A STUDY TO EVALUATE THE PERFORMANCE OF BLACK SOUTH AFRICAN URBAN INFANTS ON THE BAYLEY SCALES OF INFANT DEVELOPMENT III.

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ABSTRACT

South Africa (SA) needs a suitable tool to evaluate child development as no such tool exists at present. Well known standardised tests are designed in First World Countries but pose problems when used on different populations. The Bayley Scales of Infant Development, a tool designed and normed in the United States of America (USA) is considered to be the gold standard in infant assessment. The revised and updated, 3rd edition was published in 2006. No studies have been done on its use on populations other than the USA. The USA and SA populations are very different and therefore may perform differently on developmental tests since previous research has shown that African infants perform better than USA infants.

The main aim of this study was to use the Bayley Scales of Infant and Toddler Development III (Bayley-III) to evaluate the performance of a cohort of black urban African infants in South Africa, in an effort to determine whether it is a suitable tool for use on this population. The Hypothesis was that SA and USA children perform similarly on the test. Other objectives included assessing whether gender or anthropometric indicators influence performance.

The revised 3rd edition of the Bayley Scales of Infant Development (Bayley-III) was used to assess the performance of 122 black African infants at several urban clinics in Gauteng, South Africa. The sample consisted of infants falling into four age categories; 3, 6, 9 and 12 months. SA scores were compared to USA norms. Scores were compared across age groups, subtests and sex. Height, weight and head circumference was also measured, converted into z-scores and correlated with test scores.

Overall the SA mean score was 103.4, which is statistically significantly higher ($p=0.0007$) than the USA mean of 100.For subtests, the mean score was 99.7 for the cognitive, 106.8 for the language and 103.5 for the motor subtests as opposed to 100 for the USA. Therefore the results of this study showed that SA scores were statistically significantly higher than the USA norms. Gender differences in scores for specific subtests were found, indicating that girls and boys perform differently developmentally at different ages. However this analysis was at subgroup level with individually small numbers and further research is required to investigate this. Anthropometric indicators such as height, weight and head circumference were found to have no significant association with scores on the test, indicating that growth had no effect on development in this population

Although the overall SA mean (103. 4) was statistically significantly higher than the USA mean (100), clinically the difference is small when one considers the variability of development. Developmental milestones can be reached within a range of months and can vary considerably. The Bayley-III is therefore a suitable tool to use on this population. More research is recommended to assess a larger more diverse group, including all age groups for which the Bayley-III caters, as well as on all population groups in SA.

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DECLARATION

I_____________________________ declare that this research report is my own work except where indicated by references. This research report is being submitted as partial fulfilment of a degree in Master of Medicine (Child Development and Community Paediatrics) at the University of the Witwatersrand. It has not been submitted before for any other degree or examination in any other University.

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Date:

LIST OF ABREVIATIONS

BSID-Bayley Scales of Infant Development 1^{st} edition (1963)

BSID-II- Bayley Scales of Infant Development 2^{nd} edition (1993)

Bayley-III-Bayley Scales of Infant Development 3^{rd} edition (2006)

WHO-World Health Organisation

MGRS-Multicentre Growth Reference Study

BMI-Body Mass Index

HIV/AIDS- Human Immunodeficiency Virus/ Acquired Immunodeficiency syndrome

HC-Head Circumference

IQ- Intelligence Quotient

SD-Standard Deviation

SA- South Africa

IUGR- Intra-uterine growth restriction

CI- Confidence interval

USA-United States of America

CP-Cerebral palsy

TBV-Total brain volume

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CHAPTER 1

INTRODUCTION

In humans, infant development follows a set pattern. Normal infants will follow this pattern while abnormal infants will deviate from it. There is a range of deviations or variations that can still be considered normal. These deviations can be the result of many factors which influence development (Aina & Morakinyo, 2005; Campbell, Vander Linden & Palisano et al, 2006).

Infants are developmentally assessed to detect abnormalities and initiate early intervention. Developmental assessment takes on many forms and careful consideration is necessary to determine which type of test is suitable (Johnson & Marlow, 2006).

The Bayley Scales of Infant Development third edition (Bayley-III) is a standardised test used to assess infant development and it was created in the United States of America (USA) (Harris, Megens, Backman & Hayes, 2005). It was chosen as a suitable test to use in this study for various reasons. In South Africa (SA) there is no such tool available for our population; therefore tools from other countries are used. The Bayley-III was chosen as it has been most recently updated, is well known and has been widely used when compared to other developmental tests. It is also registered for general use when compared to other tests such as the Griffiths Mental Scales which can only be used by psychologists and doctors. The Bayley-III assesses cognitive, language and motor development (Tieman BL, Palisano RJ and Sutlive AC, 2005), which was the overall goal of assessment in this study.

SA is a developing country, facing many of the challenges, which have been identified to potentially affect child development (Saloojee H & Pettifor J, 2005; Chopra, Lawn, Sanders Barron et al, 2009). South African children are developmentally at risk and to ensure they reach their potential, suitable assessment practice is needed. This study uses the Bayley-III on a SA urban black African population to see how they perform when compared to USA children between certain ages and to thereby determine whether it is a suitable test to use on this population.

1.1 Typical infant development

Infant development is a measure used to assess normality and predict future outcomes in children. Normal infants will follow a pattern of development. Deviations from this are common and considered normal in different populations. This means there is a range of normal development (Richter, Griesal & Rose, 1992; Kuklina, Ramakrishnan, Stein, Barnhart et al, 2004; Papalia, Wendkos Olds & Duskin Feldman, 2009).

1.2 Abnormal infant development and the need for assessment

Infants with abnormal development will show deviations from the typical pattern of development. The degree of deviation will determine the degree of abnormality.

Appropriate assessment of infant development allows for early identification and treatment of problems arising in childhood (Johnson et al, 2006). This ensures that a child reaches his or her full potential by limiting the impact of problems and preventing secondary complications.

Developmental assessment in infancy is difficult due to the variations which exist in milestone achievement (Pivik, Dykman, Jing, Gilchrist & Badger, 2007) and the many factors influencing development (Richter et al, 1992). Developmental assessment is necessary for routine and high risk cases, to detect problems early and initiate prompt intervention (Johnson et al, 2006). Where possible all children should be developmentally assessed or screened to ensure they are given the opportunity to reach their maximum potential. Early intervention is also cost efficient as it prevents secondary complications and long term adverse outcomes.

1.3 Factors affecting development

Many factors influence development, resulting in varying rates of normal as well as abnormal development. Development in children can be affected by an individual child's characteristics, such as their innate genetic make-up, personality or their gender (World Health Organisation (WHO) Multi centre Growth Reference Study (MGRS), 2006:66-75; Grantham-McGregor, Cheung, Cueto, Glewwe et al, 2007; Walker SP, Wachs TD, Meeks Gardner J, Lozoff B, Wasserman GA, Pollitt E, Carter J & the International Child Development Steering Group, 2007). It can also be influenced by their physical environmental and social environmental circumstances (WHO MGRS, 2006:66-75), which include; quality of stimulation, geographic location, poverty, nutrition, infectious disease like malaria and HIV(Human Immune Deficiency Virus), exposure to violence and exposure to contaminated water and toxins (Grantham-McGregor et al, 2007). Nutritional deficiencies identified as detrimental risk factors for development include iodine and iron deficiencies as well as growth stunting (Walker et al, 2007; Grantham-McGregor et al, 2007). Growth, which is influenced by nutrition, is a major factor which can impact on infant development. (Gale, O'Callaghan, Godfrey, Law et al, 2004; Grantham-McGregor et al, 2007; Ivanovic Leiva, Perez, Olivares et al , 2004; Kuklina et al, 2004; Lima et al, 2004; Pivik et al, 2007; Sacker, Quigley & Kelly, 2006; Walker et al, 2007 and WHO MGRS, 2006:96-101).

Due to the many factors affecting development, finding an assessment tool that suits all populations is almost impossible. This means each population may need their own assessment tool, which is designed for them or other tools designed elsewhere may need to be tested and adapted to suit the population it will be used on.

1.4 Assessment tools

Different methods are used to assess child development and clinical assessment can vary between professionals. Various developmental assessment tools are available to make this type of assessment easier and finding a suitable one is essential. Tests can be standardised or non-standardised and vary in their psychometric properties (Johnson et al, 2006).

Screening tools are convenient as they are affordable and can be administered by almost anyone. Standardised tools are costly and require examiners with special qualifications. Standardised tests are psychometric tools designed to measure an individual's developmental status and compare it to what is expected of that individual at their specific age. Individual results are compared to a norm. These tests are structured to be performed in a standard manner with a qualified examiner who administers the test according to strict protocol. This ensures objectivity and allows the test to be used on large populations by multiple examiners (Johnson et al, 2006).

There is a need for standardised tools. Although they are time consuming and costly they provide objective, valid and reliable information on a child's developmental level in comparison to its peers. These tools can be diagnostic in comparison to screening tools which only highlight the need for further investigation. Standardised tools can be helpful in classifying the levels of delay and the areas in which such delay occurs (Johnson et al, 2006).

The process of standardising tools, known as standardisation involves testing a large number of individuals with the test which was designed for them. They are known as the normative sample. Thus an individual's score can be compared to this standardised score. These types of scores are age-adjusted and follow a normal distribution, with a prescribed mean and SD (standard deviation). Standardised tests are subject to stringent analysis of their psychometric properties during development. They are assessed for representativeness, reliability and validity. The better a tool's psychometric properties, the more valid, reliable and accurate conclusions can be drawn about a particular child's (who is subjected to the test) development. (Johnson et al, 2006).

There are merits and demerits to using standardised tools. Standardised tests are based on the population of the country of origin of the test and may not be appropriate for use on all populations (Richter & Griesel, 1988; Richter et al, 1992; Aina et al, 2005; Westera, Houtzager, Overdiek & Wassenaer, 2008). Large differences exist in populations across different areas. These include socio-economic, geographic, nutritional, cultural and biologic differences, which have been known to impact on infant development to such an extent as to result in varying rates of development (Walker et al, 2006). Therefore what is the norm for one country may not be the norm for another country. This is an important consideration when tools are used for different populations for which they are designed, as it may invalidate results (Richter et al, 1988, 1992; Aina et al, 2005; Westera et al, 2008).

Further problems may be encountered if tests are used which have outdated normative data, for example, if the population has changed. This will mean that scores achieved may be inflated or deflated. The use of standardised tests can further be limited by the cost, time and expertise needed and inadequate standardisation procedures, which will affect the psychometric properties and hence the reliability of the instrument. Finally a test must be used for the correct purpose for which it was designed and further monitoring of infants with problems is necessary, due to their poor predictive validity (Johnson et al, 2006).

Standardised tests however allow for accurate assessment of infant development. They are useful in that they also allow for classification of a child's developmental level, in terms of, areas of delay and severity and they can give an indication of appropriate intervention. (Johnson et al, 2006).

1.5 Bayley Scales of Infant development

The Bayley Scales of Infant development, first edition (BSID) and the Bayley Scales of Infant Development II (BSID II-2nd Edition) are well known standardised tools with adequate psychometric properties and have been widely used for research and clinical purposes (Harris, Megens, Backman and Hayes, 2005). They are known as the gold standard of infant assessment (Harris et al, 2005) and are reliable, valid tools used to assess infants' mental and motor development from 0-42 months of age (Gauthier, Bauer, Messinger & Closius, 1999; Campos, Santos, Goncalves, Goto, Arias et al, 2006).
The BSID and BSID II released in 1969 and 1993 respectively have been followed by the improved, updated Bayley Scales of Infant Development III (Harcourt, Bayley-III Tech report 2, 2007). Since previous research showed that South African infants perform better than USA infants on the BSID (Richter et al 1988), it was felt that similar differences may be found in the updated version and therefore a similar study on the Bayley-III is necessary.

1.6 The SA situation and the need for a suitable assessment tool

In SA there is no standardised assessment tool designed specifically for our population. Various tools are used, most standardised ones being from First World countries such as the USA or UK (United Kingdom). These tools are based on a very different population to the SA one. SA needs a suitable standardised assessment tool to assess infant development. This is for use on high risk infants such as HIV positive infants, premature infants and infants with prenatal and perinatal risk factors (Johnson et al, 2006). The Bayley-III is a well known, recently updated tool, which could serve this purpose. However this tool was standardised in the USA, which has a very different population to SA. In 1992 a study was published on the use of the BSID (1st edition) on black South African infants. The results of this study showed that South African infants scored significantly higher than the American standardisation sample (Richter et al 1992) and as a result it was necessary to create local norms. Therefore we do not know whether a similar situation would exist when using the updated version and hence whether it is suitable for use on the SA population without the creation of local norms.

1.7 Purpose of the study

South Africa is in need of a standardised assessment tool, which is suitable for testing child development. The Bayley Scales of Infant and Toddler Development (Bayley-III) is a well known standardised test, however since it was normed in the USA and different populations have different rates of development, we need to ensure that it is suitable for use on our population.

Aim:

Hence this research report aims to evaluate the performance of black African urban infants in Gauteng, South Africa on the Bayley-III.

Objectives:

Its' objectives include:

1-To determine whether the Bayley-III is an appropriate tool to use on the black urban population in Gauteng, South African.

2-To determine whether gender affects performance on the Bayley-III

3-To determine whether height, weight or head circumference have any correlation to infant scores

It was felt that during this study there was the opportunity to determine whether growth had any influence on infant development in terms of scores on the Bayley-III. Further by chance equal numbers of males and females were assessed in the study and it was decided to compare their scores to see if gender influences development in terms of scores on the Bayley-III. However these were not the main objectives of the study. The main objective was to evaluate the performance of South African urban black African infants on the Bayley-III, in order to determine whether it is an appropriate tool to use on this population.

The 3rd edition of the Bayley-III was chosen to be used for this study. A sample of black urban South African infants was tested with the Bayley-III to evaluate their performance on this test, which was standardised in the USA. The purpose of the study was to give practitioners an indication as to whether it was suitable for use on black, urban infants in Gauteng, South Africa. The Bayley-III was also chosen for use in this study for the following reasons

-convenience (easily available at no cost)

-it is a new updated version and there are no studies yet done on its validity for use on infants in South Africa

-it is a well known and widely used standardised tool

-there is a need for the use of such a standardised tool in South Africa

-it can be used by a number of professionals

Hypothesis

The Null Hypothesis is that South African and American scores do not differ while the alternative hypothesis is that the two scores are different. A directional alternative hypothesis is not possible as there is no indicator of what to expect for this recently revised tool.

Conclusion

Assessment of infant development is an essential part of public health. It allows for early detection and treatment of problems, which prevents further complications and maximises a child's potential. Standardised tests such as the Bayley-III provide objective reproducible indications of a child's developmental level (Johnson et al, 2006). However problems arise when tools normed on one population are used on a different population (Richter et al, 1988, 1992; Aina et al, 2005; Westera et al, 2008). This is because many factors affect development and rates of normal development vary. South Africa is in need of a standardised tool, which can be used on its population. The Bayley-III is the only standardised tool that has been most recently revised and updated. In the present study 122 black African urban infants in South Africa were assessed using the Bayley-III. Their scores were compared with the normative sample from the USA to determine whether it is a suitable tool to use on this population. The results of this study will provide information on whether the Bayley-III and its norms can be used on black urban infants in Gauteng, South Africa or whether we require our own norms.

CHAPTER 2

LITERATURE REVIEW

Introduction

In humans the first few years of life represent a transition period where helpless infants requiring complete care gradually develop the skills to be independent individuals. This process of development refers to skill acquisition in different areas such as cognitive, language, motor and social skills. These skills are achieved as children reach predictable stages known as milestones (Aina et al, 2005); however although they are predictable in terms of sequence, variations in sequence and timing exist in typical development (Pivik et al, 2007).

At risk infants and those with suspected delays need to be developmentally assessed or screened to identify problems and start intervention early (Johnson et al, 2006). This will ensure that children are given the chance to reach their full potential and minimise secondary complications.

Many factors influence development such as individual child characteristics, physical environmental factors and social environmental factors (Walker et al, 2007). These can alter the rate of development in normal and abnormal ways. They can therefore enhance or constrain development.

Appropriate assessment is necessary to detect delays in development, and different tests are available for this purpose. Assessment of infants requires a sound knowledge of normal development. This provides the examiner with a basis for what is to be expected of a child at a certain age (Campbell et al, 2006: 33) and will assist with interpreting results. Different tools are available but standardised assessment tools are ideal measures used to provide accurate, reproducible information on a child's level of functioning. Standardised tests are designed to assess infant development according to data collected from the country from which the test originated. This data is used to create norms and forms the basis for comparison of individual scores to a norm (Johnson et al, 2006). However there is much variation in rates of normal development and development is influenced by many factors. Therefore using tools may be problematic if used on different populations for which it was designed.

The Bayley Scales of Infant Development III (Bayley-III) is a well known standardised tool, normed in the USA with excellent psychometric properties which is used to assess development in infants (Harris et al, 2005). However when considering the Bayley-III as a suitable tool for use in SA, one must consider that using such a test, which was normed on a different population to the one being tested can be problematic or unfair.

South Africa (SA) is a developing country with a very different population to the USA. It faces many challenges to child health (Saloojee et al, 2005; Chopra et al, 2009) and the children in SA are at risk of developmental delays due to many factors. SA needs a suitable tool to assess children. This study used the Bayley-III, to assess the performance of black urban infants in SA. It also evaluated the influence of growth and gender on performance on the test. The above issues will be expanded on in this chapter.

2.1 Typical Development

Development is defined as the "process of developing" or "a specified state of growth or advancement" (Pearsali J(Ed). The concise Oxford dictionary. 10th Ed. New York: University Press, 1999:392). The process of development during the first few years of human life refers to an average rate of mental and motor progression in children as they reach predictable stages known as milestones (Aina et al, 2005). Milestones are used to describe typical development and are included in a number of standardised tests of child development. The child's achievement of milestones and the age at which they are achieved are compared to normal milestone achievement age ranges. (Lima M, Eickmann, Lima A, Guerra et al, 2004).

Development is dependent on complex processes in the brain and body. It involves extensive brain growth, in the form of neural maturation, myelination and synapse formation. It also requires body growth, involving changes in size and body proportions. Development is evident in the following areas; cognitive, language, fine motor, gross motor and social skills. However, developmental processes are influenced by many factors (Aina et al, 2005; Campbell et al, 2006), and as a result of this there is a range of variation in what is considered typical development (Kuklina et al, 2004).

