking chair with their infants in the KMC position. Rocking movements had to be slow and gentle, not exceeding twenty per minute. The vestibular system is the most advanced system at birth and it needs continual controlled input for further development (Maurer and Maurer, 1988; Murray-Slutsky and Paris, 2000).

3.6.2.6 Support group for mothers

The occupational therapist spent the rest of the daily hour visit with the mothers by providing general support and training within the group. She started with a session of progressive relaxation, which helped the mothers to release some tension that they had built up while trying to cope with and care for their premature infant. This relaxation was followed by discussions of relevant issues pertaining to prematurity, for example: understanding the needs of such infants and how to respond to their cues; explaining the importance of the SDCP; the importance of attending follow-up visits; and other matters raised by the mothers. The purpose of these group activities was to give the mothers support and encouragement to participate in the SDCP.

3.7 DATA COLLECTION

After obtaining written consent, the following data was collected during the different phases of the research study for participant mothers from both the intervention and control groups.

3.7.1 At recruitment

The demographic and anthropometric profile was developed from the information obtained by the occupational therapist from mothers. Literate mothers filled in a questionnaire on their own (see Appendix C). Non-literate mothers were assisted by the occupational therapist. The questionnaire consisted of the biographical and medical information of the mother and her infant. Aspects solicited about the mothers were age, living conditions, marital status, level of education and whether the infant was her firstborn. Aspects obtained about the infants were sex, gestational age, birth mass, mass on enrolment in the programme and whether they had been ventilated. This information was then captured and analysed for comparability of both study groups.

3.7.2 During hospital stay

In the intervention group the occupational therapist daily recorded various aspects such as the infants' reaction in the KMC position during the vestibular input and support group time, the participation of mothers in the SDCP, as well as the number of hours spent in KMC (see Appendix D1). The control group was monitored daily only in respect of the time spent in unstructured KMC (see Appendix D2).

A daily checklist as discussed in section 3.6.2.1 (see Appendix B) was ticked off three times per day by the occupational therapist or the nursing assistant tasked with KMC. The purpose of this was to manage the environmental conditions conducive for optimal sensory development of the intervention group who participated in the SDCP.

3.7.3 Evaluation of the infants after discharge

The entire study sample was followed up at six, 12 and 18 months (corrected age). The Test of Sensory Functions in Infants (TSFI) (described in section 2.10.1) was used to do a sensory developmental assessment at each age level. The researcher was 'blind' to these assessments. All the names of the participating infants were sent to the principal medical officer responsible for the follow-up visits at the 'At Risk Clinic' at Tygerberg Hospital. Neither the principal medical officer nor the researcher knew to which group the infants had been allocated until the end of the project, when the occupational therapist who conducted the SDCP revealed the status of the infants. The follow-up assessments were scheduled to coincide with the follow-up visits to the 'At Risk Clinic' for preterm infants at Tygerberg Hospital.

With their last sensory developmental assessment at 18 months corrected age, all infants were also assessed on the Griffiths Mental Developmental Scales – Revised: Birth to Two years (described in section 2.10.2). This was done ‘blind’ by the same principal medical officer mentioned above at the ‘At Risk Clinic’ at Tygerberg Hospital.

3.8 STATISTICAL ANALYSIS

Statistical measures included repeated measure analysis of variance (RANOVA) which was used to measure the progress of the two groups over time (time-group interaction) and to compare the difference in performance between the two groups (group effect) at the different follow-up stages of assessment (six, 12 and 18 months). This statistical method permits analysis of repeated measures on the same individuals; so that it can test for a difference between groups or within the same groups at different stages over time (Pereira-Maxwell, 1998). A one-way analysis of variance (ANOVA) was used to compare the two groups with regard to performance on the Griffiths Mental Developmental Scales (Grant Knapp, 1985).

Another statistical approach, namely, the Bonferoni *t* procedure, which is used for planned multi-comparisons, was employed to analyse the development of the sample group over time (time effect) for the duration of the study. This procedure is frequently used when several significant tests are used simultaneously on the same body of data. The Bonferoni *t* procedure is versatile, because it is valid for either equal or unequal sample sizes. This method also applies for a finite number of contrasts, pair-wise comparisons and linear combinations, as was the case in the current study (Dawson-Saunders and Trapp, 1990).

The guideline used to determine the significant differences between the intervention and control groups was a significance level of 5% ($p<0.05$). Numbers were rounded off to two decimal points.

CHAPTER 4

DEMOGRAPHIC AND ANTHROPOMETRIC PROFILE OF STUDY GROUPS

Chapter 4 presents and discusses the demographic and anthropometric data of the study population (intervention and control groups) as well as the sample size.

4.1 DEMOGRAPHIC PROFILE OF THE STUDY POPULATION

4.1.1 Recruitment of infants for the study

The occupational therapist working in the Paediatrics Department of the hospital recruited the infants and allocated them alternately to either the intervention or control group (see section 3.4.4). Table 4.1 gives a representation of all the participants in the study. Eighty-nine subjects were recruited, 44 were allocated to the intervention group and 45 to the control group, but only 22 participants in the intervention group and 20 in the control group completed the 18-month follow-up period. The 42 subjects who completed the study will be referred to as the study sample or study population.

Table 4.1 Summary of the recruitments in the study

89 prospective subjects	**89 subjects randomised**		**Total**
	Intervention group	**Control group**	
Recruitments	**44**	**45**	**89**
Total withdrawal	22	25	47
No follow-ups	*14*	*19*	*33*
Follow-up (1)	*4*	*3*	*7*
Follow-up (2)	*3*	*2*	*5*
Disabled	*1*	*1*	*2*
Study sample	**22**	**20**	**42**

The time for the follow-up visits had to be very strictly adhered to in order to get valid results on the TSFI at six, 12 and 18 months (corrected age). Most of the infants who dropped out of the study were excluded because they did not turn up for the appointment or they came too late for the results to still be valid for that specific age group. The reasons for withdrawal from the study are summarised in Table 4.2.

Table 4.2 Reasons for withdrawal from study

Categories of reasons	Factors
Administrative factors	• Wrong appointment dates • No change of address received – no reminder could be sent out for appointment
Mother-related factors	• Did not come back for follow-up visits and could not be tracked in time • Did not inform hospital of address changes
Infant factors	• Past testing age • Disabled
Research factors	• If infant missed one follow-up, s/he had to be withdrawn from the study

4.1.2 Profile of the mothers

The status of the mothers of the recruited infants was analysed in terms of variables such as age, educational level, marital status, parity and living arrangements in order to get a sense of the socio-economic status of the population category to which the study sample belonged. These maternal variables for the intervention and the control groups formed the ‘baseline’ for ascertaining the comparability of the two groups at the outset of the programme.

The following sub-sections illustrate that the mean age for the mothers at the time of birth was 24 years with a mean educational level of grade 8. They were mostly unmarried, lived with their parents and the infants were mostly their firstborn.

4.1.2.1 Age of the mothers

The ages of the mothers ranged from 15 to 35 years at the time of the infant’s birth. Table 4.3 gives a comparison of the ages of the mothers in the intervention and control groups, and indicates that there was no significant statistical difference (p=0.59).

Table 4.3 Age of the mothers

Indicator	Study sample n = 42		Intervention group n = 22		Control group n = 20		p value
	Mean	SD	mean	SD	mean	SD	
Age (years)	24.0	5.6	23.59	1.21	24.55	1.27	0.59

4.1.2.2 Marital status

Although no significant difference between the intervention group and the control group was found with regard to marital status (p=0.23), a higher percentage of intervention group mothers were unmarried compared to those in the control group (see Table 4.4).

Table 4.4 Marital status

Marital status	Study sample n = 42		Intervention group n = 22		Control group n = 20		p value
	n	%	n	%	n	%	
Married	15	36	6	27	9	45	0.23
Unmarried	27	64	16	73	11	55	

4.1.2.3 Parity

A comparison of the two groups with regard to parity in table 4.5 indicates that there was more primi-parity in the intervention group than in the control group. However, this trend was not found to be statistically significant (p=0.13).

Table 4.5 Parity

Pregnancy status	Study sample n = 42		Intervention group n = 22		Control group n = 20		p value
	n	%	n	%	n	%	
Primi-parity	26	62	16	73	10	50	0.13
Multi-parity	16	38	6	27	10	50	

4.1.2.4 Educational level

The educational level of the mothers of the study sample ranged between no schooling (2.5%, n =2) to completion of grade 12 (36%, n =15) (see Figure 4.1). More than 50 percent of mothers had a school qualification higher than grade 8. The educational level of the intervention and control groups were very similar and presented no significant difference (p=0.96).

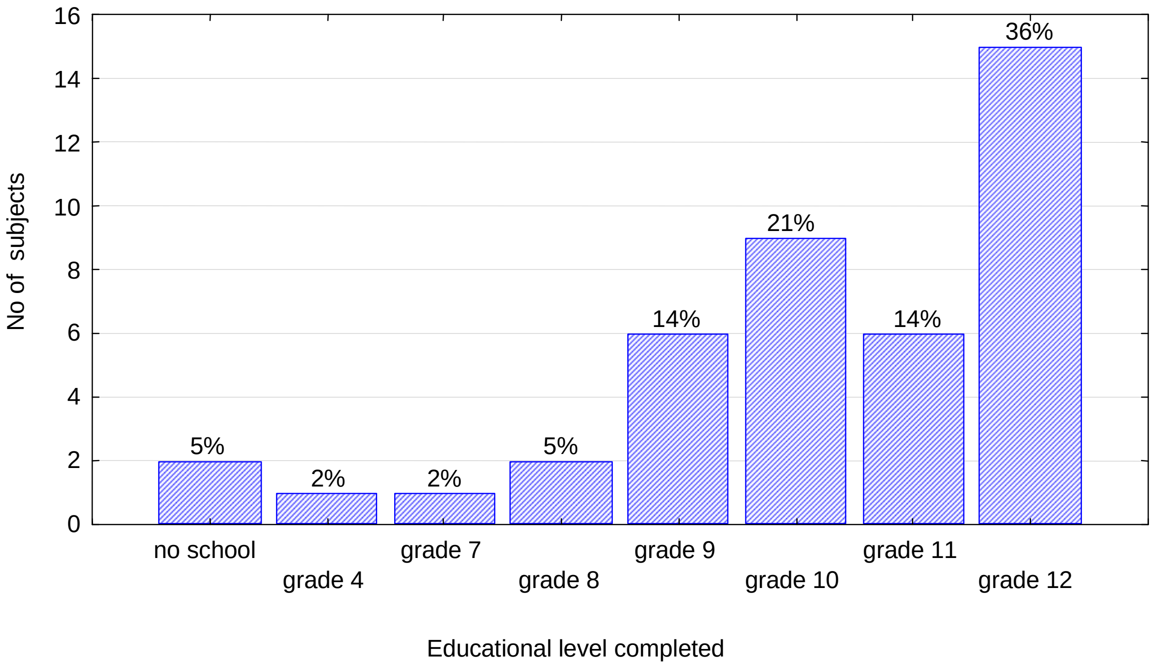

Figure 4.1 Educational level of the mothers in the study sample

4.1.2.5 Living arrangements

Figure 4.2 gives a graphic depiction of the living arrangements of the mothers at the time of the study. Twenty-eight (67%) of the mothers of the study sample were living with their parents, whereas five (12%) stayed with other family members. Another nine (21%) had their own homes and stayed with their husbands.

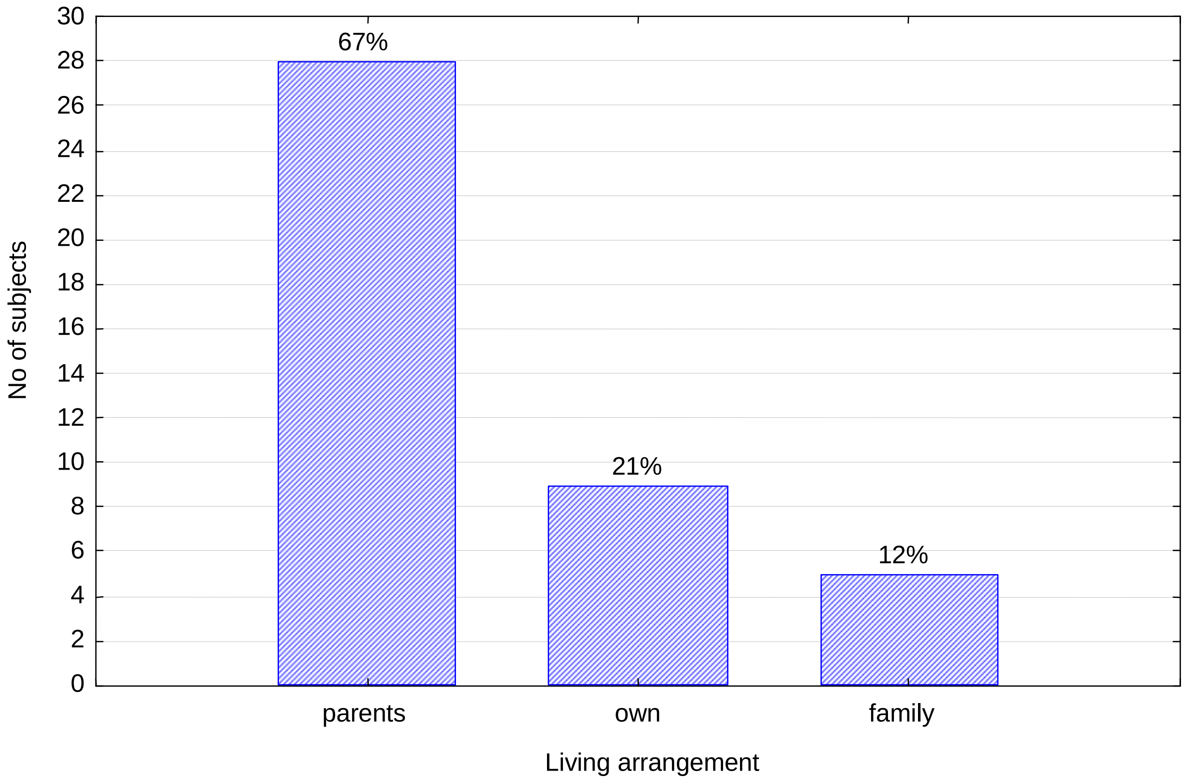

Figure 4.2 Living arrangements of the mothers in the study sample

4.2 ANTHROPOMETRIC DATA OF THE STUDY SAMPLE

The infants of the study sample (n=42) were also analysed according to gender, gestational age, birth weight, weight at enrolment into the programme and whether they had been ventilated.

