VISUAL PERCEPTION AND MOTOR FUNCTION OF CHILDREN WITH BIRTH-WEIGHTS UNDER 1250grams AND THEIR FULL TERM NORMAL BIRTH WEIGHT PEERS AT FIVE TO SIX YEARS OF AGE.

A Cape Town Study

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DECLARATION

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I am grateful to the parents and children

who participated in this study

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Abstract

This study aimed to assess and compare the visual perceptual, visual motor integration and motor abilities of infants weighing less than 1250 grams at birth and a matched group of normal full birth weight controls at the age of five to six years. The group of infants with birth weights below 1250 grams were born during the period July 1988 to June 1989 at Groote Schuur Hospital (GSH), Cape Town or in midwife obstetric units in the Peninsula Maternal and Neonatal Service (PMNS) and referred to the neonatal intensive care unit at GSH. The very low birth weight (VLBW) infants were assessed at 1 and 2 years of age in 1989 & 1990. The present study was part of a broader study that included the examination of developmental outcome of these infants, using the Griffith's Mental Development Scale (Griffith's). The study recognised the complex interaction of biological and environmental factors and their influence on development and attempted to describe the confounds that may have influenced outcomes.

The VLBW children were shorter in stature than their full birth weight counterparts. They were also significantly lighter and had smaller head circumferences. Psychometric evaluation with the Griffith's showed the VLBW children to fall predominantly in the normal range, though their performances were significantly inferior to that of the full term children. The greatest differences between the groups were in scores for the subscales performance and practical reasoning of the Griffith's.

Visual perception, visual motor integration, fine motor skill and gross motor function were all significantly poorer in the VLBW children.

There was no correlation within the VLBW group between the test results and birth weight, gestational age, growth status, neonatal hospital stay or social status.

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DEFINITION AND DESCRIPTION OF TERMS:

Unless stated otherwise the descriptions have been taken from The Perinatal Education Programme (PEP), University of Cape Town (1993).

Attention Deficit Hyperactivity Disorder (ADHD):
The essential feature of ADHD is a persistent pattern of inattention and/or hyperactivity impulsivity that is more frequent and severe than is typically observed in individuals at a comparable level of development (DSM-IV-R 1994)

Appropriate for gestational age (AGA):
Infants with normal birth weight for their gestational age fall between the 10th and 90th centiles on the weight for gestational age chart.

Extremely low birth weight (ELBW):
Newborn infant weighing less than 1000 gram. Infants weighing less than 750 grams are sometimes referred to as micronates or fetal infants.(Hack & Fanaroff 1988)

Full birth weight (FBW)
Newborn infant weighing more than 2500g

Gestational age (GA):
Gestational age is measured in weeks and can be determined in-utero through a good obstetric history, by date of last menstrual period, uterine size, time of quickening, first auscultated heart sounds, and ultrasonography early in the second trimester.
Postnatal gestational age is assessed through physical and neurologic criteria, based on criteria developed by Dubowitz(1970), (which is said to be unreliable at less than 33 weeks gestation, tending to overestimate GA), and Ballard

(1979), (whose physical criteria are said to provide more accurate assessments and are less likely to overestimate GA than neurologic measures)

Intrauterine growth retardation (IUGR):

Growth retardation refers to a *delay in the progression of normal growth* of the fetus, affecting size at birth.

Symmetric or proportional IUGR (type 1) refers to a *growth pattern* in which the growth of both the fetal abdomen and head are decreased proportionately *and is ascribed to an insult early in pregnancy.* It is consequently characterised by long periods of subnormal growth with poor developmental outcome.

Asymmetric or disproportional IUGR (type 2) refers to the growth retarded fetus in whom a disproportionate decrease in the size of the fetal abdomen with respect to the head is seen. This is also called "head sparing" and is ascribed to a later insult. The long term prognosis of type 2 IUGR is good. (Pollack & Divon 1992)

Learning Disabilities (LD):

Refers to a heterogeneous group of disorders manifested in significant difficulties in the acquisition and use of listening, speaking, reading, writing, reasoning or mathematical abilities. These disorders are intrinsic to the individual and are presumed to be due to a central nervous system dysfunction. Although learning disability may occur concomitantly with other disabling conditions (for example sensory impairment, mental retardation, social and emotional disturbance) or environmental influences, it is not the direct result of those conditions or influences. (Hammill 1990)

Low birth weight (LBW):

Newborn infant weighing 2500 grams and less_and may or may not be born preterm.

Motor skill (MS):

Motor skill refers to the acquisition of movement abilities that are learnt and not necessarily innate. These fundamental skills are characteristic of the development of the child from 3 to 7 years of age and include the locomotor patterns of running, jumping, galloping and skipping and the ball handling skills of throwing, striking, kicking and bouncing (Williams 1983).

Preterm:

Infants that are born before 37 weeks are called preterm infants and are at an increased risk of problems in the newborn period.

Small for gestational age (SGA):

Infants that are small in measurement *and* in weight for gestational age using crown heel length, ponderal index and growth data are SGA. Some SGA infants are genetically small and not IUGR.

Underweight for gestational age (UGA):

Birth *weight* equal to or less than the 10th centile expected for gestational age. (Lubchenco 1966)

Very low birth weight (VLBW):

Newborn infant weighing 1500 grams and less and may or may not be preterm.

Visual motor integration (VMI):

Visual motor integration is a composite of behaviours requiring visual perception and motor coordination (Beery 1982). It is often referred to as fine eye-hand coordination.

Visual perception (VP):

Visual perception is an intermediate step in information processing between vision and cognition, involving interpreting and organising the physical elements of a visual stimulus (Hammill 1993).

CHAPTER ONE

1.0 Introduction:

1.1 The infant weighing below 1250 grams

Introduction and problem statement:

There is a belief that well infants born pre-term, without intrauterine insult or neurological signs, appear to "catch up" without intervention and at school age are indistinguishable from their peers (Lukeman 1993, Allen 1993, Drillien 1980). With improved medical practice and technology, there has been an increase in the survival of very preterm infants as well as infants born later in term, but of very low birth weight. These survivors need long term follow up, as studies worldwide have shown a higher incidence of handicap and neurological sequelae (Hadders Algra 1988, Marlow *et al* 1989 , Teplin *et al*,1991, Veen *et al* 1991) Studies from Sweden have shown the prevalence of cerebral palsy in preterms to have increased during recent years, in the presence of the concurrent drop in perinatal mortality (Hagberg 1989).

The burgeoning literature on the outcome of the low birth weight (LBW) infant has implicated a wide spectrum of neurodevelopmental, intellectual, academic and behavioural sequelae. Aylward *et al* (1989) and Escobar *et al* (1991) in methodological reviews and meta-analyses of studies of these infants found that methodological and conceptual differences across studies contributed to inconsistencies in findings, complicating the ability to draw accurate comparisons and make generalisations regarding long term outcomes from these studies.

Those very low birth weight (VLBW) and extremely low birth weight (ELBW) infants that do not have an overt handicap and are regarded as "normal" require follow up as they may have more subtle problems, developmental delay or have difficulties with learning that may not be evident in early infancy or toddlerhood. (Ornstein 1991, Aylward *et al*)

A number of recent studies of school aged VLBW & ELBW survivors showed a higher incidence of general developmental slowness, specific cognitive deficits, as well as specific learning difficulties, hyperactivity and attentional deficits, resulting in grade repetition and increased utilisation of educational resources when compared with reference groups. (Saigal *et al* 1991,1992; Ornstein 1991 Victorian Infant Collaborative Study Group 1991, Mc Cormick 1992; Hack 1992; Smedler 1992; Hille 1994). In contrast, a number of investigators in earlier studies suggested that the great majority of infants of VLBW were indistinguishable from fullterm infants by 4 years of age on intellectual and neurodevelopmental measures. (Drillien *et al* 1980, Eilers *et al* 1980, Stewart *et al* 1981.) However, many earlier studies used traditional psychometric scales of infant competence, such as the Bayley Scales (1969). Performance on these scales proved to have little relation to later cognition (Mc Call 1979; Kopp & McCall, 1982; Rose *et al* 1991), and this may explain why children were put into "sound" categories too early. This confirms the need to know whether the assessments done at one and two years satisfactorily predict outcomes later in childhood, in order to improve surveillance and management of vulnerable infants (Roth 1994). Early assessments may be misleading, as correction for prematurity may also incorrectly place children in a healthy group (Siegel 1983; Miller *et al* 1984). Kitchen, reporting on findings from the Victorian Infant Collaborative Study Group (1991), confirmed that comprehensive assessments at 5 years correlated better with 8 year scholastic outcomes than the assessments at 2 years, which tended to underestimate milder disabilities.

Another factor, complicating analysis of outcome findings, is the erroneous tendency to view low birth weight groups in a homogeneous fashion. Touwen (cited in Aylward 1989) suggested three subgroups for VLBW babies: (1) extremely premature infants (gestational age) with AGA birth weights, (2) less premature infants with SGA (UGA) birth weights and (3) older preterm and term infants with extreme SGA birth weights. This classification scheme is important, as the ultimate outcome of babies in these groups can vary markedly.

In addition a number of earlier studies that included comparisons against more subjective observations such as neurodevelopmental sequelae neglected to make comparisons against control groups (Aylward 1989).

The child's visual perceptual function, visual motor integration and gross and fine motor abilities, in pre-school and upon school entry are indicators of non verbal and performance adequacy that are of primary importance in successful scholastic achievement and ability to achieve activities of independent living at age appropriate stages. (Larsen 1975, Newcomer 1973, Williams 1983, Hammill 1990 Myers 1990, Cornelissen *et al* 1994). Although there have been recent studies investigating language function (Le Normand 1995), visual perception & visual motor integration (Saigal 1991, Teplin 1991, Smedler 1992), gross and fine motor function (Marlow *et al* 1989, Deplane 1991), the literature predominantly explores *general* cognitive abilities in ELBW & VLBW infants in the preschool years. This study aimed to determine if more specific non-verbal components of function were significantly more compromised in preschoolers and school entrants of VLBW and if notable differences were observed in sub groups. This is important for early identification of specific dysfunction and for future planning and provision of curative and rehabilitative measures and specialised curricular planning (NEPPI 1993, Green *et al*,1992)

Researchers world wide are acknowledging the importance of considering the complexity of the inter-relationship between biological and environmental factors affecting development (Escalona 1982, Pfeiffer *et al* 1990, Sameroff *et al* 1993) This underscores the importance of both the individual's status and the care giving environment as sources of variance when considering outcomes and predicting future functioning.

1.2 The importance of follow-up of infants with birth weights below 1250 grams in South Africa.

The Western Cape essentially has a dual economy. On the one hand there is a well developed industrialised first world community that reflects economic and social well being. Other communities in peri-urban areas are overcrowded, under-developed and poverty stricken communities. These people face many social and economic hardships, comparable to those of third world countries. South Africa has the typical health problems of the western world of obesity, ischaemic heart disease and hypertension on the one hand and on the other, poverty, malnutrition, tuberculosis and pneumonia, reflecting third world conditions. The communities living in the greater Cape Town metropolitan area are a representation of this dichotomy and are comparable to most major cities in southern Africa.

The Africa Fund *South Africa Fact Sheet* (1990) puts the average infant mortality rates of whites from the more affluent communities at 12 per 1000 live births, in contrast to 100 per 1000 for blacks. Accurate estimates of the percentages of infants born with low birth weight are not available for the whole South Africa, but overall population statistics put South Africa in the **high** grouping for under five mortality rate countries; 64th out of 129 countries listed (Unicef 1993). In terms of *child health* standards, South Africa can therefore be viewed as a third world country.

The Neonatal Intensive Care Unit (NICU) at Groote Schuur Hospital (GSH) is a government-funded tertiary referral unit for high risk, sick and preterm infants. It serves the predominantly third world, indigent communities in the Cape Peninsula. Those in first world situations have medical insurance. They utilise private health care and thus were not part of this study. Although this causes some difficulty in forecasting disability in defined populations, it has important implications for the provision of services in the Cape Peninsula.

Whilst there has been a proliferation of follow-up studies of low birth weight infants, very low birth weight infants, and extremely low birth weight infants that have described the numerous adverse sequelae of being born very early and very small (Aylward 1989, Wolke 1991, Escobar 1991), these studies have essentially emanated from first world countries. Of the estimated 25 million low birth weight infants born in 1990, about 24 million were born in developing countries (Shah 1994), yet there is a paucity of published research on the longer term status of LBW infants and VLBW infants from developing and third world countries, with the resulting lack of knowledge of their abilities at various developmental stages within the societies in which they function and grow up. International focus has been on the reduction on child mortality (the one out of 13 who die) with less attention being given to the quality of life of "the 12 who survive" (Jacobs 1995).

In greater Cape Town LBW and VLBW infants have been followed in early infancy and at one and two years (Molteno *et al* 1990; Westcott, 1986; Deeny, 1987; Thompson *et al* 1993, Kirsten *et al* 1995).

A research group from the University of the Witwatersrand have reported the findings of a six year follow up of NICU survivors, with the main emphasis on determining the value of intervention to the VLBW infant at high risk (Goodman 1985 & Rothberg 1991).

A developmental follow up pilot study of VLBW infants undertaken at the University of Natal at age two and four (Talbot 1990), yielded an insufficient sample size for valuable statistical analysis. Seven subjects were examined and no controls were studied. The difficulty in tracing subjects was cited as a primary difficulty.

This researcher could not find published studies from this country reporting on specific cognitive, visual perceptual or motor integration functions in LBW or VLBW preschoolers other than the Witwatersrand study that assessed children for neurological anomalies and effect of intervention (Rothberg *et al* 1991). No studies of school entrants or school attenders reporting on outcomes for South African populations were found in publications at the time of writing.

The need for long term follow up of this important group of children had been identified by researchers from the NICU at GSH (Thompson *et al* 1993), and has been acknowledged world wide. Regional and national follow-ups are recommended by Escobar (1991) to inform health policy and service delivery. It is equally important for the formation of policies, changes in treatment and management protocols at individual NICU's. Most importantly, parents deserve accurate prognostic information.

A prospective two year follow-up study of infants with birth weights of less than 1250 grams, born at, or referred to the NICU at GSH, was therefore undertaken, starting in July 1988, with the aim of documenting mortality, morbidity and neurodevelopmental outcome. The outcomes at 1 and 2 years of age were published in 1993 (Thompson *et al* 1993) A copy of the published article is included as Appendix A, with permission from the first author. This current study formed part of the ongoing follow-up of that birth cohort, considering outcomes at age five to six years of age. At the current follow-up, matched full birth weight controls were included in the assessments.

1.3 Aims of the study

The aims of the study were to compare the visual perceptual, visual motor and gross motor abilities, as well as developmental levels of infants weighing less than 1250 grams at birth, at ages five to six years, with a matched group of normal FBW controls of the same age and gender and similar socioeconomic background and to describe the confounds that could influence outcome. The hypothesis being that the VLBW group would have significantly more developmental difficulties and specific problems with visual perception and motor function than their peers who were born at term of normal birth weight.

1.4 Objectives:

1.4.1 To compare VLBW children with controls on performance on the Griffith's Mental Development Scale (Griffith's) at age five and six years.

1.4.2 To determine whether children with birth weights below 1250 gram had visual perceptual, visual motor integration and/or motor problems, utilising standardised tests and clinical observation, when compared to a control group at age five and six years.

1.4.3 To compare children at age five and six years developmentally according to their birth weights in the following groupings: weighing less than 1000 grams and weighing between 1000 and 1250 grams and full birth weight controls.

1.4.4 To compare visual perception, visual motor integration and motor function in SGA and AGA infants at age five and six years.

1.4.5 To correlate findings on the Griffith's subtest of eye hand coordination (Griffiths 1976) with the Developmental Test for Visual Perception (DTVP-2) subtest for eye hand coordination.

1.4.6 To find out if VLBW children had significantly more problems with attention, concentration and inhibition of activity level than their peers at age five and six years.

1.4.7 To determine whether socioeconomic factors affected developmental outcome in this cohort.

CHAPTER TWO

LITERATURE REVIEW

Effects of biological and environmental factors on the development of very low birth weight children.

Infants born with birth weights of less than 1250 grams have a higher incidence of neurodevelopmental and cognitive problems than their full term counterparts. A downward trend in cognitive development in preschool years has been described (Escalona 1982, Williams *et al* 1987, Leonard 1990). Because relationships between social factors, perinatal complications, cognitive and neuromotor development are complex and intertwined, some children are exposed to both biological and environmental risk. Studies generally ascribe the downward trend in performance to this combination of risk or double hazard (Escalona 1982), with environmental factors increasing in importance as the child gets older (Weisglas-Kuperus 1993). Non-optimal biologic and environmental factors often work synergistically to affect later functioning.

Despite the concensus that environment significantly affects developmental outcome the specific relationship between environmental and biologic risk is not absolutely clear.

Biological risk

The question of **biological risk** rekindles the old debate between Little and Freud; Freud's view being that cerebral palsy is a condition that arises before birth and Little's being that it is a disorder of the perinatal period (Bax 1993). There are a variety of risk factors in the prenatal, perinatal and post natal period that need to be considered when entering the "biological risk" debate, particularly in relation to the child with minor or mild impairment. These include, biological or medical factors such as obstetric complications and severity of neonatal illness as well as social and environmental factors within which the pregnant mother functions.

Studies on biologically based developmental risk have spanned at least six decades. In the past twenty to thirty years studies of a wide range of biological conditions such as preterm birth, perinatal trauma and prenatal infection associated with an increased probability for cognitive, social and affective and physical problems have proliferated. The research methods employed in studies of mostly infants and young children, have been diverse, including longitudinal, cross sectional, mixed models, case study, descriptive and experimental designs (See Kopp *et al* 1983 for review).

Biological risk for the VLBW infant encompasses prenatal, perinatal and post natal periods. In general, the earlier the risk, the more serious the potential effects. Overall it has been estimated that 85-90% of all serious intellectual and neurologic sequelae stem from **adverse prenatal events** (Hagberg 1975).

For some infants the risk may even start before conception, as mothers of LBW infants have higher proportions of previous LBW infants, may have histories of hypertension, neurological or psychiatric disorder or have higher incidence of congenital anomalies in their families (Dunn 1986). Previous failure to utilise antenatal care, being black and not married have been reported in most centres conducting follow-up studies on VLBW infants in the United States of America. The number of teenage pregnancies amongst LBW infant mothers appear to have risen in recent years in the United States, from only 12.4% in 1987 to 22% in 1991 (Hack 1991).

During pregnancy, the inseparable interrelationship between maternal problems and the viability of the embryo and fetus are well documented. A variety of **antenatal** problems are more frequently recorded in the infant weighing less than 1250 grams. These are: i) a greater proportion of maternal dietary inadequacy and poor maternal weight gain, ii) higher frequency of bleeding in the second trimester, iii) more frequent pre-eclampsia, iv) 16-20 percent babies born with VLBW are from multiple pregnancies and v) more mothers of LBW infants smoke more than 10 cigarettes a day during pregnancy (Dunn & Robertson 1986).

The adverse **perinatal** events that are more frequently recorded with this population are: i) higher percentages of recorded ruptured membranes, more than 12 hours before delivery, ii) thirty to forty percent of high risk immature deliveries are associated with breech presentation or other abnormal lie, iii) higher number of low (below 7) Apgar scores and v) higher percentages of recorded cyanosis and need for resuscitation. (Hack & Fanaroff 1988)

Neonatal and pre-discharge morbidity and survival of the VLBW infant will not be discussed here in any detail as many factors appear to play a role in survival. Many methods of treatments have been introduced and have not been uniformly applied, explaining some differences in outcome in studies reviewed. Further compounding differences in outcomes are differences in socio-demographic factors, differing centre-based philosophies and protocols for antenatal and perinatal care, different infant and mother characteristics and differing methods of data collection. It is however important to note that the severity of neonatal illness is linked to the overall wellness of that child in later life. It is clear that survival of ELBW and VLBW infants has increased in the developed world over the past three decades, but many problems peculiar to the preterm neonate still torment those responsible for their care. With "aggressive methods of neonatal care", many infants do well if oxygenated with care. However multisystem disorders of stabilisation and homeostasis may develop (Table 1). The incidence of each possible complication increases with *decreasing* gestational age and birth weight (Hack & Fanaroff 1988).

TABLE1:

Multisystem list of **neonatal** problems related to immaturity

General: - Hypothermia, transepidermal fluid loss
Central nervous system: Depressed Apgar, apnea, intraventricular hemorrarhage.
Lung: Respiratory distress syndrome, pulmonary immaturity, pneumonia, chronic lung disease.
Heart: Patent ductus arteriosus, congestive cardiac failure.
Gastrointestinal: Feeding intolerance, necrotising enterocolitis, cholestasis, intra-abdominal haemorrhage, hyperbilirubinemia.
Hematologic: Anemia, bleeding disorders.
Immune system: Infections (bacterial, viral & fungal)
Eye: Retinopathy of prematurity (ROP)
Metabolic: Hyperglycemia, hypoglycemia, hypocalcemia, osteopenia, rickets hyperkalemia & acidosis.

(From: Hack M & Fanaroff A A. How small is too small? Considerations in evaluating outcome of the tiny infant. Clinics in Perinatology - Vol15, No4, December 1988.)

Many studies have examined the longer term consequences of specific medical risk factors, such as intracranial hemorrhage and bronchopulmonary dysplasia, of VLBW as they affect development (Leonard 1990). Three distinct pathologies of the preterm brain, each with a presumed different perinatal aetiology, have been reported on by Leviton & Giles and Brown *et al* (Forfar *et al* 1994). These are: 1) periventricular haemorrhage-subependymal (germinal plate) and intraventricular haemorrhage with or without post haemorrhagic hydrocephalus; 2) infarctive periventricular leukomalacia and 3) non-infarctive perinatal telencephalic leuko-encephalopathy. However VLBW seldom has a single identifiable medical risk factor. It seems likely that there is no single aetiology, but that the vulnerability of the fetus, due to a wide range of factors such as nutritional status or infection during pregnancy, may be a priming factor to allow some adverse perinatal episode to tip the balance from vulnerability to disability (Bax 1993). It appears that the aetiology of cerebral palsy is clearer than that of the so-called *new morbidities* of learning disabilities and organic behaviour problems.

An important early model of the effect of biologic risk on developmental outcome, based on retrospective studies was the **continuum of reproductive casualty** (Pasamanick 1967). The basic assumption of this model was that the severity of developmental disabilities (including cerebral palsy, epilepsy, mental retardation, behaviour disorder and learning problems) is influenced by severity of perinatal complications. For example, a more serious condition such as cerebral palsy would be associated with more obstetric and perinatal complications than would a milder disorder such as a reading problem; the greater the degree of perinatal complication, the greater the deviancy. This model ascribes negative outcome *primarily* to biologic risk. However *prospective* studies do not always support this model. An example of this is described in the extensive studies by Drillien and co-workers (Drillien 1980) on low birth weight infants born in the seventies. Data from Scottish infants revealed that in the higher socio-economic classes, cognitive defects among LBW infants, declined from 26 points to 13 points between the ages of 6 months and 4 years. In the lowest social class group, however, the deficit increased from 26 to 32 points. By age 5 to 7 years, few children from middle class homes had mental handicaps unless their birth weight was less than 3,5 pounds. In general there were more children with mental handicaps in poor homes, regardless of birth weight. In the lowest two socio-economic classes, LBW had a 27% rate of dysfunction (IQ<90), but the rate for those born at term was 14%. No difference in rate of dysfunction was found in the upper two socio-economic groupings between pre-term and fullterm children, confirming the interactive relationship between biologic and environmental risk.

More recently the interactive effects of environmental and biologic risk were demonstrated more precisely in the studies by Hunt *et al* (1988) in Britain and Weisglas-Kuperus *et al* in the Netherlands (1993).

Hunt and co-workers followed 108 LBW children born in 1978 up to the age of 8. Ratings of neonatal illness and parental level of education influenced outcome at age 8. However, when these biologic and environmental ratings were dichotomised, (low versus high neonatal illness; low versus high parent education), level of neonatal illness primarily influenced the likelihood of normal/abnormal outcome, whereas the parental education influenced the severity or degree of disability. Of those children whose parents had a lower education, 30% had moderate to severe problems, whereas 10% of children whose parents were more highly educated experienced moderate to severe problems. Low parent education plus high neonatal illness yielded almost a 55% rate of moderate to severe problems. In contrast approximately 9% of children with high parental education and high neonatal illness displayed problems of the same magnitude. In their study the environment had a tempering effect on the abnormality, but did not determine whether it occurred.