Brain Development

Humans require an extended period of time to develop compared to other animals and developmental changes in the brain are seen up until adolescence. During infancy and early childhood, growth of dendrites and synaptic connections occur. In later childhood excess synaptic connections are removed. The excess of connections which form in infancy may be the reason for neural plasticity and the type of learning which occurs at this time. (Huttenlocher P, 1990). Brain development begins within the first month of conception. By six months gestational age nearly all the neurons of the mature brain are present. Once neurons are formed, they migrate to specific regions of the brain where they will serve a particular function. Neurons differentiate to take on special roles and synaptic connections are formed (synaptogenesis) to allow for communication between cells. Synaptogenesis continues through childhood but many more connections are made than is necessary. This gives the brain immense potential but it also makes it inefficient. Synaptogenesis is followed by a process of pruning where unnecessary connections are eliminated. Experience plays a role in determining which connections are pruned or not. Those connections most used are retained and inactive ones disappear. Therefore a lack of stimulation can result in a permanent loss of function. For instance prolonged visual deprivation as a result of congenital cataracts in infancy can result in unused visual pathways being lost completely if the problem is not corrected early on in childhood. (Thompson, 2001). Two forms of brain development have been described. Experience-expectant development is where common experiences in early life provide catalysts for typical brain development. For instance visual stimulation is a catalyst for vision development. The second type which occurs throughout life is the Experience-dependent type, where individual experience creates opportunities for new growth and refines existing structures. In comparison to Experience-expectant brain development, Experience-dependent development depends on individual rather than typical everyday experiences. (Thompson, 2001).

The developing human brain is a dynamic, changing system, starting soon after conception and continuing into late childhood (Huttenlocher P, 1990) with rates of development varying according to region. Sensory regions undergo the most intense development in infants, while brain areas related to higher forms of reasoning continue to develop up into adolescence. (Thompson, 2001). During foetal life and the first four postnatal months, rapid expansion of cortical volume is seen, while later gain in brain weight is due to myelination of sub-cortical white matter. (Huttenlocher P, 1990) In infants, development of the visual and auditory cortex peaks at about two to four month's age, thereafter gradually lessening. The receptive language and speech production areas (angular gyrus and Broca's area) development peaks at about seven to ten months, thereafter lessening (Grantham-McGregor, 2007). In the visual cortex anatomical changes and development coincide. According to Huttenlocher (1990), the visual cortex reaches its maximum volume at 4 months. At birth few synaptic connections exist but at 4 months there is a rapid burst in synaptogenesis, which is associated with a sudden increase in visual alertness (Huttenlocher P, 1990). Cortical association areas like the frontal cortex grow more slowly (Huttenlocher P, 1990), with peaks in higher cognitive function (prefrontal cortex) development occurring between one and three years (Grantham-McGregor, 2007). Thus the areas of the brain involved in higher functioning are the last to develop. It is clear that the first two years of life are a critical time in a child's development as they involve rapid brain growth and intensive motor and cognitive development (Lima M, Eickmann, Lima A, Guerra et al, 2004).

During the first two years of life, brain development also plays a major role in neurodevelopmental disorders. Studies have shown a 10% increase in total brain volume (TBV) in the first year at which point the infant brain is 72% of the adult volume. In the 2nd year of life TBV increased only by 15%. Gray matter growth accounted form the majority of this growth in the 1st year, increasing by 149%, while white matter volume increased by 11% and the cerebellum by 240%. Myelination of white matter is rapid after birth and the adult pattern is present by the end of the 2nd year. The rapid improvement in infant motor co-ordination and balance may be explained by the phenomenal growth of the cerebellum in the 1st year. The cerebellum also is involved in many cognitive functions. Since there is such a large amount of growth occurring in the cerebellum in the 1st year, this may indicate that this growth is needed for later cognitive development. Thus brain growth in the 1st year of life is rapid and extensive and it is slower in the 2nd year. These changes describe the structural basis for cognitive and motor development in infancy. (Knickmeyer, Gouttard, Chaeryon et al, 2008).

The first five years of life are critical for the emergence of skills which will provide future scholastic success. These include language, mathematics, reading skills, and self-control skills. Therefore assessment in this critically vulnerable period is necessary to ensure interventions are implemented. Early intervention is the key to success due to the brain's plasticity during this time, which makes it capable of benefiting from environmental interventions. The time of greatest risk and opportunity is therefore the early childhood years. (Fernald, Kariger, Engle and Raikes, 2009).

Although domains of development are usually studied separately they are not independent of each other. Motor development creates opportunities for cognitive development and vice versa. For instance children with developmental difficulties are commonly found to have co-occurrence of motor and language problems. A large proportion of children with reading difficulties also have developmental co-ordination disorder (DCD), while children with primarily motor problems often have co-existing learning problems. In children under two years of age, speech and language problems have been found to be associated with delay in early motor milestone achievement. Language and motor problems may occur together due to a genetic basis for the problems or due to them sharing a common neurocognitive mechanism (possible cerebellar function involved in temporal processing). (Viholainen, Cantell, Lyytinen P and Lyytinen H, 2002). This is understandable considering expressive language in particular, requires motor co-ordination. These findings suggest that children with delay in one domain may require assessment of other domains of development and that treatment of certain domains such as motor development can have beneficial effects on other domains such as language or cognitive development (Viholainen et al, 2002). Further the Dynamic Systems Theory suggests that regressions may occur in motor development when new skills emerge. Language development is non-linear with plateaus and regressions, which are suggested to be a result of environmental influences and interactions between all domains of development. (Nip, Green and Marx, 2009).

Summary

Therefore the first year of life is a critical period for brain growth and disruption of this can have long term effects on brain structure or function. The 1st year presents a period of high susceptibility to insults but also large opportunities for success of therapeutic interventions. This suggests the need for identifying developmentally at risk infants within this time period and implementing interventions early. (Knickmeyer, et al, 2008).

Therefore in the context of this study, the first year of life is critical to future developmental potential in children and this is the reason development in the first year of life was chosen to be studied.

2.1.1 Cognitive development

Milestones for cognitive skills exist and are used to measure a child's development. These milestones follow a pattern from basic to more complicated (Papalia et al, 2009).

Normal developmental theories

Several theories on normal development have developed over time to assist with understanding development. These include the Neural-Maturationist (Gesell, 1928-1975), Cognitive-Behavioural (Skinner, 1972), Cognitive Piagetian (Piaget, 1952) and Dynamic Systems Theory (Thelen and colleagues, 1987- 1995). (Campbell et al, 2006:35).

The Neural- Maturationist theory suggests that functional behaviours occur as maturation of the nervous system takes place. Stages of reflex development can be assessed for evidence of neural maturation and more complex behaviours depend on activity in higher levels of the nervous system. This involves hierarchic maturation of the nervous system. (Campbell et al, 2006: 35).

Two types of cognitive theories exist to explain skill development. The first is based on BF Skinner's (1972) behavioural approach to development. In this approach the environment shapes cognitive and motor development. Contingent learning is emphasised with reinforcement coming from the environment. Developmental stages are not used to explain the reasons for behaviour; they are simply used as descriptions. (Campbell et al, 2006:36).

The second type is Piagetian theory based on the work of Piaget (1952). In this approach there is emphasis on the interaction between environmental opportunities and maturation of neural structures (Campbell et al, 2006: 36). Piagetian theory focuses on changes in quality of function and how the mind adapts to the environment (Papalia et al 2009:179). Knowledge gained from action due to reflex activity is later based on experience. Several stages are used to form the framework of development of cognitive systems. The 1st is the sensori-motor intelligence stage (0-18/24months), the 2nd is the period of representational thought (1, 5/2yrs-6yrs) and involves language development. The 3rd is the concrete operations stage and the final stage, the formal operations stage (starts at 11yrs). (Campbell et al, 2006: 37).

The Dynamic Systems Theory (Thelen and colleagues, 1995) places equal importance on neural maturation and other processes which may influence development. Development occurs as the individual recognizes environmental affordances and appropriately selects responses. Multiple systems work together each developing at its' own rate. Stages of development are forms of stability which develop as the systems work together (Campbell et al, 2006:37).In the past motor development was believed to follow a typical sequence which was genetically programmed. Now days it is rather seen as a continuous interaction between a child and their environment. Thelen (1995) felt that maturation alone did not explain motor development but that it required interaction between child characteristics and environmental affordances (Papalia et al, 2009:163).

Newer theories include the Information-Processing approach, the Cognitive Neuroscience approach and the Social Contextual approach. The first looks at processes involved in perception, learning and problem solving. The second examines brain structures involved in cognitive abilities and the third looks at the influence of environment (in particular that of the caregivers) on learning (Papalia, et al, 2009:179).

Summary

All the above theories on development involve brain maturation, environmental shaping of development and a combination of these. It is clear that both external and internal processes play a role in development. Further these theories apply to all areas of development including, language and motor areas.

2.1.2 Language development

Infants acquire language skills through the development of a combination of physical, cognitive and social skills. Physical structures for sound production mature and neuronal connections are made which associate sound with meaning. Social interaction then further facilitates the development of communication (Papalia et al, 2009:202). These skills are achieved at specific ages. Much the same as motor skills, they follow milestones, which involves the achievement of identifiable skills in a sequence. Rates of speech and language development also vary but follow the same sequence.

Language acquisition theories

Language acquisition theories follow the principal of nature or nurture. Skinner (1957) said that language development depends on experience. Infants make sounds and caregivers reinforce those that resemble purposeful speech. Babies also imitate sounds which are reinforced by caregivers. Chompsky (1957, 1972) on the other hand felt that human brains have an inbuilt capacity for language. Chompsky's (1957,1972) ideas are known as the Theory of Nativism and he further notes that all children follow an age-related sequence of attaining language skills regardless of formal teaching. Nativists feel that human brains, unlike animals have structures on one side which are larger than the other side, specifically for language skills. This suggests that an innate mechanism for language is localized in the left hemisphere. This theory fails to explain differences in language abilities among children. Today it is believed that a combination of nature and nurture are necessary for language development. Children have inborn language abilities which can be stimulated or inhibited. Language development is influenced by brain development and pathway maturation as well as social interactions with caregivers. (Papalia et al, 2009: 206)

2.1.3 Motor development

Motor skills emerge due to combined physiologic changes (muscle strength, balance) socio-emotional changes (motivation), and experience (the opportunity to practice). (Fernald et al, 2009).

In general the process of reaching developmental milestones follows a predictable pattern. Motor development is no exception and motor milestone achievement follows a sequence where one milestone prepares for the next (Kuklina et al, 2004, Papalia, et al 2009:206). The World Health Organisation Multi-Centre Growth Reference study (WHO MGRS) studied the timing of achievement of motor milestones and found that 90% of children achieve motor milestones sequentially. The MGRS created windows of achievement to represent the normal variation in timing of motor milestone achievement (WHO MGRS, 2006:86-95). Therefore motor milestones, like walking, may appear at varying points during a window, yet follow a set sequence (Kuklina et al, 2004; WHO MGRS, 2006).

Therefore all the above developmental domains undergo extensive growth and development in the first year of life, highlighting the need to monitor these. This study assesses the above three domains but excludes socio-emotional development.

2.2 Abnormal development and the need for assessment in children

The brain is particularly vulnerable to insults in the first few years of life (Kuklina et al, 2004), which can have long lasting structural and functional effects on the brain (Grantham-McGregor et al, 2007) and thus on development. Insults may present as delays in communication, cognitive or motor development and can range from mild to severe. Therefore in the context of this study abnormal development needs to be assessed and treated early on.

Basic routine screening in the first few years detects children needing further investigation. These children can then undergo comprehensive assessments. (Johnson et al, 2006). This will allow for the benefits of early intervention (Nair, Phillip, Jeyaseelan et al, 2009).For example early detection of a child with hearing loss will result in treatment with hearing aids and speech and language therapy. This will assist the child with achieving language skills they may have missed out on had they not been diagnosed early, thereby preventing developmental delay and later speech, language or scholastic problems.

2.3 Factors affecting development

Many of the achievements infants make in the first year are attributed to an innate maturational process. However the extent to which these achievements rely on experience and environment is often overlooked. Since the periods of most rapid development are the same periods in which an infant is most vulnerable to insults (Thompson, 2001), it is important to understand which factors can affect development as this will influence the intervention which best meets the needs of a specific child. As mentioned previously, internal and external factors affect child development. These can be categorised as physical environmental, individual child characteristics and social environmental characteristics.

Encompassing all these, poverty and its associated health, nutrition and social problems are limiting children's potential in developing countries (Grantham-McGregor et al, 2007) such as SA. These are predominantly external factors but brain development, which is an internal factor, can be influenced by external factors and can subsequently affect development.

The many confounding variables, which influence development, are difficult to isolate and prioritise specifically (Pivik et al, 2007). Due to these variables, developmental abilities differ across different populations. As these variables are interrelated, assessment is complex especially when tools are used which have been designed for a different population to the one being tested. The many factors mentioned indicate how malleable development is. Development can be enhanced by interventions especially those targeting environmental influences. (Fernald et al, 2009). The following factors, which influence a child's development, will be expanded on in this section; they are physical environmental factors, social environmental factors and the individual child's characteristics.

2.3.1 Physical environmental factors

2.3.1.1 Financial resources and poverty

Poverty and its associated health, nutrition and social factors are limiting children's potential in developing countries (Grantham-McGregor et al, 2007), such as SA. In a study done in Brazil with infants under twelve months of age, environmental factors, in particular poverty, were found to influence child development more than biological factors (Lima et al, 2004). Poverty was said to directly affect the quality of the home environment, resulting in a lack of resources for infant stimulation. Differences in quality of the home can negatively impact development, for example mud floors resulted in parents preventing infants from crawling on the floor as it grazed their knees. This affected motor milestone achievement as well as cognitive and perceptual development, since crawling precedes the development of these skills. Further they found that cognitive development was positively influenced by the presence of a father possibly due to increased financial security. Further, development in low birth weight infants was improved by better quality of the home environment as it was said to acts as a buffer for the negative impact of the low birth weight. (Lima et al, 2004).

SA is struggling to eradicate poverty (Chopra et al, 2009). Large proportions of the population live in poverty and this may affect the developmental potential of children, especially black children which account for the majority of children in SA (Saloojee et al, 2005).

2.3.1.2 Nutrition, growth and development

Nutrition plays an important role in both brain and body growth. It can therefore substantially influence development. Children grow faster in the first three years of life than at any other time. Growth involves increases in size and alterations in body proportions. In infants the brain grows more than the body so that their heads are disproportionally large in comparison to their bodies (Papalia et al, 2009: 145), but by 5 years of age their bodies resemble adult proportions (Thompson, 2001). Change also occurs in eyes, ears and other sensory organs. Growth results in more regular sleep-wake cycles reduced crying or unexplained fussiness and greater mood predictability. (Thompson, 2001). Physical growth and development follows a cephalo-caudal and proximo-distal pattern. Sensory motor development occurs similarly with children using their hands and faces before the lower parts of their bodies. (Papalia et al, 2009: 145).

Genes influence a child's stature but they interact with environmental influences such as nutrition and living conditions, such that good nutrition and nurturing result in taller and heavier children. Growth in girls follows a similar pattern to boys, although girls are somewhat smaller and shorter than boys (Papalia et al, 2009:145). Since in infants the rapid growth occurring is metabolically demanding, a nutritionally adequate diet is crucial (Thompson, 2001).

In developed countries thinner, more cylindrically proportioned children walk earlier than do top heavy, chubbier children, indicating that stature influences motor development. Children in developing countries have been found to walk up to 3 months later than well nourished American or European children. Rural Guatemalan infants walked 2-3 months later than these and 1 month later than Indonesian and Pakistani infants. Their walking ages were similar to infants from Papua New Guinea. These variations around the world could be due to differences in definitions of motor development, different methods of data collection, and differences in genetics and child rearing practices. (Kuklina et al, 2004).

The perception of a child's maturation (usually done on size) can affect the caregiver interaction and encouragement of skills, which the caregiver perceives as age appropriate. This can influence a child's achievement of certain skills as they are encouraged and practiced more. (Kuklina et al, 2004).

Walker et al found that of the four major risk factors affecting development, three were nutritional. They included stunting, iodine deficiency and iron deficiency anaemia (Walker et al, 2007; Grantham-McGregor et al, 2007). Nutrition is influenced by poverty and educational level of the caregiver. In SA high levels of poverty may affect the nutrition of children.

Poor diet and growth affect the development of the central nervous system and can result in disturbances in brain maturation, especially the division of cortical cells, myelination, dendritic synapse development and activity of neuro-transmitters (Kuklina et al, 2004). Brain growth and development determines a child's ability to develop normally.

The WHO has formulated Child Growth Standards based on length, height, head circumference (HC), weight and age. These describe how children should grow under optimal conditions. They allow for comparisons of children’s growth to a norm to determine adequacy. These standards were created from international samples who were breastfed, healthy and growing up in environments which were conducive to growth. However they are said to be suitable for assessing children's growth, regardless of where they live, their socio-economic status, ethnicity or food source. (WHO MGRS, 2006:76-85). Growth can therefore be measured in terms of height for age, HC for age, weight for age and weight for height.

Stunting (height for age < 2SD below the mean) by 2-3 years age is significantly associated with later cognitive deficits, poor school achievement and school dropout. Stunting is caused by poor nutrition and is a common problem in developing countries such as SA. Grantham-McGregor showed that height for age < 2SD and absolute poverty are good predictors of poor cognition and poor school achievement. (Grantham-McGregor et al, 2007).

HC is an indicator of nutritional status and in particular brain growth. Microcephaly (HC < 2SD below the mean) and macrocephaly (HC>2SD above the mean) are assumed to be indicators of brain pathology. Microcephaly is commonly associated with decreased brain volume, decreased IQ (Intelligence quotient) and poor academic ability. (Ivanovic et al, 2004). Inadequate growth in HC therefore, indicates poor brain growth, which in turn indicates poor development.

Micronutrients such as iron, zinc and essential fatty acids have been proposed to affect child development as mentioned, and in developing countries multiple nutrient deficiencies are common due to poor diet quality on weaning. Few studies have been done on the effect of this type of intervention but, food supplementation has been shown to result in an earlier age of walking. Iodine deficiency and iron deficiency anaemia are major risk factors influencing child development(Walker et al, 2007; Grantham-McGregor et al 2007), while minor risk factors include zinc deficiency (Grantham-McGregor et al, 2007). Nutrition has a large role to play in these types of deficiencies and it can be easily corrected by fortifying commonly consumed foods. These types of deficiencies are more common in developing countries like SA. Children aged twelve months with moderate to severe anaemia and mildly underweight had poorer motor performance, possibly due to reduced activity and biochemical brain changes (Lima et al, 2004). Children are also more vulnerable to the effects of drugs in the early years where their physical systems are maturing than later on (Thompson, 2001).