The distribution between sexes in the study sample was 50 percent male (n=21) and 50 percent female (n=21). The same equal distribution applied for the intervention group (11 males, 11 females) and the control group (10 males, 10 females).

Only 26 percent of the subjects had been ventilated for short periods before enrolment in the study (n=11) and 74 percent had not (n=31).

The rest of the anthropometric data of the study sample is summarised in Table 4.6.

Table 4.6 Anthropometric data of the infants in the study sample

Indicator	INTERVENTION GROUP n = 22				CONTROL GROUP n = 20				STUDY SAMPLE n = 42				p value
	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max	
Gestational age (weeks)	**29.64**	1.65	29	30	**30.65**	1.76	30	31	**30**	1.7	27	33	0.06
Birth weight (grams)	**1043g**	198	972g	1114g	**1231g**	120	1157g	1306g	**1132g**	189.2	676g	1468g	**<0.01**
Enrolment weight (grams)	**1130g**	112	1084g	1175g	**1217g**	99	1169g	1265g	**1171g**	113.6	1001g	1345g	**0.01**

The mean birth weight (p<0.01) and weight at enrolment (p=0.01) of the infants in the intervention group were significantly lower than those in the control group, with a trend towards a lower gestational age (p=0.06). The small sample size may have contributed to this discrepancy. There were however no other differences in demographic and anthropometric variables between intervention and control groups.

4.3 RELEVANCE OF DEMOGRAPHIC AND ANTHROPOMETRIC DATA

The demographic and anthropometric profiles of the subjects indicate that the randomisation of the two groups resulted in comparability with regard to the following indicators:

- Mean age of the mothers (p=0.59);
- Marital status of the mothers (p=0.23);
- Whether infants were firstborn (p=0.13);
- Level of education of mothers (p=0.96);
- Gestational age of infants (p=0.06); and
- 50:50 distribution between the sexes in both groups.

As already mentioned in section 4.2 above, a significant difference only existed between the two groups with regard to weight at birth and weight at enrolment in the programme. The significantly lower birth and enrolment weights in the intervention group, something only discovered when the statistician did the final analysis, raises the question whether these differences compromised the validity of the results. According to Potgieter (2005) lower birth weight can be associated with serious handicaps like cerebral palsy or less visible deficits such as lower intelligence, learning and behavioural disorders. It could therefore be suspected that the sensory development of the control group would be more advanced than that of the intervention group. This, however, did not prove to be the case, supporting the effectiveness of the SDCP.

CHAPTER 5

TEST RESULTS AND DISCUSSION

In Chapter 5 the test score results of the Test of Sensory Function in Infants (TSFI) and the Griffiths Mental Developmental Scales are presented and discussed. Both tests were described in Chapter 2 in sections 2.10.

5.1 RESULTS OF THE TEST OF SENSORY FUNCTIONS IN INFANTS AT SIX, 12 AND 18 MONTHS CORRECTED AGE

The scores on the TSFI were firstly analysed in terms of the progress of the intervention and control groups independently over a period of 18 months, at the three intervals of six, 12 and 18 months (time-group interaction). The second analysis compared performance of the intervention and control groups relative to one another. The scores of six, 12 and 18 months were added together (group effect). In the third analysis the study sample's sensory development over 18 months at the three intervals of six, 12 and 18 months was analysed (time effect). This information is summarised in table 5.1.

Table 5.1 Results of TSFI at six, 12 and 18 months corrected age

Variable	**Time-group interaction**		**Group effect**		**Time effect 6, 12, 18 mth**		**Time effect 6–12 mth**	**Time effect 12–18 mth**
	F	**p**	**F**	**p**	**F**	**p**	**p**	**p**
TSFI-Sub-test 1 Reactivity to tactile deep pressure	0.13	0.88	4.90	**0.03***	0.77	0.47	0.38	0.75
TSFI-Sub-test 2 Adaptive motor functions	0.41	0.67	4.98	**0.03***	40.00	**0.00***	**0.00***	0.22
TSFI-Sub-test 3 Visual-tactile integration	1.07	0.35	11.95	**0.00***	1.50	0.23	0.09	0.29
TSFI-Sub-test 4 Ocular-motor control	2.19	0.12	2.31	0.14	1.24	0.30	0.64	0.28
TSFI-Sub-test 5 Reactivity to vestibular stimulation	0.90	0.41	8.13	**0.01***	1.72	0.19	0.27	0.47
TSFI-Total	**0.92**	**0.91**	**13.59**	**0.00***	**9.57**	**0.00***	**0.00***	**1.00**

* Significant differences

5.1.1 Results of sub-test 1: Reactivity to tactile deep pressure

5.1.1.1 Sensory tactile progress of groups over time (time-group interaction)

Although the control group constantly progressed at a lower level than the intervention group, the two groups did not display any significant differences in their pattern of progress at intervals six, 12 and 18 months (p=0.88). Therefore, both groups' tactile processing developed at a constant pace over the 18 months period (see Figure 5.1).

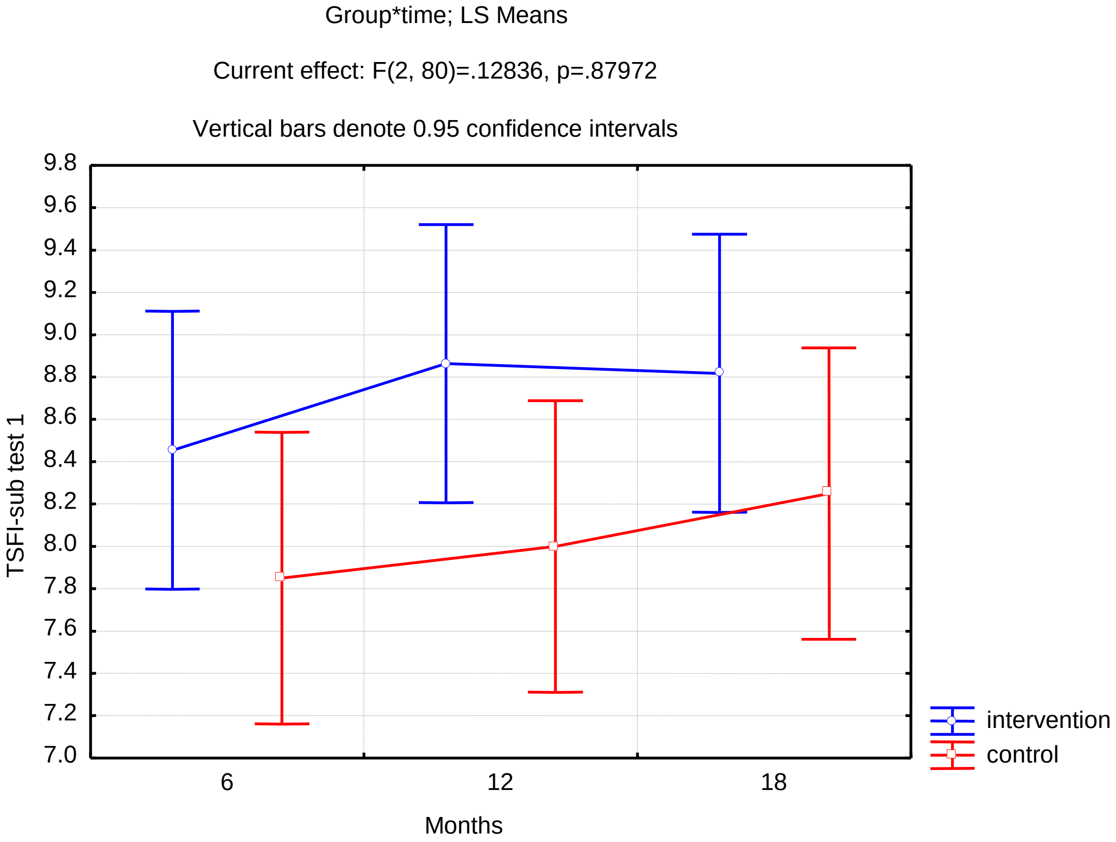

Figure 5.1 Results of the time-group interaction of TSFI sub-test 1

5.1.1.2 Tactile performance of both groups relative to one another (group effect)

The two groups were compared in terms of their sensory tactile performance over the 18 month follow-up period (see Figure 5.2). A significant difference was found between the two groups (p=0.03).

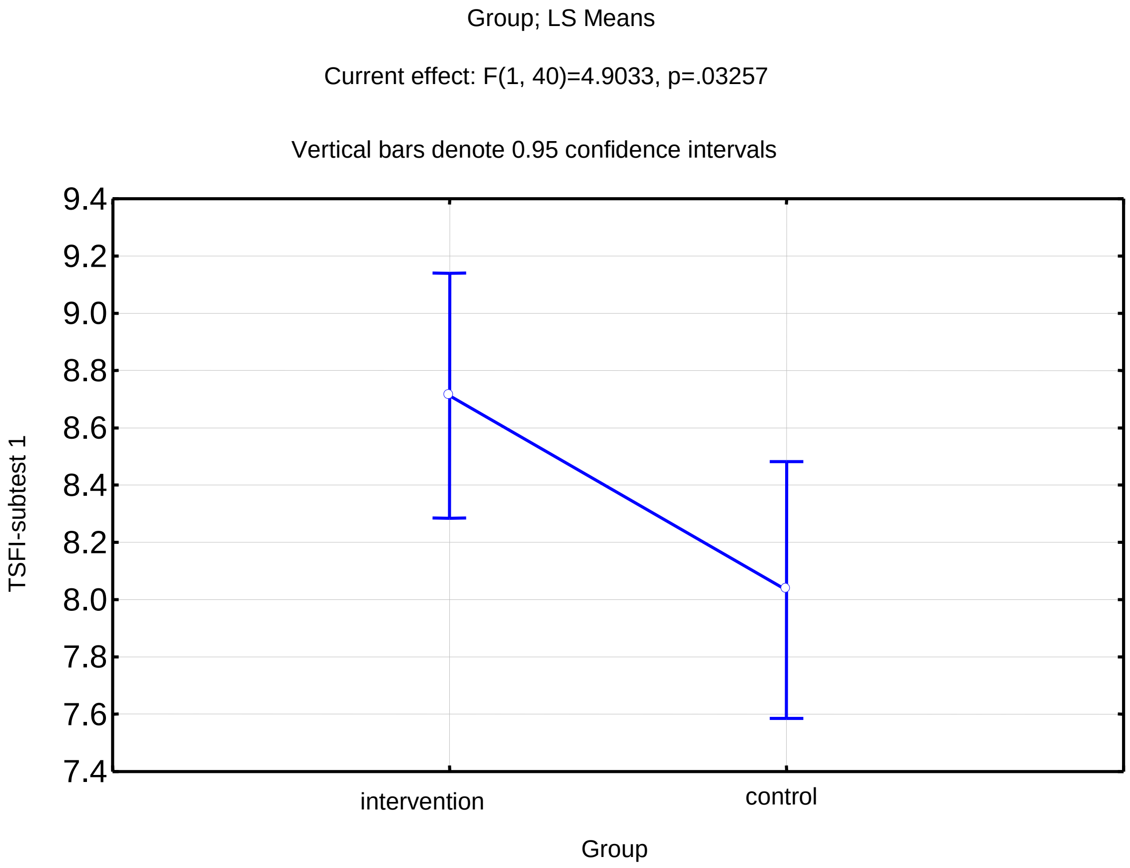

Figure 5.2 Results of the group effect of the TSFI sub-test 1

This score is an indication that the intervention group could tolerate deep tactile pressure better than the control group over the follow-up time period between six and 18 months. This could be an indication that the tactile experience included in the Sensory Developmental Care Programme (SDCP) had a longer lasting effect on the tactile systems of the intervention group compared to that of the control group.

The following aspects of the tactile intervention in the SDCP could account for the difference between the two groups:

1) Maintaining an optimal environment by regulating the incubator temperature, keeping the nesting cushion in the incubator and assuring that the infants were only dressed in nappies (section 3.6.2.1).

2) Handling techniques: The first to be applied was deep pressured touch when touching or holding the infant. Another technique used during any caregiving procedure was to keep the infant in a contained, flexed position with the limbs in the midline (section 3.6.2.2).