Weiglas-Kuperus and her co-workers (1993) studied a group of 79 VLBW survivors at ages one, two and three and a half and used neonatal ultrasonographic findings and an infant neurological assessment as biological indicator and home environment inventory as a sociodemographic indicator. Development was assessed by using tests of cognitive and mental development. In a stepwise regression analysis of biological as well as social factors, the neurological score alone was the best predictor of cognitive development at 1 year (mean quotient 96), explaining 64% of the variance. From 2 years (mean quotient 86) of age onwards, the best predictors of cognitive development were the neurological score *together* with the home inventory, explaining 46% of the variance. It was found that children at high biological risk were able to catch up on their cognitive delay in a highly stimulating home environment. Children at low as well as high biological risk in a less stimulating home environment showed a decline in cognitive development.

Forfar *et al* (1994) supported the continuum of reproductive casualty for *congenital abnormalities* and *cerebral palsy* and postulated that a wide range of disabilities are manifestations or associations with cerebral palsy, including abnormal posture and mobility, epilepsy, mental retardation, specific learning difficulty, deafness, slow speech development visual problems and organic behaviour problems. The lower the birth weight the higher the risk that an infant will suffer from a *serious* developmental defect. In their long term follow-up to ten years of age of Scottish low birth weight children, they found that 10 of the 29 surviving disabled children had significant congenital abnormalities. The study reported on stillbirths, neonatal deaths, survival and disability. It was indicated that higher stillbirth and neonatal mortality rates, but lower disability rate in the <1500g group compared with the 1500-1999 gram group, suggest that death in the former removed many who, given a higher birth weight, would have survived with disability. They found a *prenatal factor* to be evident in 10 of the 29 disabled children in the study. Of the cerebral palsied children 27% also had serious congenital abnormalities. The study illustrated the limited influence of low birth weight on IQ as there was no significant difference between the IQ s of infants below 1500 grams and those between 1500g and 2000g. It also drew attention to evidence of the limited influence of low birth weight and IQ in the relationship of disability to IQ, showing that low IQ was linked to disability rather than to low birth weight itself. The correlation between intelligence and social class was emphasised, with 3 percent of any population the IQ would be expected to be below the third centile. The four children in their study with IQ below 70 were all in social class 3 and 4. Forfar et al postulated that over- representation of lower social classes in any low birth weight study tends to increase the number with low IQ . A demonstrated relationship between moderate to severe disability may disappear when the outcome is standardised according to the parental social class and maternal education.

The studies described above seem to discount the plausibility of the continuum of reproductive casualty as an explanatory model for the *declining abilities* of the VLBW child free of frank cerebral palsy and congenital anomalies. An alternative explanation, **the transactional model**, assumes a degree of plasticity to be inherent in both the child (biologic component) and the environment (Sameroff et al 1993). The child in this instance is considered as able to constantly reorganise and adapt or self-right. A poorly stimulating environment would interfere with self-righting, with the resultant increase in the probability of a disrupted child - environment trans-action, whereas a more positive environment enhances resiliency. Outcome studies of VLBW infants free of major handicap generally support this "continuum of caretaking casualty" approach to development.

From early **toddlerhood** environmental influences start to have strong effects on measurable cognitive and mental ability. The true biologic risk of the VLBW and ELBW infant and its concomitant perinatal complication are thus best measured in later childhood, by indices of neurosensory impairment that are *not* highly influenced by environmental factors, such as sensory perceptual and motor skills (Lewis *et al* 1989, Pfeiffer *et al* 1990). This present study considered specific visual perceptual and motor outcomes in a socio-environmentally homogeneous population.

Environmental Risk:

The early environment is different for the very preterm infant. Not only is there the adaptation too early to extra-uterine life before term, but in many instances the common neonatal care includes separation from the mother which may affect the mother-child relationship. As a large number of preterm VLBW babies are also very ill, mothers do not handle their babies or spend as much time with them as they would with a full term well infant. Many preterm babies have not developed a strong enough sucking reflex to be breast-fed by their mothers. The emotional and psychosocial factors are therefore different in very preterm babies from their fullterm counterparts that establish normal bonds with their mothers. Any of these early factors may contribute to a poorer start in life and thus affect the child's development. How and to what extent is not clear, but the negative impact may in some instances be lasting for both mother and child (Greenberg & Crnic 1988).

As the transactional model indicates, it is not possible to isolate the effects of biological stress from social, educational and cultural factors. As in all human development, the child born with a very low birth weight must be studied and understood in his or her social context.

Wachs (1991) has enumerated three historical stages of research on the impact of the environment on development. In the earliest stage, studies determined that variability in the environment was related to variability in development. The environment was characterised by *social address* variables, such as socioeconomic status (SES) which do not affect the child directly but indirectly impacts on family LIfestyle, availability of resources such as food and medical attention and socio-political status. These have more recently been termed **distal** variables. In the second stage, studies were characterised by an exploration of the relation between more *specific* environmental variables, such as parent responsivity, availability of appropriate play materials and opportunities for varied daily stimulation. These **proximal** variables are not consistently related to SES (Bradley, 1989). This is due to the relatively large amount of variability in the distribution of proximal variables within each SES category (Sameroff et al, 1993). In the third stage, the most recent research addressed the importance of organism-environment *interactions* in understanding the complex relationship between environmental and individual characteristics and development.

Parental mental health and particularly maternal mental health have for some time been considered key protective factors against risk (Rutter 1979). In a study of 129 infants with birth weights < 1250 grams Leonard and her colleagues (1990) found that the factor that was associated most highly with the highest incidence in *later* abnormality was the parenting risk factor. In the Leonard study fifteen percent of the 129 infants had referrals for abuse or neglect.

There is yet another set of environmental factors that affect children, albeit indirectly. These are the amount and nature of maternal support and the amount of stress in the family's life. Families that are overburdened by life crises are less likely to provide environments that will provide stimulating, varied experiences that will foster cognitive growth or emotional support to children when needy (Garcia-Coll *et al* 1986).

Studies that have considered biologically or medically high risk infants in less optimal environments found them to have the worst long term outlook (Bradley 1994). Brooks-Gunn *et al* (1992), in their study on early intervention for children up to 3 years, found however that the higher the birth weight, the more the child was able to benefit from intervention.

Investigators have documented numerous relations between the social contexts within which families function and developmental outcomes (Bronfenbrenner 1989). Across studies, one of the most ubiquitous predictors or risk indicators is socioeconomic status (SES). Studies generally view SES as a variable that may reflect a number of family risk factors, including low parental education, poor housing, overcrowding and chronic unemployment. Some researchers postulate that there is a need to separate SES into component variables and to evaluate how these variables relate to outcomes in children from chosen groups (Garcia-Coll 1990). Others have suggested cumulative risk measures, incorporating distal and proximal variables into a single environmental index (Sameroff *et al* 1993). However this "combination index" may obscure specific influences. If populations or groups are viewed over a period of time the proximal variables may alter, whilst the distal SES related variables may remain more stable. The distal variables that have across studies, been the most predictive were those of SES and maternal education (Sameroff *et al* 1993). Positive features may also ameliorate the effects of environmental risk (Goduka 1992).

In many environments indicators of soundness or intactness of families are difficult to measure, as the structures of families are extremely varied and are perhaps best looked at as *households*. Whilst the absence of the father in the nuclear family may be viewed as a risk factor in some communities, the presence of other adult males such as grandfathers, cousins or uncles who fulfill certain fundamental caring roles in households, may counter the loss of the paternal presence. (Reynolds 1989, Richter 1995).

Although the influence of SES on development is acknowledged, its influence is less well described in studies of learning disability. Kavale (1988) argued that learning disability and cultural-economic disadvantage are strongly related. However SES has received limited attention as an independent or even a descriptive variable in literature referring to learning difficulties. Many studies on learning difficulties make no reference to SES in their samples (Durant 1993). In the majority of studies reported by Durant, SES was described in vague terms, for example "subject's schools were located in middle class areas". Only 11 % of studies, reviewed by Durant, used precise and quantified terms, such as ratings on standardised scales.

A number of studies following VLBW infants into later life report that children that are lost to follow-up and more particularly those that the researchers were *unable to trace* are said to be more at risk for poor outcome all round (Escobar *et al* 1991). This implies strongly that the environmental factors that exclude these children from assessment are perhaps the most unfavourable and not reported on.

Follow-up studies of children that had a high risk birth status suggest that outcomes later in life are more related to the ongoing caretaking context than to the initial biological risk (Greenberg & Crnic 1988).

It is important to acknowledge that preterm very low birth weight babies are more vulnerable *generally* and thus more susceptible to environmental influences than their full term peers. A less-than-optimal environment will serve to amplify the effects of biological risk, whilst a highly stimulating environment may attenuate these biological effects.

VLBW follow-up study reviews:

There is still considerable apprehension and uncertainty regarding the long term outcome of these high risk children. Whilst it is generally accepted that improved neonatal care has resulted in lower mortality rates (Escobar 1991), it is not clear whether major handicap has been reduced or merely remained stable. Despite increased focus on the more subtle long term morbidities and learning problems, the incidence of these is not clear (Escobar 1991).

In the meta-analysis by Aylward *et al* (1989) (of LBW children, involving 600 subjects in a review of 80 studies published in the decade before 1989), the *LBW* children (combined groups): 49% were normal, 36% suspect and 14% abnormal. Of the *control* children 76% were normal, 24% suspect and less than 1% abnormal. The combined average intelligence (measured in DQ or IQ), of all low birth weight groups was 97.77 (SD 6.19) whereas the control subjects had an average of 103.78 (SD 8.16); a statistically significant difference. No differences in mean IQ/DQ scores were found among the LBW, VLBW and ELBW sub groups, showing that the smaller babies were not doing any worse than their larger counterparts. However Aylward found evidence that subtle dysfunctions, indicative of learning disabilities were not usefully detected by IQ measures, and recommended that better assessment of visual-motor integrative and visual-spatial function, academic performance and behavioural problems such as attention deficit disorders was necessary.

Escobar et al studied 111 published studies on the surviving VLBW infants between 1960 and 1990; all from the developed nations (Escobar *et al* 1991). No studies reported survival of infants weighing less than 500grams. The great variety in method of reporting on numerous factors, such as study populations, impairment, disability and handicap and determinants of outcome was emphasised in this meta analysis.

The conclusions arrived at concerning the studies were:

1) Small database - In total 26 thousand babies were reported on in nearly thirty years (40 thousand are born yearly in the USA alone). Smaller numbers of infants were *actually evaluated*, for outcomes such as cerebral palsy. Only 1000 ELBW infants were reported on.

2) Lack of agreement on denominator, limiting value of comparisons and precluding comparisons with data on vital statistics based on numbers of live births.

3) Lack of agreement on what constitutes adverse outcome.

4) Data and reports were limited to periods of follow of up to or less than three years.

5) Little improvement in methodology over a period of thirty years.

Conclusions with regard to VLBW survivors:

1) Widely divergent results from studies conducted in the same time period.

2) Median incidence of cerebral palsy (CP) was reported at 7.7% ; showing little variation over time. Assuming the incidence of CP in the general population to be 2 per thousand, the *relative risk for CP amongst VLBW infants is 38 times higher than the general population.*

3) The estimate of incidence of disability from the reports studied was at about 25%. This figure was said to possibly be an underestimate, as morbidities such as lung disease were not always reported. Many factors influence the variability of reports on disability outcomes, such as size of study, age of children at time of evaluation and variability from centre to centre with regard to diagnostics.

4) A striking increase in morbidity as the period of follow up lengthens.

5) The United States reported higher incidences of disabilities.

Ornstein *et al* (1991), critically reviewed follow-up studies of VLBW of school age before 1989. Twenty five studies where accepted for their review. The presence of major handicap in VLBW infants varied from 6-24%. When broken down, CP rates varied from 2-9%, visual impairment from 2-38%, hearing loss from 2-44% and mental retardation from 7-27%. The wide ranges in findings were ascribed to variability in diagnostic criteria. The majority of articles reported a fairly constant rate of handicap between 6% and 12 %. Minor brain dysfunction, soft neurological signs or transient neurological anomalies were described more commonly in VLBW school age children. Rates varied from 23 to 69%. IQ results where significantly lower than matched controls. Greater variability and discrepancies amongst verbal and performance scores where recorded for VLBW children. Increased incidence of learning problems, especially with mathematics and reading were described. Greater needs for special education, remedial therapy and grade repetitions were recorded and varied from 10 to 71%. Inattention and hyperactivity as well as behavioural problems occurred in 30-50% of the VLBW children. In some instances these behavioural problems at two years were more powerful predictors of performance deficits at five years than SES. Visual motor integration was one of the more frequently reported deficits, particularly with the ELBW children. Gross motor delays, poor balance and coordination were found, but studies failed to correlate these deficits with other measures. Motor impairment rates varied from 20-69%. Fine motor skill deficit influencing writing was identified in up to 69% of ELBW school going children, compared to only 10% in controls.

Outcomes of infants of VLBW - pre school and early scholastic abilities.

Several recent studies have evaluated VLBW children at early school age, following the meta analysis of Aylward *et al* and Escobar *et al* and the overview of Ornstein (Lloyd *et al* 1988, Hunt 1988, Marlow *et al* 1989, 1992, Vohr *et al* 1985, Abel-Smith *et al* 1990, Leonard 1990, Saigal *et al* 1990, Teplin *et al* 1991, Klein 1989, Hack 1991 & 1992, Mc Cormick 1990, 1992, Rickards 1993, Hille 1994, Weisglas-Kuperus

1994, Klebanov et al 1994, Roth et al 1994, Forfar et al 1994,). What is apparent in the majority of these studies is the presence of scholastic under-achievement in the apparently normal VLBW children.

In a study in **Wolverhampton**, Lloyd (1984) compared the abilities of VLBW children with normal birth weight sibling controls and found small differences in IQ, but despite this, 28% of the VLBW children were performing poorly at school in comparison to only 3% of siblings. Lloyd (1988) followed this population and reported that at ages five to nine years, 53% of the 45 VLBW children were performing below average, compared with 22% for the control children. This is a tendency noted throughout the studies reviewed that have been published since; despite normal IQ, approximately only half of the children were performing satisfactorily at primary or junior school level on both subjective and objective measures, compared to between 70 and 80 percent of controls that were achieving within normal range.

In the two follow up studies on a specific VLBW group reported on by (Marlow *et al* 1989 & 1993) in **Liverpool, England** it is of interest to note that the pre-school study (Marlow *et al* 1989) failed to identify accurately the sub group of children with *specific educational* difficulties two years later (Marlow 1993). The number of children that had shown difficulties previously had increased over the intervening two years. In this study, where children with major disability were excluded, 48% of VLBW children had problems with academic work compared to 19% of controls. Their study confirmed that IQ tests were not valuable predictors of scholastic and academic underachievement and suggested that the motor tests used at six years (TOMI) better predicted subtle problems in children who later had learning problems; motor testing correctly identified 15/16 children with multiple problems with a low positive predictive value but a high negative predictive value. It was acknowledged that socioeconomic environmental influences and pressures increased when children went to school, despite the family structure and social status remaining similar. Teachers found the VLBW children to have more problems related to emotional difficulties, such as worries, fears, unhappiness, tics and fussiness. A good correlation between parental perceptions and teacher ratings of problems in the children was found in index and control cases.

The **Dutch children** followed by Hille *et al* (1994) also presented with high school failure in children with very low birth weight. This study followed a national cohort of children born in the Netherlands in 1983 and therefore studied a substantial number of children weighing less than 1500 grams (813 children). Although the study did not exclude major disability, they found only 11% of children coping in the mainstream free of any assistance by the age of nine years. A significantly greater need for special education in boys was found. Both in this study and in general it was found that boys in Holland were twice as likely to be in special education, suggesting that there is no real interaction between preterm VLBW and gender.

Very low birth weight children born in 1980 in **Melbourne, Australia**, were followed from birth with a matched, randomly selected hospital control group (Rickards 1993). The VLBW group performed significantly less well at *eight years* than their full birth weight counterparts on the Wechsler (WISC-R) intelligence test. Teachers rated the VLBW group of children as more clumsy and as more "unforthcoming and unassertive". Significantly more parents reported that their children were not coping at school.

Of the long term ELBW survivors in the **Victoria Infant Collaborative** study group (1991) in Australia (89 children), ten children, at the age of eight were attending special school for disabled children. Of the remaining 79 children, attending regular schools, 70 were reported *by their parents* to be coping at their grade level in a grade appropriate for their age. Unfortunately this study did not test the teachers ratings or perceptions of the children and no controls were studied in comparison.

In a follow up study of 247 VLBW 8-9 year old children born in **Cleveland, Ohio** (Hack et al 1992), it was found that these children performed significantly less well on tests of intelligence, language, reading, mathematics, spelling visual and fine motor abilities. The areas where the difference was not significant were speech and behaviour. The study included children with major handicap. When children with major handicap were excluded from the equation, differences persisted in the above areas with the exception of social competence, reading and spelling. When the VLBW group was reduced to neurologically normal children with normal IQ, the difference between them and their fullterm counterparts persisted to be significant in the areas of expressive language, memory, visuomotor and fine motor function and in measures of hyperactivity. It is important to note that all test results were based on the preterm children's *corrected ages.*

School achievement in four birth weight categories (ELBW n=247, VLBW n=346, LBW n=724 and FBW n=724) was studied in a large collaborative study sample (Klebanov *et al* 1994). Indicators of school achievement that were used, included grade failure, placement in special class, classification as handicapped and mathematics and reading achievement scores. The results showed that as birth weight *decreased* the prevalence of grade failure, placement in special class and classification as handicapped *increased.* The lowest birth weight category scored the lowest of all groups on math and reading achievement tests. This was true even in the ELBW group that were of normal intelligence. Four times as many ELBW children were classified handicapped compared to FBW children.

One of the few large studies documenting the cumulative nature of health status at school age (8 to 10 years) of 611 VLBW survivors (McCormick *et al* 1992), found that decreasing birth weight was associated with increased morbidity. Children with birth weights below 1500 grams were more likely to experience multiple health problems. It was also found that approximately 50% of the ELBW group (total number ELBW = 247) had limitations on one or more ADL (activities of daily living) measures in contrast to only 17% of the full birth weight controls. On behavioural and mental health indices significantly more problems were evident in the VLBW group.

Follow-up into early adolescence:

The longitudinal studies by Dunn (1986) in Canada of children born in the late sixties and early seventies, followed LBW children into early adolescence and found the excess of behavioural problems in those children that were grouped as minimal brain dysfunction in their early years, and it would be of interest to know if this would be true of children born in the eighties with lower birth weights.

Are developmental outcomes different for preterm infants that are small for gestational age, when compared to those that are very low birth weight but appropriate for gestational age?

The general literature on VLBW preterm infants do not always report on the SGA infants outcome, and if this is done, the AGA group is usually significantly larger in numbers.

Fetuses with IUGR and infants who are SGA are identified by comparing their size of growth pattern with set norms. Some reasons for SGA are benign, whilst others may render the infant vulnerable to several perinatal complications. It appears that the developmental outcome of the SGA infant depends on the aetiology of the small size *as well* as the resulting perinatal complications (Allen 1993).

The main growth spurt of the human brain occurs between 25 weeks gestation and plus minus 25 weeks postnatal age. When growth failure or failure to compensate for earlier deprivation occurs during this significant period, there is a greater risk of reduced brain growth, a smaller head circumference and later intellectual impairment (Stewart 1981).

Preterm SGA infants have been found to have a higher incidence of both cerebral palsy and mental retardation than either full term SGA infants or preterm AGA infants (Allen 1993). In the Vancouver study, Grunau (1986) found a significantly higher number of SGA preterm children to be in need of specialised education.

When considering the literature on SGA infants it becomes evident that little research has been published on the differences in morbidity or outcome of the different subtypes of IUGR that survive the neonatal period. Balcazar

(1990), found in a study considering early neonatal mortality (first three days post natally) of an urban poor population in Mexico City, that proportionate IUGR had a significantly greater mortality than disproportionate IUGR.

Martikainen (1992), in her study on the effects of IUGR and its subtypes on the development of the preterm infant, found that children with asymmetric IUGR had lower visual-auditory perception scores and social ability scores on the Denver Developmental Screening Test than in the control group at the corrected age of 18 months (+ or - 2 months), whilst those with symmetric IUGR differed from the controls in ALL developmental sectors *except visuo-auditory perception*. This confirms the general perception that children with symmetric IUGR are at highest risk for poor overall neurodevelopmental outcome.

The significance of *severe intrauterine growth retardation* for developmental disorders was emphasised in a study of three groups of low birth weight infants by Hadders-Algra and Touwen (1990) at six years of age. In this study a relationship in severely growth retarded infants, born at term, was found between head circumference below the third centile and minor neurological dysfunction at six years. The findings indicated that the brain may resist minor degrees of undernutrition ("brain sparing"), but only to a certain degree.

An important factor, not always reported in the literature, is whether or not the children were outborn, as the heterogeneousness of the obstetric approach may account for differences in management and, therefore outcome. Ideally all pregnancies where the growth retarded foetus is recognised, should be managed in perinatal ICU or if not, according to a set protocol for the district. Ounsted (1989) thus noted that only the most gravely ill babies and those with the lowest birth weights were transferred to centres that reported on outcomes and that **this** accounted for the poor prognosis of the SGA infant.

In considering the group of children and their outcomes it appears of fundamental importance that one looks at the individual, rather than the group in terms of outcome, as a multiplicity of factors appear to play a role with regard to outcome, particularly the preponderance of low socio-economic groups, poverty and maternal undernutrition in children born SGA.

Visual perception, visual motor integration and motor function in the VLBW preterm infant.

Visual Perception:

Visual perceptual skills are thought to be the best reflectors of underlying neurological difficulties and may predict later learning disability (Siegel 1983*).

Generally tasks used to measure visual perception involve some visual motor integration or eye hand activities. There is however a significant body of research that stresses the importance and value of measuring visual perception independently of all motor involvement. Visual perception and motor function are to a considerable extent autonomous systems (Hammill 1993). There is very little research on VLBW infants that acknowledges this. Visual perception has not been assessed widely as a specific function in VLBW infant follow up studies. If visual perception and movement coordination are separate systems, depressed performance on tests of visual motor integration (VMI) may represent problems in one, but perhaps not in the other area, bringing into question statements about the validity of a diagnosis of a visual perceptual problem when using a VMI test.

To validate the importance of assessing these systems as separate entities, Newcomer and Hammill (cited in Hammill 1993) administered a motor reduced visual perception test and a visual motor integration test to three groups of children with cerebral palsy who differed in degree of motor handicap from mild to severe. They found that on the motor reduced visual perception test, the mean for all three groups was the same, while on the VMI test the mean was highest for the mild group and lowest for the severe group. It is therefore important to acknowledge that clumsy or motorically impaired children be measured not only on tests of VMI to determine reasons for under achievement in performance, but also on visual perceptual tests.

Students with visual spatial problems frequently have difficulty with self help skills, handwriting and some components of mathematics (Johnson 1995). Visual spatial weaknesses are also prevalent among students with non-verbal learning disorder. Such difficulties result in faulty spatial orientation, reversals of letters or letter and numerical order. Visual spacial problems may interfere with the acquisition of early reading skills, interpretation of script and aspects of mathematics and geometry (Johnson 1995). Problems in a specific area concerned with visual processing and integration typically have secondary impacts on higher levels of learning (Ayres 1972).

There is a growing body of literature that suggests that early measures of visual processing have been found to have predictive value for later cognitive abilities (Rose *et al* 1991). The infants ability to attend differentially to novel stimuli or familiar stimuli have been investigated by various researchers, but the studies by Rose (1983) Rose *et al* (1985) and Rose & Feldman (1989) are of particular interest as they have investigated preterm infants. The 1989 study compared VLBW infants with full-terms on measures of visual recognition memory and cross modal transfer. They found that more deficits were present in the preterm VLBW group. The preterm VLBW group required longer exposure times for familiarisation with stimuli and their manner of exploration of stimuli differed from their full birth weight peers. As recognition memory encompasses a number of distinct cognitive processes linked to visual perceptual processes, such as discrimination, encoding, retrieval and particularly visual attention, the findings may be suggestive of specific visual perceptual deficits strongly linked to cognition in VLBW infants.

A study by Ross et al (1992) explored the effects of subependymal and mild intraventricular lesions on visual attention and memory in 10 month old VLBW premature infants. The researchers compared 30 VLBW premature infants with mild, isolated germinal matrix haemorrhage without ventricular dilatation, who were mostly found to be normal neurologically, with 30 VLBW premature infants without heamorrhage and 30 term infants on tasks of visual attention visual memory and memory for location. The purpose was to determine if defined brain injury affected specific cognitive function. The findings provided some evidence that subcortical damage, occurring perinatally may affect visual attention as well as overall mental ability. The researchers felt that further study of these groups of children was warranted to determine if such children continue to show delays in cognition, associated with subcortical prefrontal cortex functioning, or whether, with brain development and adaptation, these differences in groups disappear over time.