Finally, breastfeeding has been consistently found to enhance development in infants. It has been found to benefit the attainment of gross motor milestones (Sacker et al, 2006), cognitive abilities (Gale et al, 2004; Walker et al, 2007), language (Pivik et al, 2007) and emotional abilities (Papalia et al, 2009:145). Breastfeeding is associated with better cognitive function than formula feeding, due to the presence of certain fatty acids in breast milk which are not present in formula (Lima et al, 2004). Human milk is a poor source of iron and zinc but can be a good source of protein, vitamins (water soluble vitamins like B12) and minerals such as selenium and iodine. The quality of breast milk is however influenced by maternal nutrition, which can be affected by poverty. These all contribute to development. (Kuklina et al, 2004).

Evidence of the effects of nutrition on development

Kuklina (2004)

Stunting is one of the major risk factors affecting development as mentioned above (Walker et al, 2007; Grantham-McGregor et al 2007). A longitudinal study done by Kuklina (2004) on the effect of growth and nutrition on motor development, found that growth in length and weight (length for age z-scores and weight for age z-scores) in the first year of life, rather than birth size predicted age of walking. Z-scores refer to the distance a sample is from the mean in standard deviations. It is a comparison of the sample data to the normative data. It tells you whether the result is above or below the norm and by how much. Walking is an important milestone to achieve as it encourages independence, exploration and physical activity, which influence cognitive, perceptual and socio-emotional development as well as further motor development. Therefore this study showed how poor growth can constrain gross motor development. (Kuklina et al, 2004), and hence all areas of development.

Animal protein consumption in infancy was also strongly associated with an earlier age of walking and studies have shown that vegetarian infants have slower language and gross motor development. It has been suggested that certain domains of development may be more sensitive to diet than others. Further animal protein consumption may itself be a marker for intake of micronutrients in a bio-available form as well as for quality of caregiver stimulation. (Kuklina et al, 2004).

Kuklina's (2004) study used an average sample size of infants from a rural area in Guatemala. Its limitation was however that it did not adequately assess socio-economic circumstances which may have impacted on gross motor development. Although maternal age, education, birth order and socio-economic status were adjusted for, they are not adequate proxies for factors such as quality of the home and caregiver-child interaction. The study should have analysed parent-child interaction, child-rearing practices, social support and family size as well as collecting quantitative data on breastfeeding's contribution to nutrient intake. (Kuklina et al, 2004). Also the sample size should have been larger to make the study's results more generalisable.

Lima (2004)

A study conducted in an impoverished urban part of Brazil consisted of a healthy sample of 245 infants followed up from birth to twelve months. This study was done in an urban part of Brazil and used an average sample size. Infants were only assessed at 12 months. The infants came from different hospitals and socio-economic and demographic data were collected for the infants, while nutrition and morbidity was also assessed. It was found that birth weight and infant sex (boys performed worse than girls) were significant determinants of cognitive performance, while weight for age and haemoglobin concentration was associated with motor development. (Lima et al, 2004).

WHO MGRS (2006)

The WHO (2006) evaluated the relationship between physical growth (a measure of nutrition) and the achievement of six motor milestones. Five different countries were included and the sample size was large .The milestones included independent sitting, crawling, standing with assistance, walking with assistance, standing independently and walking independently. The authors looked at associations between children's z-scores for growth and the age at which they attained their milestones. They found statistically significant associations between age of sitting independently and; weight for age, weight for length and Body Mass Index (BMI) for age z-scores. Higher z-scores for these were associated with earlier sitting. In the same study higher z-scores for length for age were associated with a delay in standing alone. (WHO MGRS, 2006:96-101).

According to the authors, these associations however had no real practical use since the numbers were small when one considers the variable ages of milestone achievement amongst children. The authors concluded that in healthy populations, the attainment of these six gross motor milestones is independent of growth (WHO MGRS, 2006:96-101). Although this was a large study it was biased in that it included only healthy children. It is possible that in less healthy populations, growth's effect on motor development may be more marked. The study's strength is that it did include children from regions all over the world. Despite their conclusions they did report that anthropometric measures did influence motor milestone achievement. It is possible that they also influenced other aspects of development such as cognitive or language skill development.

Conclusion

It is difficult to compare the above studies as they are so different. Lima (1994) found that weight for age and haemoglobin concentration improved motor development. WHO agreed with Lima (1994) and found that increased weight for age benefited sitting, while Kuklina's (2004) study found that increased weight for age benefited walking. Therefore the studies are in agreement that increased weight benefits motor development.

WHO also found that increased height for age slowed the age of standing. This contrasts with Kuklina (2004) who found that increased height for age benefited walking. It may be because the WHO used healthy children living in optimal conditions in their study, while Kuklina's study sample came from rural Guatemala. The WHO study was a bigger study than Kuklina's (2004) but possibly standing and walking are influenced by different factors such as body shape and stature more than height or weight.

In all these study's nutrition influenced motor development and may affect other developmental. domains. Intra-uterine growth restriction (IUGR) has also been identified as a risk factor for development (Grantham-McGregor et al, 2007) . Therefore there is evidence that prenatal and postnatal growth and nutrition can impact development (Grantham-McGregor et al, 2007, Gale et al, 2004; Ivanovic et al, 2004) and more research is needed in this field.

2.3.1.3 Shelter

The type and quality of shelter a child has is related to financial resources and poverty (See 2.2.1 a). In a study assessing the influence of ethnic differences on development, some differences in development found were due to socio-economic factors, such as overcrowding and dampness in the home (Kelly, Sacker, Schoon and Nazroo, 2006), rather than ethnic factors. This study included a large sample size, but only looked at infants at nine months, so we do not know what effect there may have been, if any, in children at other ages. More research is needed in this field. However it is clear that poor quality home environment, which is related to poverty and financial resources, can have a negative effect on development. In SA many people live in shacks in informal settlements or squatter camps. These have poor sanitation and are overcrowded. Thus many children in SA are at risk of poor quality shelter affecting their developmental potential.

2.3.1.4 Geographic location

As part of their MGRS, the WHO also investigated regional differences in motor milestone achievement ages. They looked at differences across geographically diverse countries, namely Ghana, India, Norway, Oman and the USA. They found differences in age of milestone achievement between sites. These were said to be due to cultural care practices and not physiological differences. The authors felt that these differences reflected typical development in healthy populations from different environments and cultures and they concluded that for the purpose of creating international standards of gross motor development it was still appropriate to pool data from all sites. (WHO MGRS, 2006:66-75).

Among sites, the age of achievement of independent sitting was the most variable. The least variable ages of achievement were found for crawling, independent standing and independent walking milestones. The Ghanaian sample showed the earliest age of milestone achievement, while the Norwegian sample the latest ages of achievement. Ghanaian caregivers encouraged infants to increase their milestone achievement, while Norwegians followed a system focused on waiting for the child to show an interest first. The authors of the study suggest that crawling, independent standing and independent walking require more co-ordination. This makes their ages of achievement less likely to be influenced by caregiver training. (WHO MGRS, 2006:66-75). In other words these skills are less likely to be affected by caregiver training.

Since the MGRS found differences in ages of motor milestone achievement across different countries, it is possible that although the authors suggested it was due to cultural care practices, environmental influences may have played a role. Whatever the reasons, it is clear that motor development can vary across geographic location and we can expect cognitive and language skills to vary too.

In a South African study, statistically significant differences were found between urban and rural infants' cognitive and motor performance. Using the Bayley Scales of Infant Development (BSID), infants' motor scores were found to differ at ages 2, 18 and 24 months, while their mental scores differed at ages 3, 4, 18, 24 and 27 months. Generally urban scores were higher than rural scores. (Richter et al, 1988). This suggests that even within a country differences in developmental rates exist because of geographic location.

Major environmental exposures, which are related to geographic location, have been found to impact negatively on child development. These include contaminated water and toxins such as lead, arsenic, manganese, pesticides and methyl-mercury (Walker et al, 2007).

In Sub-Saharan Africa factors such as infectious disease for example intestinal parasites, HIV/Aids, diarrhoea and malaria are affecting child development. 40% of paediatric admissions in parts of Sub-Saharan Africa are due to severe malaria (Walker et al, 2007). Geographic location will determine which children are more at risk of these.

Finally exposure to violence is a risk factor affecting child development (Walker et al, 2007). Many children in developing countries are exposed to community, political-sectarian violence and war. In SA, a particularly violent country (Chopra et al, 2009) a high level of morbidity exists due to violence and injury. Studies show that in SA children exposed to violence have higher levels of depression, attention problems, aggression and post traumatic stress disorder. Similar findings exist for children exposed to missile attacks in Israel (Walker et al, 2007). Therefore geographic location can determine what risk factors children are exposed to and therefore influence their developmental potential.Thus in the context of this study, finances, poverty , nutrition, shelter and geographic location all influence development particularly in developing countries such as SA with its high levels of poverty, unemployment, disease and violence.

2.3.2 Individual child characteristics

Individual child characteristics such as age, gender, race, genetics and health may all impact on child development (Kelly et al, 2006, WHO MGRS, 2006:66-75, Walker et al, 2007). These influences are often difficult to isolate.

2.3.2.1 Age and health

Prematurity is in itself a risk factor for neuro-developmental delay (Lima et al, 2004) and needs to be considered as a factor which can affect development. Prematurely born children, may need to be assessed at their adjusted age until 2yrs by which time they should have caught up to their peers (Faure and Richardson, 2002). A child's corrected age is their chronological age minus the amount of time they were premature. Correcting infant ages is controversial as regards whether it should be done at all and at what age it should be discontinued. Correcting a child's age may obscure indicators of developmental delay while no correction may result in over diagnosis. In a study of late preterm (36-38) versus term infants, late preterms whose ages were uncorrected, achieved significantly lower cognitive scores than term infants. However, when corrected ages were used, infants performed similarly (Romeo DM, Di Stefano, Conversano , Ricci , Mazzone , Romeo MG and Mercuri , 2010.) This is one way in which age influences development. The other way is simply related to normal development. Children at specific ages can be expected to do certain things, while younger children will be unable to do them.

Chronic illness in a child can affect their development. Children who are chronically ill may be delayed and this needs to be considered when assessing the seriousness of their delay and the possibility of their catching up. Regular hospitalisation in the early years can limit a child's ability to participate in normal activities and can affect their development of social skills. Sick infants are irritable and less responsive to their social environment. This can present as a challenge to caregiver behaviour and therefore affect a child's development. Maternal anxiety as a result of a sick child can result in less effective parenting in infancy. The result may be over protectiveness, maternal separation anxiety, poor boundary setting and behaviour problems in children. Restrictive, controlling caregiver behaviour has been associated with poor cognitive development and social skills later on in children. (Zelkowitz, 2004-2006). A small study done on infants with cancer in the first year of life found that when the primary caregiver is available (physically and emotionally), children's development is resilient to the effects of prolonged illness, which means that chronic illness in these infants had no effect on their development (Noll RB and Kulkarni R, 1989). In developing countries it has been suggested that infectious disease is a possible determinant of motor development, but there is a lack of sufficient research in this area. Diarrhoea is a common cause of child morbidity in developing countries and impacts on growth significantly by increasing pre-existing nutrient deficiencies. This is due to increased nutrient loss, impaired absorption, and decreased food intake. Infections or illness cause malaise and reduced physical activity as well as less psychosocial stimulation from caregivers. (Kuklina et al, 2004). Thus age or illness can directly or indirectly affect development.

2.3.2.2 Gender

Previous research points to trivial differences in general intelligence measures between the sexes, however the suggestion was that more notable, consistent differences are present in specific abilities (Galsworthy Dionne, Dale and Plomin et al, 2000; Wallentin , 2008).In adults the human cortex differs between males and females. Males have larger brains than females with a higher average neuronal density, but smaller neuronal units or neuropil (a region of synapses between axons and dendrites). These structural differences may result in males having better cortical function in particular areas like visuo-spatial and mathematical skills. For females, large amounts of neuropil could result in larger numbers of connections and dendritic arborisation resulting in better integration of information from sources specifically in language and memory tasks (Romeo and Di Stefani, 2010).

It is widely known that girls and boys differ in maturational timing. Girls grow faster than boys reaching 50% of their adult height earlier. Girls have been found to be less active than same age boys. These observed gender differences are possibly due to girls being more developmentally mature. Motor development may be linked to activity level; therefore age related reductions in activity levels may be indicative of girls being further along the motor maturation path. Similarly gender differences in cognitive performance may also reflect maturational rate differences. (Eaton and Piklai Yu, 1989).

Gender differences are also seen in immature brain injury where males are more biologically vulnerable than females (Romeo DM, Cioni , Battaglia, Palermo and Mazzone , 2010). Possible explanations for the cognitive differences are the neuroprotective effect of female hormones as well as differences in histo-morphological features (Romeo and Cioni, 2010). For motor performance, better motor performance in females may be because females have better cognitive function which encourages early exploration or earlier neuro-biomechanical maturity which results in motor exploratory behaviour and thereby more skill acquisition. (Romeo and Cioni, 2010).

Cognitive development and gender

Being male is a risk factor for poorer neuro-developmental outcomes, however no differences in general cognitive ability between genders exist. For example in preterm infants, males are more at risk of mental retardation and have lower scores than females in developmental tests, while males are also more at risk of cerebral palsy. In a study of late preterm (36-38) versus term infants, more males than females were found to have low cognitive scores in the preterm group while in the term group gender scores were similar. (Romeo and Di Stefani, 2010). In a study in India consisting of 100 males and 100 females ages 12-24 months, boys and girls scores for mental development, were found to be on par (Dhanda and Chikara, 2008). In another study mentioned earlier, gender significantly influenced infant's mental scores and girls outperformed boys (Lima et al, 2004).Only two of these studies above assessed infants in the first year of life. The different age ranges make these difficult to compare. However the consensus is that girls outperform boys.

Language development and gender

Anatomical differences in the brain, genetics and the role of the X chromosome have been proposed to explain gender differences in language and cognition (Galsworthy et al, 2000; Wallentin, 2008). These differences include variations in cerebral lateralization, grey matter volume, corpus callosum size and shape, cortical volume in language related areas and hippocampal differences. Hormonal influences have also been suggested to explain gender differences in verbal abilities. (Wallentin, 2008).

A review of the literature by Wallentin (2008) et al on gender differences in verbal abilities, found that girls are at a slight advantage to boys when it came to early language acquisition. These differences disappear as children get older. No gender differences in language proficiency were found but Wallentin’s (2008) review found that language related deficits have a clear gender bias for instance, stuttering, autism and dyslexia which are more common in males. (Wallentin, 2008).

Wallentin's (2008) review included a twin study by Galsworthy (2000) et al, who found that girls performed significantly higher than boys on verbal and non-verbal cognitive tests at age two years. Galsworthy (2000) also found significant differences in the aetiology of gender differences in verbal cognitive ability in terms of genetic and environmental differences. Therefore they concluded that sex-specific factors have an influence on early language development, but not on non-verbal cognitive development. (Galsworthy et al, 2000). The finding that, early on, girls were superior in their acquisition of language skills was consistent with the explanation that differences in early language acquisition form part of generalised gender differences in development. (Galsworthy et al, 2000; Wallentin, 2008). The above studies do not assess infants in the first year of life but one can assume that gender differences may exist in this period too and further research is needed in this area.

Motor development and gender

Inconsistent evidence exists on gender differences in motor development. Either no differences are observed or boys are found to be more delayed and vulnerable to stressors. (Papalia, 2009:145; WHO MGRS, 2006:66-75; Pollatou, Karadimou and Gerodimos, 2005; Lima et al, 2004).

Although boys tend to be bigger and more active than girls, no gender differences are said to exist in motor development in infants (Papalia, 2009:145). The MGRS assessed the influence of gender on development. Six motor milestones were longitudinally observed in infants between 4 and 24 months of age across different sites. The results showed that no significant differences existed between boys' and girls' age of milestone achievement. (WHO MGRS, 2006:66-75).

However, small but inconsistent differences between sexes in age of achievement of motor milestones were found, with girls tending to achieve milestones earlier than boys. All sites had statistically significant differences between boys and girls in ages of achievement of independent sitting and standing, both being earlier by about 7 days in girls. However since the differences were small, they were said to have no practical relevance and did not justify the need for gender specific norms. (WHO MGRS, 2006:66-75).

Interestingly, two sample t-tests evaluating site-specific and motor milestone-specific differences between the sexes, found statistically significant differences in 5 out of 30 comparisons (WHO MGRS, 2006:66-75). These were:

-Independent sitting (In India)

-Walking with assistance (in USA)

-Independent standing (in Oman)

-Independent walking (in Ghana and Oman)

When all sites were pooled, independent sitting had the most statistically significant gender differences in age of achievement (WHO MGRS, 2006:66-75).

Despite the above findings, the WHO still supports the method of pooling data for sexes to establish international gross motor standards for both sexes (WHO MGRS, 2006:66-75).

Although the WHO study pooled data for gender differences to create their standards, there were differences in gender motor development and this may need to be considered when assessing children. Therefore the trend in findings for gender differences is: either no differences exist or girls achieve milestones earlier than boys. Further research in this field is necessary to confirm or refute this.

Summary

Gender differences in development exist (Galsworthy et al, 2000). Girls tend to outperform boys in cognitive, language and motor skills. Perhaps this is due to girls maturing neurodevelopmentally faster than boys, as previously suggested (Eaton and Piklai Yu, 1989). This could have implications for assessing different genders at the same chronological age; however more research is needed in this field.

2.3.2.3 Race and genetics

Ethnic influences in child development are difficult to pinpoint and little research exists in this field. A combination of nature and nurture is required for development. Genes can influence development (Fernald et al, 2009) and language disorders in particular have a genetic basis (Galsworthy et al, 2000; Viholainen et al, 2002; Wallentin et al, 2008).

As part of the Millennium Cohort Study a sample of United Kingdom (UK) born infants were investigated to see if ethnic differences existed in milestone achievement. The study sample consisted of the following ethnic groups; white, Indian, Pakistani, Bangladeshi, black Caribbean, and black African and Kelly (2006) found that ethnic differences do have an influence on development. Although only infants at nine months age were included, ethnic differences were found to affect the achievement of gross motor milestones. Black Caribbean and black African infants were found to be less likely to have gross motor delays at nine months age compared to white infants (Kelly et al, 2006).

Some differences found were explainable as being due to socio-economic factors, as mentioned before (2.3.1.3). Other differences were not explainable and may be due to inherent biologic differences (Kelly et al, 2006).

The Millennium Cohort Study included a large sample size, but only looked at infants at nine months of age, so we do not know what effect there may have been, if any, in children at other ages and more research is needed in this field.