3) Structured KMC, where the mothers of the infants had to wear the KMC top provided, which offered constant deep pressure and kept the infant in the contained position. Transfers of the infant in and out of the KMC position were also done by using the correct handling techniques (section 3.6.2.3).

4) Positioning of the infant in the incubator, where the effect of the nesting cushion together with the correct handling methods played an important role (section 3.6.2.4).

5) Support group discussions with the mothers, which explained the reasons and importance of the SDCP and motivated them to continue (section 3.6.2.6).

Many studies refer to the tactile sense as the first sensory system to develop and the system that offers the best opportunity to develop the emotional and mental well-being of the infant (Biel and Peske, 2005; Agarwal, Enzman Hagedorn and Gardner, 2002; Jacobs and Schneider, 2001). Researchers like Anand and Hickey (1987), Stevens, Johnston, Franck. Petryshen, Jack and Foster (1999) and Cignacco, Hamers, Stoffel, Van Lingen, Gessler, McDougall and Nelle (2006) found that the environment of the NICU, where the infants are exposed to poor handling and positioning techniques and many painful intrusive procedures, is not conducive for the development of the infant. This study however demonstrated that the SDCP has the potential to counteract the negative impact of the environment of the NICU and to promote somatosensory development.

5.1.1.3 The sensory tactile development of the study sample over time (time effect)

There were no significant differences in the outcome of the sensory tactile development of the two groups in the study sample over time six, 12 and 18 (p=0.47) months; six to 12 (p=0.38) months and 12 to 18 (p=0.75) months (see Figure 5.3). According to the analysis, the tactile sense of all infants developed at an even pace during the first 18 months of life. This pattern of progressive tactile development coincides with the normal maturation pace of the touch sense as the axons responsible for tactile discrimination complete myelination only by 24 months post birth (Eliot, 1999; Gardner and Goldson, 2002; Kranowitz, 1998; Sullivan, Wilson, Feldon, Yee and Meyer, 2006).

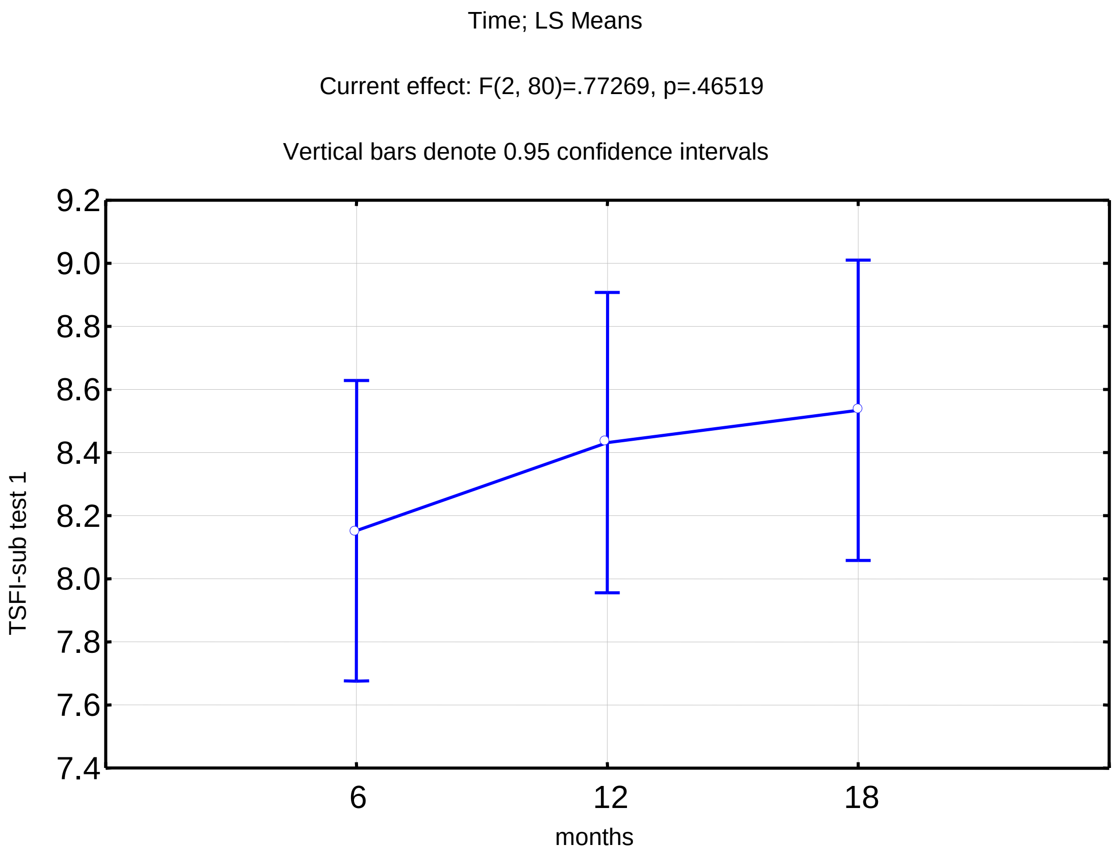

Figure 5.3 Results of the time effect of the TSFI sub-test 1

5.1.2 Results of sub-test 2: Adaptive motor functions

5.1.2.1 Adaptive motor progress of groups over time (time-group interaction)

Although the control group constantly progressed at a lower level than the intervention group, the two groups did not display any significant differences in their pattern of progress between six and 18 months (p=0.67) (see Figure 5.4). However, there was a strong tendency for progress to be faster in the period between six and 12 months, which correlates with the normal motor developmental pattern of infants. Gross motor skills such as independent sitting, pulling to stand, crawling, standing independently and walking develop during this period. While fine motor skills such as controlled reach and grasp, pincer grasp, clapping of hands and releasing of objects become significant within the same period (Eliot, 1999; Nichols, 2005).

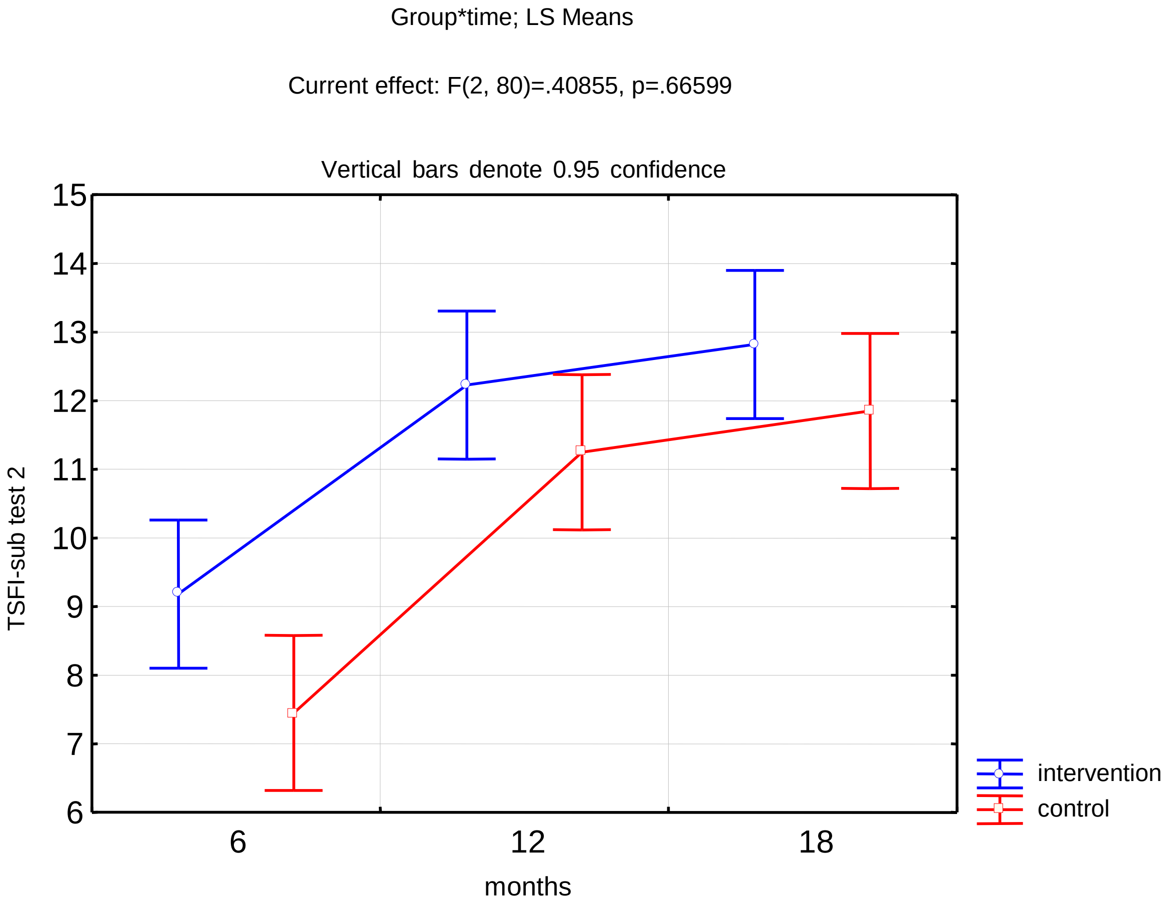

Figure 5.4 Results of the time-group interaction of TSFI sub-test 2

5.1.2.2 Adaptive motor performance of both groups relative to one another (group effect)

When compared in terms of their adaptive motor functions over the 18 month follow-up period, there was a significant difference between the two groups (p=0.03) (see Figure 5.5). This score is an indication that the intervention group's motor functions as a response to the intervention of the SDCP were better than that of the control group over the follow-up time period of six, 12 and 18 months.

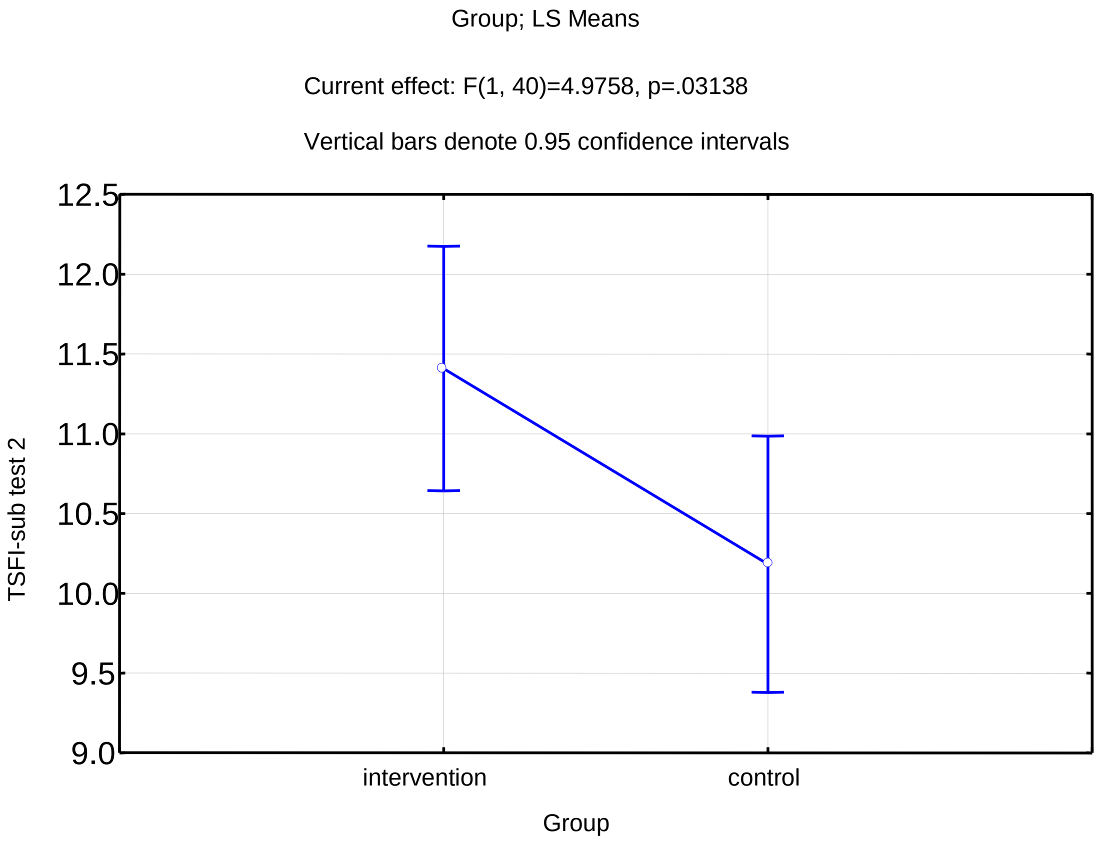

Figure 5.5 Results of the group effect of the TSFI sub-test 2

The better adaptive motor performance could have been caused by elements of the SDCP such as:

1) Following the correct handling techniques of containment, flexion and midline orientation of the extremities when caring for the infant (section 3.6.2.2).

2) The flexed and contained position of the infant in the nesting cushion in the incubator (section 3.6.2.4).

3) Flexion of the infant, with the extremities positioned in the midline while in the KMC top during structured KMC (section 3.6.2.3).

4) The daily vestibular input (section 3.6.2.5), which could have had an important influence on the development of the balance and equilibrium reactions of the infants. The contained handling and positioning techniques used in the SDCP promote better proprioceptive-motor development, which have a great effect on the organisation of motor patterns of infants (Als, 1986; Monterosso, Kristjanson, Cole and Evans, 2003; Gardner and Goldson, 2002; Hunter, 2005; Kranowitz, 1998). Sweeney and Gutierrez (2002) also emphasised the importance of correct handling and positioning of the infant in the NICU in order to prevent postural and skeletal malalignment.