Despite the excitement of researchers about the predictive possibilities of early measures of visual recognition & memory, McCall and Carriger in their meta analysis of studies undertaken in the 1980's caution against the attribution of too much value to these measures. (Mc Call *et al* 1993).

Abnormal development of visual function following IUGR has been suggested by Stanley et al (1989) in a study conducted in the Department of Child Health in Bristol . These authors suggest that the primary visual cortex is likely to be one of the areas of the brain most likely to be affected by IUGR, due to its particularly rapid development during the last trimester of pregnancy, a stage when most growth retardation takes place. As such it may affect development in two ways; firstly by reducing the size of the visual cortex and secondly by abnormal structural growth. Their study measured vernier acuity (the ability to detect an offset between two lines), which reflects the accuracy with which relative spatial position can be determined visually; this implies that this ability is mediated by central processes within the visual system, probably at a cortical level. Because catch up growth was considered complete by 9 months post term this was deemed an appropriate time to assess this type of visual development in IUGR infants. The 18 index children were those who were neurologically normal and who differed only in the size of their heads. The 20 controls were normal infants. Though this reader found the procedures of assessment highly specialised and technically difficult to interpret, it was felt that the findings were of value. These were that visual function that was dependent on central processing of the retinal image was reduced by IUGR. "The reduction appears due to abnormalities in the central rather than the peripheral visual system." p 99 (Stanley et al 1989) As IUGR is associated with a high incidence of learning disabilities in later childhood and if sensory cortical maps are less accurate in growth retarded infants, this might contribute to the later development of such disabilities.

Aylward et al (1989) and Ornstein et al (1991) suggest that the **focus of assessments should be on clearly defined specific deficits.** Whilst there have been the investigations on visual attention and habituation to novel stimuli, i e the infants ability to encode, extract and retain information as discussed above (Ross 1985 & 1989), few studies have isolated the assessment of visual perceptual processes other than those that are part of the non-verbal components of standardised IQ tests such the Wechsler (WISC).

Teplin and coworkers (Teplin *et al* 1991) have assessed visual perception and visual motor control in a group of 28 ELBW children at the age of six years and compared these functions to full birth weight full term controls. The controls were significantly superior in visual spatial and short term memory and visual motor control.

Visual Motor Integration (VMI) in VLBW children:

The integration of visual and movement functions into age appropriate eye hand function is an extremely important aspect of learning. It is of fundamental importance in the preschool year and upon school entry because drawing skills in preschool become refined as precursors for writing abilities (Beery 1989). Much of children's measurable performance in school is based on what is produced in writing and perhaps regrettably, children are tested or examined to a major extent for what they put down on paper. Children with good drawing and copying skills usually progress to writing with relative ease and if they produce neat and tidy work, they receive the recognition and approval of their teachers, parents and peers. Consequently they develop self-confidence and a positive image of themselves. Mastery in VMI, as with motor skill, enhances an already secure self concept, whereas failure undermines the self image and may reinforce failure, as children who do not succeed, frequently avoid tasks that they are not good at. In such a way they deprive themselves of the practice and exposure necessary for mastery (Smyth 1992).

Children with significant VMI problems are at increased risk for learning difficulties in areas dependent on these skills, such as writing (Lukeman & Melvin 1993). Studies of LBW survivors have examined perceptual motor integration tasks and have found an excessive number of distortion and integration errors on visual copying and other perceptual tasks (Hack *et al* 1992, Saigal *et al* 1991).

A study by Hunt (1988) indicated that eight year old VLBW children with problems in VMI have a 34.4% incidence of learning disability. Poor VMI in follow-up studies of VLBW infants have been sufficiently significant to suggest its clinical importance in this population. It is important to note that children with normal DQ and IQ in the VLBW populations nevertheless had problems with VMI. Hunt (1988) found that 80% of her population had normal IQ, but that the IQ test score patterns of 45% of the VLBW group were unusual, suggesting specific intellectual problems, even when the IQ was above normal. Usually only about 5% of normal populations have these atypical patterns, confirming underlying (less obvious) intellectual characteristics that may predispose this population to learning difficulties.

Vohr and Garcia-Coll (1985) also found that VLBW children with normal DQ had VMI problems; 45% of such children had VMI scores below the 25th percentile.

Motor abilities and skills of VLBW children:

Some children have greater than average difficulties in the acquisition of motor skills and then often remain awkward or clumsy in their execution of: i) **gross motor skills** such as hopping, skipping, jumping and climbing, learning to swim or ride a bicycle, ball handling skills, such as kicking, throwing, catching, casting, hitting with a bat or racquet or ii) **fine eye - hand skills** such as age appropriate handling of implements (knife & fork, scissors, controlling and holding a pencil), doing shoe laces and buttons or connecting zippers.

A variety of terms have been used by authors from a range of disciplines to describe problems with motor skill in otherwise normal children. These children have been described as motor impaired, motorically awkward, developmentally dyspraxic, minimally cerebral palsied, visuo-motor disability and perceptual motor difficulties. Commonly, however such children are described as "clumsy" (Gubbay 1975, Henderson 1987, Smyth 1992). Although the colloquial and medical sense of the word can be confused, it is however concise, descriptive and commonly used. A problem with clumsiness is the difficulty of specifying the *level at which motor skill is said to be impaired*, as children vary widely in their ability to perform motor skill (Gubbay 1975). The arbitrary basis on which impaired motor skill is determined has raised important questions regarding the necessity for or the importance of intervention (Leary 1987).

The recent DSM-IV-R (1994) classification of motor skills disorder as Developmental Coordination Disorder (DCD) (315.4) sees the essential feature of the disorder as marked impairment in the development of motor coordination. The diagnosis is made according to the following criteria: Impairment has to significantly interfere with academic achievement or activities of daily living, coordination difficulties are not due to a medical condition (such as cerebral palsy, hemiplegia or muscular dystrophy) or pervasive developmental disorder and if mental retardation is present, the motor difficulties have to be in excess of those usually associated with it.

A number of tests of motor ability have been developed (for a review see Henderson 1987). The motor tests usually include measurements that have potential problems in that the skills measured may to some extent depend on the kind and nature of exposure that the child has had to them (for example scissor cutting , bead stringing and ball handling). It may not be easy to observe the *underlying reason* for failure to perform the tests adequately, unless the tester also handles the child and examines the sensory, tactile, kinesthetic and muscular functions as well as the more integrated functions of balance and equilibrium. How the child performs may be more important than whether he passes the criteria (Smyth 1992). Moreover cultural differences appear to influence the acquisition of motor skills. Ehrhart et al (1987) for example tested a sample of British children on Gubbay's Test (1987) (which was standardised on an Australian sample) and found differences. In particular it seemed that Australian children were better at gross motor tasks while their British counterparts seemed to be better at fine motor tasks.

Given the wide normal distribution of motor ability, variability in rate of development and the often subjective judgement of the observer (for example teacher versus parent), the identification of DCD remains problematic. Whilst on the one hand it is acknowledged that tests may not validly identify children with DCD, available tests provide the only objective and quantifiable measure of motor ability.

Virginia and Robert Bruininks compared the motor functions of 55 learning disabled (LD) students with non learning disabled children and found the LD students to perform significantly poorer than their normal peers. Their greatest deficiencies were on tasks requiring body equilibrium, controlled fine visual motor movements and bilateral coordination of movements involving different parts of the body . All these_areas include complex motor patterns that require the integration of visual and kinesthetic senses with motor responses (Bruininks 1977).

Motor difficulties in VLBW children have been found in studies by Marlow (Marlow *et al* 1989 & 1993). A fall in impairment score was noted between the 6 year olds and two years later. The control group of children in the Marlow study continued to perform better on motor tests than the VLBW children, even at 8 years.

Elliman *et al* (1991), studied a group of 171 children with birth weights below 2000 grams at the age of seven on fine and gross motor tests modified from Touwen and Gubbay and found the differences between VLBW and term controls to be highly significant, particularly in tests of finger opposition, finger nose touching and diadokoninesis. Their analysis found the SGA children to be significantly less able and girls were better on all tests.

Language abilities of VLBW children.

Psycholinguistic development of VLBW children is not frequently investigated as a specific function. In the Vancouver study, Washington (1986) points out that there have been few attempts to distinguish LBW children exhibiting delays in language development from those with disorders in communication. The same may be said for VLBW and ELBW infants as they are considered to be at greatest risk for language delay (Lukeman *et al* 1993). Whilst it is acknowledged that significantly more language delays are present in VLBW children (Le Normand 1995), the underlying reasons for poor linguistic outcome is not clear. The important influence of the infant-caregiver interaction on receptive language has to be acknowledged and the complexity of studying the quality of this interactive process is possibly the major reason for limited research in this important area.

The cognitive component of language development, usually tested as the verbal component of IQ tests, was found to be lower in the LBW group when compared with FBW counterparts in the longitudinal Vancouver study undertaken by Washington et al (1986). This indicates *long-term* difficulties with language based intellectual competence. Delays in language development have major implications for the acquisition of reading and spelling skills (Bishop & Adams, 1990), and as such may to a large extent account for later difficulties with educational achievement and learning difficulties in this group of children.

Attention Deficit and Hyperactivity in VLBW children.

Restlessness and hyperactivity are frequently recorded in studies of VLBW children (Marlow *et al* 1993, Mc Cormick *et al* 1990, Teplin 1991 *et al,* Saigal *et al* 1991) Measures include parent and teacher ratings according to child behaviour checklists such as the Conners, Adelaide and

Achenbach rating. Some studies recorded the presence of hyperactivity in their VLBW samples, but did not always indicate the method or measure used (Hack 1992). None of the studies reviewed used the DSM criteria for attention deficit hyperactivity disorder (ADHD). It is not clear what overall percentage of VLBW population have problems in this area. It is also unclear if the *ELBW* group show more evidence of ADHD.

Head circumference and intellectual function in VLBW children:

The existence of a relationship between head circumference and brain development has been reported by many investigators and it has been suggested that head growth may be of prognostic significance for intellectual development (Babson 1974, Dunn 1986, Hadders Algra *et al* 1990)

Amelioration of the impact of a preterm birth of an infant of very low birth weight - Intervention attempts.

Few centre based intervention programmes have directly targeted VLBW children. The Infant Health and Development Programme (IHDP) was a multisite randomised clinical trial to test the efficacy of educational and family support services over and above high quality pediatric follow up and referral offered in the first three years of life on reducing the incidence of developmental delay in LBW pre-term infants (Mc Cormick *et al* 1993). The IHDP was based on the premise that LBW infants would benefit from the types of intervention used successfully for socio-economically disadvantaged children. The IHDP employed a randomised controlled trial over eight different sites with varying sociodemography and health care use for 280 children weighing less than 1500grams at birth. One third was allocated to intervention and two thirds to follow-up only. Surveillance was offered to the entire group. The intervention group received weekly home visits for the first year and fortnightly visits thereafter, centre based educational intervention for five days a week and parent support groups. This was provided from three to 36 months of age at which stage all children were assessed for cognitive development on the Standford Binet, behavioural competence on the Achenbach and health status. Despite the heterogeneity of the sample, there were substantial improvements in cognitive development in all but the lowest IQ groups and CP children. The 29 cerebral palsied children were said *not to have benefited* from an intervention of the nature provided; these were also the children with lower IQ (below 70). Differences in behaviour scores were not found between groups. The attrition rate was low, with 92.7% of children remaining in the programme.

Physiotherapy intervention for VLBW infants; findings from a study conducted at the University of the Witwatersrand

A group of eighty babies with birth weights <1700 grams and gestational age <34 weeks were allotted to normal, at-risk and impaired groups at 3 months corrected age, according to a neurodevelopmental score (Rothberg 1991). Children who needed definite intervention were all seen. Within the normal and at risk groups, infants were alternately assigned to intervention and non intervention groups. Intervention constituted being seen once a month and mothers being provided with a home programme for the first year. Follow-up beyond the first year was scheduled to include at least two visits per year for the following two years. During this time children were assessed for further intervention and school readiness. At six years 49 children were fully evaluated and no differences between the physiotherapy intervention and control groups were found. None of these children had a Griffith DQ below 84 at the six year assessment and the only significant subtest score difference was on the locomotor subtest. The findings suggested that the type of intervention offered yielded no short term benefit.

CHAPTER THREE

METHODOLOGY:

The methods used included two pilot studies and the main study of VLBW children and their full term peers.

3.1 PILOT STUDIES

Two pilot studies were undertaken:

3.1.1 Pilot 1 - Test Use:

The first pilot study involved an investigation into the appropriateness of the use of tests for visual perception (VP) and motor skill (MS). There were no tests for VP or MS standardised on South African children.

Occupational therapists working with children with a variety of developmental problems in various service settings in the Western Cape were pre-selected, approached and interviewed to determine which tests were most frequently used and found to be most appropriate for local populations.

3.1.2 Tests of Visual Perception:

1) The Southern California Sensory Integration Tests (SCSIT) (Ayres 1980), was a test battery commonly used by occupational therapists locally and country wide. The test was standardised on children in the USA but has been revised in the USA as the Sensory Integration and Praxis Test (SIPT)(Ayres 1989). The revised version needs specific training and certification for use in the USA and the results are analysed by mainframe computers in California, making it inaccessible and impractical for use outside the USA. Despite the revision, the "old" SCSIT is still widely used by South African certified users. The full test requires approximately one and three quarter hours to

administer and is frequently done in two sittings, particularly with preschoolers.

2) The Gardner Test for visual perceptual skills (Gardner 1982) has been used in Cape Town since the mid nineteen eighties, but therapists did not recommend it for preschoolers as they felt it was too long and not sufficiently interactive.

3) The Developmental Test of Visual perception (commonly referred to as the Frostig Test (Frostig 1961)) was widely used until the late nineteen seventies, but became discredited because of criticisms of the validity of certain subtest components. These have subsequently been revised in 1991. The revised version (DTVP-2) (Hammill 1993) had extensive reliability and validity research done, was nationally standardised in the United States of America and has been used by some institutions and therapists in private practice in the Western Cape. The test has motor reduced visual perceptual sub-tests and visual motor sub-tests, making it amongst the most comprehensive perceptual tests currently available. It takes approximately thirty to forty minutes to administer. Therapists were aware that the various socio-economic and cultural groups may achieve differently on tests for visual perception, primarily, perhaps, due to varying exposure. Kindergarten and junior school teachers from a variety of areas in the Cape Peninsula were asked to consider the items of the DTVP-2 test and to judge whether the requirements would be too foreign or obscure for their school populations. The general consensus was that children would have to master very similar visual and visual motor sets to the test items of the DTVP-2 once they go to school.

3.1.3 Visual Motor Integration Test:

The Developmental Test of Visual-Motor Integration by Keith Beery (1989) was one of the most widely used tests in the Western Cape. It was also frequently used by other child specialists. It is a pencil and paper test where geometric forms are copied in order of developmental difficulty, thus combining visual perceptual skills with eye hand coordination in drawing. It is easy to administer and score.

3.1.4 Motor tests:

The Test of Motor Impairment (Stott 1984) (TOMI) (Henderson revision) was isolated as a commonly utilised motor test. The test has been standardised on US and British children and used on VLBW pre-school populations elsewhere (Drillien 1980, Marlow *et al* 1989, Roth *et al* 1994)

Therapists generally found that its use was appropriate for child populations in the Western Cape and it could be administered in the home in one visit.

The Bruininks Oseretsky Test of Motor Proficiency (BOTMP) (1978) in its complete form was also used. Despite its comprehensiveness, the complete form was found to be too long to do in one sitting, thus making it less popular. The short form was therefore used in preference.

On the completion of the first pilot study, the TOMI and the BOTMP short form were identified as motor tests of choice and the DTVP-2 as the test of choice for visual perception and VMI. The Beery, though found to be a good choice, was discarded as the DTVP-2 had VMI components, as did the Griffiths and it was felt that the inclusion of the Beery would over test this function in the children. The other tests were discarded due to length of administration or problems with current validity. Afrikaans translations for the tests were obtained to ensure uniformity in administration.

3.1.5 Clinical observation of neurological integrity.

Many experienced therapists used a series of non standardised observations and tests, formulated and gathered over time, using experience and clinical judgement in determining difficulties. Many of their observations were also based on other research. This researcher also included a series of clinical observations based on personal clinical experience and on the Touwen & Prechtl (1970), Dunn (1981) and Denkla (1985) guidelines. These clinical observations were used to supplement the standardised tests and are presented in Appendix C.

Names of schools and institutions where therapists were interviewed are presented in Appendix D.

3.2 Pilot 2 - "Try out"

The second pilot study involved the trial of the selected tests on a group of children without problems attending pre-school. This investigated how long it would take to administer the tests. As the research team from the GSH NICU were only able to allocate one day a week over six to seven months for this research work, the children from the VLBW study cohort had to be assessed in one visit to complete the work in the allocated time. This portion of the pilot study was undertaken with 5 year old children at a hospital creche preschool with the approval of their parents, to determine if four children (two in the morning and two in the afternoon) could be assessed on the VP and MS tests, observed clinically and mothers interviewed.

This was found to be viable, allowing children a snack break in between tests on the Griffiths and the tests of VP, MS and observation. Fifteen to twenty minutes were allocated for the parent interview to gather demographic data and family information *after* the completion of the children's assessment.

METHODOLOGY OF MAIN STUDY

3.2 STUDY DESIGN:

The research undertaken took the form of an analytic case control study, where an existing group of children of VLBW were examined and compared with a matched set of controls from the same birth cohort. The researcher was blind to the birth history of the children being studied at the time of evaluation.

3.3 SUBJECTS:

3.3.1 VLBW Study population:

The study population was drawn from all the ELBW and VLBW infants born in the period July 1988 to June 1989 at the neonatal unit at GSH or who were born at midwife obstetric units of the PMNS and referred to the NICU at GSH because they were at risk. Those with congenital anomalies, physical handicap, cerebral palsy and sensory loss were excluded from the study, making the selection criteria consistent with procedures used in most investigations of this population group (Aylward *et al* 1989, Escobar *et al* 1991). The course of the complete birth cohort of that given period and their developmental outcomes have been described and published previously (Thompson *et al* 1993) and appears as Appendix A for easy reference. (Reprinted with permission from first author.)

The children in the cohort were Afrikaans and English speaking children, whose parents were not on medical aid, living in urban and peri-urban Cape Town. To ensure some degree of homogeneity, it was decided to assess the seventeen Xhosa first language speaking children separately and to report on their outcomes and findings at a later stage. Molteno (1985) noted that whilst developmental milestones in a group of children from this region were similar to those reported in the literature, there was a fall off in development in later years, closer to school entry. In order therefore to draw meaningful comparisons between ELBW, VLBW & FBW children, matched controls were essential, as the tests used were not standardised on children of this region. Careful matching would also lower the likelihood that the less than optimal social conditions from which the majority of the cohort emanated, would influence performance outcomes.

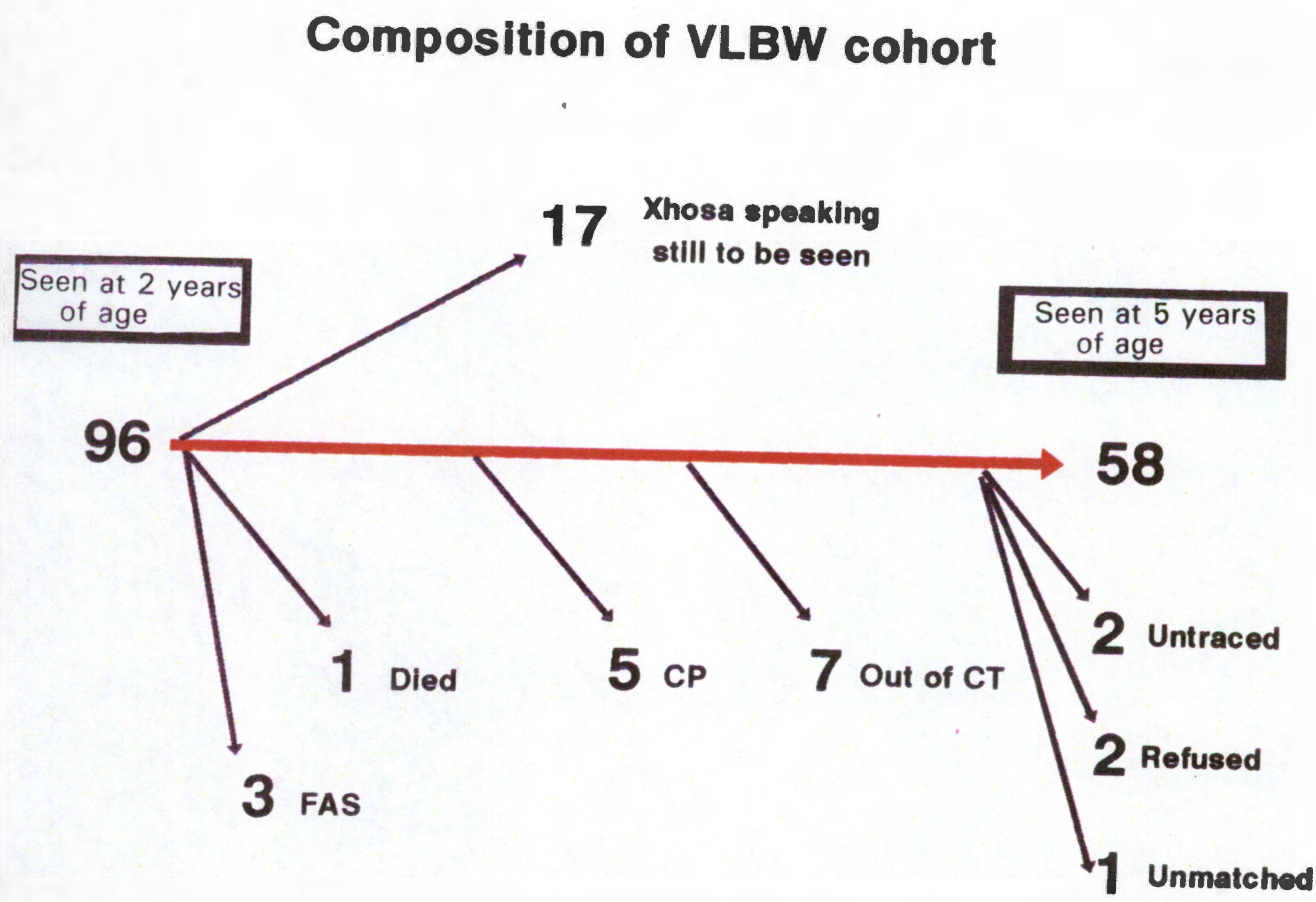
A trained research assistant (CP)* with specific experience in community work and tracing of participants from communities in this region, located the VLBW group and recruited the controls. She also informed participants of requirements, gained their consent and scheduled appointment times in agreement with the NICU researcher, (CMT)*.

The inception cohort assessed at two years of age numbered ninety six children. Of these, seventeen were Xhosa speaking, and excluded from this study but assessed later. At five to six years of age two children were not traced, one child died of a brain tumour, seven children moved outside of the Cape metropolitan area, five children were diagnosed as cerebral palsied (CP) and three with fetal alcohol syndrome (FAS), and were excluded on those grounds. One mother of a set of twins refused participation. One of the study group children was assessed for developmental outcome, but excluded from the study analysis, due to the death of his mother the previous year, making the allocation of a suitable matched control impossible.

* CP = Mrs Connie Phillips & CMT = Dr Clare Thompson

At age five to six years fifty eight children VLBW children were assessed (Figure 1).

FIGURE 1



The mean age of the VLBW group at five to six years was 70.44 months. Their mean birth weight was 1042,67 grams, with a mean gestational age of 32.17 weeks. There were thirty boys and twenty eight girls. There was one set of twins, both boys.

The distribution of the VLBW group in terms of birth weight, age and sex are presented in table 2 and the distribution with regard to age, sex and growth status are presented in table 3. Fourty five out of fifty eight VLBW children were SGA; a little over 77%.

TABLE 2:

VLBW study group distribution according to birth weight

Birth weight	Number	Mean age	Sex
Below 999g	21	71.08 mts	11 boys, 10 girls
1000 - 1250g	37	70.35 mts	19 boys, 18 girls

TABLE 3

VLBW study group distribution according to growth status

Growth status	Number	Mean age	Sex
AGA	13	70.29 mts	8 boys, 5 girls
SGA	45	70.71 mts	22 boys, 23 girls

<u>3.3.2 Selection of controls</u>:

This study selected neighbourhood and family controls to match current socio-economic situation of the family. The following factors were controlled for:

Socioeconomic class.