It is clear that individual child characteristics such as age, gender, race and genetics can influence infant development as described above. In SA many children suffer from ill health and chronic disease thus their development may be compromised and developmental assessment is needed. In this study gender is assessed to see if it is associated with any major differences in children's performance.

2.3.3 Social environmental factors

The social environmental factors influencing development include education of caregivers, care giving practices, family and cultural practices.

Caregivers Responsibilities

Optimal development in infants requires adequate prenatal and postnatal care, screening for developmental delays, ensuring adequate nutrition and protecting children from disease, toxins, injury and any hazardous exposure. This is predominantly the caregiver's responsibility but requires support from society and government. This includes ensuring the quality of paid caregivers and any people who work with children. People who work with children need to be sensitive to children's' needs and must be equipped with the knowledge and resources necessary to do this. Ensuring our children are given the best ultimately shows commitment to improving society at large. Society would be wise to value those who relate to children daily since early relationships are so important. (Thompson, 2001).

The core environment surrounding infants consists of people. Relationships provide them with security, nurturance and cognitive, language and motor stimulation. Many of these come naturally to the sensitive caregiver, who can provide for the needs of infants optimally just by doing what is natural to them. Stressed, depressed or absent caregivers struggle to fulfil these needs. (Thompson, 2001).

A child's potential is dependent on a caregiver's protection and care. Due to children's poor judgment of potentially dangerous situations, accidents are a leading cause of injury in children. A caregiver's responsibilities include; ensuring a child receives timely vaccinations, medical care when necessary, adequate diet, early vision and hearing screening (Thompson, 2001) as well as access to education.

Caregiver sensitivity

All learning occurs in a social context and the role of a caregiver in a child's development is crucial (Thompson, 2001).Psychosocial risk factors linked to child development include, caregiver sensitivity, responsiveness to child, and caregiver affect. These factors have been found consistently to be related to children's cognitive and socio-emotional competence and are influenced by culture and poverty. Studies show that maternal sensitivity and responsivity has a positive effect on infant attachment, cognitive ability and behavioural problems, while maternal depression can have a negative impact on child development. (Walker et al, 2007).

Cultural care practices

Culture is defined as “the customs, institutions, and achievements of a particular nation, people, or group” (Pearsali J(Ed). The concise Oxford dictionary. 10th Ed. New York: University Press, 1999: 348). Culture is influenced by geographic location, religion, access to education and health care, political and economic structures. Cultural beliefs impact on, parenting behaviour and practices and skills may emerge earlier when encouraged by a particular culture. This needs to be considered when different populations are compared (Fernald et al, 2009). According to the Dynamic Systems Theory as described earlier (2.1.1) emphasis is placed on the environmental influence on development. Motor development follows a sequence but the timing of this sequence can be influenced by cultural factors. Well nourished and nurtured children develop normally but normal in one country is not normal in another. African babies are said to be more advanced than US and European babies in sitting, walking and running. For example, Ugandan babies walk at 10 months, US babies at 12 months and French babies at 15 months. These differences may be due to ethnic or cultural care practice differences. Some cultures encourage early development and others do not, for example Jamaican mothers use handling routines daily to encourage development and their infants sat, crawled, and walked earlier than English infants whose mothers did not follow such routines. (Papalia et al, 2009).

In the WHO MGRS (2006) described previously (2.3.1.4), cultural care practices were found to influence the age of motor milestone achievement between countries. The authors felt that these differences reflected typical development in healthy populations from different environments and cultures. For example Ghanaian children showed the earliest age of milestone achievement, while the Norwegian children the latest ages of achievement. Ghanaian caregivers encouraged infants to increase their milestone achievement, while Norwegians followed a system focused on waiting for the child to show an interest first. Of the six studied gross motor milestones, the authors of the study suggested that crawling, independent standing and independent walking in particular require more co-ordination. This makes their ages of achievement less prone to influence by caregiver training. (WHO MGRS, 2006:66-75). The other milestones like sitting, assisted standing and assisted walking therefore are more prone to influence by caregiver training.

In Kelly's (2006) Millennium cohort study, socio-economic factors such as mother's education, household income and cultural traditions, were some of the causes of differences in motor milestone achievement in nine month old infants. Again, we do not know what effect there may have been, if any, in children at other ages and more research is needed in this field. (Kelly et al, 2006). The presence of a father in the home had a positive impact on development, possibly due to increased finances or family stability (Lima et al, 2004).

Culture can influence the way in which a caregiver responds to a child. In some cultures males are more revered and more is expected of them than girls. This may influence their caregiver's interaction with them or the type of stimulation they receive. One of the four major factors, which prevent children from reaching their developmental potential according to Walker et al, is decreased cognitive stimulation, which would be influenced by poor care giver education or any of the above mentioned factors. (Walker et al, 2007).

Therefore cultural care practices and quality of care giving, affects motor development and can be expected to affect other domains of development too. These socio-environmental factors may influence children in SA as their culture in particular, is very different to that of the USA. This will impact on their assessment. For the purposes of this study, the domain of development related to socio-emotional behaviour was not studied. This domain can be influenced by all the above factors and can influence other domains of a child's development.

Summary

Physical environmental, individual child characteristics and social environmental factors can all impact on a child's development. These are all interrelated and difficult to isolate. Many of the above mentioned factors affecting development are preventable or modifiable conditions and can be addressed through intervention programmes. Further, many of these are present in developing countries such as South Africa, where children are exposed to multiple risk factors (Walker et al, 2007).These factors highlight the possible differences, which can be expected to be found in different populations and indicates the complexity of assessing development. It shows that assessment tools must be able to incorporate variations and distinguish pathological from normal differences.

2.4 Tools used to assess typical development

Multiple factors , which can influence development make assessing children a complex task, thus a suitable assessment tool is needed, that while allowing for minor differences, still has the ability to detect pathological ones. A tool should also look at all areas of development and be able to detect which areas are delayed as this will help with appropriate diagnosis, referral and treatment or remediation. Different tools are available and include standardised, non-standardised and screening tools.

Screening tools have the benefit of being easy to administer. They involve parental input and have been found to correlate well with direct assessments. However caregivers or teachers may inflate scores, interpret items differently according to cultural differences and report a child's abilities inaccurately. Screening tools are also not diagnostic. Direct forms of assessment allow for first hand information gathering and minimise recall bias. These gold standard measures offer high quality data, but require extensive training. They also face the challenge of the difficulty associated with assessing young children. Their accuracy depends on quality of the test and appropriateness for certain populations. (Fernald et al, 2009).

The selection of an appropriate test, will involve factors such as reliability and validity of the measure, qualifications of the assessor as well as the purpose of testing and the child's individual characteristics (Tieman, Palisano and Sutclive, 2005). Some authors suggest that each country should produce their own tool suited to their population (Westera et al, 2008). However this is a costly undertaking, which may not be feasible in developing countries, such as SA. SA needs a suitable tool to assess all areas of child development. Types of assessment tools which are available will be discussed and include screening tools, non-standardised tools and standardised tools. Since delays in one developmental domain can affect the achievement in other domains, comprehensive assessment, which includes all domains, is necessary. (Fernald, Kariger, Engle and Raikes, 2009).

2.4.1 Screening tools

Screening tools are one method used to assess child development. They are cost and time efficient but may not be diagnostic or accurate enough as they are often completed by non-professionals. They may however be useful in determining which children need further investigation. Examples of screening tools are parent questionnaires such as the Ages and Stages Questionnaire (ASQ), the Pediatric Evaluation of Developmental Status (PEDS), the Minnesota Child Development Inventory (MCDI), the Kent Inventory of Developmental Skills (KIDS) and the Parent Report of a Child's Abilities revised for preterm infants (PARCA-R). These are all designed to identify children in need of further investigation. (Johnson et al 2006). Screening tools have become increasingly popular and are believed to be more accurate than previously estimated (Kerstjens JM, Bos AF, ten Vergert MJ, de Meer G, Butcher PR and Reijneveld SA, 2009). Scores that are 3 SD below the mean have been known to better predict significant disability (Johnson et al, 2006). Developmental screeners which can be used by trained professionals include the Denver II screening test, the Bayley Neuro-Developmental Screener and the Batelle Developmental Inventory. These tools however require time and effort to administer and interpret (Kerstjens et al, 2009).

2.4.2 Non standardised tools

Well known non-standardised tools, which are available, include the Touwen Infant Neurological Exam and the Amiel-Tison Neurological Exam. Other tools, like the Hammersmith Infant Neurological Exam, are standardised through small samples. (Heineman KR, Hadders-Algra M, 2008). These tools do not provide reliable, valid results and are not ideal for assessing children. The use of a combination of assessment tools with long term follow up has been recommended. This is however impractical, time consuming and a not suitable, particularly in SA.

In SA the START is a developmental screener, which assesses all elements of development. START stands for Strive Toward Achieving Results Together. It was developed in SA as a home based assessment and intervention programme. It targets developmentally delayed children from age 0-7yrs and is scored using checklists. It covers five domains such as gross motor, communication (receptive and expressive), fine motor /cognitive skills and activities of daily living. It is currently available in English and Zulu. (HSRC, 2010). Its function is to assist caregivers in identifying developmental delay; however it has not been standardised, is outdated and to the authors knowledge no research on its use exists. Perhaps if it were revised, it may be useful in SA, as it has been designed for this population.

2.4.3 Standardised tools

Standardised tests, although costly and time consuming, are suitable for identifying and monitoring problems in development. They are an acceptable outcome measure and provide a valid, reliable assessment of a child's development compared to the norm. These tools also provide information on the level of a child's development and the areas of weakness. (Johnson et al 2006). Developmental tools can be standardised and tested for validity and reliability. By comparing them to a gold standard tool, they can be measured for specificity, sensitivity, and other psychometric properties (Kerstjens et al, 2009).

2.4.2.1 Standardisation

Standardised tests are psychometric measures which provide a comparison between a child's performance and a norm. The norm refers to a group of children with similar characteristics and functioning. Measures used in standardised tests are formally administered by a trained examiner. The examiner follows a strict format for administering and scoring the test. This ensures maximum objectivity in result interpretation. Test scores achieved without the use of the strict guidelines are rendered invalid. This type of test lends itself to large scale use and routine follow up, as different examiners may perform the test and get similar results due to the strict format. Comparisons can be made between groups or individuals and the norms.

Standardisation of the test involves administering it to a large group, for whom it was designed, known as the normative sample. Individual scores can be compared to these norms to reflect a child's present functioning. These scores are called norm referenced or standardised scores. They follow a normal distribution with a mean and standard deviation (SD) and are age specific. Typically the mean is 100 and the SD 15. Standardised scores can include T-scores (mean 50, SD 10), scaled scores (mean 10, SD 3) and z-scores (mean 0, SD 1). The amount that an individual's score deviates from the mean of the normative sample will describe their developmental level. Other norm referenced scores that can be derived from standardised tests include percentiles and age equivalents. (Johnson et al, 2006). In this study norm referenced scores are used, with a mean of 100 and SD 15.

Standardised tests are analysed to determine their psychometric properties which include, representativeness, reliability, internal consistency, test-retest reliability, inter-rater reliability and validity. Standardisation itself does not ensure that a test is psychometrically adequate, however. High reliability and validity indicate better psychometric properties, meaning one can draw more accurate conclusions about a child's current level of functioning developmentally. An important property of a tool is how recently it was standardised. The Flynn effect occurs when a score increases over time in a standardised test. This is a common problem with standardised tools and children's' performance can be misinterpreted if old norms are applied. Finally, standardised tools are costly. Suppliers sell the test and scoring forms, which is necessary to ensure it is used in as standard a way as possible. These tests are also only allowed to be purchased by people with sufficient qualifications or experience. (Johnson et al, 2006).

When selecting a standardised test, one should consider the quality of its psychometric properties, its purpose and the population it will be used on. The following standardised tests, which can be used to assess child development, will be discussed; the Griffiths Mental Scales (Griffiths), the Bayley Scales of Infant Development II(BSID-II), the Ages and Stages Questionnaire(ASQ), the Batelle Inventory (Batelle), the Developmental Assessment of Young Children (DAYC), the Mullen Scales of Early Learning (MSEL), the Denver Developmental Screening Test (Denver) and the Miller Function and Participation Scales (M-Fun-PS).

Griffiths and BSID-II.

The most frequently used standardised tools are the Griffiths Mental Scales (Griffiths) and the Bayley Scales of Infant and Toddler development (BSID-II). The Griffiths Scales assess locomotor, personal social, hearing and language, eye-hand co-ordination and performance domains. The age range is ages 0-23 months and it takes 30-60 minutes to administer the test .The Griffiths can be used by psychologists and clinicians with training in developmental assessment, it requires a 5 day certification course, and was standardised in 1996. (Johnson et al, 2006).

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The BSID-II is the most widely used and assesses cognitive, language and motor domains. The age range is 0-42 months, it takes 30-90 minutes to administer and was last standardised in 2006. It can be used by professionals with qualifications and experience in treating young children. (Johnson et al, 2006).

ASQ

The ASQ is a widely used standardised screening tool. It consists of 19 questionnaires ranging from 4-60 months and takes 10-15 minutes to complete. A minimal reading level is required and it covers the following domains; communication, gross motor, fine motor, problem solving and personal social skills. It has also been translated into several languages. (Young Kim E and Kyung Sung I, 2007, Kerstjens et al, 2009).

Batelle and MSEL

The Batelle Developmental Inventory II(Batelle II) and the Mullen Scales of Early Learning(MSEL) are less well known standardised tools for assessing child development. The Batelle II assesses personal-social, adaptive motor, communication and cognitive domains. Its age range is 0-8yrs, it takes 1-2 hrs to administer and can be used by psychologists and paraprofessional for example teachers. It was standardized in 2003. (Johnson et al, 2006).

The MSEL assesses fine motor, visual reception, receptive language, expressive language and gross motor skills. Its age range is 0-68 months; it takes 15-30 min and was standardised in 1989. It can be used by people with experience in clinical assessment of young children. (Johnson et al, 2006).

DAYC

The Developmental Assessment of Young Children (DAYC) identifies children from 0-5 years who are in need of early intervention. It takes 10-20 minutes to administer and no qualifications are required. This is a standardised test with norms, based on a large sample done in 1996. The DAYC consists of five domains; cognition, socio-emotional development, communication and physical development, which can be used individually or as a complete battery. (Western Psychological Services, 2009).

The Denver II

The Denver II is a revision of the Denver Developmental Screening Test and charts normal development. It covers four domains; personal social, fine motor adaptive, language and gross motor and can be used on children from 0-6 years of age. It was published in 1992 and was standardised on a large sample of children who were representative of the 1980 US census population. The Denver II has been translated into several languages. It has also been re-standardised on children in 12 countries to create national norms. (Frankenburg W and Dodds J, 1992). The norms for the Denver were developed according to the western norms and may not be valid for assessing children from other cultures (Papalia et al, 2009). The Denver II norms are outdated as they were done on a 1980 sample of children and the USA population has changed since then.

Miller Function and Participation Scales (M-Fun-PS)

The Miller Function and Participation Scales can be used on children from 2 years, 6 months-7 years, 11 months of age. It is a new test published in 2006 and takes 55-65 minutes to administer. Its purpose is to assess a child's functional performance as it relates to school participation and it provides standard and criterion referenced scores, which have evidenced strong reliability and validity. It addresses activity and participation incorporating the International Classification of Functioning, Disability and Health (ICF) framework as well as body structure and function. (Pearson, 2010). This new tool is not as well studied as other tools. It also requires experience and insight in child development to interpret results. Since this is a fairly new test, it will need to undergo research to gain the same popularity as the BSID-II.

In summary the Griffiths, MSEL, DAYC, and Denver II have outdated norms. The Batelle is less well known and the M-Fun-PS is very new. The Bayley-III is well known, extensively used and has the most recently updated norms.

2.4.2.2 Merits and demerits of standardised tools

The biggest concern with standardised tools is its use on populations which differ to that of the norming sample. Many available tools have been adapted to suit specific target populations. For example some tools with country specific norms may be used in other countries but with norms which have been adapted to suit the population. Clinicians using tools without local norms need to be aware of possible differences which may exist across populations. Many tools require rigorous training and certification before a clinician can use them and some tests are only permitted to be used by appropriately qualified clinicians. (Johnson et al, 2006).

The disadvantages of standardised tools are

- Tools become outdated if populations change, therefore need regular updating.
- Population differences limit their use
- Expensive and time consuming

The advantages are

- Good for large scale use and routine follow up
- Different examiners can test the same child and get the same result
- Scores can be compared to norms
- Enables diagnoses of the area and severity of delay

The Bayley-III has the most recently updated norms .The Bayley-III assesses cognitive, language and motor development (Tieman et al, 2005) and can be used by therapists, psychologists and doctors. In this study the overall goal of assessment is to identify abnormal development in fields of communication, motor and cognitive development. The Bayley Scales of Infant Development third edition (Bayley-III) is detailed enough to do this and it is for this and for numerous other reasons, which will be outlined below that it was chosen as a suitable test to use in this study.

Appropriate assessment tools are needed to assess children, particularly in developing countries like SA where they are at risk of not reaching their full developmental potential. Choice of the appropriate tool is paramount. Of all the above mentioned tests, a standardised test is the most suitable for use in the context of this study and the Bayley-III, was chosen for its good psychometric properties, updated norms and reputation.

2.5 The Bayley Scales of Infant and Toddler development

The Bayley Scales of Infant Development II (BSID II-2nd Edition) is a widely used standardised assessment tool for clinical and research purposes and is known as the gold standard of infant assessment (Campos et al 2006; Harris et al, 2005; Gauthier et al, 1999). The Bayley Scales of Infant Development (BSID-1st Edition) and BSID II (2nd Edition) released in 1969 and 1993 respectively have been followed by the Bayley Scales of Infant Development III (Bayley-III-3rd Edition) (Harcourt, Bayley-III Tech report 2, 2007), released in 2006. These norms are the most recently updated of the well known standardised tests.

2.5.1 Properties of the Bayley-III

The Bayley-III is a revised edition of the BSID II. It is fully comprehensive and measures cognitive, language (expressive and receptive), motor (gross and fine), social-emotional, and adaptive behaviour (Harcourt, Bayley-III Tech report 2, 2007).

Standardisation

The Bayley-III is an American designed tool with norms based on the USA population. The normative sample consisted of 1700 typically developing children (born 36-42 weeks gestation) aged from 16 days to 43 months 15 days. Typically developing children were defined as those without significant medical complications at or after birth as well as infants without medical or behavioural diagnoses. Males and females were equally represented. The sample was stratified, based on information acquired from the October 2000 US Census. Stratification was based on demographic variables such as race, age, sex, parental level of education and geographic region. Races included proportions of whites, African Americans, Hispanics, Asians and other minority groups. (Bayley N, 2006).