5.1.2.3 Adaptive motor development of the study sample over time (time effect)

The outcome of the adaptive motor development of the study sample over the time periods six, 12 and 18 months and six to 12 months displayed significant differences (p=0.00 for both periods), while for the age group 12 to 18 months no significant differences were seen (p=0.22).

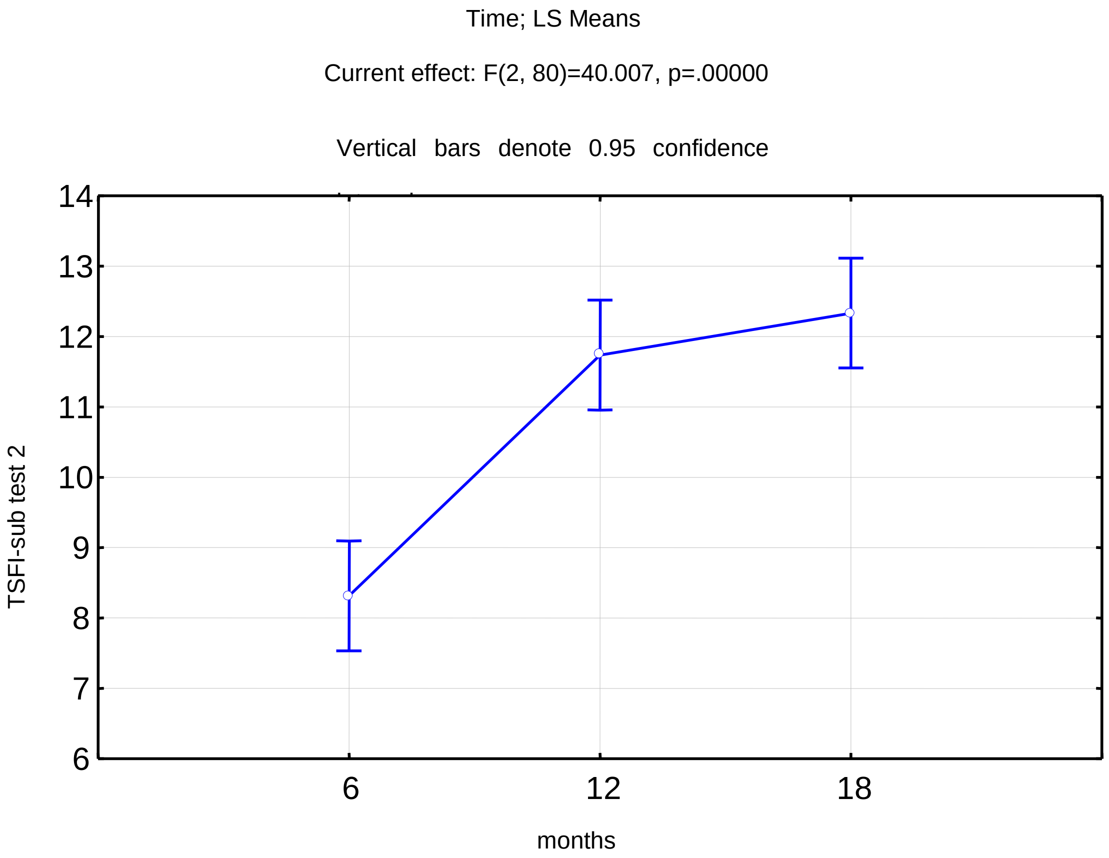

Figure 5.6 Results of the time effect of the TSFI sub-test 2

Figure 5.6 clearly illustrates that adapted motor functions of the study population developed faster in the period of six to 12 months, which is in accordance with the normal motor development pattern (Eliot, 1999; Gardner and Goldson, 2002; Nichols, 2005). The SPCD's contribution to this was discussed in section 5.1.2.2.

5.1.3 Results of sub-test 3: Visual-tactile integration

5.1.3.1 Progress of visual-tactile integration of groups over time (time-group interaction)

Although the control group constantly progressed at a lower level than the intervention group, the two groups did not display any significant difference in the visual tactile integration pattern between six and 18 months (p=0.35) (see Figure 5.7).

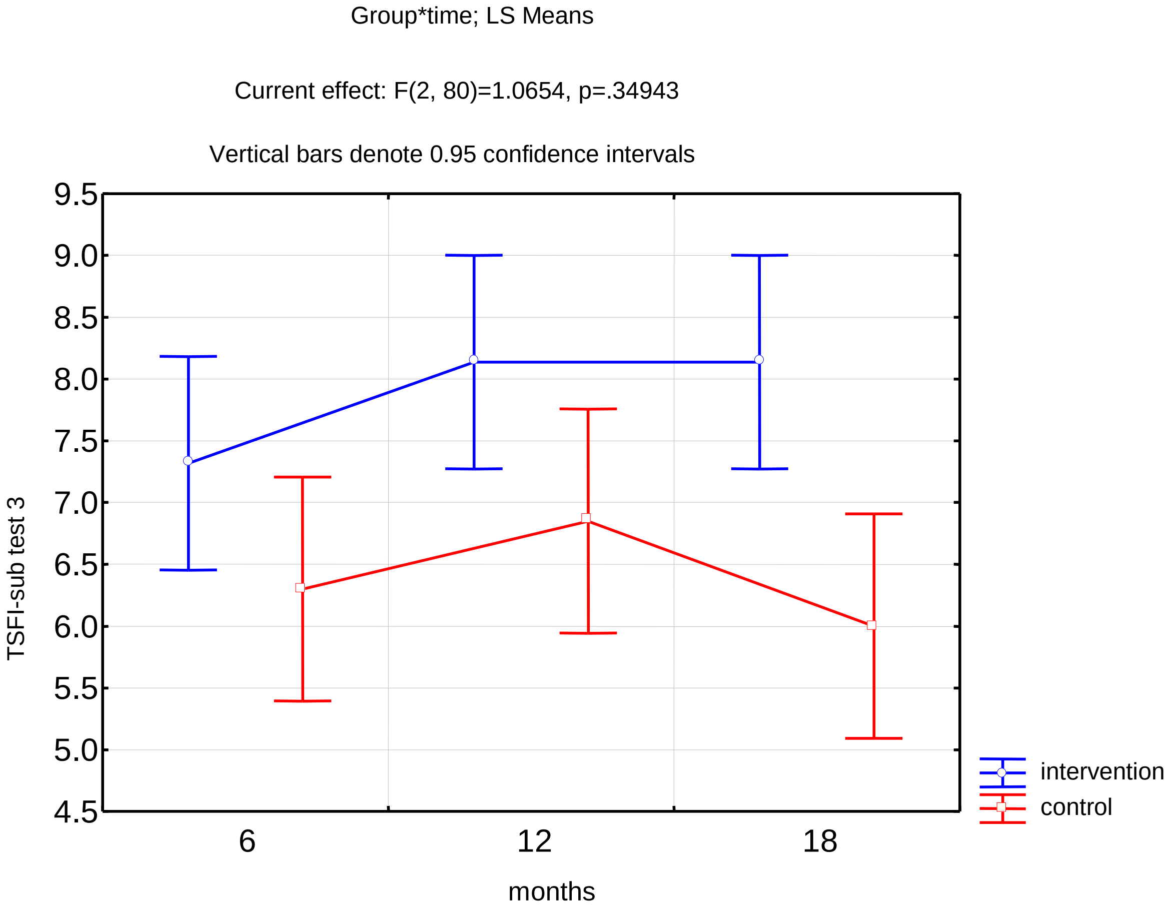

Figure 5.7 Results of the time-group interaction of TSFI sub-test 3

A trend towards slower progress in this regard of the control group between 12 and 18 months was noticed and could be attributed to the lower tolerance level of tactile input as was found in section 5.1.1.2.

5.1.3.2 Visual tactile integration of both groups relative to one another (group effect)

The two groups were compared in terms of visual tactile integration over the 18-month follow-up period and a significant difference was found between the two groups (p=0.00) (see Figure 5.8).

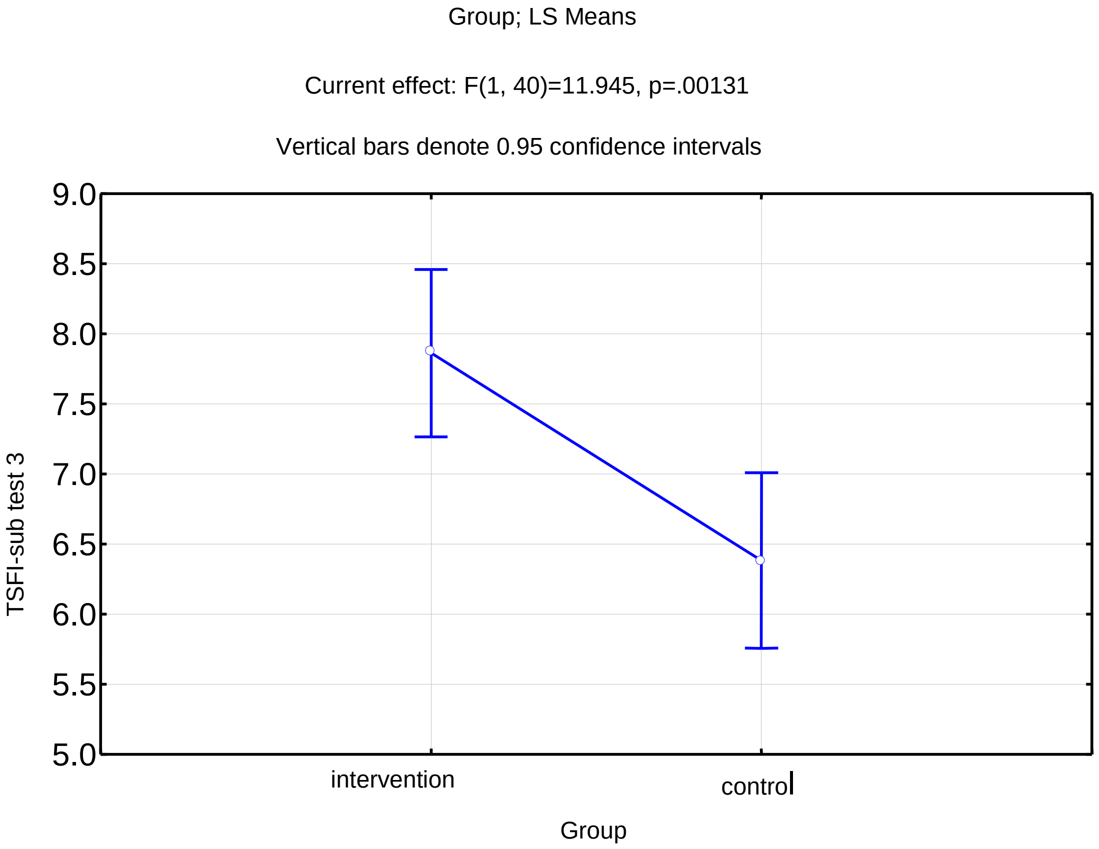

Figure 5.8 Results of the group effect of the TSFI sub-test 3

This score is an indication that the intervention group could integrate combined visual-tactile experiences better than the control group over the follow-up time period between six and 18 months. The explanation for this could be that the infants in the control group displayed a lower tolerance level for tactile input than those in the intervention group, as was discussed in section 5.1.1.2. Another reason, however, could be the control of visual input that was incorporated in the SDCP, where the light in the room had been reduced in order to protect the infants' visual system from unnecessary over-stimulation. The controlled visual stimuli could have had an organising effect on the development of the visual system of the infants in the intervention group and therefore have contributed towards better integration with other systems. This correlates the findings of the studies by Gottfried and Gaiter (1985) and Stanley and Craven (2004) that an inappropriate pattern of visual stimulation could produce long-term alterations in neuro-sensory functions.

5.1.3.3 The visual tactile integration of the study sample over time (time effect)

The outcome of visual tactile integration of the study sample did not display any significant differences over the time periods six, 12 and 18 (p=0.23) months, six to 12 (p=0.09) months and 12 to 18 (p=0.29) months (see Figure 5.9).