Housing type and household density.

Marital status and intactness of family.

Breadwinner/s and work type.

The primary carer.

Maternal education and age.

Number of siblings and the rank of sibship.

Preschool or creche attendance.

In some instances relatives such as cousins of the index children were used as controls. The controls were all fullterm with full birth weights. The mean age of the control group was 69.99 months. The study attempted to ensure that the socio-environmental factors were as similar as possible for the VLBW and control children, in this way ensuring similarity in confounding environmental influences.

As a significant number of children in the birth cohort of this study, in both the study population and control sample, came from socioeconomic groupings that could be described as disadvantaged, the group was a fairly homogeneous group from urban, peri-urban communities in an area of the Western Cape.

3.4 Methods and Instruments:

All the 59 study group children (58 plus one unmatched child) and the 58 matched controls were assessed personally by the researcher. Apart from eight controls that were not assessed on the same day as their VLBW match, the rest of the VLBW children were seen on the same morning or afternoon assessment session as their controls as planned according to the second pilot study.

The children were assessed in a specifically allocated room in the Department of Neonatology of the Department of Paediatrics, University of Cape Town in the old GSH block. Where possible they were accompanied by their mothers or in some instances by both their parents. Parents and children were provided with snacks and a return travel fare.

All the children in the study population and their controls were assessed on the Griffith Mental Development Scale (Griffith's) by CDM * and CMT. The Griffiths was the measure previously used by the NICU at GSH, in studying the outcomes of this cohort at one and two years of age. The Griffiths has already been used in South Africa (Rothberg & Goodman 1991, Thompson 1993, Neser 1989, Buccimazza 1990)

* CDM = Prof. Chris Molteno

and in other parts of the world in assessing LBW and other at risk populations (Hanson 1987, Roth 1994, Stjernqvist 1995)). Studies done in SA and elsewhere have shown positive correlations with the JSAIS (Junior South African Individual Scale Intelligence Test), Bayley scales and the Griffiths (Heimes 1983, Ramsay 1980).

All children were assessed anthropometrically for height, weight and head circumference. The head circumference was measured with a tape placed over the supra orbital ridges and the occipital protuberance and the highest value was recorded.

The following assessments were done on the children by this researcher:

The tests were consistently given in the following order:

1) Developmental Test for Visual Perception (DTVP - 2)

This tests comprises eight subtests:

1. Eye Hand Coordination (EHC). Measures the ability to draw precise straight or curved lines in accordance to visual boundaries.
2. Position in Space (PS). Measures the ability to match figures according to their common features with regard to spatial positioning.
3. Copying (CO). Measures the ability to recognise the features of a design and to draw it from a model.
4. Figure-Ground (FG). Measures the ability to see specified figures even when they are hidden in a rival background with confusing complex material.
5. Spatial relations (SR). Measures the ability to connect dots with pencil on paper to reproduce visually presented patterns.
6. Visual Closure (VC). Measures the ability to recognise a stimulus figure when that figure has been incompletely

drawn.

7. Visual Motor Speed (VMS). Measures the rapidity with which a child can make certain marks in certain designs.

8. Form Constancy (FC). Measures the ability to match two figures that vary on one or more discriminating features (i.e. size, position, and/or shade)

PS, FG, VC and FC constitute the "pure" visual perceptual tests, free of, or reduced in motor components; requiring only the ability to indicate the correct stimulus on the part of the child. They measure the Motor-Reduced Visual Perceptual Quotient (MRVPQ).

EHC, CO, SR and VMS constitute the ability to combine visual perception with more integrated complex eye hand coordination tasks and measure the Visual Motor Integration Quotient (VMIQ)

Together the MRVP and VMI tests make up the composite General Visual Perception Quotient (GVPQ).

2) Test of motor impairment (TOMI)

Abilities assessed by the TOMI are:

<u>1) Manual dexterity:</u>

1.1 Posting coins into container with preferred and non-preferred hand (Time taken).

1.2 Threading beads onto a string (Time taken).

1.3 Drawing a line on a track shaped like a flower with pen with least deviation.

<u>2) Ball handling skills:</u>

2.1 Catching a bean bag

2.2 Rolling a tennis ball into a goal.

<u>3) Static Balance</u>:

One leg stands - preferred leg and non preferred leg.

<u>4) Dynamic balance:</u>

4.1 Jump over a cord at set heights

4.2 Walk a number of steps with heels raised

Particular strengths of the TOMI tests are :

1 easy to administer and demonstrate,

2 simple to score, objectively,

3 involves simple equipment, easy to assemble and carry,

4 equally familiar to boys and girls

5 requires minimal verbal comprehension or memory from the child,

6 requires minimal visual perceptual skill

3) Bruininks Oseretsky test for Motor Proficiency (short form)

Areas assessed by the scale are described by the following sub-tests:

1 Running speed and agility - consists of a 30 yard shuttle run.

2 Balance : assesses the child's ability to maintain bodily equilibrium in:

i) a stationary position (standing on a preferred leg on a balance beam).

ii) an act of movement (walking forward heel to toe on a balance beam).

3 Bilateral coordination: assesses the child's ability to coordinate hands, feet or hands and feet in various sequential or simultaneous patterns using both sides of the body.

4 Strength: uses broad jumps to test distance and landing stance.

5 Upper limb coordination: Assesses the child's abilities to track visually and to coordinate eyes and hands in gross motor skill (catching a tossed ball and throwing a ball at a target)

6 Response speed: measures speed of hand and arm response to a moving visual target.

7 Visual Motor control: assesses fine eye hand coordination using paper and pencil tasks.
8 Upper limb speed and dexterity: measures manipulative dexterity (sorting cards) and hand & arm speed (making dots in circles with the preferred hand).

The subtest structure is based upon literature on the motor development of children, a factor analysis of test items and results previously published factor analyses. The 14 item short form was constructed from data obtained in the standardisation program, based on the following characteristics:
1 the size of the correlation between the item and its subtest and total test scores,
2 the range of ages for which the item provided significant and useful information about motor proficiency,
3 the amount of time needed to arrange equipment and administer the item,
4 the ease of scoring.
Adaptations of the Bruininks Oseretsky test had been used elsewhere in studies on VLBW children (Teplin *et al* 1991 Smedler *et al* 1992)

This study chose the use of two tests, one standardised on a North American sample (Bruininks Oseretsky) and the other on a British and US sample (TOMI - Henderson revision).

4) Clinical observations of neurological integrity accompanied the visual motor integration, fine motor and gross motor tests. The series of clinical observations were based on the observations of Touwen & Prechtl (1979) Dunn (1981) and Denkla (1985). Children who were experiencing difficulties with aspects of the motor tests were examined additionally, to determine possible underlying cause. Appendix C details these observations.

5) Parental interview and feedback

Mothers were interviewed through a semi-structured interview format to determine socio-environmental indicators, parental perceptions about their child's functional abilities, motor control (gross and fine), exposure to pencil/crayon and paper tasks and behaviour. Where appropriate, parents were asked about attempts to find help if problems were experienced (Appendix B).

Upon completion of all tests, parents were given feedback on their child's abilities.

6) Attention deficit and hyperactivity

The criteria for measuring the presence of ADD and ADHD, were according to the DSM-IV-R (1994), determined by recordings of deficits in attention and inability to inhibit activity levels by two evaluators and the parental testimony (Appendix B).

3.5 Analysis of results:

3.5.1 Raw data:

On the data capture sheet (Appendix E), the following data has been summarised: child number, classification into VLBW and matched control (C), age, sex, birth weight, gestational age, growth status (AGA or SGA), DTVP-2 quotients MRVPQ, VMIQ and GVPQ, Griffiths, subtests and total scores expressed in quotients, TOMI total scores and BOTMP percentile scores.

The inability of the child to complete the test accounts for the missing values for some tests. In such instances the missing value was excluded from analysis. However in feedback to parents refusal to carry out a test was interpreted that the children themselves believed they could not perform or that disturbed behaviour interfered with performance. In such an instance the behaviour was recorded and related to parents.

3.5.2 Correction for preterm birth:

All the scores on the tables of the standardised tests for the VLBW preterm children were *read against their uncorrected age.*

3.5.3 Socio-environmental description:

A coded questionnaire was used for the socio-demographic data collection according to the Parent Interview Questionnaire (Appendix B). The socio-demographic variables (Appendix F) were grouped together to determine if the VLBW and control groups were well matched. To compare the two groups of categorical variables, a Chi - square test or Fisher's exact test was used.

3.5.4 In comparing the VLBW and control groups on all standardised measures or dependent variables, unpaired t tests were used. Unless stated otherwise the Mann-Whitney Two sample test (Kruskal-Wallis test for two groups) was used to determine the probability value (p-value), which was set at the conventional p equal to or less than 0,05 as significant.

The EPI Info Version 5 and 6 software packages were used for analysis of data.

CHAPTER FOUR

RESULTS

Sociodemographic details

The majority of families from the entire cohort (VLBW & Control) came from home environments where the children's mother had not completed schooling beyond standard eight and over 70% of breadwinners were in manual employment in semi and unskilled labour or unemployed at the time of their child's assessment. More than half were in the socioeconomic grouping where they were either failing to make ends meet or barely managing financially. This meant that a number of families were experiencing financial hardships that bordered on or constituted poverty.

The two groups were well matched socio-demographically. In comparing the VLBW children and control children on fourteen variables, no statistically significant differences were found on class, housing type and density, marital status and family intactness, who the breadwinner was and the type of work of the breadwinner/s, who the primary carer of the child was, the maternal educational level, age and her employment status, number of siblings and rank of sibship and whether the child attended preschool or not.

The socio-demographic variables, comparing the two groups are presented in Appendix F.

The anthropometric characteristics of the VLBW group and control groups are presented in Table 4. A further breakdown and comparison of the VLBW group for gestational age (SGA versus AGA), presented in Table 5.

Table 4
ANTHROPOMETRIC DETAILS OF INDEX AND CONTROL GROUPS:

	VLBW group n=58	**Control group** n=58
Mean pre-school age in months:	70.62	69.98
Median interquartile range	61.83-80.03	57.16-77.43

	VLBW	Controls
Pre-school **mean weight** in kilograms:	16.98	19.16
Range:	11-21	15-27
Standard deviation:	1.98	2.56
	*p-value:0.000029	

Pre-school **height** in centimeters:	VLBW	Controls
Mean:	110.48	112.91
Range:	91 - 128	101 - 132
Standard deviation:	5.66	6.36
	p-value:0.059622	

Pre-school **head circumference** in centimeters:		
Mean:	49.82	50.74
Range:	44.5-53	48.5-53
Standard deviation:	1.49	1.11
	*p-value:0.001218	

Table 5

Anthropometric details of SGA and AGA sub-groups in the VLBW group:

	AGA N = 13	SGA N = 45
Pre-school mean **weight** in kilograms:	17.4	16.9
Range:	16 - 19.5	11 - 21
Standard deviation:	1.1	2.2
	p value: 0.306301	

	AGA n = 13	SGA n = 45
Pre-school mean **height** in centimeters:	110.62	110.44
Range:	100-119	91-128
Standard deviation:	4.57	6
	p value: 0.573526	

Table 5 continued:

	AGA	SGA
Pre-school mean **head circumference** in centimeters:	50.01	49.73
Range	47 - 53	44.5 -52
Standard deviation:	1.59	1.48
	p value: 0.524564	

No statistically significant differences on anthropometry were recorded between SGA and AGA VLBW children.

There were also no statistically significant differences between the ELBW and VLBW groups on anthropometry.

Performance on standardised measures:

The VLBW group and control groups were compared by unpaired t-tests on the four standardised measures or dependent variables. Unless stated otherwise, The Mann-Whitney Two sample test (Kruskal-Wallis test for two groups) was used to determine the p-value, which was set at the conventional p equal or < 0,05 as significant.

The results were all highly significant.

Comparison of VLBW group with controls on the Griffith's: (First objective)

The results of the Griffith's are presented in table 6. The scores presented in bold type are quotients.

The scores presented on Figures 2 and 3 are quotients.

TABLE 6: GRIFFITH'S SUBTEST SCORES OF VLBW AND CONTROL GROUPS

GRIFFITH'S QUOTIENTS OF VLBW AND CONTROLS:

Mean (range) Test Scores given as quotients:

TEST		VLBW	CONTROL	p-value
Locomotor		**109**	**116**	
	range:	(72 - 127)	(100 - 140)	0.000707
	std dev:	10.18	9.87	
Personal Social		**100**	**107**	
	range:	(78 - 128)	(84 - 129)	0.002381
	std dev:	11.20	11.11	
Hearing & Speech		**85**	**92**	
	range:	(64 - 113)	(66 - 123)	0.001829
	std dev:	9.75	10.90	
Eye Hand Coordination		**89**	**96**	
	range:	(65 -118)	(67 - 126)	0.003164
	std dev:	11.12	12.43	
Performance		**85**	**95**	
	range:	(60 - 115)	(65 -129)	0.000737
	std dev:	11.64	15.36	
Practical Reasoning		**83**	**93**	
	range:	(58 - 120)	(72 - 119)	0.000051
	std dev:	11.95	10.94	
Composite Griffith's Developmental Quotient (DQ):		**92**	**100**	
	range:	**(76 - 109)**	**(81 -117)**	**0.000008**
	std dev:	**7**	**7**	

All the p-values indicate a significant difference between VLBW and Control groups.

34.5% (20 children) of the VLBW group achieved a Griffith's DQ below 90, as opposed to **8.6%** (5 children) of the control group.

Two VLBW children achieved a DQ below 80 and none below 76. None of the control children achieved a DQ below 80 (Figure 2).

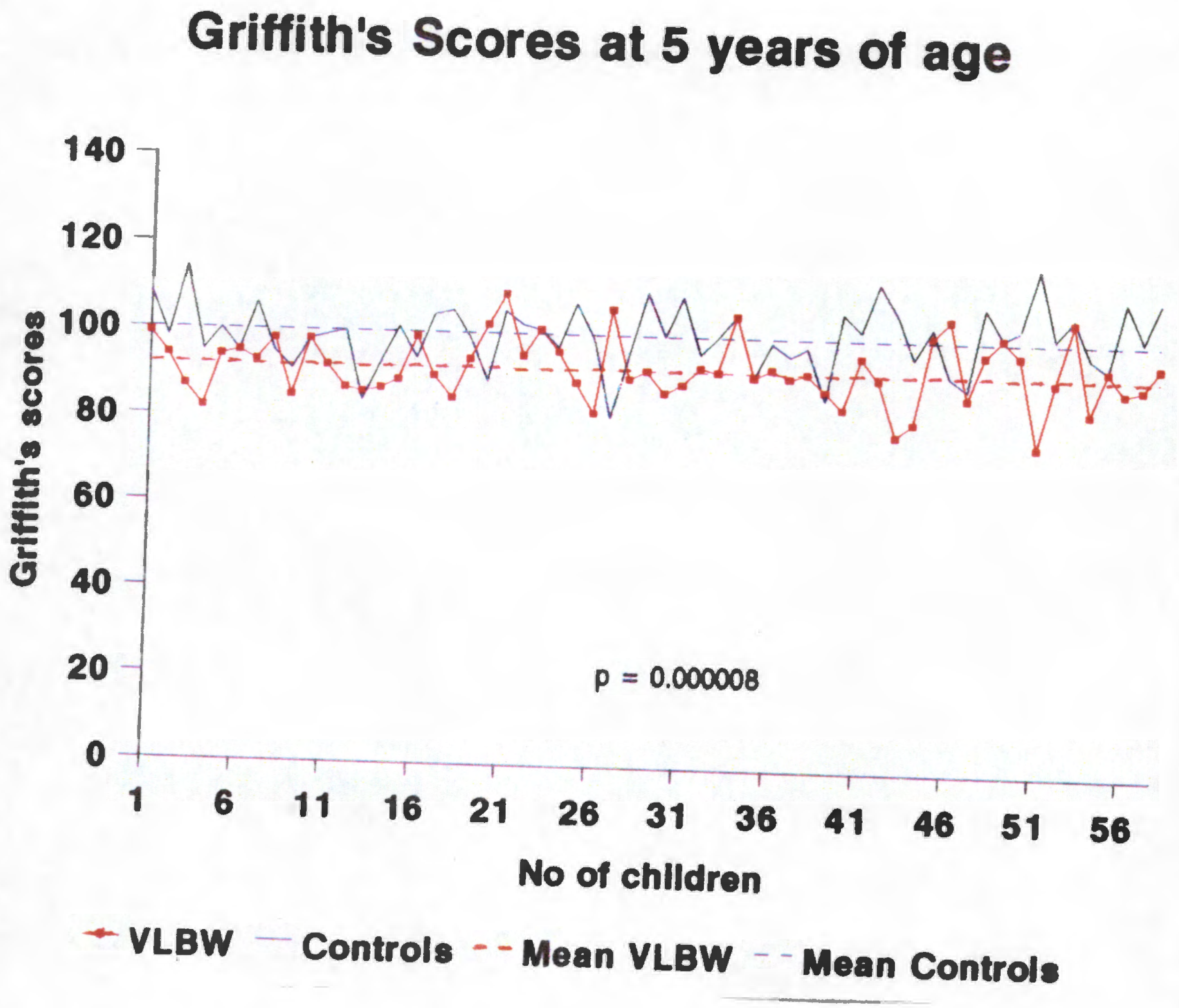


FIGURE 2

Griffith's Quotients of 58 VLBW and 58 controls

No significant differences were found in the Griffith's DQ's of the boys and girls of either the VLBW or control groups. The mean DQ of the VLBW boys was 92,5 and that of the girls 92.2, with a probability value of 0,993784.

On the Griffiths Scales of Mental Development, particularly large mean differences of seven or more points were obtained in the subtests, with more than ten scale point differences on Performance and Practical Reasoning.

As can be seen from Figure 3, the mean subtest totals of Hearing and Speech, Eye Hand Coordination, Performance and Practical Reasoning were all below 90 in the VLBW group with the controls achieving above 90 on all subtests.

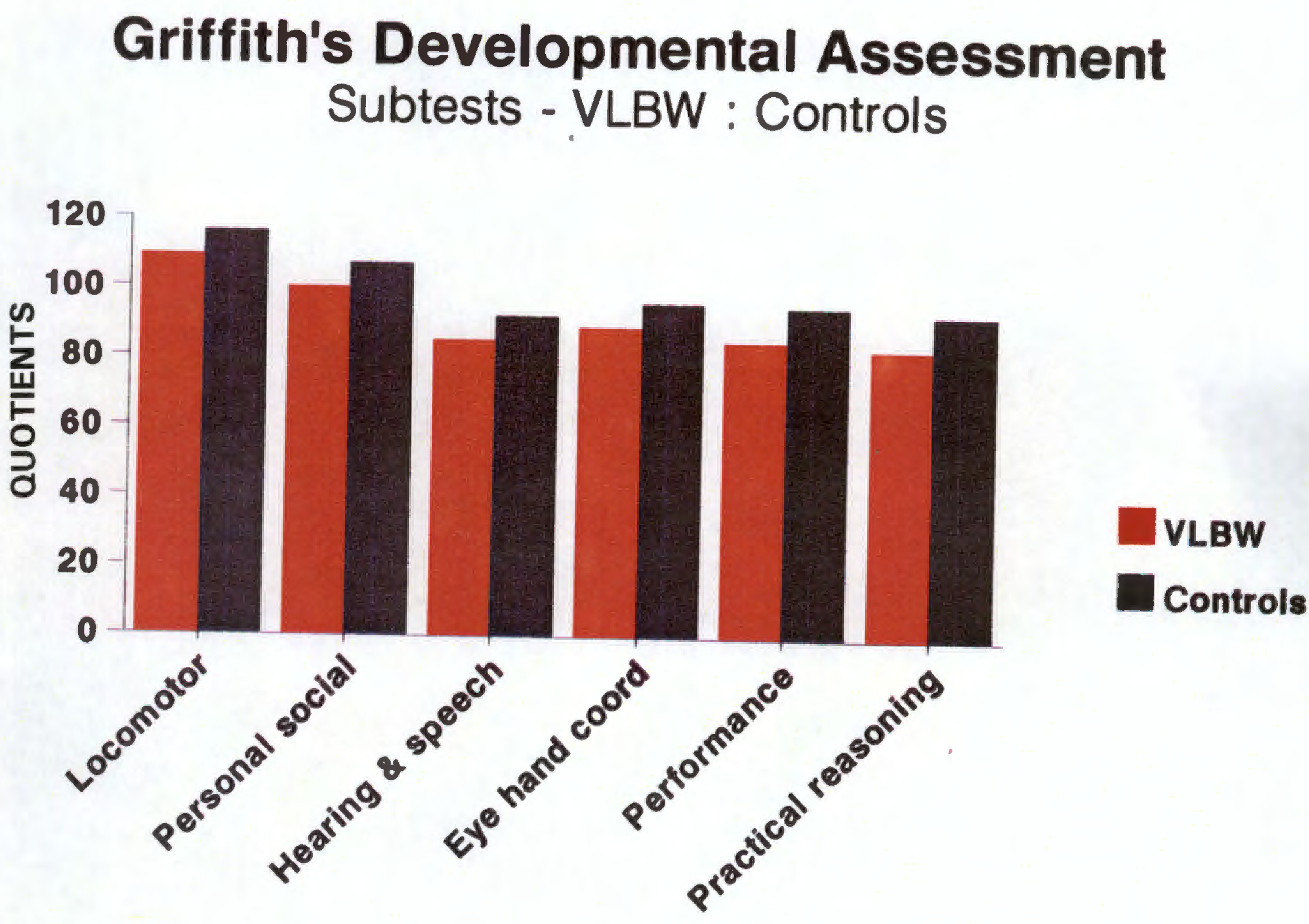


FIGURE 3

GRIFFITHS'S SUBTEST RESULTS OF VLBW AND CONTROL GROUPS

The Griffiths DQ's of the AGA (13 children or 22%) and the SGA (45 children or 78%) groups were compared through an analysis of variance. The Mean DQ of the AGA group was 93

and that of the SGA group was 92 with no statistical difference between the two (p-value 0.669033).
The same analysis was repeated with the three birth weight categories of the VLBW group, those weighing below 900grams (11 children or 19%) those weighing between 900 and 999grams (10 children or 17%) and those weighing 1000 grams and more (37 children or 44%). The mean DQ's were 91, 93.5 and 92 respectively with no statistically significant differences between the three groups.

Findings on the Developmental Test for Visual Perception - second edition (DTVP-2): Comparison between VLBW children and controls for VP and VMI. (Objective 2)

Table 7: VISUAL PERCEPTUAL FUNCTION:

Developmental Test of Visual Perception - DTVP-2			
Individual tests standard scores (SS) presented as means*			
	VLBW SS	Control SS	p-value
Eye Hand Coordination:	8.2	9.1	0.0003764
Position in Space:	7.5	8.9	0.000318
Copying:	8.4	9.7	0.000307
Figure Ground:	9.3	10.6	0.009122
Spatial Relations:	7.1	8.1	0.001316
Visual Closure:	5.9	6.8	0.023361
Visual Motor Speed:	9.2	10.1	0.0003764
Form Constancy:	10.8	12.2	0.000321

* A mean score below 8 denotes subnormal function

The standard scores of subtests of position in space and spatial relations were below 8 in the VLBW group and that of visual closure was below 8 for both groups.