Clinical cases were included in the standardisation process to ensure Bayley-III data was representative of the population. These cases, which represented about 10% of the sample, included children with Cerebral Palsy, Pervasive Developmental Disorder, and Down syndrome, prematurity, language impairment and those at risk for developmental delay. (Bayley N, 2006).

Purpose

The purpose of the Bayley-III is to identify the developmental competency of children aged 1-42 months of age, as well as to identify any deficits which may exist in the five major developmental domains. (Bayley N, 2006:1).

Reliability

Reliability refers to a test's accuracy and consistency across different situations. The Bayley-III can be used with equal reliability to assess children with different developmental levels and clinical diagnoses. Data on reliability is available in the Technical manual with regards to internal consistency, standard error of measurement, test-retest reliability and inter-rater reliability. The Bayley-III is an instrument with high reliability. (Bayley N, 2006:55-67; Campos et al 2006; Gauthier et al, 1999).

Validity

Validity is a very important quality of a test. It refers to how much evidence is available to support the interpretation of test scores for the purpose for which it was intended. Data is available on content and construct validity of the Bayley-III. Each item tested was found to correlate with the scale in which it was placed more than with other scales. Correlations between scales were in the low to moderate range. These indicate evidence of construct validity. The Bayley-III has been correlated with subtests and measures of similar content for example the BSID II, Weschler Preschool and Primary Scale of Intelligence (3^{rd}), Preschool Language Scale (4^{th}), Peabody Developmental Motor Scales (2^{nd}) and Adaptive Behaviour Assessment System (2^{nd}). The Bayley-III was found to correlate well with other instruments. Special group studies were also undertaken with comparisons between typically developing children and matched special groups, which showed that the Bayley-III is sensitive to picking up differences between children from special groups and the normative sample. The subtests of the Bayley-III have also been assessed and found to correlate appropriately. (Bayley N, 2006:69-103).

Training required

Training on the use of the Bayley-III is available via DVD or on-site workshops (Pearson, 2009).

Professionals allowed to perform test

The Bayley-III should be used by professionals who are trained in the use and interpretation of standardised tests. These people may include those with special educational training for assessing young children and those with training in infant and child development. For example; psychologists, psychiatrists, speech and language therapists, occupational therapists and physiotherapists specialising in early intervention, early interventionists, social workers, developmental paediatricians and paediatric nurse practitioners. Those who qualify will most likely have a Masters degree or should be appropriately trained in testing methods and statistics as well as have experience in early intervention. (Pearson, 2009).

Items and scoring,

To assess a child with the Bayley-III, their chronological age is determined and then used to determine the starting point in the test. The child's age correlates to a starting point indicated by a letter. The test is commenced in each subtest according to this. Reversal and discontinue rules are then applied as follows. A child must get a score of 1 for all three of the first consecutive three items at their age specific start point. Failing this the test must be started at the previous age group specific starting point. This continues until the child passes the starting rule. The test is discontinued when the child scores five consecutive item scores of 0. (Bayley N, 2006:50). The cognitive subtest consists of 91 items, the receptive communication subtest of 49, expressive communication subtest of 48, the fine motor subtest of 66 and the gross motor subtest of 72 items. The test takes approximately 50-90 minutes to administer, depending on the child's age.

Total raw scores are calculated for each subtest. These are converted into scaled scores (mean 10 and SD 3), composite scores (mean 100 and SD 15), percentile ranks and growth scores (Bayley N, 2006:106-110). Parents are required to be present when testing to encourage their child to be as responsive as possible. Parent questionnaires are available for the socio-emotional and adaptive behaviour scales. The composite scores can be compared to those of the norms and it can thereby be determined how infants are performing in each subtest in terms of qualitative descriptions for example, very superior, superior, high average, and average, low average, borderline and extremely low. Infants scoring 1.5 SD below the mean in two or more areas or 2 SD below the mean in one area are considered to be delayed. (Bayley N, 2006:106,113).

Differences between the BSID II and the Bayley-III

The BSID I was published in 1963, while the BSID II was published in 1993.The third and most recent edition of the Bayley Scales of Infant and Toddler Development (Bayley-III) was revised and published in 2006.

During its development, research showed the Bayley-III mean scores were about 7 points higher than those of the BSID II. This is a consistent finding for measures of infant development (Bayley N, 2006:77). The reason for this was probably due to changes in the demographics of the population in America. These changes included changes in proportions of children from different racial and ethnic backgrounds and regions of the country and changes in parent educational levels (Harcourt, Bayley-III Tech Report 2, 2007). It must be mentioned that the cognitive scores in the BSID and BSID II (1^{st} and 2^{nd} edition) include language whereas in the Bayley-III (3^{rd} edition) they are a separate score. This will influence comparisons of results between the different editions of the test.

Revisions:

Many changes were made to the Bayley-III and can be found in the manual, some include:

-developing five distinct scales (as per federal and state guidelines) for child assessment.

-strengthening its psychometric properties by expanding floors and ceilings, improving evidence of validity and reliability and re-examining item bias.

-improving the Bayley-III's clinical utility. (Bayley N, 2006:77).

In summary the aims of these changes were to meet legislative requirements and assessment needs, improve content coverage, accuracy of administration and scoring and updating the norms on the Bayley-III. (Bayley N, 2006).

To the present author's knowledge there are no articles available on research into the Bayley-III, other than the above mentioned. Further in SA, no standard assessment practice exists according to the author's knowledge. Public clinics provide basic child care which is free for children under 6yrs. This involves vaccinations and monitoring of growth. A minimal amount of screening for developmental delay is done and this is recorded on the road to health card (RTC) by nurses.

2.5.2 The use of tools on populations which differ to the norming sample

One of the concerns with standardised tests as mentioned earlier is the use of them on populations which differ to the norming sample. In 1992 a study was published on the use of the BSID (1st edition) on black South African infants. The results of this study showed that South African infants scored significantly higher than the American standardisation sample particularly in the motor scale from 2-10 months of age and the mental scale from 4-15 months of age (Richter et al 1992). African infants were significantly advanced in motor and mental development up to 15 months compared to white American infants. From 18 months to 30 months of age no differences were found in development between the white American infants and the black South African infants (Lynn R, 1998).

This highlighted the issue of African infant precocity, the fact that black infants are found to be developmentally advanced compared to white infants in the early months. These findings made it necessary to question the validity of using Western normed assessment tools on African populations. (Richter et al, 1988, 1992).

The researchers of the above study formulated a set of norms for black South African infants as a supplement to the BSID, to assist with interpreting scores for this specific population. These norms were based on healthy infants, who were representative of the population of black infants in South Africa. These norms would assist with comparison of an infant in this population with his peers rather than with American infants. (Richter et al, 1988).

A similar study done in 2005 on the BSID on 128 Nigerian children found that Nigerian infants scored above the normal values for the American infants, especially in the lower age groups of 2, 4 and 8 months. The study sample consisted of 16 apparently healthy infants in each age group. In their study they assessed children at 2, 4, 8, 10, 18, 24 and 30 months of age. The authors felt that the higher gross motor and fine motor scores supported past studies' descriptions of African infant precocity. The authors felt that, because development varies according to race, geographic location and culture, it necessitates the formation of local norms for these groups. (Aina et al, 2005). However this study had a small sample size and more research is needed on other populations to support these results.

Even when local standardisation is available, one can still encounter problems. Westera et al did a study comparing the results of children's BSID II scores which were calculated using Dutch and USA normative data and test procedures. The study sample consisted of preterm infants assessed at corrected ages. Clinically relevant large differences were found in the mental and psychomotor index scores, with the Dutch scores being higher than USA scores. This was especially evident at 6 and 12 months of age. The reasons for this may have been due to bias in the Dutch norms, which used smaller numbers of children to generate their norms. However the authors' recommendation was for countries to develop and use their own norms. (Richter et al, 1992; Westera et al, 2008), which are validated wherever possible and that the process of validation should be similar to the process used to validate the norms in the country from where the test comes. They felt that due to cultural, economic and social influences, without the use of original norms, clinical decisions can not be made regarding a child or group of children's development. (Westera et al, 2008).

The above evidence suggests that infants develop at different rates due to physical environmental, individual child characteristics, and socio-environmental differences.

Since these differences, which exist in infant development are normal, problems arise when comparing different populations to one another. In particular it may not be acceptable to use a test standardised with American norms on the South African population.

Caution needs to be exercised when comparing culturally or demographically different infants to what is considered 'normal' in one country as is the case in this study. Clinicians need to be aware of possible differences in the population they are assessing, which may be normal. They need to know the population they are testing in order to interpret results with care and they need a sound knowledge of normal development. Further revision and updating of norms in developmental tests is essential (Richter et al, 1992), as well as testing tools for their validity before use on different populations.

The Bayley-III is a well known, recently updated standardised tool and was chosen for use on the South African black population in this study.

2.6 The South African situation

South Africa is a country with a unique population structure. SA is classified as an upper-middle income country, although huge income inequality exists and poverty affects nearly half the population. Due to political issues and discrimination large disparities exist in child health across the country (Saloojee et al, 2005). Since the arrival of democracy in 1994, several improvements have been implemented. Although political change has aimed to decrease inequalities in health provision (Chopra et al, 2009), much still needs to be done.

Children in developing countries are at risk in terms of development. They are more likely to be delayed as they are exposed to more factors which put them at risk. They are also more susceptible to deficiencies in basic health and nutrition than children in the developing world. These deficiencies result in delayed cognitive and physical development (Fernald, et al, 2009). South Africa is a developing country with a large proportion (approximately one third) of the population consisting of children, two thirds of which live in rural areas (Saloojee et al, 2005). Most of these are catered for by the public health system, which is under strain due to lack of finances, resources, and the brain drain (Saloojee et al, 2005; Chopra et al, 2009). A small minority of the population receives private health care at a 1st world level but the majority of illnesses presenting in children are typical of a developing country (Saloojee et al, 2005, Chopra et al, 2009).

Social problems faced by SA include income inequality and high levels of unemployment and poverty. SA is struggling to reach their Millennium Development Goals (MDG) as a result of several challenges. These include challenges to life expectancy (which has decreased due to HIV related illness like TB) as well as violence, chronic disease, mental health disorders, and maternal and neonatal mortality. These place increasing demands on the weakened health system. (Chopra et al, 2009).

Improvements which have been made to the health system in SA include free access to primary healthcare for children less than six years of age and for pregnant women as well as improvements in social child grants. Child health issues that have been identified and addressed include birth defects, albinism, foetal alcohol syndrome, Down syndrome, neural tube defects and children who are underweight or overweight. The national health department adopted the WHO strategy to target five major illnesses in 1997. The IMCI (Integrated Management of Childhood Illness strategy targets diarrhoea, pneumonia, measles, malaria and malnutrition. (Saloojee et al, 2005). Other improvements include reductions in vaccine preventable diseases such as polio, diphtheria, hepatitis B, measles and tetanus. Measures have been implemented to control diarrhoea, pneumonia, malaria and malnutrition. Since 2003 Nevirapine has been made available for pregnant mothers and since 2004 highly active anti-retroviral treatment (HAART) has been made available in government institutions, for children and adults. (Saloojee et al, 2005). Improvements have also been made to increase availability of sanitation, clean water and electricity, which has decreased communicable disease mortality and morbidity (Saloojee et al, 2005; Chopra et al, 2009).

Despite the improvements many challenges in health care in SA exist. SA is plagued by high levels of infectious disease particularly HIV and TB. These increase family poverty and the burden of care on the elderly and young .It also overwhelms the health services resulting in poorer service delivery. Nutrition, especially under nutrition is a problem as a result of the social factors described above. These result in stunting, wasting and micronutrient deficiencies (Vitamin A, iron). Overweight and obese children are also a growing problem. Nutritional programmes have been implemented with legislation requiring the fortification of basic foodstuffs as well as feeding schemes (Saloojee et al, 2005).

One of the greatest health challenges facing SA is HIV. SA child mortality rates have increased since their baseline for the MDG in 1990 predominantly due to HIV and poverty along with poor implementation of interventions (Chopra et al, 2009.) HIV results in increased maternal and child mortality and increased orphans. These impact on long term child morbidity resulting in poor quality care. HIV in SA has resulted in a large proportion of chronically sick and dying children, placing a huge burden on the health system. (Saloojee et al, 2005). Antiretroviral (ARV) treatment programmes as well as prevention of transmission from mother to child (PMTCT) have been implemented, however only a small proportion of those who need ARVs are receiving it. Aids orphans, child headed households and street children are another problem caused by the HIV pandemic and aggravated by a lack of institutional care facilities.

Despite efforts to improve the health and social systems, SA is falling short of reaching its Millennium Development Goals (MDG). Insufficient goal achievement is at present evident in the following areas; combating HIV/Aids, malaria and other diseases as well as in achieving universal primary education. No progress had been made in improving maternal health and reversed progress has occurred in eradication of extreme hunger and poverty and reducing child mortality under five years. The goals related to gender equality and empowering women is the only MDG on track. (Chopra et al, 2009).

Therefore it is clear that the South African picture is very different to that of a developed country such as the USA. SA faces many social challenges and health challenges, such as high levels of unemployment, poverty and HIV. In the context of this study the SA situation is therefore an important factor to consider as it may impact on the performance of SA children on a USA designed, standardised test.

Conclusion

Infant development in the first few years is rapid. Early identification of problems ensures early intervention, which limits the impact of problems children may experience. Many factors affect child development such as physical environmental, individual child characteristics and social environmental characteristics. These may limit a child reaching their full potential and can influence the rate of development across populations so that what is expected in one population is not what can be expected in another. SA is a developing country and as such faces the many problems these types of countries do. The impact of the HIV pandemic has had a huge influence on child health in Sub-Saharan Africa.

Previous studies have suggested that African infants are precocious in development when compared to American infants (Richter et al, 1992). This may be due to cross-cultural, ethnic and environmental differences which exist in rates of infant development. Further research in this area is needed to confirm or refute these suggestions.

South Africa does not have a standardised tool for assessing development; while assessment and standard practice is inadequate. Different assessment tools exist and choosing the correct one is difficult. Screening tools are cost and time efficient but may not be diagnostic enough. Standardised developmental tools are expensive but offer reliable reproducible results.

The Bayley-III is a standardised tool which efficiently assesses all developmental domains. It was standardised in the USA and was chosen for use in this study. Due to the many risk factors children in SA are exposed to they are at risk of not reaching their potential. A suitable tool is needed which can identify and diagnose developmental delay in specific areas. The Bayley-III may be such a tool but since it was normed on a different population to the SA one it must be assessed for validity before use.

No studies have been done on the validity of the Bayley-III on different populations as yet. Therefore it may not be valid to test children from South Africa or countries other than America with the Bayley-III. The Bayley-III and any other tools used on children should be assessed for validity before use.

This study focuses on evaluating the performance of this population on the Bayley-III, thereby determining whether the Bayley-III is a valid tool for practitioners to use to assess black urban South African infants. It also assesses whether test results are influenced by anthropometric indexes or gender.

Development in children is rapid, complex and easily influenced in the first year of life. Assessment is critical during this time to ensure timely intervention, when the child is most likely to benefit. Many of the key factors affecting development are present in SA. This highlights a need for developmental assessment. However child development varies across populations and it may be unfair to use tests designed on populations which differs to that being tested. The Bayley-III is possibly a suitable tool but needs to be assessed for applicability to the SA population.

CHAPTER 3

METHODOLOGY

The aim of the study was:

To evaluate the performance of black South African urban infants in Gauteng, South Africa on the Bayley-III.

The objectives were:

1-To determine whether the Bayley-III is an appropriate tool to use on the black urban South African population in Gauteng.

2-To determine whether gender affects performance on the Bayley-III

3-To determine whether height, weight or head circumference have any correlation to infant scores.

The aims and objectives were reached by testing 122 children at specific ages with the Bayley-III. The following outlines the research methodology of the study.

3.1 Research design

The research design of this study was cross sectional. The Null Hypothesis was that the South African and American scores do not differ while the alternative hypothesis was that the two scores are different. A directional alternative hypothesis is not possible as there is no indicator of what to expect for this recently published and revised tool.

3.2 Sample

3.2.1 Subjects:

For the purposes of this study it was decided to focus on black urban infants in the Gauteng area of South Africa. This would include the black population attending municipal clinics in this area. Children attending clinics for immunisations are generally healthy and should be performing at their optimum. The clinics used in this study were located in Yeoville, Bezuidenhout Valley and Johannesburg City Centre. These are predominantly attended by black urban Africans. Thirty infants in each of the following age groups 3, 6, 9 and 12 months were recruited. Most infants were brought to the clinic by their mothers, a close relative or caregiver. The sample chosen was a convenience sample of children who were available and fulfilled the inclusion criteria.

3.2.2 Inclusion Criteria

i) Clinically or apparently normal infants were allowed to participate.

ii) Infants participating were three, 3, 6, 9 and 12 months or within 16 days of that age.

iii) Only black African infants born in South Africa were assessed. No proof of nationality was required and foreign immigrants from other African countries were included if their child had been born in South Africa. No proof of this was requested, parents were just asked to confirm verbally, where their child was born.

3.2.3 Exclusion Criteria

i) Infants with an apparent clinical abnormality.

ii) Infants with cerebral palsy, any syndromes or other obvious disability.

iii) Premature infants (Born less than 37 weeks gestation).

iv) Infants who were any race other than black African.

3.2.4 Sample size

Sample size was limited to resources which restricted the study to 120 subjects which were distributed over 4 age groups so as to measure a required 30 subjects in each age group in order to acquire enough scores to draw conclusions from. From a statistical point of view a sample size of 30 subjects per group, is the minimum required for estimation of a mean and Standard Deviation and a Confidence Interval, which is based on a normal (Gaussian) distribution (z). One hundred and forty five infants were assessed in total, 122 infants were included in the data analysis. The remaining assessments were either not completed due to the child being unhappy or were excluded due to errors or missing data. The sample consisted of 62 males and 60 females, approximately half each. This was by chance and not intentional.

3.3 Measurement tools

The third edition of the Bayley Scales of Infant and Toddler development (Bayley-III) was used to assess normal development. This tool takes approximately 1 hour to administer and can be used to assess child development from 1 month to 42 months.

It is fully comprehensive, assessing all areas of development such as motor, language and cognitive areas (Bayley N, 2006).

The Bayley-III provides four types of norm-referenced scores: scaled scores, composite scores, percentile ranks and growth scores. Confidence intervals are available for the scales and developmental age equivalents are available for the subtests (Bayley N, 2006). The present study derived only scaled scores and composite scores for analysis.