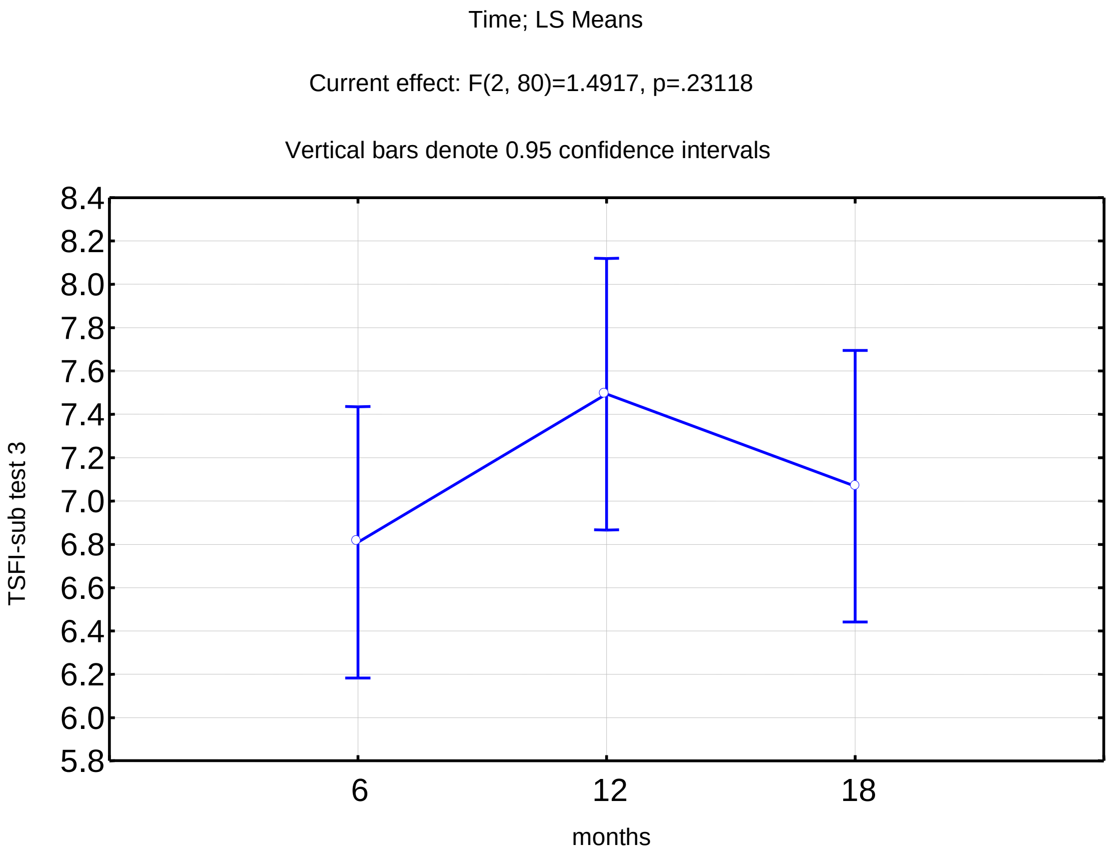

Figure 5.9 Results of the time effect of the TSFI sub-test 3

However, there is a tendency towards better integration during the time period six to12 months than 12 to 18 months. This tendency is confirmed by Eliot (1999) when she noted that eye movement and visual attention shift from largely sub-cortical to dominantly cortical in the first year of life. Gardner and Goldson (2002) also found that visual investigation of the environment is the primary source of learning in the first 12 months of an infant’s life. Parham and Mailloux (2005) highlighted that visual tactile integration takes place during the first six to 12 months after birth.

5.1.4 Results of sub-test 4: Ocular-motor control

5.1.4.1 The progress of ocular-motor control of groups over time (time-group interaction)

The two groups did not display any significant differences in their progress of ocular-motor control between six and 18 months (p=0.12) (see Figure 5.10).

A trend towards faster progress of the control group between 12 and 18 months was observed. The trend correlates with the slower progress of the control group on adaptive motor function (see section 5.1.2.2) which includes eye movements in the first 12 months. As the motor function improves, the eye movements also improve, as was the case in the control group after 12 months. This phenomenon may be attributed to general age maturation of the infants, normally associated with better motor control, including the eye muscles. Better eye muscle control results in better eye tracking, which in turn increases the range of eye-movement and also peripheral vision (Eliot, 1999; Broody, 1987). The sub-test assesses both these aspects.

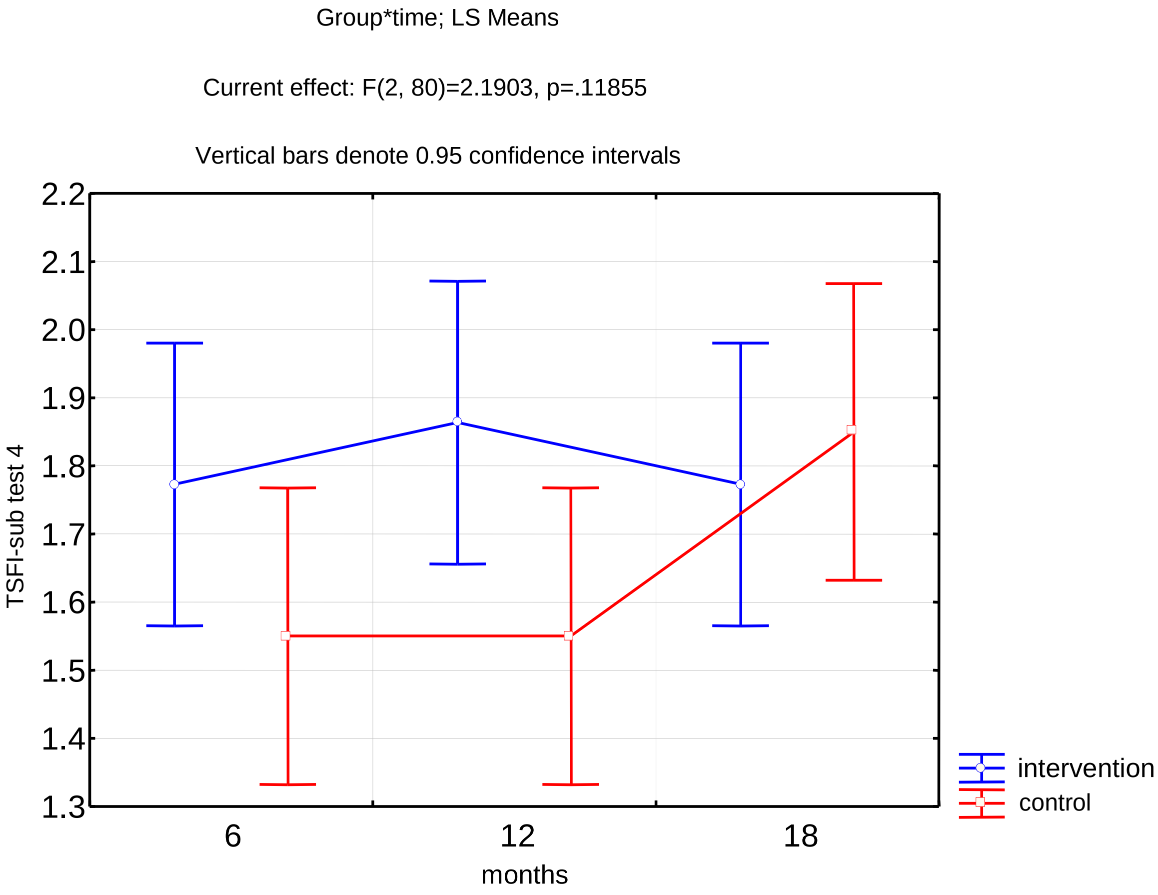

Figure 5.10 Results of the time-group interaction of TSFI sub-test 4

5.1.4.2 Ocular-motor control of both groups relative to one another (group effect)

The two groups were compared in terms of ocularmotor control over the 18 month follow-up period. No significant difference was found between the groups (p=0.14) (see Figure 5.11). This score is the only group effect score in the TSFI that did not show any significant differences between the two groups. The progress which the control group made in the time period from 12 to 18 months was rapid and possibly due to normal maturation of muscle control as already indicated in section 5.1.4.1.

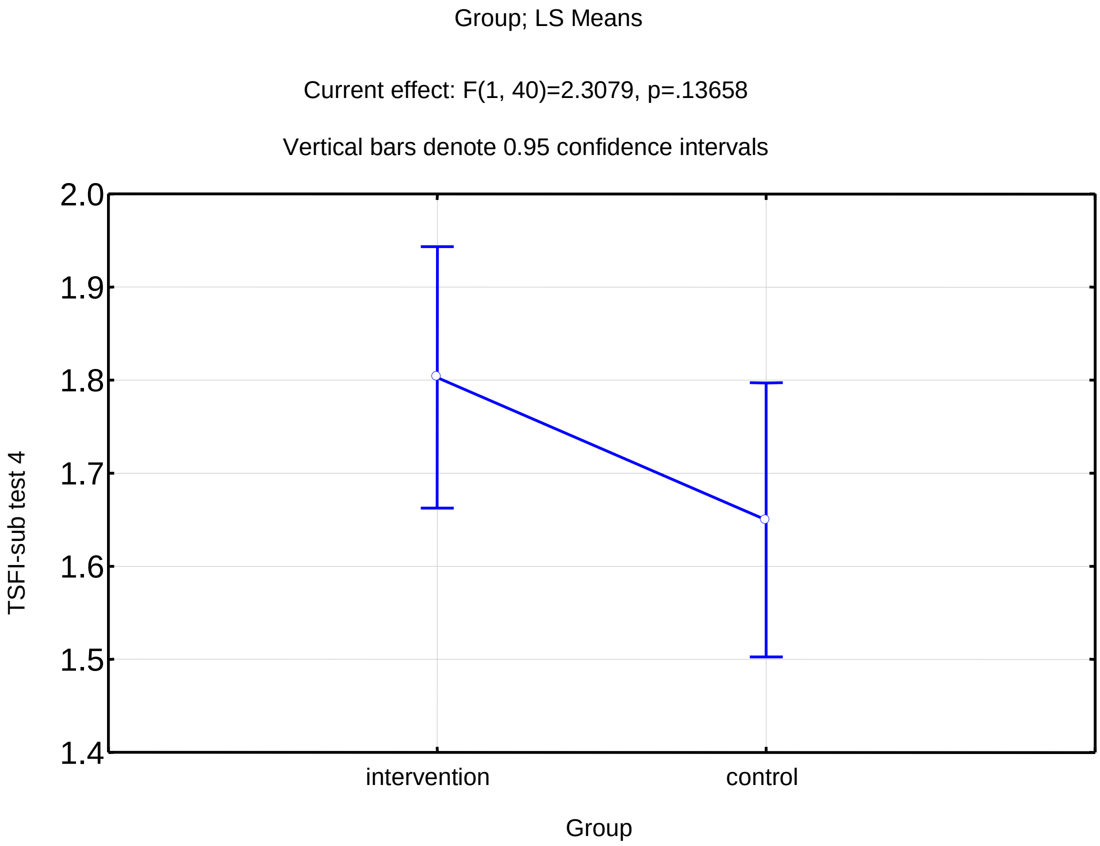

Figure 5.11 Results of the group effect of the TSFI sub-test 4

5.1.4.3 The development of ocular-motor control of the study sample over time (time effect)

The outcome of the development of ocular-motor control of the study population over the time six, 12 and 18 (p=0.30) months, six to 12 (p=0.64) months and 12 to 18 (p=0.28) months did not display any significant difference (Figure 5.12). A relatively even progress pattern was observed between six and 18 months.

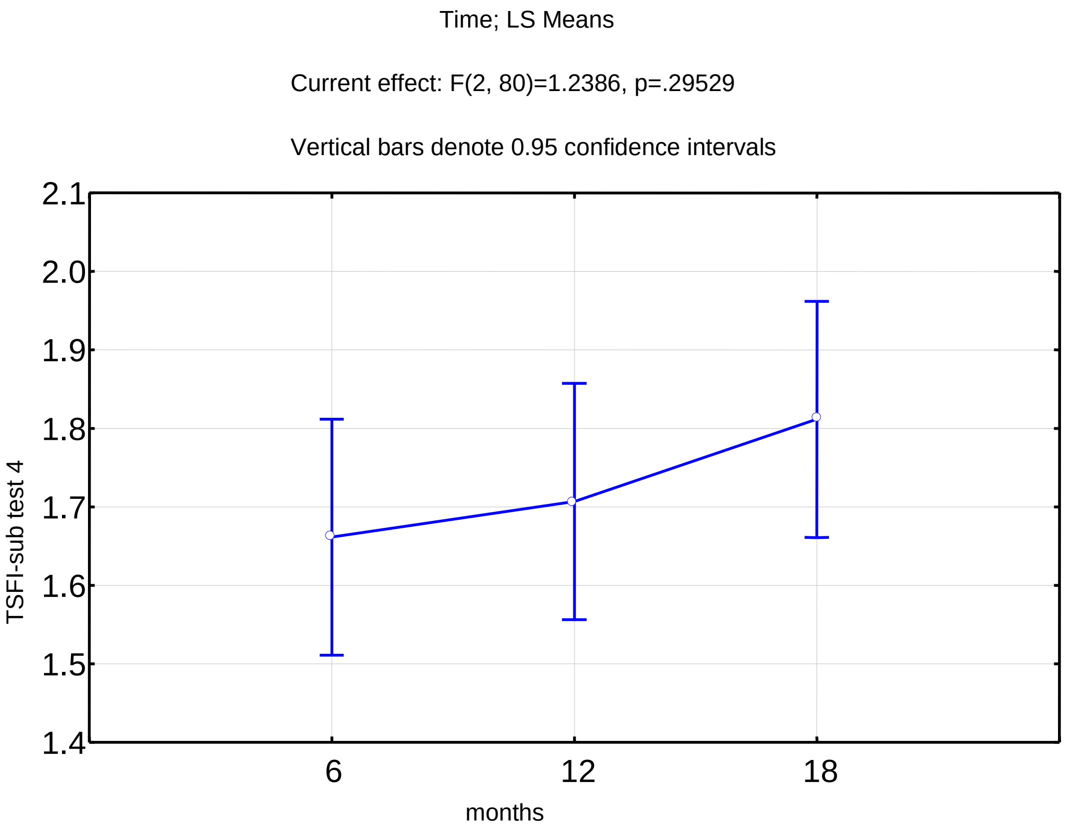

Figure 5.12 Results of the time effect of the TSFI sub-test 4

5.1.5 Results of sub-test 5: Reactivity to vestibular stimulation

5.1.5.1 Vestibular progress of groups over time (time-group interaction)

Although the control group constantly progressed at a lower level than the intervention group, the two groups did not display any significant differences in their pattern of progress between six and 18 months (p=0.41) (see Figure 5.13).