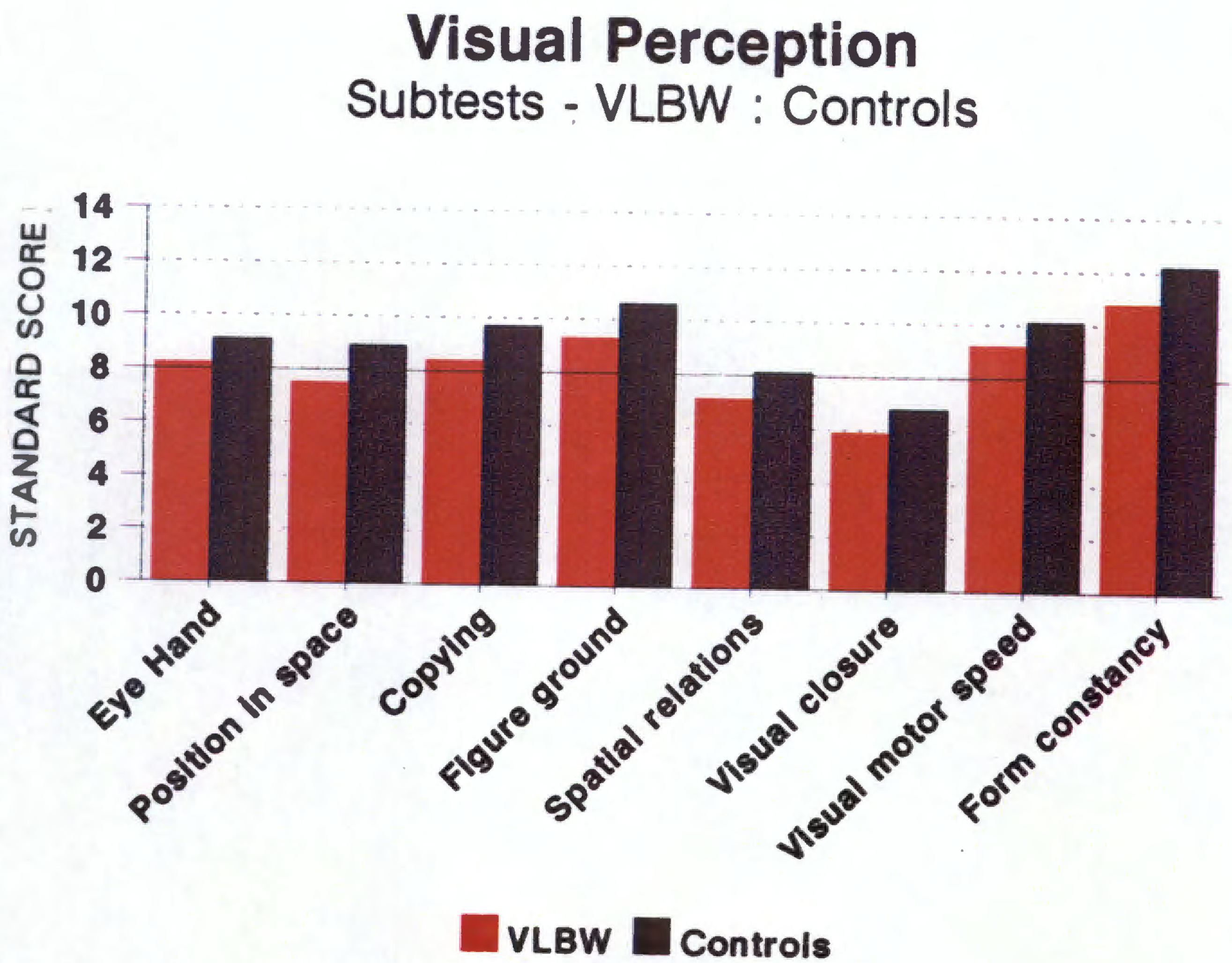


FIGURE 4

DTVP-2 SUBTEST RESULTS FOR VLBW AND CONTROL GROUPS

TABLE 8: DTVP 2 - COMPOSITE SCORES

DTVP 2 - Composite scores: Given in means (range): SD = standard deviation	VLBW:	Control:	p-value:
General Visual Perceptual Quotient (GVPQ): SD:	87.47 (68-104) 9.2	96.55 (71-130) 9.4	*0.000018
Motor Reduced Visual Perceptual Quotient (MRVPQ): SD:	89.64 (67-107) 10.2	97.76 (73-125) 9.8	*0.000121
Visual Motor Integration quotient (VMIQ): SD:	86.86 (68-106) 9.3	95.29 (72-133) 9.1	*0.000036

* all p-values statistically significant

Descriptive details from standardisation sample (DTVP-2 1993):

Quotients:	Rating:	Quotients:	Rating:
> 130	very superior	80-89	below average/ borderline
121-130	superior		
111-120	above average	70-79	poor
90-110	average	<70	very poor

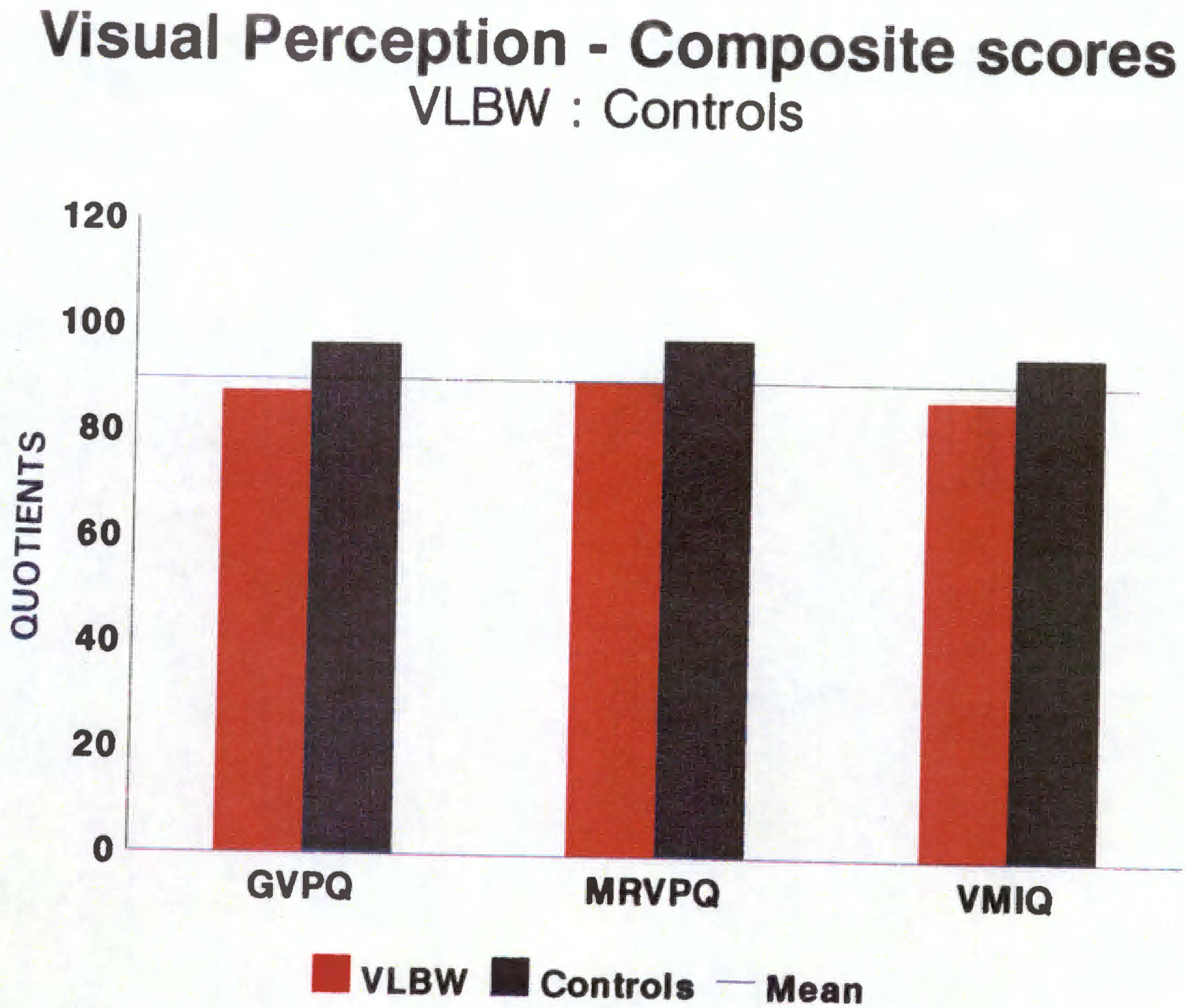


FIGURE 5

DTVP-2 COMPOSITE SCORES OF VLBW AND CONTROL GROUPS

<u>Comparison of this cohort with the standardisation sample:</u>
The GVPQ of more than half (53% or 31 children) of the VLBW group was recorded below 90 as compared to 15.5% (9 children) of controls. Of the thirty one children in the VLBW group scoring below 90, ten scored between 70 and 79 and two below 70. Only two control children scored below 80 and none below 70.

The MRVPQ of 46% (27 children) of the VLBW group was recorded below 90 as opposed to 17% (10 children) of controls.

The VMIQ of 60% (35 children) of the VLBW group was recorded below 90 as opposed to 21% (12 children) of controls.

Intra-Ability discrepancy analysis on the DTPV-2

A difference score between the quotients (MRVPQ & VMIQ) of 9.3 or more is considered to be significant.

In conducting a difference analysis, it was found that 17 children (29%) in the VLBW group had performed significantly poorer on visual motor integration than motor reduced visual perceptual tests compared to 8 of their normal birth weight controls (13%) This constitutes a significant difference, with a probability value of 0,0421266.

Comparison of VLBW with controls on motor function: (Objective 2)

Results from the TOMI and BOTMP are presented in tables 9 and 10 and illustrated in figures 6,7 and 8.

Table 9: RESULTS ON TEST OF MOTOR IMPAIRMENT

TEST OF MOTOR IMPAIRMENT (TOMI) Combined and individual scores shown as median (interquartile range): Lower scores indicate fewer problems

	VLBW	Control	p-value
Combined scores:			
Manual dexterity:	1.4 (0-6.0)	0.5 (0-3.0)	0.000625
Ball skills:	0.6 (0-3.0)	0.2 (0-2.0)	0.003698
Dynamic balance:	0.9 (0-6.0)	0.3 (0-2.0)	0.001637
TOMI TOTAL:	**1.5 (0-12.50**	**0.5 (0-5.0)**	**0.001661**

TOMI Score interpretation according to standardisation sample:

Scores equal and below 3.5 are considered to be within mean range.

Scores between 4 and 5,5 suggest a moderate motor problem; in the standardisation sample 10% of children scored in this range.

A score of 6 or more indicate a definite motor problem.

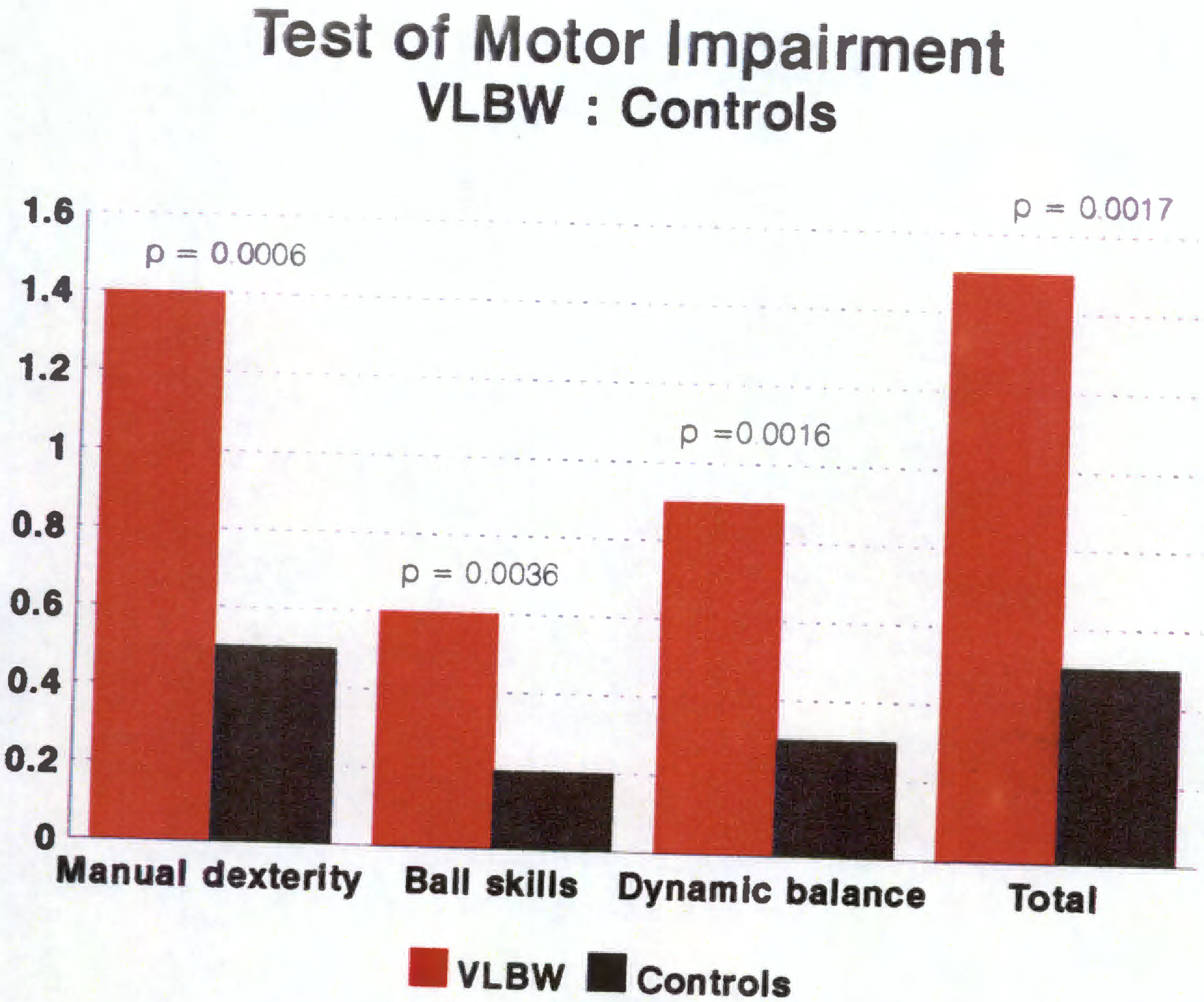


FIGURE 6

RESULTS ON SUBTESTS OF TEST OF MOTOR IMPAIRMENT

Comparison of this cohort with the TOMI standardisation sample:

The total mean score of the VLBW and control populations of this cohort was below 3.5, and therefore within normal range.

Mild to moderate motor problem:

Seven children from the VLBW group (12%) scored between 4 and 5,5 on the TOMI Total, suggesting a mild to moderate motor problem. Two children in the control group (3%) scored in this range.

Definite motor problem:

Twelve children in the VLBW group scored above 6 (22%); six girls and six boys. None of the controls scored above 6.

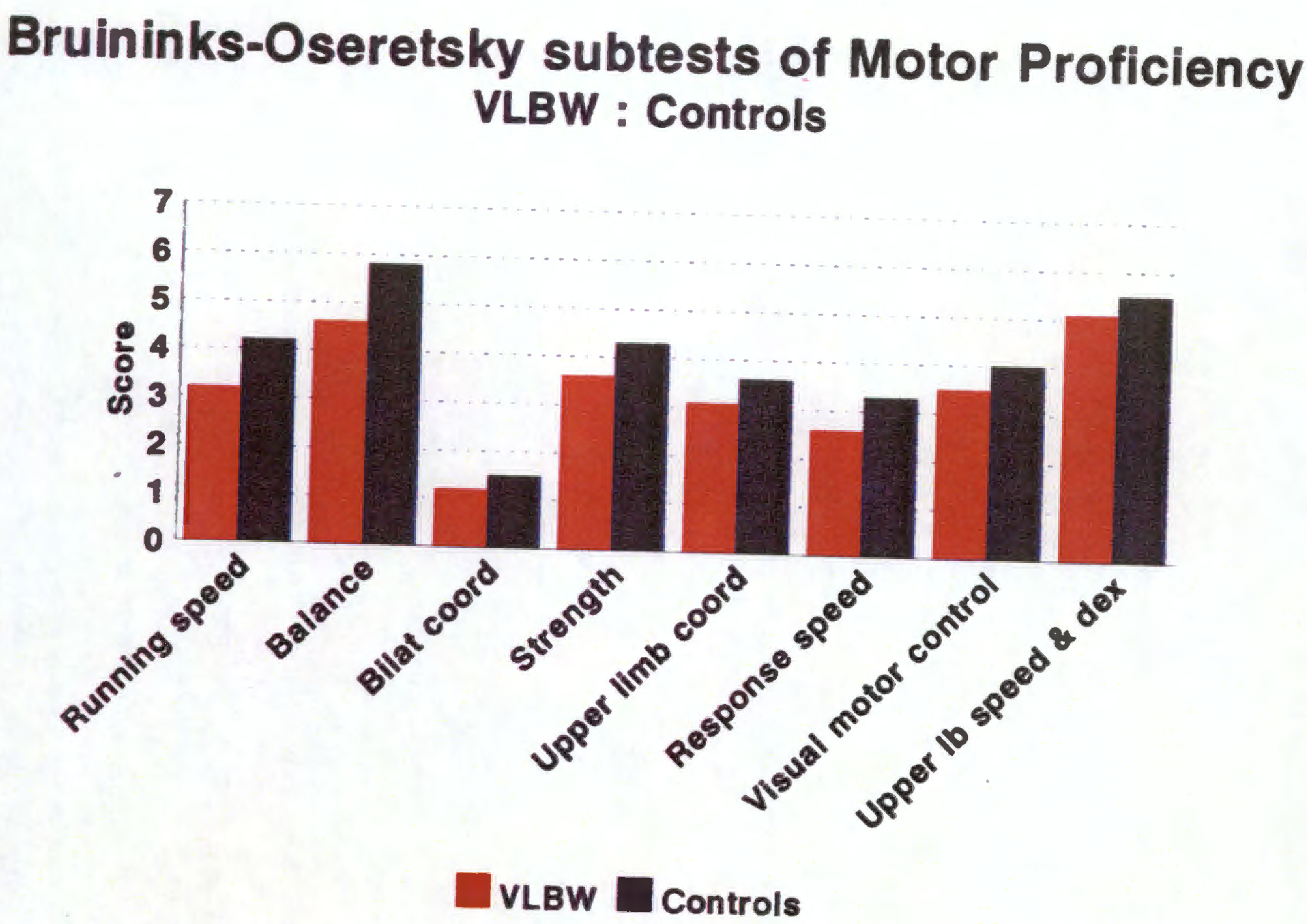
The accompanying clinical observation checklist confirmed a combination of problems with muscle tone, posture, trunkal stability, associated reactions and upper limb functions such as diadochokinesis, thumb-finger-touching, pencil grip and control and motor planning in the 19 children with moderate to definite motor problems.

Table 10 : BOTMP subtest results:

BRUININKS - OSERETSKY test of motor proficiency - short form (BOTMP)
Subtest point score (PS), standard scores, percentiles and stanines are shown as mean:
Standard deviation is recorded as SD

Subtests 1-8		VLBW group PS	CONTROL group PS	p-value
Running speed (BOTMP1)		3.2	4.2	0.004627*
	SD:	1.8	1.5	
Balance (BOTMP2)		4.6	5.8	0.003466*
	SD:	2.1	2.2	
Bilateral Coordination (BOTMP3)		1.2	1.5	0.005892*
	SD:	0.6	0.7	
Strength (BOTMP4)		3.6	4.3	0.004827*
	SD:	1.4	1.2	
Upper limb coordination (BOTMP5)		3.1	3.6	0.025462
	SD:	1.3	1.1	
Response speed (BOTMP6)		2.6	3.3	0.007494*
	SD:	1.6	1.4	
Visual Motor Control (BOTMP7)		3.5	4.0	0.037917
	SD:	1.4	1.2	
Upper limb speed and dexterity (BOTMP8)		5.1	5.5	0.164170
	SD:	1.6	1.5	
BOTMP Standard Score:		**49.36**	**57.33**	**0.000020***
BOTMP Percentile:		**49.38**	**71.94**	**0.000023***
BOTMP Stanine		**4.8**	**6.4**	**0.000017***

* p-value significant



KEY: Bilat coord = Bilateral coordination.Upper limb coord = Upper limb coordination. Upper lb speed & dex = Upper limb speed and dexterity.

FIGURE 7

BOTMP SUBTEST RESULTS OF VLBW AND CONTROL GROUPS

Comparison of this cohort with BOTMP standardisation sample for the short form.

Standard scores: Standard scores between 43 and 57 are considered average.

Stanines: stanines are standard scores that range from low (1) to high (9). Stanines of 4, 5 & 6 are average.

Percentile ranks: Percentile ranks range from 1 to 99, with 50 representing the average.

The VLBW and control group means were both within the average range on standard scores, stanines and percentiles on the BOTMP short from.

<u>Comparison of VLBW and controls on the BOTMP short form:</u>
The differences between VLBW and controls were again highly significant on the composite scores. Unlike the TOMI the upper limb strength, coordination and control functions were not as significantly different in the BOTMP (Fig 8).

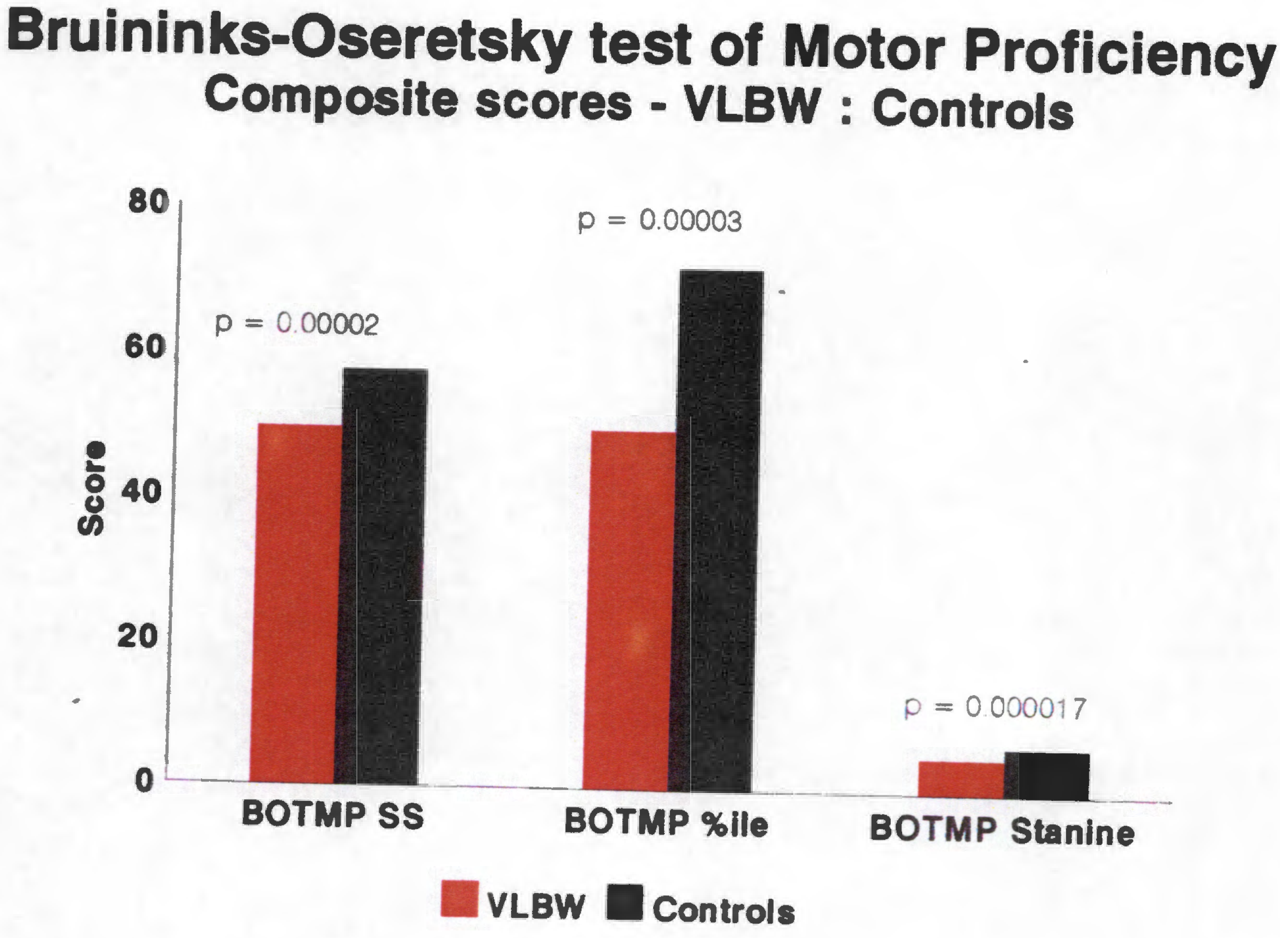


FIGURE 8

BOTMP COMPOSITE SCORES FOR VLBW AND CONTROL GROUPS

Of the twelve children that were found to have definite motor problems on the TOMI, ten (5 girls & 5 boys) also performed below the 23rd percentile on the BOTMP *these were all VLBW children (17% of the VLBW group)*. As none of the control children fell into this grouping the difference is highly significant.