Each infant was assessed according to their age and scores were derived for each area- namely cognitive, motor and language. The behaviour rating scale was not used for the purposes of this study. Scores obtained were; cognitive, gross motor, fine motor, expressive language and receptive language composite and scaled scores.

Further, to assess height and head circumference a standard tape measure was used, while weight was measured with the clinic scale. These were not specially checked for calibration and the three different scales at the three clinics may have been differently calibrated. This could have affected the results.

3.4 Research Procedure

3.4.1 Recruitment:

Subjects taking part were recruited from municipal clinics in Gauteng. Permission from the head of each clinic and the Health Department was obtained (See Appendix F). Municipal clinics included Bezuidenhout Valley, Johannesburg City Centre and Yeoville.

Subjects met the inclusion and exclusion criteria as described. They were randomly assessed when they attended the clinic for vaccination, prior to vaccination. Caregivers of infants attending the clinic for immunisation were approached by the researchers to find out how old their babies were, while they were waiting in the queue. Infants were identified at the ages of 3, 6, 9 and 12 months or within 16 days of this by double checking their exact date of birth on their clinic card.

Those caregivers whose infants fell in the inclusion criteria were told about the study. If interested in participating, the infants' caregivers were given an information sheet to read and they were invited to participate in the study.The information sheet stated the purpose of the study, and asked their permission to have their child take part in the study (See Appendix C). Once they had read the information sheet and consent form, they were asked to sign the consent form to give their consent that their child participate in the study.

Clinic sisters assisted with translation if necessary and explained the contents of the information sheet and consent form to caregivers. Caregivers who gave written consent were then taken to an assessment room and their child was assessed for 45 minutes to 60 minutes. If they lost their place in the queue (which could be very long) it was arranged with the sisters involved that they were allowed to go straight through for immunisation after completing the assessment.

3.4.2 Assessment procedure

To assess a child with the Bayley-III firstly their chronological age was calculated. This was then used to determine the start point in the test. The age correlates to a start point indicated by a letter. The test is commenced in each subtest according to this. Reversal and discontinue rules are then applied as follows. A child must get a score of 1 for all three of the first consecutive three items at their age specific start point. Failing this the test must be started at the previous age group specific start point. This continues until the child passes the start rule. The test is discontinued when the child scores five consecutive item scores of 0 (Bayley N, 2006: 50). Infants who became fussy were given a break for a feed or nappy change if necessary. If infants continued to be fussy or needed to sleep assessment was discontinued and those infants were not included in the sample.

In addition to the Bayley-III test, each child's height and head circumference was measured with a tape measure, and then documented. Height was measured lying down from the top of their head to their heels. Head circumference was measured above the ears, midway between hairline and eyebrows and around the occiput or largest circumference of the head. These were non-standardised measures and accuracy was not controlled for, therefore results using these measurements are not reliable. Each infant's weight was recorded from their road to health card, which had been measured by the clinic nurse on that day. Infants were weighed, by a nurse on an infant scale with all clothes removed. This was a problem as different nurses measured weight and scales may have differed in calibration. Therefore measurements are not accurate or reliable. Any results using height, weight or head circumference must be viewed with caution due to this. The infants' gender was also recorded.

Unfortunately no information regarding the child or caregivers' background was taken. A socio-economic questionnaire could have been included, which would have been valuable to the study, however the committee that accepted the protocol, did so on condition the researcher remove the socio-economic questionnaire(HESSE) that was originally included in the protocol. This is the reason no socio-economic information was collected during this study.

3.4.3 Data collectors

A research assistant assisted the researcher with data collection. Both were trained in the administration of the Bayley-III and had experience and training in early child development.

Reliability was ensured through consistent use of the Bayley-III. Inter-rater reliability was ensured by making sure assessors derived the same scores when testing the same children at the same time.

The data collectors were trained on the Bayley-III in 2007 by two therapists, who were also lecturers in Paediatric Physiotherapy at the University of the Witwatersrand with experience in using the Bayley-III and in early child development. They had been trained in the USA, by the distributors of the kit.

3.4.3.1 Inter-rater reliability

Unfortunately the Bayley-III manual does not describe how inter-rater reliability was tested or statistically analysed. For this study it was done as follows. A pilot study of twelve assessments was carried out, wherein both assessors assessed the same infant at the same time and compared results for scoring to ensure inter-rater reliability. These assessments were done together, with assessors scoring independently. This was done prior to assessing infants independently. These twelve infants were excluded from the sample.

3.5 Data collection

The researcher assessed 28 (3 months), 23 (6 months), 31 (9 months) and 21 (12 months) old children. The assistant assessed 3(3 months), 7 (6months), and 9 (12 months) old children. The researcher did most of the assessments as there were no funds to pay the assistant. Assessments took 60 minutes on average.

Scoring and interpretation of delay was done according to procedures stipulated in the Bayley-III manual. On completion of the assessment, raw scores were immediately calculated and converted to scaled scores (with a mean of 10 and a SD of 3) (Bayley N, 2006: 108) and composite scores (with a mean of 100 and a SD of 15) (Bayley N, 2006: 109). The composite scores were compared to those of the norms and it was determined how infants were performing in each subtest in terms of qualitative descriptions. These include the following descriptions: extremely low (69 and below), borderline (70-79), low average (80-89), average (90-109), high average (110—119), superior (120-129) and very superior (130 and above). Infants scoring 1.5 SD below the mean in 2 or more areas or 2 SD below the mean in one area were considered to be delayed (Bayley N, 2006:106). These infants were referred for further investigation to a paediatrician attending the clinic as this was the procedure stipulated by the sister in charge. A letter of referral was given to the caregiver and they were advised on how to assist their child in the areas of weakness, through exercises, activities and positioning advice. Caregivers of infants, who scored adequately in total but were delayed in certain areas, were also given advice on how to encourage development in their child's weak areas.

Each child's height, weight and head circumference was recorded on the record form and were measured as described above.

3.6 Data analysis

All data collected was analysed by the Medical Research Council of South Africa. Raw scores were converted to scaled and composite scores in order to compare them to USA norms. Data was summarised using means of composite scores for each subtest. Composite scores were calculated from the scaled scores. They range from 40 – 160, with a mean of 100, and a SD of 15. These scores can be used to compare a child's performance across all the scales (Bayley N, 2006: 109).

Descriptive analysis was used to evaluate data. P-values less than 0.05 and correlations greater than 0.7 were considered statistically significant. Descriptive statistics inclusive of 95% confidence intervals were determined for each of the four age groups. Confidence intervals were determined for all subtests, and express the precision of test scores.

A comparison of South African (SA) scores and Bayley-III norms was done using the Student's t- test. The latter was done since for the USA only summarised data, for example mean and SD, are available. Testing was done at the 0.05 level of significance. Infants scoring one or more standard deviations below or above the norms were considered to be significantly delayed or advanced.

The following variables and tests were used:

One-sample Student's t-tests were done to compare mean cognitive, language and motor composite scores in the study sample to the USA norms.

One way analysis of variance (ANOVA) was done for:

- assessing mean cognitive composite score differences across age group
- assessing mean language composite score differences across age group
-assessing mean motor composite score differences across age group

A two- way ANOVA was done for

-assessing cognitive, language and motor composite scores by age group and by gender. Gender was included as a variable since by chance almost equal numbers of males and females were included in the sample. It was not an objective initially to be included in the study.

Finally weight for age, height for age and head circumference were converted into z-scores for age. A correlation coefficient (Pearson's product-moment correlation coefficient) was calculated to determine whether there were any correlations between the z-scores and cognitive, language and motor subtest scores. This was done to determine whether anthropometric parameters influenced scores on the Bayley-III. The t-test was used to determine whether the correlation coefficient differed significantly from zero.

3.7 Ethical considerations

Clearance from the Human Research Ethics Committee (Medical) of the University of the Witwatersrand was obtained prior to commencement of this study. (Clearance number: M070815). This was unconditional (See Appendix B).
Approval to conduct this Research in the Health Department of the City of Johannesburg was also obtained prior to commencement (See Appendix F).

Conclusion

One hundred and twenty two black urban African infants from three municipal clinics in Gauteng, South Africa were assessed with the Bayley-III. These infants fell into four age groups, three, six, nine and twelve months. Their scores on the Bayley-III were compared with the USA norms. They were also compared across age group and subtest (cognitive, language, motor). Scores were also assessed for differences across gender by age group and subtest. Finally anthropometric measurements were taken to assess their growth and these were correlated with test scores to determine whether growth had any influence on cognitive, language or motor abilities. The above test results were analysed and will be presented in the next chapter.

CHAPTER 4

RESULTS

In this chapter the results of this study will be presented. Data from 122 black African infants, who underwent the Bayley-III assessment, were analysed. This represented 30/31 subjects in four groups aged 3, 6, 9 and 12 months. Approximately half the subjects were female and half male. (See Appendix E for details on subjects). Subjects were recruited from three clinics in Gauteng. These clinics were chosen for convenience as were the subjects.

The overall sample mean scores will be compared to the USA norms to determine how the sample performed on the test and whether the Bayley-III is a valid test to use on black South African urban infants. Performance on the test is carefully evaluated by assessing subtest scores. These are graphically presented and described to show differences between and within age groups. Each subtest (cognitive, language and motor) is described in terms of mean scores, differences between age groups and gender differences in performance on the Bayley-III. This is done to determine whether age groups perform differently and whether gender influences performance. Finally height, weight and head circumference are presented to determine whether they correlate to infant scores.

4.1 South African versus USA scores

4.1.1 Mean SA versus USA scores overall

Mean composite scores for the USA were 100 with a SD of 15. Mean composite scores for the South African sample was 103.4 (p-value= 0.0007). Therefore overall, the SA sample had statistically significantly higher scores than the USA.

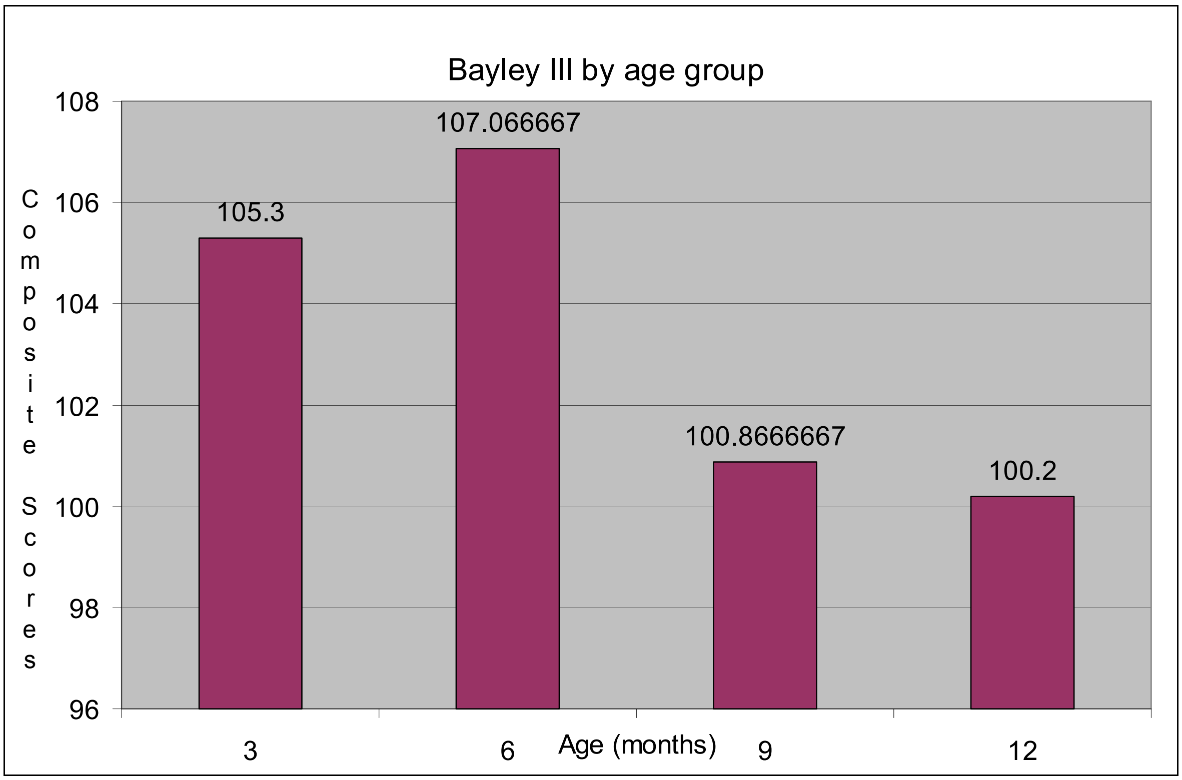

Figure 4.1 Overall mean scores for SA on the Bayley-III

4.1.1.1 SA scores according to subtests

Composite score means for the SA sample (n=122) were 99.7 for cognitive, 106.8 for language (includes receptive and expressive) and 103.5 for motor (includes fine and gross motor skills). (See table 4.1 and Figure 4.2 for study sample scores).

Table 4.1 Composite cognitive, language and motor mean scores

(* for significant p-values, indicates how significantly mean sample scores differ from USA norms)

Parameter	Group	N	Mean(sd)	95% CI	p-values
Overall score means	3,6,9,12	122	103.4		0.0007
Cognitive	Total	122	99.7(15.84)	(96.8;102.5)	0.824
	3M	31	101.0(21.87)	(93.0;109.0)	0.808
	6M	30	99.8(11.71)	(95.5;104.2)	0.938
	9M	31	97.4(8.84)	(94.2;100.7)	0.115
	12M	30	100.5(18.07)	(93.8;107.2)	0.881
Language	Total	122	106.8(13.76)	(104.4;109.3)	<0.001 *
	3M	31	104.9(12.46)	(100.3;109.4)	0.0375 *
	6M	30	115.1(14.52)	(109.7;120.5)	<0.001 *
	9M	31	107.1(13.07)	(102.3;111.9)	0.005 *
	12M	30	100.4(11.13)	(96.2;104.6)	0.845
Motor	Total	122	103.5(12.92)	(101.2;105.8)	0.0031 *
	3M	31	110.0(10.47)	(106.1;113.8)	<0.001 *
	6M	30	106.3(14.30)	(101.0;111.7)	0.022*
	9M	31	98.1(8.83)	(94.8;101.3)	0.232
	12M	30	99.7(14.08)	(94.4;105.0)	0.908

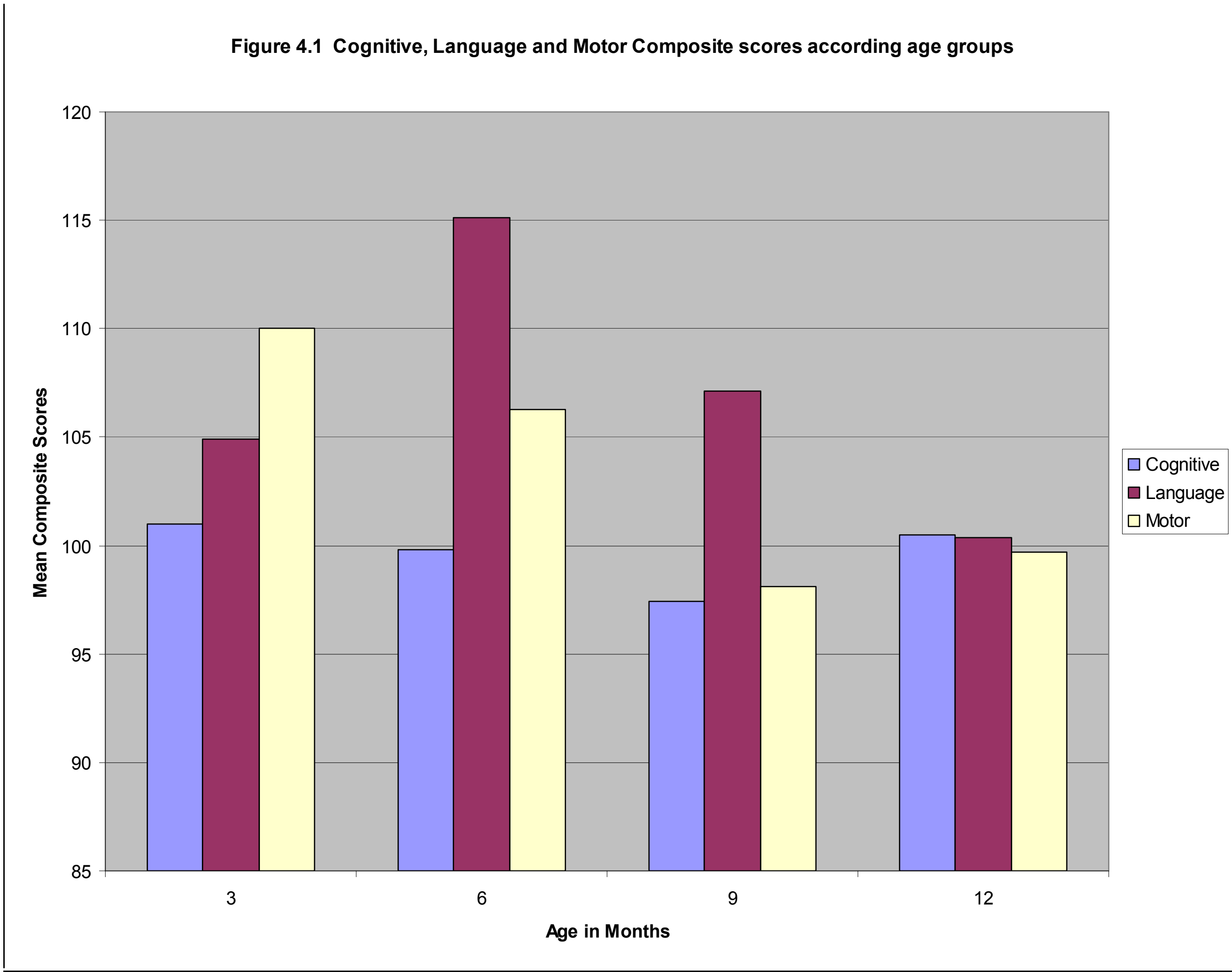

Figure 4.2 Cognitive, language and motor mean composite scores according to age groups

4.1.2 Differences between age groups

Younger age groups (2 to 7 months) tended to have higher scores than older age groups (6 to 12 months). (See table 4.1). This is just an overall observation and is not statistically proven.

4.1.3 Differences within an age group

This section looks at differences in subtest scores (cognitive, language and motor) within an age group.

At 3 months:

Motor scores were significantly higher than cognitive ($p=0.007$) scores. Motor scores were not significantly different from language ($p=0.1285$) scores. Language scores were not significantly different to cognitive scores ($p=0.248$).