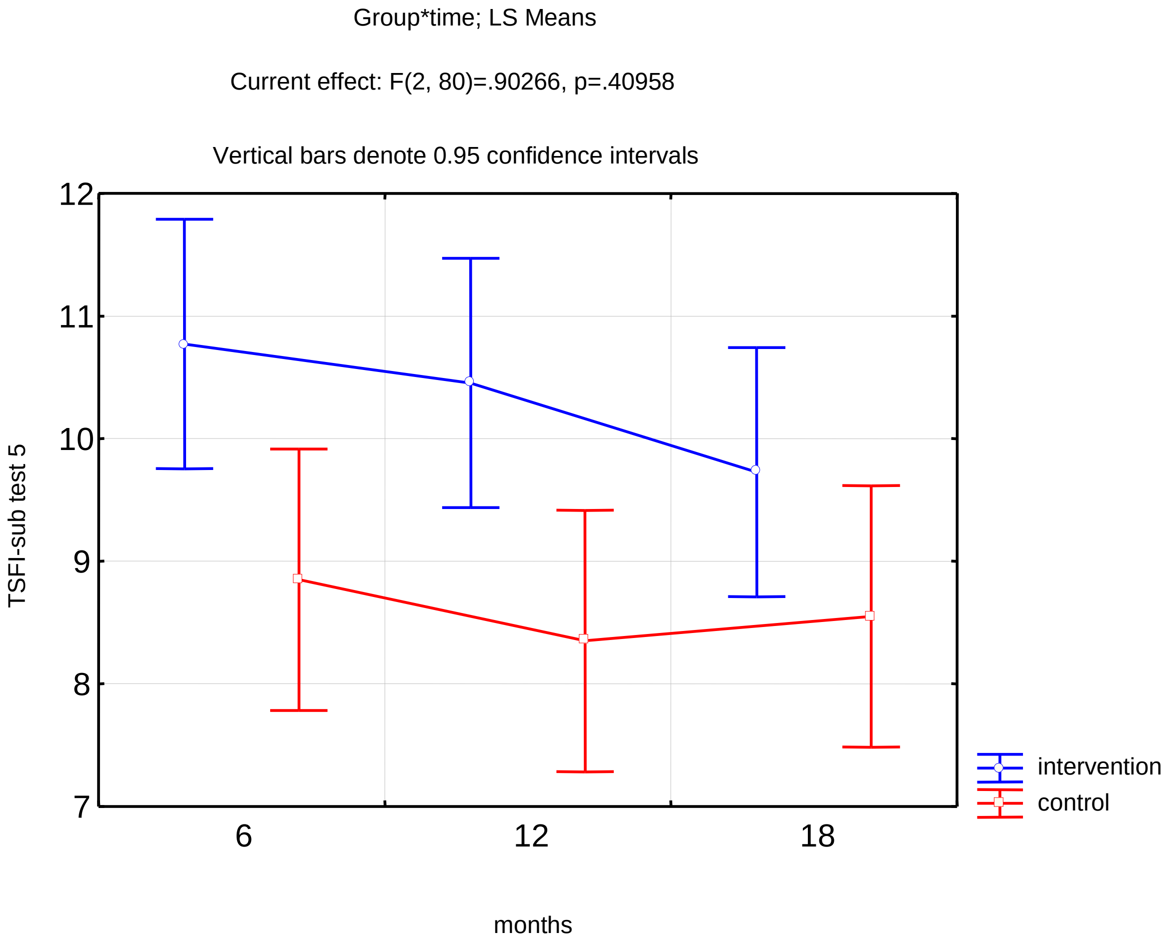

Figure 5.13 Results of the time-group interaction of TSFI sub-test 5

There was a trend towards better vestibular progress in the control group from 12 to 18 months, which correlates with the ocular-motor control progress over the same period as has described in section 5.1.4.1. The fact that vestibular sensory information is processed in close association with somato-sensory and visual sensory input (Eliot, 1999; Hain and Helminski, 2007) could be the reason why the same trend was observed in both sub-tests between 12 and 18 months.

5.1.5.2 Vestibular performance of both groups relative to one another (group effect)

The two groups were compared in terms of their sensory vestibular performance over the 18-month follow-up period. A significant difference was found between the two groups (p=0.01) (see Figure 5.14).

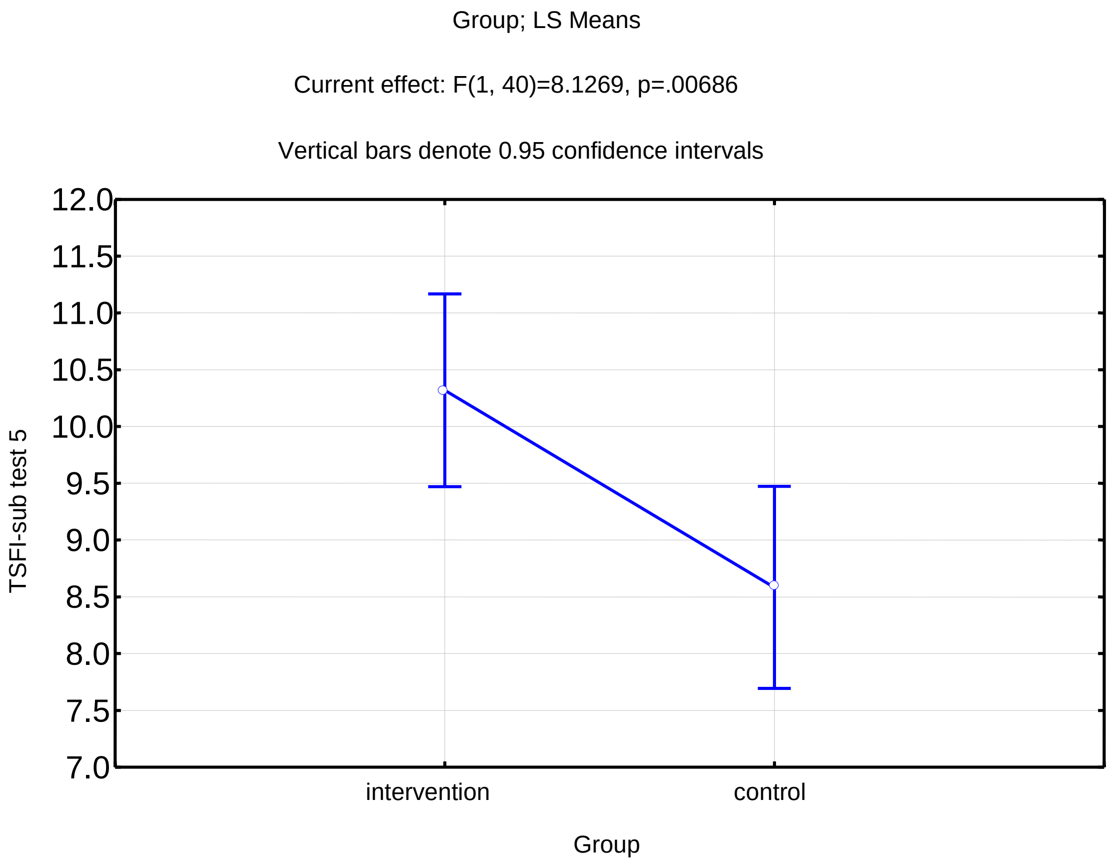

Figure 5.14 Results of the group effect of the TSFI sub-test 5

This score is an indication that the intervention group could tolerate vestibular stimulation better than the control group over the follow-up intervals of six, 12 and 18 months. The difference in the two groups could be ascribed to the following aspects of the SDCP:

1) Handling techniques such as the slow contained movements used during caregiving practices and transfers (section 3.6.2.2).
2) Structured KMC where the infant was transferred correctly to the KMC top, positioned upright and exposed to movement of the mother (section 3.6.2.3).
3) The daily vestibular programme, which consisted of slow rhythmic movements executed by the mother with the infant in the KMC position (section 3.6.2.5).

These aspects had a longer lasting effect on the vestibular systems of the infants in the intervention group, compared to that of the control group.

5.1.5.3 Development of the vestibular system of the study sample over time (time effect)

The outcome of the development of vestibular function of the study population over the time periods six, 12 and 18 (p=0.19) months, six to 12 (p=0.27) months and 12 to 18 (p=0.47) months did not display any significant difference (see Figure 5.15).

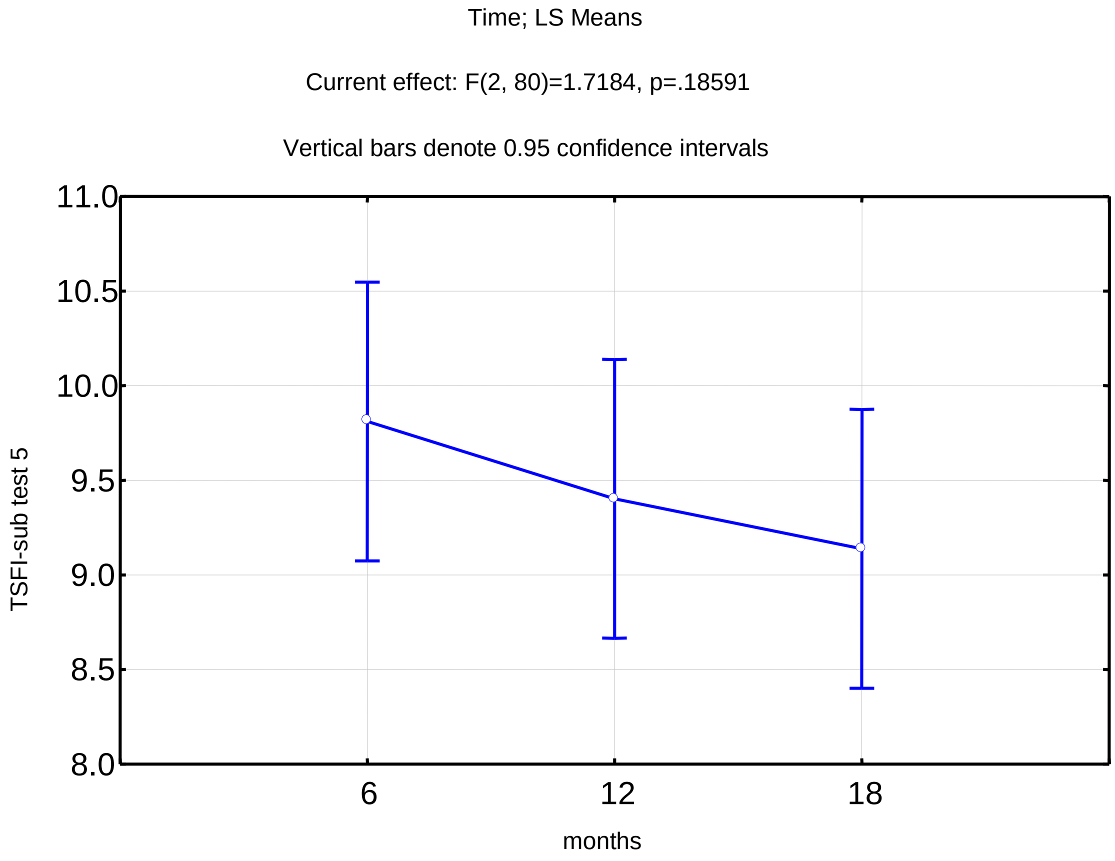

Figure 5.15 Results of the time effect of the TSFI sub-test 5

A tendency towards slower vestibular developmental progress after six months can be observed in Figure 5.15. In accordance with Hain and Helminski (2007), this tendency seems to correlate with the normal sensory development of the vestibular sense, which is the most highly developed sense at birth, but slows down in development six months after birth. The reason for this rapid development early in life is that early onset of vestibular abilities is critical for the proper development of the neurological system (Eliot, 1999).

5.1.6 Results of the total score of the TSFI

5.1.6.1 Total sensory progress of groups over time (time-group interaction)

Although the control group constantly progressed at a lower level than the intervention group, the two groups did not display any significant differences in their pattern of progress between six, 12 and 18 months (p=0.91) (see Figure 5.16).