Agreement between TOMI and BOTMP:

On examining the correlation (Pearson's product moment correlation) and level of agreement (Kappa analysis of agreement) between the TOMI and BOTMP on the whole population tested, there was a good agreement, beyond chance, between these two tests. An analysis of agreement is more valuable in this instance (Bland & Altman 1986), with Kappa = 0.545455 and a Z value of 4.74.

Whilst there was a correlation between the locomotor subtest of the Griffith's and the two motor tests, the level of agreement was poor. Only one child had a locomotor DQ below 90. This child had a definite motor problem on both TOMI and BOTMP.

Diagnosis of motor skill disorder:

Because of the high level of agreement between the BOTMP and TOMI tests, the ten VLBW children (17%) that had definite problems in both tests, could, with reasonable certainty be classified as developmental coordination disorder (DCD) (DSM IV 315.4 p 53). All these children had a GVPQ and VMIQ below 90. Seven of these had a discrepant score of more than 10 points between visual perception and motor integration (higher MRVP, lower VMIQ).

Clinical observations:

Problems with holding arms in the extended position was more evident in the VLBW children, with more evidence of deviations, such as dropping or raising arms, pronating when supinated or spooning of fingers.

The reduced ability to remain in the stable upright posture when seated was also more significantly present in the VLBW group with difficulty in stabilising the trunk without slouching, leaning or resting on one arm when seated.

Although slight problems with muscle tone (low tone) was recorded in the VLBW children, control children were also recorded to have such slight problems, without the presence of the neurological soft signs.

The finer controlled movements in diadochokinesis, thumb-finger-touching and controlled use of the pencil also posed more difficulties for VLBW children when compared with the controls. Significantly more problems with the organisation and planning of motor acts were recorded in VLBW children (Table 11)

The children that were noted to have definite problems with diadochokinesis, thumb-finger-touching, pencil grip and control and motor planning were all consistently below 90 on the VMIQ of the DTVP-2.

Difficulty with idea formation or conceptualisation of what was required in the preset, requested motor tasks or acts, demanding organisation of thoughts and planning of coordinated acts from the child was recorded more frequently in VLBW children, suggesting motor planning problems as part of DCD.

Table 11: RESULTS OF CLINICAL OBSERVATION

Clinical observation checklist for neurologigal integrity
(See Appendix B) for description of observations):
Score representations 1= no problem noted
2= slight problem
3= problem clearly noted

Task	VLBW			Control			p-value
	1	**2**	**3**	**1**	**2**	**3**	
Eye movement	54	3	1	58	0	0	0.10777504
Muscle tone	48	9	1	54	4	0	0.17126594
Arm extension test	47	8	3	56	2	0	0.049099<-
Posture	51	6	0	58	0	0	0.010067<-
Truncal stability	48	8	0	58	0	0	0.008833<-
Protective react	48	5	0	56	2	0	0.1970436
Equilibrium react	49	4	1	57	1	0	0.1954324
Associated mvt	40	15	3	49	8	1	0.1378144
Range of mvt	58	0	0	58	0	0	1.0000000
Diadochokinesis	35	16	5	47	11	0	0.021826<-
TFT	28	21	7	43	15	0	0.003815<-
Finger identify	44	9	1	55	3	0	0.0786359
Pencil grip	38	13	3	49	7	2	0.19670547
Pencil control	32	15	8	51	6	1	0.001124<-
Motor planning	17	17	18	35	20	3	0.000212<-

<- P-value significant

Key to abbreviations: react = reaction, mvt = movement, TFT = Thumb-finger-opposition, Finger identify = finger identification.

Handedness:

Left handedness was not more significantly present in the VLBW or in the control group.

Outcome at 5-6 years by perinatal and neonatal status (Objectives 3 & 4):
An analysis was done of the outcome at five years in relation to birth weight, gestational age, whether ventilated or not and days of stay in neonatal intensive care. Gestational age below 30 weeks was not more predictive of a poor outcome on the four standardised measures, than a gestational age above 30 weeks. No significant difference was found between the SGA and AGA group on the four standardised measures, although the SGA group of children were consistently less capable, weighed less, were of smaller stature and with smaller head circumference. The mean GVPQ of the AGA children was 88.54 and that of the SGA children was 87,16 with a p-value of 0,69787. The mean MRVPQ of the AGA children was 90.39 and that of the SGA children was 89.42, with a p-value of 0,681112. The mean VMIQ of the AGA children was 88.15 and that of the SGA children was 86,49, with a p-value of 0.614217. The TOMI total score means for the AGA and SGA groups were 2,85 and 3,00 respectively, with a p-value of 0,887206.

A birth weight less than 1000 grams was not more predictive of small stature, weight or head circumference or of a poorer ability on the four standardised measures within the VLBW group. The mean GVPQ of the less than 1000gram children was 88.43, compared to 87,03 of those weighing more than 1000 grams. The mean VMIQ of those weighing less than 1000 grams was 87.71 and those weighing more than 1000 grams was 86,36.

The TOMI total means of children weighing less than 1000g was 2,79 and those more than 1000 grams was 1.84. None of these differences were statistically significant.

Children that were ventilated or had a longer than 60 day stay in neonatal intensive care were no less capable on the four standardised measures than those that were not ventilated or that were discharged from hospital earlier.

Inter-test agreement between eye hand test of the Griffith's and DTVP-2 Subtests for eye hand coordination for the entire cohort (Objective 5).

To determine the agreement between the eye hand test of the Griffith's and the EHC subtest of the DTVP-2, a Kappa coefficient calculation was done. Sixteen children with difficulty were identified in the Griffith's eye hand test (Eye hand DQ<80) and twenty four on the DTVP-2 EHC subtest (Standard score<8). The observed agreement was 0.728571 with a Kappa coefficient of 0.461538 and a z value of 3.94. This indicates an agreement beyond chance.

Attention Deficit Hyperactivity Disorder (Objective 6). (See criteria Appendix B):

In the VLBW group, attention deficit was recorded in ten children, (17%), three girls and seven boys. Eight were also hyperactive of which seven were boys. Of these ten children with attention deficit seven had a Griffith DQ below 90, but none below 80. Of the matched controls, 3.4% (two children, both boys) had attention deficit with hyperactivity, matching their paired control in this respect. The difference between VLBW and control groups was significant with a p value of 0.015162. Five of the eight hyperactive children had greater than average difficulties on the TOMI and BOTMP. All ten children achieved below 90 on VMIQ.

Socio-environmental correlates (Objective 7):

Because maternal education and socioeconomic status are said to be strong predictors of developmental outcome in at-risk populations, a correlation analysis was done to determine if the poorer educated mothers (with only primary school education) had children with poorer abilities on the standardised measures when compared to mothers with some high school education. The differences were insignificant on all tests. This analysis was done separately for the VLBW as well as the entire cohort. When comparing the GVPQ of children with better educated mothers with those less well educated, the means were 94,32 and 92,98 respectively with a p-value of 0.53699989. Comparing the VMIQ of the two groups, the mean of the more educated mothers was 91,35 and those less well educated was 90,75, with a p value of 0.669666. The differences between the two groups were more noticeable on the TOMI, but not statistically significant. The TOMI total scores were 2.27 for less well educated mothers and 1.61 for better educated mothers with a p value of 0.104879 and on the BOTMP the mean scores were 5.53 and 5.59 for the two groups with a p value of 0,774539.

Time of assessment:

An analysis of variance was done, to compare if significant differences occurred if children were tested in the morning or in the afternoon . The difference was insignificant with a p-value of 0.9061.

Gender differences:

A similar analysis comparing girls with boys on all standardised measures found no significant difference between the two sexes.

Parental perceptions and concerns:

Twenty seven of the mothers (46%) of the VLBW children interviewed expressed concern about their child's development, either indicating difficulties with functional skills, such as dressing and eating independently, showing problems with fine or gross motor control or with behaviour. Only five of the parents (9%) of controls interviewed expressed similar concerns. The children identified as having difficulties by their parents, had all shown achievement problems in at least one of the four standardised tests done (Griffith's, DTVP-2, TOMI and BOTMP). Six of the VLBW children performed below average on all four measures (Griffith's taken as DQ<85) and all of these parents indicated developmental problems in their children. Despite the concerns expressed, parents were unable to find meaningful assistance in dealing with these problems. Only one family had enrolled the child for occupational therapy, with a private occupational therapist; this child was not one of the six with performance deficits on all four standardised tests.

CHAPTER FIVE

DISCUSSION

DISCUSSION OF THE VALIDITY OF THE STUDY DESIGN & METHOD

This study complied with the recommendations for follow up studies by Escobar (1991) and Aylward (1989) in the following:

Description of the VLBW cohort from birth to time of assessment: This study reported on the children who were excluded or dropped out from the assessment and described the course of the index population from birth to five and six years. (Appendix A & fig 1)

Consideration of perinatal course: The study considered whether those children that had a longer hospital stay were more adversely affected than their VLBW counterparts that had a shorter hospital stay, as neonatal stay has been deemed a good proxy for complications of the newborn (Scott 1989). The period of ventilation was also considered. These were found not to have had an influence on outcome. As ultrasound was not done on all VLBW children, this assessment could not be utilised.

Sub-populations: The sub-populations of birth weight categories, above and below 1000 grams were compared and given consideration, as were the AGA and SGA categories. The developmental outcomes of the sub-populations were not significantly different. In studies with larger samples with wide ranges in birth weights, correlations with birth weights and outcomes have been shown (Drillien 1980, Klebanov *et al* 1994). This study like that of Marlow (1989) and Abel-Smith (1990) with smaller numbers, did not demonstrate a relationship. Contrary to other research, we found no significant difference between the outcomes for girls and boys.

Controls: The study included matched full birth weight full term controls of similar socioeconomic background. The controls were not recruited from birth, consequently the influence of the assessments at one and two years of age and other significant life events prior to this study could not be analised.

Masking and blinding: Two of the three main examiners (CDM & self) of the children were blind to the birth history and clinical course of the children assessed, providing impartiality in observation.

Socioeconomic factors: The study considered and determined the socioeconomic background of the low birth weight and control children and attempted to ensure similarity of groups (Appendix F). The homogeneity of the study population could be considered a strength, as environmental confounders were similar in VLBW and control groups.

Determinants of outcome:
The study chose more global (international) measures of outcome and considered *specific areas of function* that were said to have higher predictive value in the longer term other than only DQ or IQ.

Attempts were made to comply with internationally accepted and recommended diagnostic criteria (DSM-IV-R criteria for ADHD and Motor Skill Disorder).

Whilst the use of more global measures is recommended, the under-exposure of local population groups to "foreign" visual and auditory material is acknowledged. The inadequacies of developmental tests, not standardised on local populations in determining the underlying deficient functions in our children, outside of cultural or "exposure" factors, is well recognised. Whatever these deficiencies, these tests are the only *objective* measures allowing direct comparisons with development across different ages currently at our disposal.

The two motor tests standardised on different continents, that were used in this study provided different tasks and standards; these proved to correlate *with* a good level of agreement. The standardisation of the TOMI on South African populations is recommended. The BOTMP in its short form may only be standardised once a complete BOTMP is standardised. Whilst this may be cumbersome, it provides measures for assessment of *older* children not covered by the TOMI.

A comprehensive assessment of the child in whom performance deficits are questioned, should include assessment tasks that are exclusively visual perceptual, requiring little or no motor abilities *and* tasks that involve visually guided behaviour that entail purely gross and fine movement skills.

<u>Correction for prematurity</u>
Whether correction should be made for *very premature* infants, remains controversial. In agreement with others, this study chose to refrain from correction for prematurity (Saigal *et al* 1991, Marlow *et al* 1989 & 1993, Hille *et al* 1994). This is also in accordance with the recommendation by Blasco in his annotation, that correction factors can be ignored after 18 to 24 months (Blasco 1989). In studies where correction for prematurity was applied in school going VLBW premature children, it was found that despite this, the VLBW students <u>still underachieved</u> in measures free from scores according to specific age standardisation tables (Hack *et al* 1992 Rickards *et al* 1993). Teacher ratings and scholastic achievement according to school standards are examples of such measures.

Parental and teacher views:

Parental perceptions were assessed and confirmed findings from research elsewhere that parents express greater concern about VLBW children than control parents (Rickards 1993 Marlow 1993). The majority of children were not yet attending school, excluding the possibility of inclusion of teacher ratings in this study.

DISCUSSION OF FINDINGS

The findings indicate that VLBW children performed significantly more poorly than their peers on the four standardised measures used (Griffith's, DTVP-2, TOMI and BOTMP) and echo the findings of studies of VLBW children born in the developed world.

The VLBW group had smaller body measurements than their full birth weight peers; this supports the findings by Ounsted (1984 & 1989) and Hadders Algra (1990). Head measurements and weights were significantly different between VLBW and controls. Although the controls were taller the difference was significant.

This indicates that development and learning on all levels were less efficient in the index group. Equally compelling is the fact that only two VLBW children scored below 80 on the Griffith's DQ reflecting significantly deficient or retarded performance levels, indicating that the differences did not imply that the VLBW group were mentally handicapped.

The particularly significant differences on the Griffith's' subscales of performance and practical reasoning as well as the lesser discrepant but equally significant differences in hearing and speech and eye-hand-coordination are disconcerting as they are of great importance in learning. The findings on the Griffith's with regard to poorer abilities on performance, practical reasoning and eye hand coordination correlate well with the findings of Forslund and Bjerre who assessed Swedish preterm four year old on the Griffith's (Forslund & Bjerre 1990).

The specific visual perceptual and motor skill measures appeared to be more sensitive to less optimal performance in apparently normal pre-schoolers than the Griffith's developmental test, which assesses more *general* functions. This was particularly true of the locomotor subtest, when compared to the TOMI and BOTMP results. It is postulated that the particular children who underachieved on the visual perceptual and visual motor integration tests, would be at higher risk of learning difficulty and academic underachievement at school age.

Although the majority of VLBW children performed within the average range for their age on the total scores of the Griffith's and the motor composite scores of the TOMI and the BOTMP, the average visual perceptual and visual motor integration functions of the VLBW group on the DTVP-2 were in the borderline-sub average range. This is indicative of more subtle developmental difficulties in the VLBW group than in the controls, particularly in the area of spatial reasoning as seen in the average scale scores being less than 8 in the tests for position in space and spatial relations. These will almost certainly contribute to reading, mathematics and writing difficulties, with greater than average problems with letter and numeric rotations, positions and sequences, once these children start school. Poor visual perception has been linked to academic underachievement and specifically to reading (Kavale 1982). Dysfunctions in visual perception may account for the scholastic difficulties found at a later age in the areas of arithmetic, reading and spelling found in school going VLBW children (Hunt 1988, Saigal 1991, Hack *et al* 1992, Klebanov *et al* 1994).

The lowest score on the DTVP-2 subtests for the VLBW and the control group was that of visual closure. This poor performance should be interpreted with caution, as the test requires a considerable amount of scrutiny of visual material and has a strong cognitive component that requires reasoning about visual material that appeared unfamiliar to this test population.

Visual memory is not assessed in the DTVP-2 battery of tests and may be considered a weakness, particularly the absence of tests for visual sequential memory, a function considered important in the acquisition of reading skills (Cornelissen *et al* 1994).

The discrepancy between visual perceptual abilities, free of motor components and visual motor integration in 29% of the VLBW children is reason for concern. Typically children with significant inter test discrepancies are at risk of learning problems and academic underachievement (Shapiro 1993). A significant number of VLBW children (60%) had recorded a VMIQ below 90, which will predispose them to writing and copying problems at school. A survey of the motor activity requirements in elementary schools in Massachusetts by Mc Hale and Cermack (1992) showed that 30-60% of the time in school was spent in mostly fine visual motor activity. This probably holds true for the majority of primary schools in the Western Cape and may explain why the child with poor VMI and poor writing skills is at a disadvantage in the sub-standards and may contribute to high levels of school failure in certain schools, previously under the then House of Representatives in the tricameral parliament (Van Rensburg 1992). This study confirms the findings by others that children of normal intelligence in the VLBW populations have greater than average problems with visual motor integration (Vohr *et al* 1985, Hunt 1988 & Saigal *et al*

1991). Hunt found that 8 year old VLBW children with VMI problems have a 34.4% incidence of learning disability. Preschoolers of ELBW in Sweden have also been noted to have particular deviation in visual motor integration (Stjernqvist 1995)

The findings indicated that *processing problems*, integrating the visual perceptual, particularly spatial reasoning and mental manipulation of space, and the finer motor process into visual motor activity for VMI were at the basis of performance deficits. The motor planning deficits noted on more subjective clinical observation confirmed this.

The clinical observations seem to indicate that *problems with movement control* account for difficulties with diadochokinesia, thumb-finger-touching and control of the pencil when drawing. Lack of *movement organisation and poor motor planning* in the tasks where more skill is required appear to underlie the visual motor integration difficulties.

The poorer abilities on thumb-finger-touching in both samples must not be interpreted negatively, as this test is usually applied to children of six years and older, but some agile five year olds are able to perform it (Touwen & Prechtl 1979). In a study conducted on Sub B children in the Western Cape, a high incidence of difficulty with thumb finger opposition and diadochokinesis was found in both groups who failed *and* passed sub A (Van Rensburg 1992).

The presence of more extraneous movements on the arm extension test may be indicative of an underlying problem with co-contraction and may also explain the higher degree of truncal instability in the VLBW group.

The full range of movement in children indicated the absence of spasticity.

Finger identification was not significantly different or impaired, indicating that the finer sensory functions of the hand and fingers did not account for clumsiness. This indicator of organicity was therefore absent.

This study's findings on the TOMI correlated highly with those of Marlow et al (1989). Their VLBW children, in the same age band as those in this study, with similar numbers (53) plus full birth weight controls, performed remarkably similarly on all the subtests to children from this study who came from a different environment. Not only were the findings on the TOMI subtests similar, but also the neurological findings of significant differences with controls on dystonic movement (as seen on test for arm extension) and diadochokinesia. Findings of truncal unsteadiness were also found. The Marlow study findings resembled those of this study with regard to the absence of a significant difference between VLBW and controls on hypotonicity or difficulty with visual following.

The findings on the BOTMP short form also correlated with the findings on Swedish children (Smedler 1992), where VLBW SGA group performance on the adapted version of the BOTMP was inferior to that of controls. Similar to this study, although with a smaller sample of an older group of children (fourteen 9-10 year olds), significant differences between VLBW and control children were found on bilateral coordination and strength. In their study no group differences were found on finger identification nor were there deficits; this corresponds with the findings in this study.

A significant number of children in the VLBW group (17%) could be classified as motor skill disorder or DCD (DSM-IV-

R). All these children had a DQ between 82 and 92 *and had difficulties with VMI*. There have been a number of reports of learning difficulties in clumsy children (for review see Smyth 1992). The review by Smyth also indicated that clumsy children were at higher risk for associated problems, such as a negative status afforded to them by their peers, increased levels of frustration by parents concerning their messiness, untidiness and general awkwardness and negative feedback concerning this, unsympathetic attitudes towards them by teachers and secondary emotional problems.

Hyperactivity and attention deficit were present in 17% of VLBW children. This finding has to be analised with some caution as the diagnosis is often fraught with controversy in general literature, because of subjective interpretations, and the unclear etiology. The presence of *ADHD can not only be ascribed to the VLBW status* of the children identified, as specific adverse family environments, marital discord and disruptive life events have been identified as risk factors for ADHD (Shaywitz *et al* 1995). The presence of ADHD in five of the ten children with motor skill disorder is however of importance and is indicative of these children's difficulty in complying with set criteria in structured motor tasks. Fidgety behaviour and extraneous movement in these children are also indicative of general neurological immaturity. The presence of ADHD has been identified in VLBW preterm children previously and in this respect this study's findings tend to agree with studies previously discussed. It was considered important to assess attention deficit, as the ability of the child to attend effectively to visual material would affect scoring on visual perceptual tests. The deficit in attention may be the underlying cause as opposed to a true perceptual deficit.

A higher percentage of mothers of VLBW children expressed concern about their child's development and these concerns were found to be borne out by problems experienced on the tests by their particular children. This supports findings by other investigators that parents appear to assess with *some* accuracy if their children are experiencing problems (Edwards-Beckett 1992). This is important to note, as the educational level of mothers from this study was not considered high, yet it was found that their instincts about their children tended to agree with the more formal findings, although the specificity of their observation was not tested.

Whilst parental perceptions about their children were assessed, the study did not consider the specific influences of the maternal mental health and general well being and the influence thereof on VLBW child development. Although it was assumed that these stressors were similar for the two groups, these important proximal factors were not determined, and could well have been more operational in the mothers of VLBW children. Mothers of children with identified problems may have a more negative or pessimistic outlook on life and view their children similarly, accounting for the comparatively high numbers of mothers of VLBW children expressing concern. Maternal mental health has long been known to be associated with problems in children, including ADHD (Cohen 1992).

Whether children attended day care, nursery or creche facilities was determined, but the quality of care of each such a facility could not be assessed. Consequently the influence of care external to the home was not determinable. It is acknowledged that this could in the longer term have either a positive or negative effect (Anderson 1989), depending on whether it was merely a holding facility or a more enriching experience. Recent work in Senegal indicated that nursery school attendance influenced motor performance, with urban nursery school attenders being more adept at imitation, coordination, precision of movement, running and balancing than their non attending counterparts (Benefice 1994).

The absence of a correlation between maternal education and outcome, can possibly be ascribed to the homogeneous nature of the entire population. Why children with slightly better educated mothers were more coordinated on the TOMI is not clear, as this was not evident on the BOTMP.

CONCLUSIONS AND RECOMMENDATIONS

The findings of this study and of other researchers of VLBW children suggest that the quality of survival of the preterm infant must still be a major concern, despite all the improvements in perinatal care. Many of the VLBW children from this study are likely to have learning difficulties when they start school at a time when the educational resources to provide the additional help (that these children require) are limited. Their productivity as citizens must be compromised if they are not provided with *appropriate* intervention.

The majority of the VLBW babies in this study were born to families with low socioeconomic status and this may have also influenced the children's overall performance. However, the controls were well matched and it is unlikely that poor social conditions were the main reason for the more depressed abilities in these VLBW children.

Recent investigations into the influence of early nutrition in pre-term infants have shown that an optimal diet during the first extrauterine month can positively influence later developmental status, particularly as this is a time of rapid brain growth (Lucas 1989). It may be pertinent for researchers here to consider the possibility of sub-optimal nutritional intake in non-breastmilk fed VLBW infants, prior to their discharge from the neonatal unit and how relevantly this problem may be addressed, given the constraints on maternal rooming-in in some tertiary care settings.

Early intervention programmes might constitute an important measure to prevent cognitive and learning problems or to minimise their effect in VLBW children from less favourable home environments. It is clear that primary prevention must consist of the prevention of *neonatal* impairment or dysfunction. However, unless a comprehensive early intervention programme is provided, a large portion of VLBW children are likely to be trapped in a cycle of events during their preschool years that can be counterproductive to their later development, learning ability and academic achievement. As a substantial number of mothers from the VLBW group of this study expressed concern about their child's development, the community support for intervention should not be difficult to secure. Future research should focus on the development of methods able to select infants in need of early intervention and should demonstrate what help is effective for which parent and which child.

The Infant Health and Development Programme (IHDP) (Mc Cormick 1993) recommend the following with regard to intervention:

1) To support the families, so that parents can engage in the highest quality of care giving that they are capable of.
2) To increase parenting competence directly, so that parents can provide more *nearly* optimal stimulation and support for their particular child (and their future children).
3) To increase the capabilities of the LBW children, so that

they can more effectively engage and become self sufficient. The three major components of the IHDP were home visits, parent group meetings and child attendance to a child development centre.
The approach used in the IHDP would be important to consider when planning intervention strategies for VLBW children.

The results of the IHDP were important as they found a significant effect on child IQ, adaptive behaviour and home environment, which meant that both the child and the quality of the care giving were improved by the programme. The IHDP philosophy and manner of implementation deserve exploration within the urban and peri-urban context of Cape Town and possibly other metropoles in South Africa with similar needs and populations. This could provide opportunity for collaborative work, so successfully done with the IHDP. An important remaining question is whether the gains that were made in the IHDP in early years, will translate into long term social and academic competence in children or improved psychosocial and parenting skills in the parents. The findings from the Witwatersrand study (Rothberg et al 1991) are discouraging. The *type of intervention and the frequency and quality thereof* appears to be of importance. Guidelines for successful home programmes used as methods of intervention amongst disadvantaged populations in poor socio-environmental situations need to be carefully considered to effect *real* change (Bazyk 1989, Maclean 1991). A consciousness on the part of care givers about the importance of their perceptions and behaviour to children's health and development, as well as a belief in their capacity to fulfil children's physical and emotional needs, has been found in several studies to be the axis around which optimal child development takes place (Tinsley & Holtgrave, 1989). The implications for this model for intervention are the importance of affirmation, support and encouragement for care givers. Health care providers should be cognisant that their attitudes and practices do not deplete the resources or devalue the accomplishments of mothers that have to contend with hardships that are often barely imaginable (Richter 1995).