At 6 months:

Language scores were significantly higher than cognitive ($p<0.001$). Motor scores were significantly higher than cognitive scores ($p=0.022$). Language scores were significantly higher than motor scores ($P=0.002$)

At 9 months:

Language scores were significantly higher than cognitive ($p<0.001$). Motor ($p<0.001$) scores did not differ significantly to cognitive scores ($P=0.776$). Language scores were significantly higher than motor scores ($p<0.001$)

At 12 months:

Cognitive, Language and Motor scores were not significantly different.

(See Table 4.2).

Table 4.2 Differences between subtest scores in each age group

Age	Parameters	P-value
3 months	Language and cognitive	0.248
	Motor and cognitive	0.007
	Motor and language	<0.1285
6 months	Language and cognitive	<0.001
	Language and motor	0.002
	Motor and cognitive	0.022
9 months	Language and cognitive	<0.001
	Language and motor	<0.001
	Cognitive and motor	0.776
12 months	Cognitive and language	0.971
	Cognitive and motor	0.775
	Language and motor	0.803

The following three sections will look at each subtest individually. It will describe three things:

(i) How the mean scores in the subtest compared to the mean USA scores.

(ii) How age groups differed in performance on each subtest.

(iii) How within age groups gender differences in scores existed.

4.2 Cognitive composite scores

(i) For the total sample (n=122) the mean Cognitive composite score did not differ significantly (p=0.82) from the USA norm of 100 (See Table 4.1).

(ii) In a one-way analysis of variance (ANOVA) age groups did not differ significantly (p=0.82) with respect to the mean Cognitive scores (See Figure 4.2).

(iii) Since sex can be expected to play a role, a two-way ANOVA was done with factors age group and sex. Also included was the interaction term for sex by age group. Again age groups did not differ significantly (p=0.77) and neither did sex categories (p=0.83) (See Appendix E 2). However there was a significant interaction (p=0.05), in particular the two sexes behaved differently at 3, 6 months and 12 months. This interaction was very likely the reason why age groups could not be determined significantly different in the pooled sample. In other words because at 3, 6 and 12 months boys and girls scores were so different this would have affected the mean scores to such an extent as to make them very similar across age groups. (See Figure 4.3).

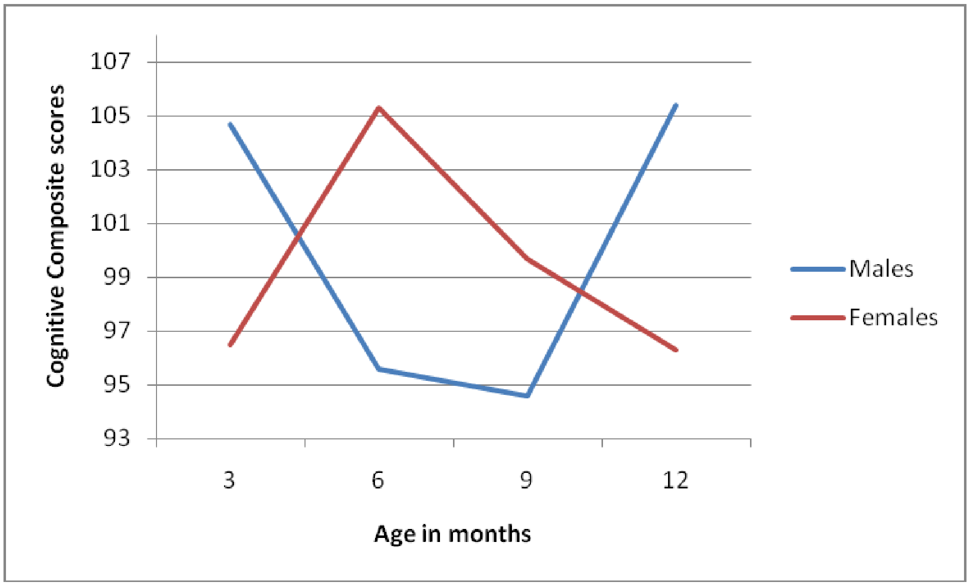

Figure 4.3 Cognitive composite scores over age, by sex

4.3 Language composite scores

(i) For the total sample (n=122) the mean Language composite score was significantly higher ($p<0.001$) than the USA norm of 100 (See Table 4.1).

(ii) Age groups differ significantly ($p<0.001$) with respect to mean composite Language scores in the 1 way ANOVA. In particular at 6 months scores were significantly higher than both at 3months ($p=0.014$) and at 12 months ($p<0.001$) while scores were only marginally significantly higher than the scores at 9months ($p=0.097$). (See Figure 4.2)

(iii) Again the groups differ significantly ($p<0.001$) in the 2 way ANOVA, while sex categories were marginally significantly different ($p=0.06$) (See Appendix E 2).Therefore for language scores overall females had marginally significantly higher scores than males. Further there was a significant interaction ($p=0.029$) noted, in particular the two sexes behaved differently at 9 months. Females tended to have higher scores than males at 9 months (See Figure 4.4).

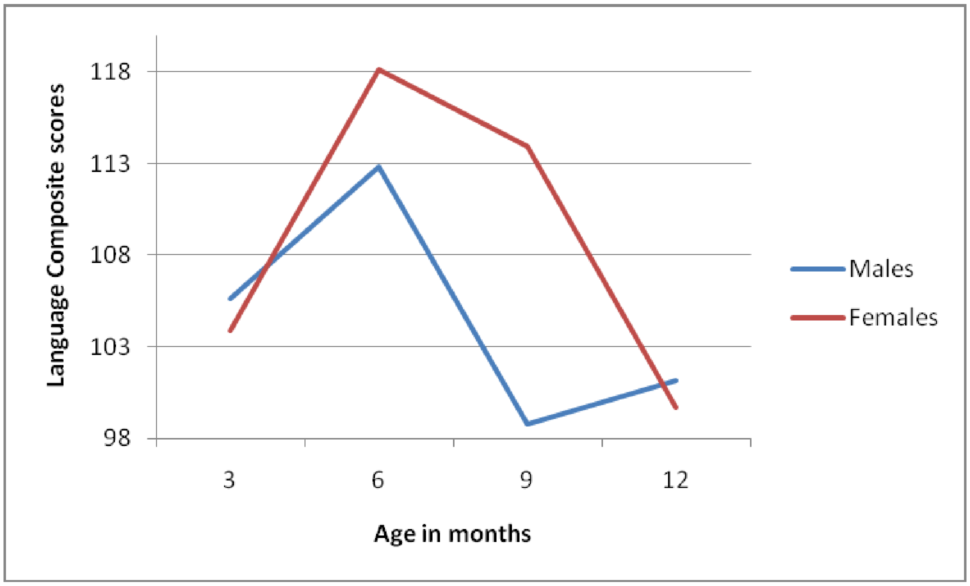

Figure 4.4: Language composite scores over age, by sex

4.4 Motor composite scores

(i) For the total sample (n=122) the mean composite Motor score was statistically significantly higher (p=0.003) than the USA norm of 100 (See Table 4.1).

(ii) In a one-way ANOVA age groups differed significantly ($p<0.001$) with respect to Motor Composite scores. In particular a statistically significant difference was found between the 3 month old group (which had higher scores) and the 9 month old group (p=0.001). Also between the 3 month old group (which were higher) and the 12 month old group (P=0.007).A marginally significant difference was found between the 6 month old group (which were higher) and the 9 month old group (p=0.053). (See Figure 4.2).

(iii) Again in a 2 way ANOVA age groups differed significantly (p<0.001). Sex categories did not differ significantly (p=0.69). (See Appendix E 2). However for individual age groups a significant interaction between males and females (p<0.001) existed, in other words they behaved differently. At 6 months females had higher scores than males, while at 12 months males had higher scores than females (See Figure 4.5).

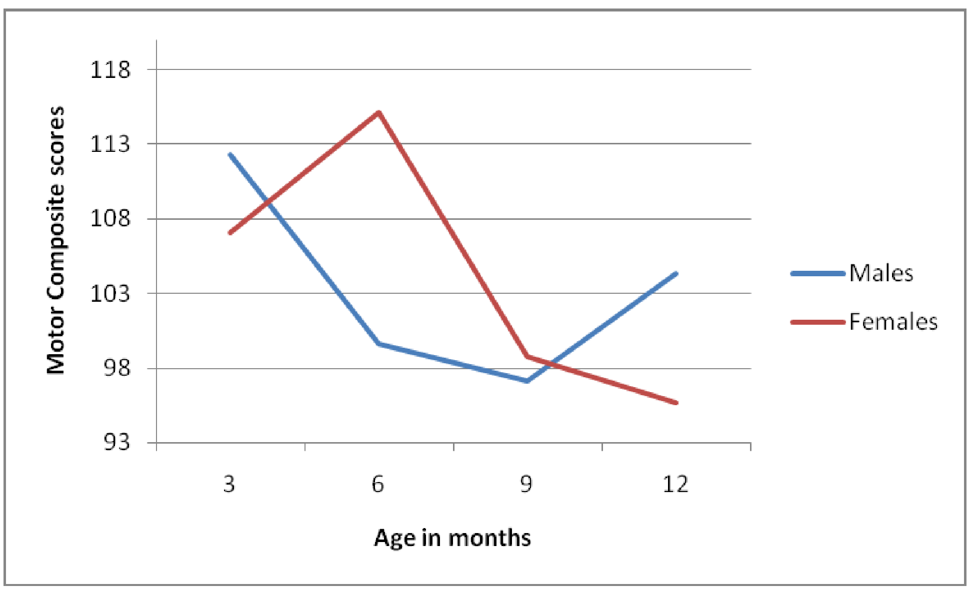

Figure 4.5 Motor composite scores over age, by sex

4.5 Height, weight and head circumference

The sample consisted of 122 healthy infants. Anthropometric parameters were investigated to see if they had any correlation with infants' scores on the Bayley-III. This was done since the Bayley-III assesses development, and growth can impact on development as discussed in Chapter 2. The following anthropometric parameters were used; weight for age, height for age and head circumference for age z-scores. Weight, height and head circumference were converted into z-scores for age. A correlation coefficient (Pearson's product-moment correlation coefficient) was calculated to determine whether there were any correlations between z-scores and subtest scores. The t-test was used to determine whether the correlation coefficient differed significantly from zero.

The following was found:

No significant strong correlations ($r>0.7$) between subtest scores and height, weight and head circumference z-scores.

Weak positive / negative correlations ($r<0.4$) were found for:

All except cognitive scores and weight for age at 3 months and motor scores and weight for age at 9 months.

Moderate correlations ($r =0.4; 0.7$) were found for:

Weight for age and cognitive scores at 3 months(r=0.4576; p=0.000) and weight for age and motor scores at 9 months (r=0.5247, p=0.0000). Since significance of correlations was set at 0.7 and above to conclude; no significant correlations were found.

Table 4.3 Weight, height and head circumference score correlations (r-value) by age

(Sign * at 0.05 level of significance and 0.7 and higher is a good correlation).

		3 Months	6 Months	9 Months	12 months	Total
		N=31	N=30	N=31	N=30	N=122
WEIGHT	Cognitive	0.4576*	-0.0172	0.1971	0.1622	0.2267
	Language	0.1919	0.0607	-0.0663	0.1976	0.0141
	Motor	0.3559*	0.1078	0.5247*	-0.1116	0.1187
HEIGHT	Cognitive	0.0299	0.0747	0.1902	0.2712	0.1382
	Language	0.0895	0.0231	0.1655	0.0948	0.0254
	Motor	-0.0074	0.1397	0.1703	-0.0627	0.0552
HEAD						
CIRCUM- -FERENCE	Cognitive	0.2407	-0.052	0.1331	0.0944	0.1325
	Language	0.0597	-0.0652	-0.1006	0.2618	0.0284
	Motor	0.1703	0.1055	0.2814	-0.1510	0.0871

4.6 Conclusion

With regard to the aims and objectives the following results were found:

SA and USA scores on the Bayley-III differed. The total mean scores for the SA sample are significantly higher than the USA means, in particular the means for the language and motor subtests. Younger age groups did better than older age groups and subtest scores differed in all age groups except at 12 months.

For language scores overall females had marginally significantly higher scores than males. Boys and girls behaved differently in the cognitive subtests of the Bayley-III at 3, 6 and 12 months, in the language subtests at 9 months and in the motor subtests at 6 and 12 months.

Height, weight and head circumference did not significantly correlate to infant scores on the Bayley-III.

CHAPTER 5

DISCUSSION

In this chapter the following results will be discussed: differences between South African scores and the Bayley-III USA norms, differences between results by age group, differences between male and female scores and correlations between anthropometric measures and scores. Finally the study's merits and limitations will be discussed and recommendations for future research will be made. The layout will follow the results chapter layout. For simplicity the results will be categorised as follows: 3, 6, 9 and 12 month old groups (referred to as 2-13 months), 3 and 6 months old groups (as 2-7 months), 6 and 9 as (as 5-10 months) and 9 and 12 (as 8-13 months).

5.1 South African versus USA scores

Mean composite scores for the USA were 100 with a standard deviation (SD) of 15 (Bayley N, 2006). This applies to language, cognitive and motor composite scores. 58% of children's scores fell within the range of 85-115, 98% of scores fell within the range of 70-130 and all scores fell within the range 55-145.

The USA is a First World country and as such their population is at an advantage when compared to SA which is a developing country. Therefore the two populations differ, not only culturally, geographically and ethnically but also in their socio-economic status, and thus their performance on a test can be expected to differ as these factors are known to influence development Further, previous studies have found that African infants scored higher than American infants on the BSID, so much so that the creation of local norms was necessary (Richter et al, 1988; Aina et al, 2005).

The SA sample consisted of 122 infants in total. These infants were black African infants living in an urban area of SA. The USA sample consisted of a stratified sample of 1700 children and included a clinical sample. Although we would expect the USA sample to be advantaged and perhaps have higher scores they did not. Unfortunately no background or socio-economic information was available on the study sample, which makes it difficult to compare them to the USA sample.

5.1.1 Mean SA versus USA scores overall

Overall, when combining all subgroups (cognitive, language and motor), SA scores were significantly higher, with a mean of 103.4 (p=0007), compared to the USA mean of 100.

These results indicate that typically developing black South African urban infants in Gauteng from the study sample, between 2 and 13 months perform better than American infants do on the Bayley-III, supporting previous claims of African infant developmental precocity.

However, although the overall SA mean (103,4) was statistically significantly higher than the USA mean (100) it is still within 1 SD -15 points (115) of the norm. Had the overall SA mean been greater than 1 SD (>115) above the USA mean (100), this would have made the test invalid for use on the sample population. Although statistically the SA sample scored significantly higher than the USA norms, clinically the difference is small when one considers the variability of development. Developmental milestones can be reached within windows of time, which can vary considerably. The Bayley-III test is therefore still suitable to use on this population. This population will just tend to have average (90-109), high average (110-119) and superior (120-129) scores especially for the language and motor subtests. These can still be considered normal. Children scoring 1 SD (85) below the mean in more than one subtest or 2 SD (70) below the mean in one subtest will be considered delayed and require intervention.

Therefore the Bayley-III is a valid test to use to assess development in infants from this population and in these age groups. Further research is necessary to determine whether the Bayley-III is appropriate for children from 13 to 42 months, which is the age range of this test. Further research is also needed to assess other populations and regions in South Africa.

The reason SA and USA scores differ may be due to differences between characteristics of the two samples. The USA sample included a clinical group (10% of the normative sample), which means that a proportion of their normative sample included infants with clinical syndromes or diagnoses. These infants would have scored very low on the Bayley-III and this would have lowered the mean values of the sample. The present study sample consisted of only healthy infants, which may be the reason why sample mean scores were higher than the USA norms. The Bayley-III norms also included infants from 36 weeks gestational age (GA) whereas in the present study infants were included from 37 weeks GA. Other reasons for the differences may be variations in developmental rates of the two populations.

In SA, primary health care is provided free of charge to children under 5 years. The majority of the population use government services, while a small minority use private health care. Municipal clinics offer vaccinations and growth monitoring. The clinics used in the study were generally in low income areas. They were very full, with queues of people waiting outside in the morning for the clinics to open. I assume that more well off families would visit private clinics or be able to travel to clinics in less busy areas. I assume that the study sample I used consisted of parents in the middle or lower class of the SA urban population, who could not afford private healthcare. This is just an assumption and not necessarily true. If this assumption is true then, despite high levels of unemployment and poverty in South Africa, this particular sample of black urban infants is performing well developmentally.

This study's results are similar to Aina (2005) et al's study, which found that Nigerian children scored much higher than the USA norms on the BSID (Aina et al, 2005), an earlier edition of the Bayley-III. During its development, research showed the Bayley-III mean scores were about 7 points higher than those of the BSID II. This is a consistent finding for measures of infant development (Bayley N, 2006). However BSID scores were higher than BSID II scores, by about 10 points in a study by Glenn et al (2001), who concluded that when comparing cohorts of children tested on different versions of the Bayley scales caution needed to be used. (Glenn, Cunningham and Dayus, 2001).Therefore it is difficult to compare the present study sample scores (Bayley-III) to BSID scores.

Richter (1992) et al, also found South African infants' scores to be much higher than USA scores on the BSID. So much so, that they created norms for black South African infants to assist with interpretation of BSID results (Richter et al, 1988). Again, Richter's study was done on a different version of the Bayley Scales to the present study, making it difficult to compare the two. However, Richter (1988) and Aina (2005) found their samples to perform better than the USA norms and this correlates with the present study's findings.

These results suggest that the Bayley-III is a suitable test to use on black South African urban infants. According to the Flynn effect we could expect scores to be higher on the Bayley-III than the BSID. The BSID and Bayley-III differ considerably, which makes comparing them also difficult, while characteristics of the South African and USA population have changed since Richter did their study. Since SA-USA differences appear smaller in this most recent study it may mean that the Bayley-III has improved as a test that can be used cross culturally or that the black South African population has changed.

5.1.1.1 SA scores according to subtests

Overall cognitive mean scores (2-13 months) for SA did not differ significantly from the USA norms. Therefore we can expect black urban infants in South Africa to score a mean of 100 with a SD of 15 for their Cognitive composite scores when using the Bayley-III.

The mean language composite score (2-13 months) was 106.8 and the mean motor composite score (2-13 months) was 103.5. These were statistically significantly higher than the USA norm of 100 (See Table 4.1), especially from 2 to 10 months. Again these differences may be due to differences in the USA sample and the study sample as suggested in 5.1.1 however this does not explain why cognitive scores were not affected as you would expect infants with syndromes to have lower cognitive scores too, not just lower language and motor scores, as language and cognition are closely related.