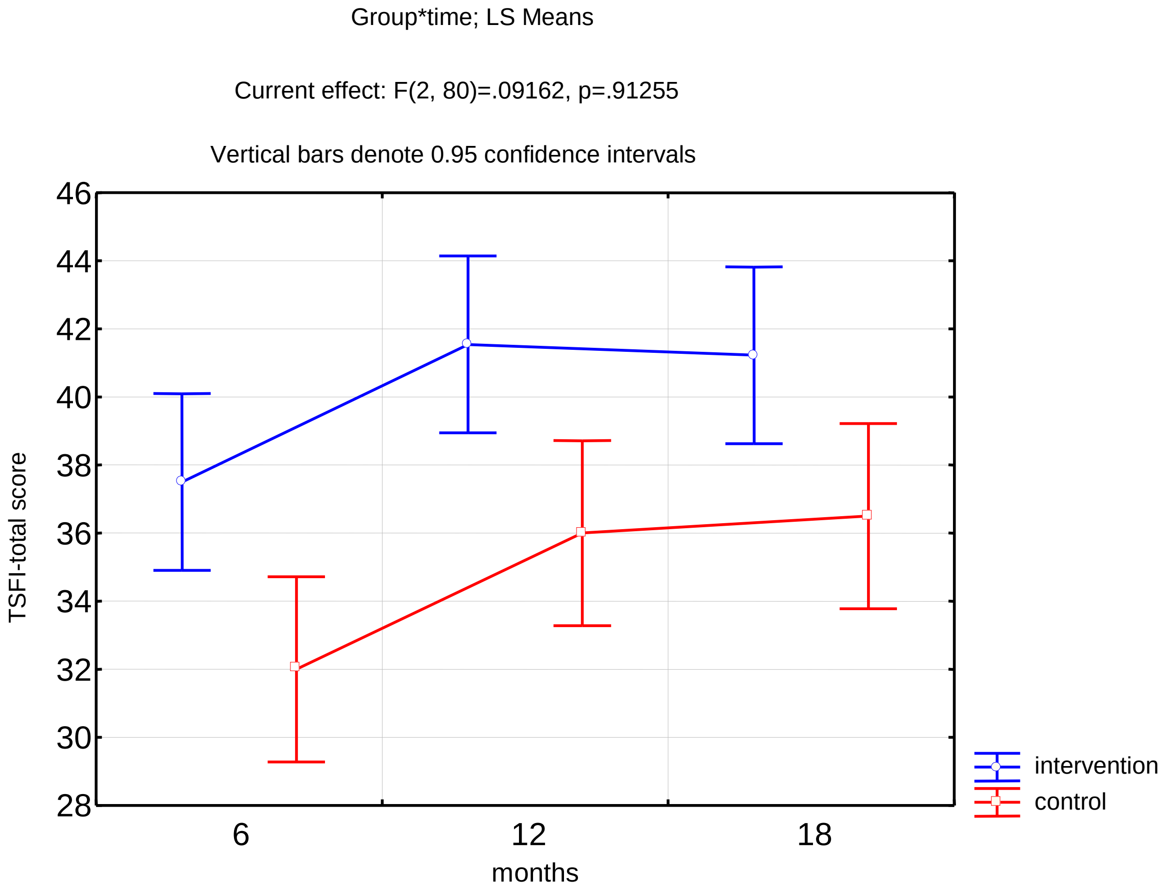

Figure 5.16 Results of the time-group interaction of the TSFI total score

In both groups it seems as if the progress was faster during the first period of six to 12 months than in the second period from 12 to 18 months. This pattern follows the normal sequence of sensory development, as highlighted by Parham and Mailloux (2005), where the infant’s sensory awareness excels in the first 12 months after birth and is characterised by a slower refinement of these sensory connections during the next 12 months.

5.1.6.2 Total sensory performance of both groups relative to one another (group effect)

The two groups were compared in terms of their total sensory performance over the 18 month follow-up period. A significant difference was found between the two groups (p=0.00) (see Figure 5.17).

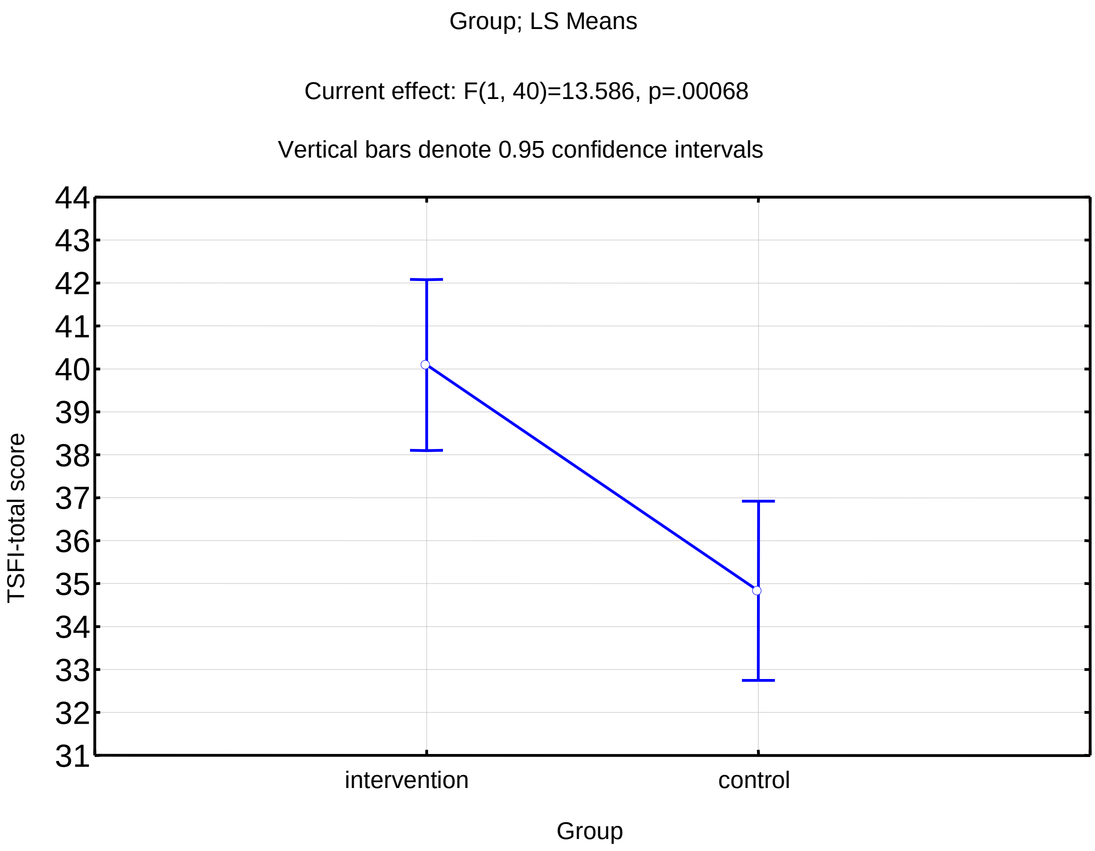

Figure 5.17 Results of the group effect of the TSFI total score

This score is an indication that the intervention group's sensory functions were more advanced than that of the control group's as measured at six, 12 and 18 month intervals. Therefore, it could be perceived that the different sensory experiences included in the SDCP as discussed had a positive effect on the sensory development of the intervention group compared to that of the control group as described in 5.1.6.1.

5.1.6.3 The development of sensory functions of the study sample over time (time effect)

The outcome of the development of sensory functions of the study sample over the time periods six, 12 and 18 (p=0.00) months and six to 12 (p=0.00) months displayed the same significant difference (p=0.00), while the period between 12 and 18 months did not display any significant differences (p=1.00). A rapid sensory developmental progress from six to 12 months, with a much slower progress from 12 to 18 months can be observed in Figure 5.18. This pattern of progress correlates with the normal pace of sensory-motor development (Eliot, 1999; Parham and Mailloux, 2005).

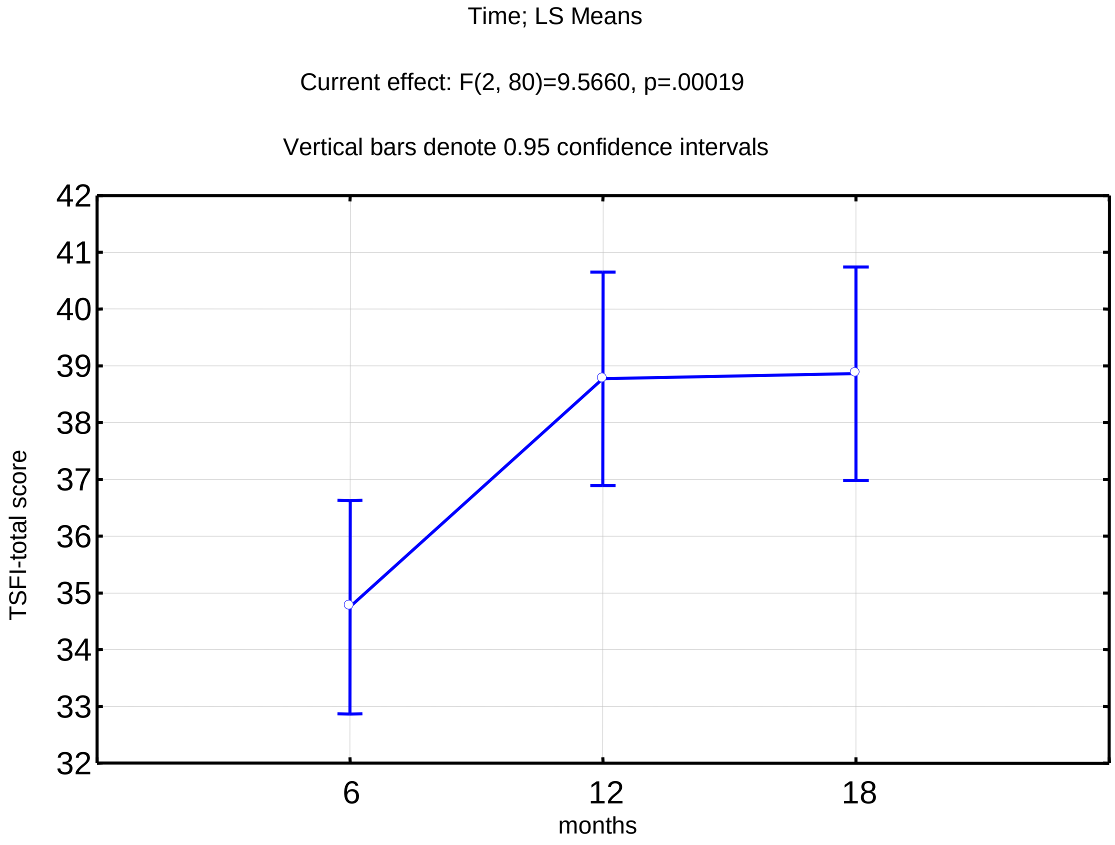

Figure 5.18 Results of the time effect of the TSFI total score

5.1.7 The relevance of the results of the TSFI for the outcome of the study

5.1.7.1 Time-group interaction

In the current study it was found that there was no significant difference between the progress of the two groups over the 18 month follow-up period (sub-tests 1 to 5 and total score).

Although the two groups made similar progress over the period from six to 18 months, the intervention group consistently measured higher on the sensory functional scale than the control group as reflected in Figures 5.1, 5.4, 5.7, 5.10, 5.13 and 5.16. It is feasible to deduce from this that the SDCP had a positive impact on the sensory development of the subjects of the intervention group during the first six months after birth, which is a peak time for sensory development to take place (Eliot, 1999; Parham and Mailloux, 2005). This finding is supported by the literature where the importance of a sensory-friendly environment for the preterm infant in the NICU is promoted (McCormick, 1997; White-Traut, Nelson and Burns, 1994). Hann (1998) found that the early information received by an infant from its environment through the sensory systems is an important contribution to the information of the final circuitry of the brain, which shapes the infant’s brain development in critical ways.

Another observation was that the progress in both groups seemed to be faster during the first period of six to 12 months than in the second period from 12 to 18 months. In the first year of life the infants become more mobile and start exploring the environment that generates sensory-rich opportunities, particularly to develop body scheme and spatial perception (Parham and Mailloux, 2005). With the foundation laid in the first year, the second year of life entails a slower process of refinement of the sensory-motor connections (Eliot, 1999). This pattern of faster sensory-motor progress in the first year of life seems to be a general phenomenon in the development of the infant, as it was also observed in the current study.

5.1.7.2 Group effect

Regarding the performance of both groups, the intervention group scored significantly higher than the control group on all the sub-tests and on the total score. Although there were no statistically significant ocular-motor control (sub-test 4) differences, there was a tendency towards a higher score for the intervention group.

Since the intervention group performed so much better on the group effect scores than the control group, it is evident that the SDCP was successful in promoting the sensory development of the pre-term infant at least up to the age of 18 months. This is supported by Eliot's assertion (1999) that each infant's unique environmental stimulation reshapes, refines and links together the fibres of the nerve axons and dendrites in order to function in concert.

5.1.7.3 Time effect

The sensory development (total score) of the study population over time for the duration of the study demonstrated a remarkable incline in the first period from six to 12 months (p=0.00) compared with the period between 12 and 18 months (p=1.00). The only other sub-test that also demonstrated the same incline for the 6 to 12 month period (p=0.00) with slower progress in development from 12 to 18 months (p=0.22) was the adaptive motor function. This correlates with the developmental stages of motor development (Monterosso et al, 2003; Nichols, 2005). As seen in the literature, the sensory-motor development of the infant progresses faster during the first twelve months of life than during any other period of its life. The reason given for this phenomenon is that the infant needs this basic development to enable it to experiment, develop and learn by knowing and using its own body (Wiener, Long, DeGangi and Battaile, 1996; DeGangi, 2000; Eliot, 1999; Parham and Mailloux, 2005).

5.2 RESULTS OF THE GRIFFITHS MENTAL DEVELOPMENTAL SCALES

The Griffiths Mental Developmental Scales were performed on the infants with their last follow-up visit at 18 months. The Griffiths Mental Developmental Scales were included in the study in order to determine the mental development of the infants, since the TSFI did not assess mental development. These scales were also discussed in more detail in Chapter 2, section 2.10. The scales consisted of five sub-scales and a total score of which the results are summarised in Table 5.2.

The mean value for the sub-scales and the total score is 100 (mean=100) with a standard deviation of 16 (SD=16) for the sub-scales and 12 (SD=12) for the total score. The scores of the study population fall within this mean (see Table 5.2). These results give additional information regarding the equivalence of the two groups in developmental areas other than sensory development. Sensory function is not tested by mentioned developmental scales.