The usefulness of nursery school as a vehicle for nutritional assistance, motor stimulation, speech and language enrichment and cognitive growth would be important to consider. The Senegalese study (Benefice 1994) emphasised the importance of nursery school in poor communities. Until such time as intervention programmes serving *specific at risk* populations are implemented, attendance to registered state nursery or preschools are strongly recommended for VLBW children from poor socioeconomic backgrounds. This recommendation supports that made by Van Rensburg in her study of school failure in children from a disadvantaged communities in the Western Cape (Van Rensburg 1992). Ideally such pre-school classes should be geographically close or attached to the primary school that the child will attend and be state funded. This will facilitate the provision of advice and support to teachers of pre-schoolers with difficulties by developmental therapists.

For this researcher, one of the most disconcerting and unfortunate findings from this study, was failure to successfully refer the children with multiple difficulties and their families to developmental therapists (physiotherapists, occupational therapists and language therapists) within the public health care system. The indigent family currently has the right to free access to these professions for their pre-school child, yet the therapists operate under tremendous work loads with waiting lists that extend beyond 18 months in some instances.

District based care of the child with serious specific learning deficits is in urgent need of attention. Such care should involve a collaborative effort between health professionals and educationalists. It is recommended that specific care protocols be developed at district level for children that are biologically and environmentally at risk of developmental and learning problems and that a "risk register" be kept at school clinic or district clinic level. Ideally the high risk infant should have a tagging measure, like a notch punched through the child health card allerting health care workers to their status. An extension to the child health card for the preschool child should be considered, as many "at risk" children fail to secure intervention after the age of two when primary immunisation is completed and well children are not routinely bought to health services for assessment of growth and development.

This study group should be followed and reassessed in middle childhood. Most studies assess the children again at eight to nine years of age (Ornstein 1991). It would be important to know how predictive the tests used at pre-school *were* of later academic underachievement.

The results from this study indicate that the Griffith's assessment of VLBW preschoolers does not effectively identify more subtle problems with visuo-spacial perception, visual motor integration and motor skills. Such difficulties, as identified through the use of specific tests for this purpose, will almost definitely affect the academic performance of these VLBW children when at school. VLBW children with normal IQ and DQ scores have been found to have academic and learning difficulties worldwide, as indicated in the literature review. The underlying deficits identified in this study may account for some of the difficulties experienced by such learning disabled VLBW children at school age. The routine, comprehensive assessment of perception, VMI and motor skill over and above assessment of IQ/DQ of all preschool VLBW children is strongly recommended, particularly those children with performance deficits that have been identified by their parents. The planning and provision of appropriate intervention is of the utmost importance, to ameliorate difficulties and prevent later scholastic under achievement.

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APPENDICES

Infants of Less Than 1250 Grams Birth Weight at Groote Schuur Hospital: Outcome at 1 and 2 Years of Age

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ABSTRACT. A prospective 2-year follow-up study of infants with birth weights of less than 1250 g was undertaken at Groote Schuur Hospital Neonatal Intensive Care Unit. For a 12-month period beginning July 1988, all live infants born at Groote Schuur Hospital or referred to the Neonatal Intensive Care Unit were included in the study cohort. The aim of the study was to document the morbidity, mortality, and neurodevelopmental outcome of these infants to 2 years of age.

Of 235 liveborn infants, 143 (61%) survived to discharge. One hundred twenty-six infants were born weighing less than 1000 g; 42% survived to discharge. One hundred nine infants weighed 1000 g or more at birth, and 83% survived to discharge. Better survival was documented for infants whose mothers attended antenatal care, who weighed more than 900 g, and who were of greater than 30 weeks' gestation. Eleven infants died in the first 6 months after discharge. One hundred six infants (83% of survivors) underwent Griffiths developmental testing and clinical assessment at 1 year of age. Ninety-six (91%) of these survivors were seen and tested at 2 years of age. Of the 106 infants assessed at 1 year of age, 6 infants had cerebral palsy, 6 were globally developmentally delayed without signs of cerebral palsy, and 1 infant showed significant motor delay with a normal developmental quotient. At 2 years of age 1 additional infant had cerebral palsy and 9 more infants are likely to be mentally retarded. At 2 years of age the major handicap rate was, therefore, 22%. Sixty-nine percent of surviving infants, and all but 1 of the infants with cerebral palsy, were underweight for gestational age at birth. There was a tendency for these underweight-for-gestational-age infants to score less well at 2 years of age. Infants who received ventilation and infants with a birth weight of less than 1000 g were not found to score less well than other infants in the cohort. *Pediatrics* 1993; 91:961–968; *very low birth weight, perinatal morbidity, perinatal mortality, underweight for gestational age, cerebral palsy.*

ABBREVIATIONS. VLBW, very low birth weight; NICU, neonatal intensive care unit; GSH, Groote Schuur Hospital; DQ, developmental quotient; NEC, necrotizing enterocolitis; UGA, underweight for gestational age; FAS, fetal alcohol syndrome.

Meaningful assessment of the outcome of very low birth weight (VLBW) infants requires long-term follow-up. Astbury et al[1] suggest that reliable estimation of adverse neurodevelopmental outcome may not be possible until school age. However, the Victorian Infant Collaborative Study Group[2] concluded that assessment of outcome at 2 years identifies most of the severely disabled children and tends to overestimate rather than underestimate later disability. Marlow et al[3] have shown that infants with birth weights of less than 1251 g have a higher incidence of handicap.

The Neonatal Intensive Care Unit (NICU) at Groote Schuur Hospital (GSH) is a state-funded tertiary referral center for sick and preterm infants. It serves the predominantly indigent sections of the Cape Town population.[4] In recent years the population of Cape Town has increased because of massive influx of families from rural areas. Many of them live in informal housing settlements on the periphery of the city. Overcrowding, unemployment, and poverty are rife. These communities are, therefore, typical of many Third World cities.

Data regarding VLBW infants in developing countries are largely unavailable. Because of the dearth of information regarding this important group of children, we carried out a prospective 2-year follow-up study of infants with birth weights of less than 1250 g born at, or referred to, the NICU at GSH. The study began in July 1988 and infants were included over a 12-month period.

MATERIALS AND METHODS

All the infants were cared for according to standard management practices in the NICU. Because of limited resources not all infants can be ventilated in this intensive care unit. For this reason infants weighing less than 900 g and of less than 28 weeks' gestation are not routinely ventilated. The decision to ventilate the smaller and younger infant depends largely on the availability of a ventilator and maternal obstetric and social history. When a ventilator is available, larger infants are ventilated when oxygen requirements exceed 90% and/or the infant has recurrent apnea.

Detailed information of antenatal and perinatal events as well as descriptive data for each infant were recorded. Each infant's gestational age was scored in the first week of life using the Dubowitz method.[5] When an infant died before being scored, the antenatal ultrasonographic examination and/or the mother's expected date of delivery was used to estimate gestational age. Where clinically indicated, infants underwent cerebral ultrasonography during the first week of life.

Survival and ventilation rates by 100-g birth weight subgroups and by gestational age were documented. Perinatal morbidity was documented for three weight categories: less than 900 g, 900 g through 999 g, and 1000 g through 1250 g.

All surviving infants were seen at 6 weeks, 18 weeks, 9 months, and 1 and 2 years corrected age.[6] At each visit a full clinical examination and neurodevelopmental evaluation[7] comprising as-

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sessment of tone, postural responses, and primitive reflexes were carried out. At 1 and 2 years of age the Griffiths Scales of Mental Development[8] were administered by an impartial observer. Infants with cerebral palsy were referred for neurodevelopmental therapy and those with squints to the ophthalmology clinic. At 9 months a hearing screen was performed with the Manchester high-frequency rattle, and at 2 years a formal hearing assessment was done using free field testing and impedance evaluation.

To assess the social status of the cohort, a social worker was employed to undertake home visits after each infant's hospital discharge. She evaluated the home conditions and financial status of the family. Her contact with the family also enabled infants who defaulted from follow-up visits to be more easily traced.

Scoring of the Griffiths Scales of Mental Developmental was done for corrected as well as uncorrected age.[9] All scores quoted are those estimated for *uncorrected* age. A normal developmental quotient (DQ) was considered to be an uncorrected score of 80 or more, borderline DQ 70 through 79, and abnormal DQ less than 70. Major handicap includes cerebral palsy, a DQ of less than 80, and blindness or deafness (Cerebral palsy is defined as a disorder of movement and posture due to a defect or lesion of the immature brain.[10]) Minor handicap includes developmental delay and a normal DQ, and/or clinically assessed hyperactivity and/or squints.

Statistical analysis of DQ results using two sample analyses was undertaken in an attempt to identify specific "high-risk" categories within the cohort. Individual Griffiths scale results were compared for sex, growth status, place of birth, maternal booking status, gestational age greater than and less than 28 weeks, and birth weight greater than and less than 1000 g. The effect of neonatal morbidity on outcome was also assessed by comparing those ventilated with those not ventilated and by comparing infants with or without bronchopulmonary dysplasia, apnea, or necrotizing enterocolitis (NEC). To assess further trends present in the cohort, multivariate cross-correlation analysis as well as regression analysis for birth weight, gestational age, 5-minute Apgar score, and duration of ventilation was performed.

RESULTS

Survival

Two hundred thirty-five infants were admitted in the 12-month period. Ten percent were outborn, mainly in the Cape Metropolitan area, and transported to GSH by ambulance under the care of "ambumedics" trained in neonatal medicine. One hundred forty-three infants survived to hospital discharge. Figure 1 shows a breakdown of survivors and infants who died (including numbers ventilated) and indicates the distribution of early (less than 8 days), late (8 to 28 days), and postneonatal deaths (>28 days).

Table 1 categorizes the infants within 100-g birth weight subgroups. Survival and ventilation rates are compared within these subgroups. Some infants were not ventilated because of clinically assessed extreme immaturity, and this explains the low numbers of infants weighing less than 900 g who were ventilated.

The survival rate for all infants was 61%. As expected, survival rates improved with increasing birth weight. The survival rate in infants weighing less than 1000 g at birth was 42%, but it doubled to 83% for those infants with birth weights of 1000 g or more.

An analysis of the survival of infants within gestational age subgroups showed the survival rate in infants of less than 30 weeks to be 34% and from 30 weeks to be 87%.

Perinatal Data

Tables 2 and 3 illustrate perinatal morbidity patterns of the cohort.

As expected, the mean birth weight and gestational age of survivors was significantly greater than that of infants who died. Sixty-nine percent of survivors were underweight for gestational age (UGA = birth weight equal to or less than the 10th centile expected for gestational age[11]), of which 82% were stunted (weight, head circumference, and length all below the 10th centile expected for gestational age), suggesting prolonged fetal growth retardation.[12] A previous study documented growth curves for the local population[13] and found them to be almost identical with those of Lubchenco et al.[11] Overall the Lubchenco growth curves are lower than other intrauterine growth charts, and the 10th centile therefore closely approximates two standard deviations below the mean.

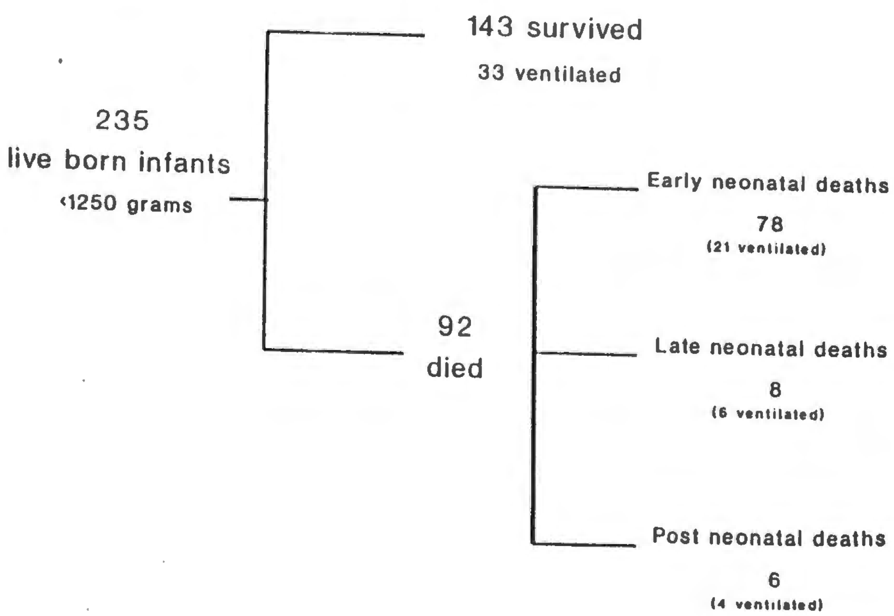

Fig 1. Outcome of the study infants at Groote Schuur Hospital.

TABLE 1. Ventilation and Survival Rates by Birth Weight

Weight, g	No.	Discharged Alive, No. (%)	Ventilated, No. (%)	Survived Ventilation, No. (%)
<800	50	10 (20)	7 (14)	3 (43)
800–899	37	23 (62)	10 (27)	6 (60)
900–999	39	20 (51)	15 (38)	4 (36)
1000–1099	41	31 (76)	14 (34)	8 (57)
1100–1199	48	40 (83)	13 (27)	7 (54)
1200–1249	20	19 (95)	5 (25)	4 (80)

TABLE 2. Characteristics of the Infants and Their Mothers*

	Survived	Died	*P* Value
Infants			
No.	143	92	
Ratio of boys to girls	71:72	48:44	NS
Birth weight, g			
Mean (SD)	1044 (149)	846 (192)	<.0001
Range	600–1250	400–1245	
Gestational age, wk			
Mean (SD)	32.0 (2.5)	27.9 (3.0)	<.0001
Range	(26.8–40)	(21–36)	
UGA, No. (%)	98 (69)	22 (25)	<.0001
Mothers			
Mean age, y	26	26	NS
Teenagers, %	20	12	NS
No antenatal care, %	20	38	.003
GPH, %	35	21	.03
Cesarean section, %	42	24	.004
Vaginal breech, %	12	21	NS

* Abbreviations: UGA, underweight for gestational age; NS, not statistically significant ($P > .05$); GPH, gestational proteinuric hypertension.

TABLE 3. Perinatal Data*

	Birth Weight, g		
	<900	900–999	1000–1249
No.	76	46	113
Survived, No. (%)	27 (36)	24 (52)	92 (81)
Died, No. (%)	49 (64)	22 (48)	21 (19)
UGA, %	47	54	52
Intubation at birth, %	30	50	33
HMD, %	51	61	35
TTN, %	7	11	28
Apnea, %	24	28	16
Ventilated, %	18	37	29
Pneumothorax, %	3	4	5
Ventilation, mean days	6	9	8
NEC, %	7	4	7
Stay, mean days	40	37	30
Assessed at 1 y, No.	18	18	70
Cerebral palsy, No.	1	1	4
Mental retardation, No.	1	2	6
Assessed at 2 y, No.	15	16	65
Cerebral palsy, No.	1	1	4
Mental retardation, No.	3	2	13

* Abbreviations: UGA, underweight for gestational age; HMD, hyaline membrane disease; TTN, transient tachypnea of the newborn; NEC, necrotizing enterocolitis.

Thirty-two percent of the survivors were black, 66% were of mixed race, and 2% were white. Forty-nine percent of infants who died were black and 51% were of mixed race.

Mothers overall were of a similar age group, but a smaller proportion in the group whose infants died were teenagers. The significant increase in the incidence of gestational proteinuric hypertension in the mothers of surviving infants reflects the fact that these mothers receive hospital care, usually as inpatients, and their infants are delivered often after a course of maternal steroids by elective cesarean section. With this kind of antenatal care these infants are more likely to survive.

Table 3 compares perinatal morbidity for all infants by three weight categories. Thirty percent of newborns weighing less than 900 g were intubated and actively resuscitated at birth. For newborns weighing more than 900 g, this figure increased to 50%. As expected, the incidence of hyaline membrane disease was higher in the lower weight categories. Approximately one fifth of newborns with birth weights of less than 1000 g had apnea. Eighteen percent of newborns weighing less than 900 g and 37% of those weighing 900 to 1000 g were ventilated. The incidence of pneumothorax was low (3% to 5%). Fewer than 10% of all infants had necrotizing enterocolitis. As expected, the length of hospital stay decreased with increasing birth weight. The mean hospital stay for survivors was 58 days (range 20 to 135 days). The mean hospital stay for infants who died was 11 days (range 1 to 48 days).

Seventy-six infants (53%) underwent cranial ultrasonography; the results were normal in 49 (64%). Leukomalacia was diagnosed in 5 infants (6%), and intraventricular hemorrhage more severe than grade II[14] was shown in 11 infants (14%).

The incidence of congenital abnormalities was 9%: three infants had fetal alcohol syndrome (FAS), seven had inguinal hernia, two had hypospadias, and one had undescended testes.

Social Characteristics

The infants managed in this intensive care unit are largely from poor socioeconomic backgrounds.[4] The family circumstances of 84% of the study infants were assessed by a social worker and 76% of the survivors were visited at home. (The remaining 24% lived either out of Cape Town or could not be visited because of sociopolitical unrest in the informal settlement areas). Seventy-six percent of the families assessed were poor and could be classified as social class V.[15] Only 46% of parents were married.

Outcome

Deaths

Ninety-two infants died in the hospital, 86 (37%) within the first 28 days. Eighty-five percent of deaths occurred within the first week of life, and one quarter of these neonates died soon after delivery (19 neonates). The main causes of death prior to discharge from the unit were immaturity and hyaline membrane disease. Infants with birth weights of less than 900 g accounted for 37% of the total births and 59% of the mortality. Infants weighing 1000 g or more at birth accounted for 46% of births and 20% of deaths.

Eleven infants died in the first 6 months after hospital discharge: three infants died of sudden infant death syndrome, five died of infection, and three died of unknown causes. Only one infant had a postmortem examination, which confirmed the clinical diagnosis of sudden infant death syndrome. Except for this infant and one infant who died in the hospital, all the causes of death were based on maternal history alone.

No infants are known to have died in their second year.

Morbidity

Study infants who became ill visited general practitioners or local infant clinics and were referred for hospitalization as required. Thirty-nine infants (37%) required hospital admission in the first year of life. Nine of these were admitted for surgical procedures (1 closure of an ileostomy post-NEC and 8 for inguinal hernia repair). The medical admissions were predominantly for respiratory illness. Four of the 30 infants admitted for medical reasons each required two admissions within the first 12 months postdischarge for recurrent pneumonia and/or wheezing.

Seventeen infants required hospital admission in the second year of life, of whom two were admitted more than once. Twenty-six infants suffered from recurrent bronchospasm, of whom six also had chronic middle ear disease with hearing impairment. An additional five infants were treated for isolated chronic middle ear disease. Two infants had febrile seizures in the second year of life.

Follow-up

Figure 2 shows that of the 143 infants discharged alive, 106 were assessed at 1 year and 96 at 2 years. Eleven infants died in the first 6 months and 8 infants were never traced after discharge from hospital. The parents of 5 infants refused to participate in the study. The remaining 13 infants were seen at some time in their first year as indicated. Of these, 5 were thought to have abnormalities at the last visit. Eleven infants who had no abnormalities at 1 year could not be traced at 2 years.

Handicap

Neurodevelopmental outcome is shown in Table 4. The outcome of the eight infants never traced is unknown. One of the five infants whose parents refused participation in the study had hydrocephalus requiring shunting in the perinatal period and had neurodevelopmental abnormalities when examined prior to hospital discharge. Two of the five infants seen only at 6 weeks of age had truncal extension with some increase in lower limb tone. Of the two infants followed until 18 weeks, one was found to have poor trunk control with excessive head lag. Two of the six followed until 9 months had abnormalities—one had severe developmental delay and the other had generalized hypotonia.

TABLE 4. Neurodevelopmental Outcome of Infants Weighing Less Than 1250 g at Birth*

	1 Year (n = 106)	2 Years (n = 96)
Lost to follow-up	26†	11‡
Normal	91	72
CP		
Spastic quadriplegia	3	3
Hemiplegia	3	2
Spastic diplegia	0§	1
DQ < 70		
With CP	3	3
Without CP	0	1
DQ 70–79		
With CP	0	0
Without CP	6‖	14¶
Hyperactive (normal DQ, no CP)	0	3
Squint	4	0#
Developmental delay	1	0

* Abbreviations: CP, cerebral palsy; DQ, developmental quotient.
† Six infants abnormal at last assessment.
‡ All normal at 1 year assessment.
§ Affected infant ill at 1 year assessment.
‖ Two infants with fetal alcohol syndrome.
¶ One infant with fetal alcohol syndrome.
# All surgically corrected by 2 years of age.

The mean DQ of 106 Griffiths assessments at 1 year of age was 90 (SD 11; range 28 to 108) and of 96 Griffiths assessments at 2 years of age was 91 (SD 13; range 21 to 112). The five scales all scored significantly less at 2 years than at 1 year and a comparison can be seen in Table 5.

Major Handicap. Cerebral palsy was diagnosed in 6 infants (5.7%) at 1 year of age. Three of these infants manifested mild spastic hemiplegia with normal DQs, and 3 had severe spastic quadriplegia with DQs of less than 50. Six infants, including 2 with FAS and 1 with developmental delay, were in the borderline range of 70 through 79. None of the neurologically normal infants scored less than 70 nor were any of the 106 infants blind or deaf.

By 18 weeks corrected age, five of the six infants with cerebral palsy had been recognized as having deviant motor development and referred for physiotherapy. The sixth infant attended follow-up at 6 weeks and was clinically normal, but then defaulted from follow-up until 1 year of age when she returnedwith spastic quadriplegia.

One infant, in whom no abnormalities were found at 1 year, showed signs of a mild spastic diplegia and a normal DQ at 2 years of age. Another infant who

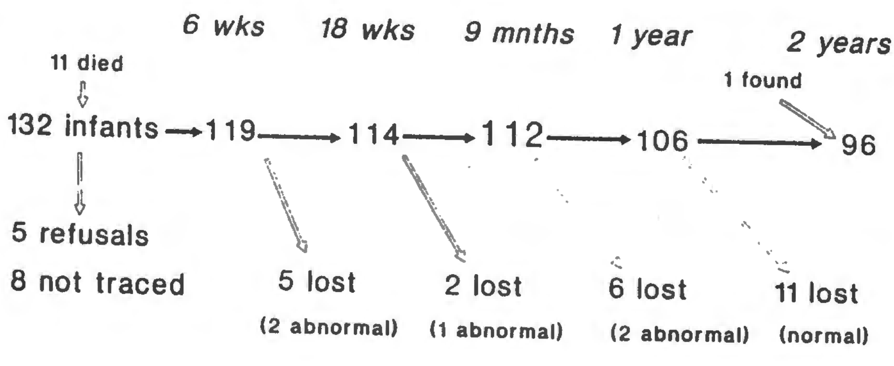

Fig 2. Follow-up to 2 years of age.

TABLE 5. Griffiths Assessment Scale Results*

Scale	1 Year	2 Years	P Value
Locomotor	102 (16)	94 (15)	.0003
Personal and Social	105 (15)	94 (16)	<.0001
Hearing and speech	109 (13)	88 (12)	<.0001
Eye and Hand	100 (15)	89 (14)	<.0001
Performance	100 (16)	87 (15)	<.0001
Practical Reasoning		93 (16)	

* Values represent mean (SD).

had mild hemiplegia at 1 year showed no abnormal signs at 2 years. The number of infants with cerebral palsy therefore remained unchanged. The DQs of the three infants with severe cerebral palsy remained less than 50. Fourteen infants, including one with FAS, had a borderline DQ and were assessed as possibly mentally retarded without evidence of cerebral palsy. Only one infant scored less than 70 and he had FAS. Three infants categorized as mentally retarded at 1 year of age were normal at 2 years, with DQs of more than 80. None of the neurologically normal infants had a DQ of less than 70. None of the infants examined at 2 years of age were blind. One infant in the mentally retarded group was thought to have some hearing impairment, but she never attended a formal hearing assessment.

Minor Handicap. At 1 year, four infants required ophthalmological intervention for strabismus. Two of the four had cerebral palsy with spastic quadriplegia. One additional infant had significant motor developmental delay and a DQ in the normal range, but this infant was ill with tuberculosis when seen at 1 year of age.