Table 5.2 Griffiths Mental Developmental Scales score results

Sub-Scales	Mean	Standard deviation	Factor analysis (F)	p value (group effect)
Sub-scale A (Loco-motor)	100.45	12.40	0.03	0.87
Sub-scale B (Personal-Social)	96.29	14.53	1.05	0.31
Sub-scale C (Hearing and language)	96. 19	13.63	0.56	0.46
Sub-scale D (Eye-hand co-ordination)	104.71	11.16	1.17	0.28
Sub-scale E (Performance)	92.90	12.85	1.14	0.29
Total Score	**97.05**	**10.12**	**0.45**	**0.51**

A one-way-analysis of variance (see Table 5.2) was used to compare the scores of the two groups. No significant differences were observed between the intervention and control groups with regard to the scores of all five sub-scales and the total score. This information is indicative of the equality of the two groups in terms of developmental areas other than sensory development.

The relevance of these results is firstly that the study population performed equally in all the areas tested within the average range allowed in the Griffiths Mental Developmental Scales. This means that the study sample was representative of a normal average population. Secondly, the groups did not expose any significant differences, which confirm the equal distribution of the two groups.

5.3 RESULTS OF THE WEIGHT, LENGTH AND HEAD CIRCUMFERENCE AT THE AGE OF 18 MONTHS

The weight, length and head circumference of the infants were measured at the end of the study (18 months corrected age) by the same principal medical officer who performed the Griffiths Mental Developmental Scales. When the two groups were compared with one another, no significant differences in values could be found, as can be seen in the summarised results of Table 5.3.

Table 5.3 Weight, length and head circumference score results

Variable	Mean	Standard deviation	Factor analysis (F)	P value (group effect)
Weight	9.95	1.3	1.48	0.23
Length	77.83	4.17	0.64	0.43
Head circumference	46.79	1.75	2.09	0.16

This outcome again means that the two groups were very equally matched.

5.4 SUMMARY

From the statistical analysis of the demographic and anthropometric profile, it can be deduced that the control group had a slight advance to the intervention group. This applies specifically to the average lower birth weight and enrolment weight of the intervention group as demonstrated in Table 4.6. The fact that the intervention group scored better in terms of sensory development despite this general drawback, underscores the success of the SDCP all the more. Their superior sensory development can therefore not be ascribed to any advantage in terms of birth or enrolment weight. To the contrary, they were generally slightly disadvantaged in this respect.

Regardless of the fact that no differences on the Griffiths Mental Developmental Scales were detected between the two groups, the intervention group scored higher on sensory development as tested by the TSFI.

Despite the relatively low number of subjects who completed the study, these results strongly promote the implementation of the SDCP.

CHAPTER SIX

SUMMARY, CONCLUSION AND RECOMMENDATIONS

6.1 SUMMARY OF THE STUDY

This study aimed at confirming empirically that a specific sensory developmental intervention care programme, of which a particular regime of kangaroo mother care formed an integral part, could be implemented in the NICU with beneficial results for the sensory development of very low birth weight preterm infants.

From the literature it became clear that there was a lack of evidence regarding the efficiency of a number of care and development programmes for VLBW preterm infants in the NICU. However, kangaroo mother care and developmental care were singled out as two approaches that hold promise. The Sensory Developmental Care Programme was designed to integrate these two approaches and was subsequently tested. The researcher was acquainted with both these approaches and has seen the positive benefits in her own practice as well. Furthermore, KMC had previously been introduced to the academic hospitals of the Western Cape and this contributed to the feasibility of integrating KMC into the intended SDCP.

A pilot study that extended over more than one year exposed a number of challenges for the execution of the actual research programme. More than one venue proved to be impractical. The study design also had to be altered due to too many variables coming into play. Hence, a simple randomised controlled study at a single hospital was preferred to a prospective comparative study. Subsequently the variables were restricted to a manageable degree.

Considering the anthropometric results, which indicated a significant difference in birth weight, between the control group and the intervention group, one could in retrospect argue that a stratified randomised control study with its pairing of subjects would have resulted in more comparable groups. In practice, however, this was not possible due to too many variables that marked the process of setting up the groups.

The Test of Sensory Functions in Infants was used to ascertain the infant’s sensory development while the Griffiths Mental Developmental Scales were employed to measure the infants’ mental development in this trial. The development of mental abilities for both groups on the Griffiths Mental Developmental Scales showed no difference between the two groups at 18 months of age. However, the results of the TSFI demonstrated a marked difference between the two groups' levels of sensory development on four of the five sub-tests.

6.2 CONCLUSION

The findings of this study pointed towards the acceptance of the *alternative hypothesis HA*, namely: The sensory function of VLBW preterm infants were significantly improved by the implementation of the Sensory Developmental Care Programme. This benefit lasted up to at least 18 months (corrected age).

The SDCP also met important requirements set by White-Traut et al (1994) for successful intervention for the preterm infant, namely, that it supported the transition from intra uterine to extra uterine life and at the same time maintained an optimal continuation of development. Another requirement is that the care of the infant in the SCDP included modulation of the stressful environment of the NICU, together with developmentally appropriate intervention methods.

6.3 EVALUATION OF THE STUDY

The SCDP was not only a complex intervention in terms of modulating the NICU environment, but the longitudinal nature of the study posed additional challenges. A time span covering four years to gather the necessary data bears witness to that. For instance, the chosen hospital changed its NICU regime mid-way during the research programme. Follow-up visits were not properly attended by some study participants. Other participants dropped out completely for various reasons, which necessitated the recruitment of new participants. Furthermore, a rise in the HIV status of prospective participants diminished the pool from which to recruit. Despite these difficulties, the study was successfully completed and yielded conclusive results.

The following were further limitations of the study:

- The original sample could not be recruited and resulted in a smaller sample group for the study.
- Infants were only followed up for 18 months.

- The population group from which the study sample was recruited mainly resorted in the lower socio-economic category.
- The study was limited to the Western Cape only.
- Only one hospital, namely, a tertiary academic hospital, was used to conduct the study.
- No funding was available for the research.
- There was a limitation of collaborators to continue with the intervention due to lack of funding.

In the course of the study other areas needing more research were identified. These include:

- Repeating the study on HIV-exposed preterm infants.
- A comparison of the development of motor patterns of an infant exposed to the SDCP to an infant receiving the basic standard NICU care.
- The best positioning of the infant in the KMC position to ensure the optimal motor developmental patterns.
- A programme to promote cluster care in the NICU.
- A training programme on handling techniques for all health care workers, including the doctors.
- Follow-up sensory-motor stimulation programme after discharge when the parents bring the infants for their three-month follow-up visits to the clinic or hospital.

6.4 RECOMMENDATIONS FOR PRACTICE

In the light of positive outcomes of the study, it is recommended that the tested Sensory Developmental Care Programme be considered for implementation in hospitals with a NICU without a developmental care programme and that hospitals with a developmental care programme review their current practices in the light of the interventions included in the SDCP. There are however certain prerequisites for the implementation of the SDCP in any hospital:

1) The availability of the mother to be the main caregiver of her infant for at least ten days or longer in the NICU.

2) The mother has to care for the infant using the KMC method for at least four hours per day, using a special cotton lycra top to give the infant the appropriate proprioceptive feedback when it moves.

3) The mother has to be prepared to participate in the recommended vestibular stimulation programme on a daily basis.

4) The nursing staff, as well as the mother, have to be taught the correct methods of handling for optimal sensory developmental care, by an occupational therapist trained in the SDCP.

5) The environment of the NICU has to meet the standards regarding lighting and sound.

6) The infant must be positioned in the nesting cushion to ensure correct positioning, containment and tactile stimulation when not in the KMC position.

The following modifications to the programme are recommended:

1) A behavioural observation of infants should be done before the programme commences, involving a team consisting of occupational therapist(s), mother(s) and other health caregivers and professionals (for example, nurses, doctors, physiotherapists). Such an observation would look at the infant’s sleep-wake cycles, stress cues, motor movement patterns, apnoea incidences and medical status. The assessment would indicate to health caregivers when and for how long to implement KMC and when and in which positions to do the routine observations and care practices such as nappy changing, feeding and bathing.

2) Including a physiotherapist in the SDCP to give input on the positioning of the infant during the programme.

3) Including a speech therapist would give guidelines on non-nutritive sucking and feeding to enrich the SDCP.

4) Six-monthly follow-up visits by the occupational therapist to monitor the infant's sensory-motor development (as tested on the TSFI) and to give the mother further support and guidance until the infant reaches 18 months (corrected age).

It is recommended that the provincial departments of health services consider implementing a standardised programme such as the SDCP in all NICUs under their jurisdiction across the country. Apart from taking care of the abovementioned pre-requisites for implementing the programme, hospitals would also have to make provision for the following resources: the specified KMC top and nesting cushion for each mother (preferably to become their property after discharge); and an occupational therapist who could spend at least five mornings a week in the NICU to help implement the programme by training mothers and other caregivers regarding handling procedures and to do the follow-up assessments and home programmes. Such occupational therapists should receive training with respect to the programme.

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APPENDIX A

DOCUMENT OF CONSENT FOR PARENTS TAKING PART IN THE SENSORY DEVELOPMENTAL CARE RESEARCH PROGRAMME

Babies that are born too early may develop slower than other babies with respect to the use of their various senses of sight, touch, hearing, movement, smell and taste. The occupational therapy department of Tygerberg Hospital is studying the effects of a programme to improve the development of these senses.

There are two groups involved in this research: One group will participate in the above-mentioned programme and the other will not, but rather follow the normal procedures of the hospital. Babies in both groups will come to the high risk clinic for three six-monthly follow-up assessments as will be arranged by the clinic.

We wish to include your baby in the study. The final results of the study will be available by the end of 2006 on request. Neither you nor your baby will be identified in the study. Please sign the contract below to give your consent to partake in the study. Thank you for your cooperation.

OCCUPATIONAL THERAPY DEPARTMENT, TYGERBERG HOSPITAL

CONTRACT

I, ……………………………………….. hereby declare my willingness to participate in the above mentioned research study for the next two years with my baby ……………………………….………I further undertake to notify the occupational therapist immediately if I have to discontinue my participation in the said study.

Signed at Tygerberg Hospital

……………………………………..	…………………………………..
Signature of mother	Date
……………………………………..	…………………………………..
Signature of witness	Date

APPENDIX B

DAILY CHECK LIST

Date: ……………………………….

	Monday						Tuesday						Wednesday						Thursday						Friday					
	9h00		12h00		15h00		9h00		12h00		15h00		9h00		12h00		15h00		9h00		12h00		15h00		9h00		12h00		15h00	
	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N
1. Is the nesting cushion in the incubator?																														
2. Is the radio switched off?																														
3. Are the blinds closed?																														
4. Are the incubators covered with receiving blankets?																														
5. Are rocking chairs in rooms?																														
6. Are plastic bins in rooms?																														
7. Check incubator temperature																														
8. Are lights switched off?																														
9. Infants only dressed in diapers																														

Y = Yes
N = No

APPENDIX C

QUESTIONNAIRE TO BE COMPLETED BY THE OCCUPATIONAL THERAPIST

A. INFORMATION OF BABY

Name	Hospital number
Date of birth	Gestational age
Birth weight	Gender

A1. Ventilated YES/NO How long …………………..

A2. Special medication YES/NO Specify ……………………..

A3. Feeding methods used presently CAVAGE / CUP / BREAST

A4. Weight when SDCP was started ……………………………………………….

A5. Gestational age when SDCP was started ……………………………………………….

B. INFORMATION OF MOTHER

Name	Date of birth
Address	
Nearest clinic/Day hospital	

B1. MARRIED/UNMARRIED

B2. Other children in family YES/NO How many …………………

B3. Other pregnancies that were terminated YES/NO How many …………………

B4. Reason for baby being born prematurely YES/NO Reason …………………

B5. Level of highest education ……………………………………………….

B6. EMPLOYED/UNEMPLOYED

B7. Living conditions: OWN HOUSE/SHARE HOUSE WITH OTHER FAMILY/RENT A ROOM

B8. What transport do you use to come to hospital YOUR OWN CAR/BUS/TRAIN/TAXI

B9. Who looks after your family while you are in hospital? ……………………………………..

C. INFORMATION ON MEDICAL STAFF

C1. Doctor in charge ……………………………………………………………………………..

C2. Other team members involved in care ………………………………………………………….

C3. Specific precautions to be taken when handling the baby …………………………………….

C4. Occupational therapist involved ……………………………………………………….....

APPENDIX D

APPENDIX D1

Tygerberg Hospital / Department of Occupational Therapy
Kangaroo Mother Care – Report Records (Intervention Group)

						Exercises					Groups					Infant's reaction 1. Sleep 2. Awake without crying 3. Awake and crying					Mother's participation & caring in group 1. Positive 2. Average 3. Negative					Number of hours in KMC				
Week	Name	Weight	Boob tube	Rocking chair	Nesting cushion	Mon	Tues	Wed	Thurs	Fri	Info 1	Info 2	Video	Activity group	Preparation discharge	Mon	Tues	Wed	Thurs	Fri	Mon	Tues	Wed	Thurs	Fri	Mon	Tues	Wed	Thurs	Fri

APPENDIX D2

Tygerberg Hospital / Department of Occupational Therapy
Kangaroo Mother Care – Report Records (Control Group)

		Number of hours in KMC				
Week	Name	Mon	Tues	Wed	Thurs	Fri