At 2 years, three infants were clinically assessed as hyperactive and extremely distractible, without signs of cerebral palsy or mental retardation.

At 1 year the overall handicap rate was 14% and the major handicap rate was 11%. At 2 years the overall handicap rate was 26% and the major handicap rate was 22%.

Griffiths Developmental Assessment

The corrected DQ has been shown to underestimate handicap in the preterm infant.[9] For this reason we calculated both the corrected and uncorrected scores and used both to obtain a range of handicap at 1 year and 2 years (Table 6). The handicap rates quoted thus far have been those obtained using the uncorrected DQ. With the corrected DQ, the major handicap rate falls to 7% at 1 year (one infant with mental retardation, six with cerebral palsy) and to

TABLE 6. Mental Retardation: Uncorrected Versus Corrected Scores*

	DQ < 80	Normal†	P Value
One year			
Corrected score	4	102	
Uncorrected score	9	97	NS
Two years			
Corrected score	7	89	
Uncorrected score	18	78	.03

* Abbreviations: DQ, developmental quotient; NS, not significant.
† Number of infants normal at evaluation.

10% at 2 years (four with mental retardation, six with cerebral palsy). The difference in numbers of infants with mental retardation becomes statistically significant only at 2 years of age.

Griffiths developmental scores at 1 year correlated well with those at 2 years. Two-sample analyses of perinatal variables did not demonstrate any significant differences in DQ, except in infants with and without NEC ($P = .007$). Notably the comparison of extremely low birth weight with very low birth weight infants and gestational age greater than and less than 28 weeks showed no significant differences in DQ results. Outborn infants scored as well as those born at GSH. At 2 years of age there was a tendency for the UGA infants to score less well ($P = .053$). This trend was not apparent at 1 year.

There was a significantly negative correlation ($P = .02$) between gestational age and the Griffiths DQ. The DQ tended to be lower in the higher gestational age groups. The infants at or near term were extremely growth retarded and likely, as other studies have shown,[16] to score less well. The duration of ventilation did not have a statistically significant effect on Griffiths score.

An assessment of the effect of social status on outcome revealed that infants from higher income groups scored significantly higher ($P = .014$) in the final Griffiths assessment. This has been a universal finding in recent follow-up studies.[17] Marital status of the parents had no effect on the final DQ.

DISCUSSION

It is important for every neonatal unit to assess the outcome of its graduates and, in the light of data obtained, alter or confirm its own management protocol. The NICU at GSH offers the unique opportunity to study neonatal outcome from a facility serving a developing community. Comparison of data with those from other NICUs must be made with caution, bearing in mind the differences in population, management protocols, and available resources. A recent and ongoing collaborative study by Hack et al[18] clearly demonstrates important and major intercenter variations of neonatal outcomes even when data are collected with a uniform protocol. Despite these differences it is useful to compare the data presented here with some international standard.

The survival rates at GSH NICU are comparable with those of Hack et al and other studies[18-20] and are almost identical with those found in a recent local study by Van Der Griendt et al.[21] The high percentage of UGA infants reflects the low-income group served by this unit, the high incidence of gestational proteinuric hypertension, and the characteristic feature of mothers in the Cape Province who tend to be thin, short, and underweight[22] and produce UGA infants.[12]

In the surviving infants the incidence of congenital abnormalities was equivalent to that of Elliman et al.[23] However, the incidence of FAS was notable in our cohort—again largely a reflection of the community served by the NICU at GSH. The subclinical effect of alcohol on the fetus is unknown but may also be an influencing factor in the percentage of underweight infants in this cohort.

A high percentage of mothers whose infants died received no antenatal care. This is a source of concern as antenatal care may improve the perinatal mortality rate from this unit.

When comparing our results with those of Hack et al,[18] sociodemographic and birth data are similar, including maternal age, race, marital status, and percentage of mothers without antenatal care. There are, however, many areas in the perinatal data where marked disparities exist. At GSH the cesarean section rate is lower and vaginal breech delivery rate much higher. This implies less active interventional obstetric care and is directly related to our conservative policy for the extremely immature infant. It follows, therefore, that the incidence of endotracheal intubation at resuscitation is lower, especially in the infants weighing less than 900 g. The incidence of apnea and hyaline membrane disease and the percentage of infants ventilated is also considerably lower despite the fact that the GSH cohort was selected from infants weighing less than 1250 g. This is due to the tendency of infants in this cohort to be UGA and therefore on average more mature than those of Hack et al.

This study differs from most others in that (1) a large proportion of the surviving infants were UGA; (2) relatively few infants with birth weights of less than 900 g survived, due to conservative management policies; and (3) the majority of families were of low socioeconomic status.

Do these factors influence outcome? It appears that the incidence of neurodevelopmental disabilities is not affected but the *type* of handicap we have found differs from other reports. Hagberg et al[24] reported the survival of increasing numbers of severely *multihandicapped* very preterm infants. Marlow et al[3] clearly demonstrated an increasing disability rate in infants weighing less than 1250 g at birth and they reported that one fifth of the handicapped infants had three or more major disabilities, especially visual and hearing impairments. None of the infants with major handicap in our study had more than two disabilities and none were blind or deaf.

The major handicap rate increased from 11% at 1 year to 22% at 2 years because of the detection of mental retardation, which is difficult to assess before 2 years of age.[25] Evidence suggests that much abnormality may lie hidden in those infants who do not return for follow-up.[26,27] If one assumes that all the infants in our cohort never seen (n = 8) and all those who showed abnormal signs when last examined (n = 7) had abnormalities, the major disability rate at 1 year is 20% and at 2 years is 30%. We believe that this is likely to be an overestimation of the actual situation and, in fact, the true disability rate is more likely to lie somewhere between the figures quoted. Recent literature reports similar major disability rates, but most reports in the past few years concern the extremely low birth weight infant.[19,28–31]

The percentage of UGA infants was exceptionally high. Even excluding infants of more than 32 weeks' gestation, 60% of the cohort was UGA. This is double that seen in other studies.[18,23] We acknowledge that recent studies have shown that scoring based on the Dubowitz method does overestimate gestational age in the VLBW infant. It is documented that growth-retarded infants generally do less well at preschool testing.[32] It will be important to retest this cohort at school age to document increasing[28] or decreasing[1,29] disability rates.

By 18 weeks corrected age we had detected a number of infants with abnormal signs on clinical neurodevelopmental assessment. All except one of the cerebral palsied infants were within this group. (The sixth cerebral palsied infant defaulted until 1 year of age.) Griffiths DQ assessment at 1 year of age did not detect more handicap than already revealed by clinical assessment if the corrected score was used. Only one neurologically normal infant had a corrected DQ of less than 80. It is for this reason that we also measured the DQ at uncorrected ages of 1 and 2 years. There is no consensus about correction of the DQ in preterm infants.[33] Some suggest correction always, others only up to 1 year of age, and still others say the DQ should never be corrected if one is reporting incidences of abnormalities. Considering all these options, we believe that the opinion of Miller et al,[9] who suggested that scores should not be corrected, is valid. At 2 years the Griffiths assessment became useful in detecting mental retardation in otherwise clinically "normal" infants. Only time will tell whether the use of the uncorrected DQ is appropriate and in fact does accurately detect those infants who remain in the mentally retarded range.

The other point to be discussed here is whether the Griffiths developmental assessment is appropriate for Third World infants, including South African blacks. The mean DQ in all scales fell from 1 to 2 years, but that for speech fell more than 20 points. This raises the question of the validity of the verbal subtest, but could also be the result of the compounding effects of VLBW and social disadvantage. Mc Call's[34] concept of a strong canalization of development in early infancy, giving way to a greater influence of other factors, particularly environmental, from 18 to 24 months, may explain this fall in DQ by 2 years of age. This issue could be resolved by the use of a matched control group when the children are assessed at school age.

We failed to show any clear perinatal predictors of poor outcome. Many studies have concluded similarly.[17] In our cohort the UGA infant scored less well at 2 years and, in fact, all except one of the infants with major handicap at 2 years of age were growth retarded at birth. The infants with NEC in our study did poorly, but this result may be weighted by three individuals with severe NEC and perforation. These infants suffered many other perinatal problems, and two of the three had abnormal cerebral ultrasonographic examinations showing hydrocephalus and leukomalacia. They have major handicap (two spastic quadriplegic, one mentally retarded).

Studies that have shown correlations with oxygen use and duration of ventilation concern the extremely low birth weight infant,[19,31] and in fact Kitchen et al[19] showed their greatest decrease in neurological abnormality over time in the less than 800-g group. It is in this weight category that infants are most frequently not ventilated at GSH.

We did not demonstrate any difference in outcome in the infants with birth weights of less than 1000 g (previous local studies have also shown this[35]), those requiring ventilation, or those with apnea in the perinatal period. This finding is again likely to reflect the smaller numbers of infants born at GSH weighing less than 900 g who survive.

The mortality and morbidity data of our cohort are similar to those of other studies,[4,23] although the postdischarge mortality is higher than that found by Elliman et al.[23] This is likely to be a reflection of the socioeconomic status of the community.

This study has defined the characteristics of the VLBW infant at GSH. Most are UGA and stunted. Twenty-seven percent of infants with birth weights of less than 1250 g are ventilated, of whom half survive ventilation and 61% survive overall. Eighty-five percent of deaths occur within the first week of life. Mothers who receive antenatal care are more likely to have a live infant, and in the study population gestational proteinuric hypertension had a protective effect on outcome because it necessitated hospital care. Attendance for antenatal care, a birth weight greater than 900 g, and gestational age greater than 30 weeks are important factors in predicting survival of the VLBW infant at GSH NICU.

Follow-up of the VLBW infant is more meaningful to 2 years of age and indeed is more revealing of true adverse outcome. At GSH, for infants with birth weights of less than 1250 g, approximately one fifth of survivors will be handicapped and one quarter of these handicapped infants will have cerebral palsy. Long-term follow-up is necessary, as assessment prior to school age is known to both overestimate major handicap[1,28] and underestimate significant learning disabilities in the VLBW infant.[30,36] Clinical neurodevelopmental assessment can be accurate as early as 18 weeks corrected age in detecting cerebral palsy. Use of the uncorrected DQ may be the more appropriate approach for detection of true handicap rates in these infants. When used in 2-year-olds, it enables the clinician to detect those infants at risk of mental retardation and allows more accurate assessment of the perinatal determinants of adverse outcome in the VLBW infant.

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Appendix B

Background Data

Name of child:

Date of birth:

Sex:

Mother's age & date of birth:

Birth order:

Brothers & Sisters
Ages

Home:

Shack on open land
Shack in backyard
Council House hired
Rented accomodation
Home owner

Home occupancy:
No of rooms exl kitchen & bathroom
No of inhabitants

Income and SES:
Unable to make ends meet
Just managing
Comfortable

Primary caregiver:
mother
grandmother
other relative
foster mother
adopted

Maternal education:
Highest standard passed at school:

Subsequent work on school leaving:

Marital status of mother:
married living with father of child
unmarried living with father of child
unmarried not living with father
divorced

Breadwinner :
Father, mother, both or other (eg Disability grant/pension)

Occupation of breadwinner

Pre-school information:
Does/did child attend:
Day care
nursery school (registered)
play school / play group
none- primarily at home

PARENTAL PERCEPTION & AWARENESS

Does primary carer feel that the child has difficulites?*

Gross motor eg awkward (Afr: lomp) clumsy when running or hopping or skipping (falling often)
yes
no

Fine motor eg incoordinate with fine hand work, tying a bow, doing up buttons, connecting a zipper of a jacket,
yes
no
Does child draw with pencil on paper
no
yes describe

Functional skills
Can child dress & undress without help?
dress
undress

Does child manage eating independently?
Is child a messy eater?

Activity level (DSM iv guidelines):

hardly ever still or exessively restless

fidgets with hands & feet squirms when seated

easily distracted by things around eg dog barking, car noise

difficulty waiting turns when required to do so

difficulty listening & then doing as asked

fails to finish jobs/chores given

cannot play quietly

talks excessively - talking interfering with ability to listen

interrupts or intrudes on others - butting in causing disruption

DC noted a problem with activity level/concentration

CM or CT noted a problem with activity level/concentration

Parent noted a problem

Has help been sought if any developmental problems were noted

---

Description of nature of help/support

Description of value of help

Any behavioural characteristics noted by parent (unprompted)

** Control child excluded from study if history of seizures or indications of clear mental handicap were related.*

Appendix C

ADDITIONAL CLINICAL OBSERVATIONS -screening

	no problem	slight problem	pronounced problem
Eye movements Focus Convergence Pursuit Localisation			
Muscle tone note low, increased or fluctuating			
Trunk stability			
Range of motion note any resistance to tests of major joints			
Diadokokinesia L R Bil note associated movements			
Thumb finger touching L R Bil note smooth transition, repeated touching, mirror mvt			
Finger Identification L R Tested behind screen			
Arm extention test eyes closed supinated & pronated note extraneous movement finger spreading, spooning			

ADDITIONAL CLINICAL OBSERVATIONS -screening

	no problem	slight problem	pronounced problem
Equilibrium reactions tested seated on small orange therapy ball			
Protective reactions forward backward R side L side tested seated on small orange therapy ball			
Posture note symmetry			
Associated reactions noted at any time			
Pencil grip			
Pencil control note on VMI of DTVP-2 & flower trail of TOMI			
Motor planning ability to copy and do dot grid of Spacial Realtions test of DTVP-2 note ability to copy gestures			

GENERAL NOTES:

APPENDIX D

Schools and institutions where therapists & teachers were interviewed for the first pilot study

In most instances the most senior therapist or only therapist in the institution was interviewed about test choices.

Red Cross War Memorial Children's Hospital

Groote Schuur Hospital - Therapist in paediatrics & language unit

Tygerberg Hospital - Therapist in pediatrics

Tafelberg Remedial School

Paarl School

Vista Nova School

Jan Kriel Skool vir Epileptici

Astra School for Cerebral Palsied

Agape School for Physical Handicap

Vera School for Autistic and learning impaired children.

Tenterten Place of Safety for children

CA	BIRTHW	GESTAT	GROWTH	SEX	SES	MATERN	EHCSS	GVPQ	MRVPQ	VMIQ	TOMITOT	BOTMPP	LOCOMO	PERSSO	HEARSF	EYEHAN	PERFOR	PRACRE	GRIFFDQ	SEQNO	ATT
75.66	900	33.2	2	2	2	5	6	91	98	85	0	54	120	109	93	83	104	85	99	27	2
78.68	1175	32.4	2	2	2	7	6	89	89	90	3	38	104	99	81	99	96	86	94	44	2
74.97	1145	33.2	2	1	2	2	5	76	82	72	3	38	99	115	88	67	69	83	87	48	2
77.73	930	30	2	1	1	1	9	85	89	84	0	72	108	82	77	74	82	67	82	29	2
70.4	1250	35.2	2	1	3	5	8	91	98	85	0	54	120	86	91	91	100	74	94	33	2
70.93	880	30	2	2	3	5	9	93	90	97	0.5	82	113	99	90	93	82	93	95	12	2
69.88	1010	30.8	1	2	2	6	8	84	82	88	0.5	38	97	120	91	91	86	74	93	11	1
76.91	1170	31.6	2	1	3	8	9	92	97	89	0	58	122	104	91	96	91	81	98	57	1
71.55	1210	32.8	2	1	1	1	9	89	88	90	0.5	27	104	99	73	93	76	66	85	52	2
73.36	960	34	2	2	3	5	9	90	91	92	0.5	58	110	104	90	101	90	85	98	50	2
70.4	1090	33.2	2	2	1	7	8	97	92	103	1.5	66	108	97	77	102	88	79	92	9	2
72.31	1125	33.6	2	2	3	7	7	74	82	68	9.5	8	94	97	83	86	78	81	87	31	2
74.67	940	31	2	2	2	6	9	83	82	87	1	58	105	97	64	89	75	86	86	28	1
77.14	1115	32	2	2	1	7	9	82	83	82	4.5	58	109	94	81	91	75	70	87	32	2
71.19	1200	34	2	1	1	3	9	76	72	83	•	•	118	104	73	76	79	85	89	26	1
74.67	880	33	2	2	3	10	9	102	106	99	2.5	42	108	95	100	105	95	89	99	25	2
72.77	885	34	2	2	3	5	7	89	97	82	5	38	107	101	79	82	93	77	90	34	2
74.21	780	28	2	1	1	6	6	81	91	74	4.5	27	112	96	88	80	69	67	85	37	2
70.34	1160	37	2	1	3	10	8	95	102	88	3	58	111	89	102	94	80	86	94	40	2
75.62	1060	32	2	2	3	7	9	98	101	97	0	69	109	98	93	111	85	114	102	18	2
67.87	1250	33	2	2	3	6	9	98	98	98	1	90	118	124	100	97	115	100	109	2	2
67.81	800	34	2	2	2	2	10	90	92	90	0	46	124	126		79	74	71	95	56	2
67.87	1100	31	1	1	3	10	8	99	100	98	1	76	115	118	91	103	94	82	101	42	2
67.87	1090	28	1	1	3	10	9	102	97	105	0.5	50	106	103	94	118	76	79	96	43	2
69.58	1070	35.8	2	2	1	4	8	89	85	93	4	31	106	91	69	94	91	80	89	13	2
74.51	1200	32	1	2	1	8	7	68	69	71	10.5	3	109	88	72	80	67	77	82	14	2
74.01	1050	29	2	1	1	4	10	104	104	106	0	84	114	108	92	114	105	100	106	22	2
68.07	850	36.4	2	1	1	9	9	81	81	83	3	82	106	97	85	91	79	79	90	38	2
69.25	880	29	1	2	2	4	8	83	84	86	0	38	116	101	78	90	90	75	92	55	2
70.24	720	26.8	1	1	2	6	9	83	90	77	6	18	114	103	77	74	60	91	87	6	1
71.94	1050	33.2	2	2	3	07	9	97	102	93	1.5	82	99	94	78	97	83	78	89	1	2
68.46	1145	33.6	2	1	3	6	8	97	102	92	2.5	38	94	94	100	94	100	74	93	46	2
71.09	1050	31.6	2	2	2	7	5	79	88	72	7.5	•	110	104	87	93	85	73	92	45	2
71.68	900	31	2	1	3	10	10	97	98	97	0	69	110	104	113	104	93	107	105	41	2
65.41	860	30	2	2	3	6	8	78	77	82	11	14	98	119	76	92	76	85	91	20	2
80.03	1250	31.4	1	1	1	8	9	91	97	87	0	34	109	104	76	81	94	94	93	5	2
77.86	700	26.8	1	1	3	10	8	84	91	81	6.5	38	104	94	86	91	86	86	91	49	2
77.23	980	32.4	2	1	1	7	9	96	97	95	0	86	112	96	81	99	86	75	92	23	2
70.27	1200	30	1	1	2	7	7	90	90	90	0	54	100	94	80	86	94	74	88	19	2
70.93	1225	40	2	2	1	4	7	78	83	76	9.5	5	99	87	85	85	82	64	84	8	1
66.98	870	31.4	2	2	3	5	10	92	102	85	0	72	125	96	99	93	75	86	96	16	2
72.77	910	28	2	1	3	7	10	86	86	86	5.5	10	107	85	90	101	82	82	91	39	2
71.52	1160	32.8	2	2	1	5	6	68	67	72	2	31	115	82	70	65	65	73	78	15	2
64.06	1240	30	1	1	1	4	9	77	70	87	8	27	100	94	72	75	72	75	81	7	1
66.82	1190	35	2	2	1	6	7	83	85	82	4.5	24	127	103	97	94	97	88	101	3	1
71.45	1240	28	1	1	1	7	8	101	107	96	0	90	123	109	103	87	109	98	105	54	2
68.73	1170	32.4	2	1	3	1	7	82	85	80	6.5	16	109	103	79	77	74	77	87	4	1
65.57	1050	30	1	2	1	7	9	96	95	97	1	79	125	98	92	82	92	92	97	36	2
63.57	990	30	2	1	1	7	11	97	97	97	0	90	110	101	88	101	104	104	101	21	2
68.4	1010	32	2	1	1	2	9	95	97	94	0	94	118	100	88	79	97	100	97	53	2
69.09	1230	34	2	2	1	4	8	83	86	84	0.5	27	72	78		90	82	58	76	47	2
64.22	1010	34.2	2	1	1	8	6	74	80	68	5	38	125	88	81	78	88	84	91	17	2
64.85	1095	30	1	2	3	8	8	93	103	83	3	42	126	123	92	86	80	120	105	24	2
65.08	1025	37.2	2	2	1	1	7	77	82	76	7	31	101	89	80	80	74	80	84	10	2
61.83	1000	33.6	2	1	2	4	9	83	80	87	0	69	119	92	87	87	87	84	94	30	2
67.61	1220	36	2	1	1	7	5	69	68	74	12.5		89	128	87	69	66	93	89	35	1
64.03	930	33.6	2	1	1	5	8	77	72	85	9.5	21	106	97	84	91	84	75	90	51	2
63.76	900	31.6	2	1	3	8	10	99	100	98	3	74	109	113	91	84	94	78	95	58	2

Key:
CA: Chronological age,
BIRTHW: birth weight
GESTAT: gestational age
GROWTH: 1 = AGA 2 = SGA,
SEX 1 = male 2 = female,
SES: 1&2 = low 3 = middle,
MATERN: highest scholastic standard completed by mother,

EHCSS: Eye hand coordination s-score (DTVP-2)
GVPQ: General visual perceptual quotient,
MRPQ: Motor reduced visual perceptual quotient,
VMIQ: Visual motor integration quotient,
TOMITOT: TOMI total score,
BOTMPP: BOTMP percentile,

LOCOMO: Locomotor DQ,
PERSSO: Personal Social DQ,
HEARSP: Hearing and Speech DQ,
EYEHAN: Eye Hand Coordination DQ,
PERFOR: Performance DQ.
PRACRE: Practical Reasoning DQ,
GRIFFDQ: Griffith DQ

SEQNO: Sequencial order number corresponding with control
ATT: Attention Deficit present = 1 absent = 2

Raw Data: VLBW group

Appendix F

SOCIO-DEMOGRAPHIC DETAILS OF INDEX AND CONTROL GROUPS:

	VLBW group n=58	Control group n=58
Socioeconomic class:		
Group 1&2 (low)	36	29
Group 3 (middle)	22	27
Total	58	56
	Chi square: 1,23	p-value: 0.26964399
Housing:		
shack open land	3	0
shack in backyard	5	7
council rent	13	11
rental/other	12	16
home owner	25	23
	Chi square: 4,15	p-value: 0.38655782
Marital status:		
married, living with father	37	37
common law	3	3
unmarried not with father	14	15
divorced	4	3
	Chi square .05	p-value: 0.98116175
Household density:		
occupancy per room:		
more than 4 persons	8	9
less than 4 persons	48	47
	Chi square: 0,07	p value: 0.7922858
Family intact:		
Yes	42	43
No	16	15
		odds ratio:0.92
	Chi square: 0.04	p-value:0.8338113
Breadwinner		
father	22	21
mother	10	9
both parents	19	21
other (eg grandparents)	3	9
grant (eg disability)	1	0
no income	3	0
	Chi square: 4.67	p-value 0.34577262
Work type of breadwinner:		
unskilled	25	31
semi-skilled	22	11
skilled	7	1
higher education	0	2
unemployed	4	3
	Chi square 0.82	p-value:0.3665440
	VLBW	**Control**
Primary carer:		
Mother	51	55
Other	7	3

	Chi square: 1.75	p-value:0.1857582
Current employment status of mother:		
Employed	28	32
Unemployed	30	25
		odds ratio:0.73
		p-value:0.4006501
Maternal education:		
School standards completed		
1	4	0
2	3	1
3	1	3
4	7	6
5	8	7
6	8	9
7	14	12
8	6	12
9	1	1
10	6	4
Total	58	55
	Chi square 0.43	p-value: 0.5116542
No of siblings:		
none	1	3
1	16	18
2	14	20
3	13	13
4	7	3
5	4	0
6	2	1
7	1	0
	Chi square 9.11	p-value:0.24486845
Rank in sibship:		
One:	28	21
Two:	13	22
Three:	8	8
More than three:	9	2
	Chi square 9.01	p-value:0.11844549
Preschool or creche attendance:		
Yes	38	33
No	20	25
		odds ratio:1.44
	Chi square 0.91	p-value 0.34282368
Maternal age:		
Mean maternal age:	31	30
Range:	22-48	21-49
	chi square:0.621	p-value 0.629244

*** P-value <0.05 is significant, >0.05 is not significant (NS)**