Developmental theories describe the need for a combination of brain maturation and environmental shaping being necessary for development, with both external and internal processes influencing them. Children have inborn language abilities which can be stimulated or inhibited. Language development is influenced by brain development and pathway maturation as well as social interactions with caregivers. (Papalia et al, 2009: 206). Perhaps in the study sample, language and motor abilities are more encouraged by care-givers than cognitive abilities in the early months. Further as discussed previously, development of the human brain varies according to region (Thompson, 2001; Grantham-McGregor, 2007). Thus regional differences in brain growth may explain differences in performance of the subtests as may different rates of development across populations.

5.1.2 Differences between age groups

In the present study, the trend was that younger age groups (2 -7 months) achieved higher scores than the older age groups (7- 13 months). Aina et al's study found the lower age groups (2, 4 and 8 months) had the highest scores overall. The older age groups' (10 to

30 months) scores tended to be slightly lower (Aina et al, 2005). Unfortunately the present study did not include children from 13-30 months of age. It is possible that younger age groups are not expected to do as much as older age groups. Therefore their scores would appear better if the test was perhaps not sensitive enough in the younger age groups or if developmental delay is less obvious early on when less is expected of a child. For instance in the first 6 months, there is more focus on motor development and less cognitive and language development and infants may appear better then in the younger age groups than the older ones.

5.1.3 Differences within age groups

When comparing scores within an age group only the 12 month old age group had similar subtest mean scores (See Figure 4.2). All the other age groups had large differences in scores with language or motor scores being higher than other scores. This may be due to variation in rates of cognitive, language and motor development in children under 12 months, who then reach a point at 12 months where they are equally competent in all areas. The implication of this is that timing and order of milestone achievement may not be as important as the fact that certain milestones should be achieved within a specified time period. Again, maybe the test is not sensitive enough for testing motor or language skills from ages 2-7 months or perhaps the study sample develop their language and motor skills earlier on than the USA sample.

At 3 months, motor scores were the highest scoring subtest. This could mean that in this population motor development is more rapid in the first three months or that the test is not sensitive enough to detect motor development at this age.

At 6 months language was the highest scoring subtest. Language skills may be particularly well developed at this age due to any of the factors affecting development as mentioned in Chapter 2, such as culture and care-giving practices.

At 9 months language was the highest scoring subtest. Again language skills may be advanced in this population at this time.

At 12 months subtest scores were similar. This may indicate that although motor and language development, in the study sample, is faster in the early months by 12 months they have slowed to reach similar levels to those of the USA sample. Cognitive scores; however appear to develop at a steadier pace than language or motor scores.

Therefore the differences discussed between the age groups may be due to a lack of sensitivity in the test or due to the sample population having varying rates of development in the early months.

5.2 Cognitive Composite scores

(i) Since scores were very similar to the USA norms of 100, it can be concluded that the cognitive part of the Bayley-III can be used on black urban infants in Gauteng. We can expect these infants to achieve scores around a mean of 100 + 15 or -15. Infants with scores less than 85 would be considered at risk. They would require further investigation and early referral for appropriate intervention.

In Richter's (1988) study, infants' mental index scores (equivalent of cognitive and language composite scores combined) were higher than USA norms from 3-15 months and not from 18-30 months (Richter et al, 1988). Aina's (2005) study scores were higher than USA norms for 2-10 months and not for 12-30 months (Aina et al, 2005). The present study only assessed children up until 12 months, but cognitive skill scores were not higher than the norms. This may be because it is a separate score in the Bayley-III whereas in the BSID and BSID II it includes language. Therefore language skills may form the basis of the increased mental index scores. Language scores may be higher because infants under 12 months have less language development and again the test may not be sensitive enough to assess language skills adequately or these infants may have advanced language skills at those ages.

(ii) Since age groups did not differ with respect to mean cognitive scores the Bayley-III can be used for the above mentioned infants at 3, 6, 9 or 12 months. However the lack of differences between groups may have been due to the large differences between male and female scores, which can be seen in each age group (See Figure 4.3). Thus this lack of differences between groups should be interpreted with caution. If such large differences between males and females had not existed, age groups may have differed significantly. In the Bayley-III norms production, although equal numbers of males and females were included, they were not assessed for differences, therefore we do not know if similar differences existed between males and females in the Bayley-III norms sample. According to Piaget (1952), the sensori-motor intelligence stage occurs from 0-18/24months. Later stages involve language development and even later stages, cognitive development. (Campbell et al, 2006: 37). Perhaps testing of older children will reveal larger differences in cognitive development. Further since developmental theories suggest brain maturation and environmental shaping is necessary for development, perhaps cognitive development will differ more in older children who have had more time to absorb the impact of environmental influences. Children under 12 months may simply be developing according to their innate brain maturation and environmental influences may be less important. For example, breastfeeding may have been the main source of nutrition in children up to 12 months and thus the impact of poverty will be less pronounced than perhaps in later years.

(iii) When comparing male to female scores it was noted that overall no significant differences existed in cognitive scores, but that at 3, 6 and 12 months there were large differences in the way males and females behaved. Figure 4.3 shows that females have higher scores at 6 months, while males have higher scores at 3 and 12 months. A previous study found that girls performed better than boys on the mental scales (cognitive composite scores) of the BSID at 12 months (Lima et al, 2004). This contradicts the present study's results; however, again mental scales included language in the BSID but were separate in the Bayley-III. Thus perhaps it was the girls' language which made their mental scale scores higher than the boys' scores. Further the sample size in the present study, in each subgroup, is small in number. Larger numbers need to be assessed to increase the statistical power of these results and further research is necessary.

Despite these inconsistencies in results, it is clear that gender differences in development may exist. As described previously, structural differences in the brain may explain why boys and girls develop cognitive skills differently. Overall males have larger brains than females, the amount of grey and white matter in certain areas differ (Wallentin et al, 2008, De Bellis, Keshavan, Beers, Hall et al, 2001) and differences have been found in the size and shape of the corpus callosum.

If one assumes that males and females develop cognitive skills at different rates, it would be interesting to note what occurs after 12 months. Perhaps by 18 or 24 months males and females have achieved the same milestones but at different rates. It may not be essential when a milestone is achieved, rather that it simply is achieved within a specified time period.

5.3 Language Composite scores

(i) The SA study sample achieved higher language scores than the USA norms between 2 and 10 months. It would appear that SA infants then have advanced language skills at this age. Or again the assessment may not be sensitive enough for assessing language at those ages. These results are similar to those in Richter's study (1992), where the infants' mental index scores (which include language) were significantly higher in SA children between 2 and 10 months, and not from 18-30 months (Richter, 1992). Perhaps in

Richter's study it was above average language skills, which elevated their mental index scores. If this were true then the cognitive part of the mental index scores may have been in the average range as it was in the present study sample. Mental index scores of infants in Aina et al’s study were higher than USA norms from 2-10 months and not from 12-30 months (Aina et al, 2005). Again it may have been the Nigerians’ language skills that caused this. The above two studies had similar results to the present study. The reason may be that different populations have different rates of development in the earlier months.

When interpreting SA language scores using the Bayley-III in future it is suggested that the assessors expect higher scores than 100 especially for the younger age groups 2-10 months. They can expect scores of 106.8 + or – 15 points.

(ii) Age groups differed significantly such that infants at 6 and 9 months had the highest language scores. Therefore in SA infants, language scores can be expected to be above average in the first 2-10 months of life.

(iii) For language scores a marginally statistically significant difference was found between males and females scores overall, with females having higher scores than males. This was particularly evident at 6 months and at 9 months. However, again the sample size being compared, in each subgroup, is small in number. Larger numbers need to be assessed to increase the statistical power of these results.

In Lima's study in Brazil, girls, performed better than boys on the mental index scales of the BSID at 12 months (Lima et al, 2004). Since the BSID mental index scale includes language, females' language abilities may be the reason their mental index scale scores were higher than males. However in the present study at 12 months girls perform much the same as boys on language scales. Overall however, girls perform better than boys on the language subtest and this may reflect different rates of development in language skills between boys and girls in the first year.

As discussed in Chapter 2, anatomical differences in the brain, genetics, hormones and the role of the X chromosome have been proposed to explain gender differences in language and cognition (Galsworthy et al, 2000; Wallentin, 2008). Girls are at a slight advantage to boys when it comes to early language acquisition, but these differences disappear as children get older (Wallentin, 2008). The finding that, early on, girls were superior in their acquisition of language skills was consistent with the explanation that differences in early language acquisition form part of generalised gender differences in development. (Galsworthy et al, 2000; Wallentin, 2008).

5.4 Motor Composite scores

(i) South African infants achieved significantly higher mean motor scores than the USA norms. This is similar to Richter's (1988) finding that infants from 2-10 months, scored significantly higher than the USA norms. In the present study it was found that between 2 and 7 months scores were significantly higher than the USA norms. However at 9 months age, in the present study infants achieved slightly lower motor scores than the USA norms. Aina's (2005) infants' motor scores were higher than USA norms at all except 10 and 30 months (Aina et al, 2005). This is in contrast to the present study where motor scores were higher except at 9 and 12 months. It must be remembered that the above mentioned studies were done using the BSID while the present study used the Bayley-III. These tests are different therefore care must be taken when comparing them to one another. Further Aina et al's study sample size differed to the present study, consisting of 128 subjects (2 months to 2,5yrs), with 16 subjects in each age group (making the numbers in each subgroup small) while the present study consisted of 122 infants (2-13 months), with 30 in each age group. However the above two studies results are similar to the present study and indicate that motor scores for all three studies were higher than the USA norms.

As described earlier (2.1.1) development follows a sequence but the timing of this sequence can be influenced by ethnic or cultural factors. African babies are said to be more advanced than USA and European babies in sitting, walking and running. For example, Ugandan babies walk at 10 months, USA babies at 12 months and French babies at 15 months. Some cultures encourage early development and others do not (Papalia et al, 2009). In this study, infants' motor scores were higher than USA scores at 3 and 6 months, but were not higher at 9 and 12 months. Therefore our results correlate with Papalia (2009) regarding African infants sitting abilities, but not with their standing abilities and we do not know about their running abilities since we did not test this age group.

(ii) Of all the age groups the 3 month old group had the highest scores for motor development. (See Figure 4.2).This correlates with Aina's and Richter's' studies, both of which found that the younger age groups did better than the older groups. Richter found that South African infants did better on the motor scale from 2-10 months, thereafter until 30 months, the scores were very similar to the USA norms (Richter et al, 1992). Aina found their Nigerian subjects scored above the norms particularly in the lower age groups from 2-8 months (Aina et al, 2005). The fact that at 3 months infant motor scores were high may be due to a lack of sensitivity in the test at the younger ages or may be due to differences in rates of development across populations, with SA urban black infants having advanced motor skills.

(iii) At 12 months males had significantly higher scores than females, while at 6 months females had significantly higher scores than males. This may be due to different rates of development in males and females. However it must be noted again, that the sample size being compared, in each subgroup, is small in number. Larger numbers need to be assessed to increase the statistical power of these results.

In contrast, Richter et al found no significant differences between male and female scores on the mental and motor scales of the BSID. In their formulation of norms they therefore did not create separate norms for males and females (Richter et al, 1992). In Lima's study of the BSID no effect of infant sex on motor scores was found (Lima et al, 2004).As yet there are no studies comparing male and female performance on the Bayley-III.

Therefore results show that, in the study sample, differences exist in subtest scores, differences exist between age groups and differences exist in gender performance on the Bayley-III. Language and motor scores were the most different to the USA norms and could reflect different rates of development.

5.5 Height, weight and head circumference

The results of the study showed no significant strong correlations between subtest scores and anthropometric measurements such as height, weight and HC z-scores. Weight for age at 3 months and cognitive scores correlated moderately as did weight for age and motor scores at 9 months. All other scores showed weak positive / negative correlations (<0.4), which were not significant. (See Table 4.2).

The lack of correlations found between anthropometric indicators and developmental indexes, may be because the sample was biased in favour of healthy infants. Our results support the WHO's conclusion that in healthy populations growth and motor milestone achievement are independent of each other (WHO MGRS, 2006 pg 86-95).

For the association between weight for age and cognitive scores at 3 months, a higher birth weight to start with, may result in healthier and developmentally advantaged infants. At 9 months infants should be pulling to stand, bear walking cruising, manipulating objects, crawling, standing and walking. It is difficult to see how weight would benefit the attainment of these skills, however this finding correlates to Lima (1994), Kuklina (2004) and WHO MGRS (2006) findings that increased weight for age benefited motor development.

Lima et al's study found that although environment had the greatest impact on child development, high weight for age and haemoglobin concentration improved motor scores, while birth weight and infant sex correlated with cognitive scores (Lima et al, 2004). Higher weight for age indicates better nutritional status, which may indicate better socio-economic status-this may be why those infants with higher weight had better scores. This does not explain the lack of correlations for other age groups and subtests. In conclusion, in the present study, height, weight and head circumference had no significant influence on scores and this lack of correlations may be due to the fact that the sample was biased to include only healthy infants.

5.6 Limitations and strengths of this study

The limitations to this study are as follows:

(i) The sample was biased to the urban, black Gauteng population attending three specific clinics and was not representative of all Gauteng clinics. The clinics were all public health clinics, chosen for convenience due to high patient turnover as well as location. The results therefore can only be applied to the particular infants from those clinics. Results cannot be applied to infants in other provinces of South Africa or other race groups.

(ii) No demographic or socio-economic information was collected from caregivers; therefore no conclusions can be made about the infants' background, socio-economic situation, home language, income, illness etc. This is a limitation of the study since as previously mentioned many factors affect development and the South African population live under a diverse range of socio-economic circumstances. Although the clinics were municipal clinics as mentioned previously one cannot assume that the attendees were less advantaged financially. A socio-demographic questionnaire would have been very useful in analysing the results. No other information was collected during the test such as medical history or family history. Again this would have been useful for analysing the results.

(iii) Inclusion criteria did not require that participants be purely South African. Therefore infants may have been from other African countries. Data on the infants' ethnic groups was not collected and there are many diverse ethnic groups living in Gauteng. This could have influenced infant performance, since cultural or ethnic differences can influence development. Results can then only be applied to black African urban infants in Gauteng, South Africa.

(iv) Height measurements were not standardised. Therefore although measurements would have been reliable they may not have been accurate. A standardised board should have been used. Thus results with regard to height must be interpreted with caution. Weight was measured by the clinic nurses and written on the clinic card. The researcher then used those measurements in the data analysis. Since different scales were used in different clinics this may have introduced error since the scales may have been differently calibrated. Also the nurses who took the measurements differed, which could have resulted in differences in the measurements. Thus results using anthropometric measurements must be viewed with caution.

(v) Each assessment took 60-90 minutes to complete and infants may have tired, which could have affected their results.

(vi) The normative sample of the Bayley-III consisted of 1700 typically developing children (born 36-42 weeks gestation). The present study sample consisted of 122 children (born 37 or more weeks GA) and did not include a clinical sample of abnormal infants as the Bayley-III norms sample did. Had a clinical sample been included in the present study, results might have been lower. Since the sample differed quite substantially from the USA sample it is difficult to compare them.

Strengths of this study are:

(i) A large sample size was used, giving the results adequate statistical power.

(ii) In this study, for most of the subjects and their care givers, English was not their first language. Since the Bayley-III was easy to administer, it could easily be used with Caregivers and children whose English was poor.

5.7 Implications of findings

The Bayley-III is a well known tool normed on the USA population. Although SA subjects such as those in the study sample performed better on the test than the USA norms, it is still considered a valid tool to use on this population, with the existing norms. SA does not need to create its own set of norms similar to that of Richter (1988). When using the Bayley-III on the population of black urban African infants in Gauteng, it can be expected that results in the language and motor subtests will most likely be in the above average range for normal infants. SA is a country with high levels of poverty and unemployment, yet black urban SA infants appear to be performing equally well, to infants from a First World country. More research is needed to assess gender differences in infant development and if large enough may warrant the need for gender specific norms for some populations.

5.8 Recommendations based on results

Further research is recommended on the Bayley-III, using a larger more diverse group to determine whether it is an appropriate test for the entire South African population. The sample should be demographically representative of the entire population including all races and geographic areas. It should include infants between 0 and 42 months, the full age range of the test. Following this, the test can be used in South Africa on all populations, if it is found to be valid. If not a set of norms can be created as before (Richter et al, 1992) to be used to interpret results. Regular updating of norms is also necessary. For the study population (black African urban), further research similar to this study is recommended to include the remaining age ranges of the test: 13-42 months.

Future studies should collect socio-demographic information on their samples in order to better analyse the results.

When using the Bayley-III on infants in this population, they can be expected to perform better than average in the language and motor areas of the Bayley-III.

The Bayley-III is a tool, which is easy to administer yet thorough. It adequately assesses all areas of development; however it takes a long time to administer and requires special training. Therefore for practicality in SA it may need to be administered to infants who have not adequately passed a screening test. In the context of the SA situation, considering time, financial and human resource restraints, a screening tool is recommended to identify at risk infants. These infants can be referred for further investigation to be assessed with the Bayley-III. The Bayley-III is too time consuming to be used for routine assessment in the SA setting.

The Bayley-III is a costly tool, which requires adequate training to be used. The cost may be an issue practitioners and government departments would consider when deciding whether to purchase it. It is nonetheless a useful tool for therapists, doctors or psychologists to use to identify a range of developmental problems and address them timeously.

Other countries wishing to use the Bayley-III should also research its appropriateness for use on their population. If necessary a set of norms may need to be created for that specific country.

Finally previous literature has suggested that gender differences in infant development either do not exist or are too small to be of significance, the present study found differences in development between boys and girls. However since the sample size being compared, in each subgroup was small, larger numbers need to be assessed to increase the statistical power of these results. Further, subgroups do not necessarily predict the performance of the population in general. Nonetheless gender differences in development require further investigation and separate gender norms may be necessary.

Conclusion

Previous studies and the present study found black SA infants performed better on the BSID and the Bayley-III than USA norms. Although statistically the SA sample scored significantly higher than the USA norms, clinically the difference is small when one considers the variability of development.

The hypothesis that differences do not exist in performance between USA and black SA urban infants is rejected. Differences do exist, with black African urban infants in Gauteng, SA, performing better on the Bayley-III than the USA norms sample. However these differences are clinically insignificant and therefore the Bayley-III is a valid test to use on black urban infants 2-13 months of age, in Gauteng, South Africa. Further small gender differences do exist in performance on the Bayley-III and anthropometric measures were not found to influence performance on the test.

CHAPTER 6

CONCLUSION

Besides the limitations of this study it has achieved its objectives. Its aim to evaluate the performance of black South African urban infants in Gauteng on the Bayley-III has revealed that SA and USA infants perform differently. Black SA urban infants score significantly higher than USA norms on the Bayley-III. This is especially true for the language subtests between 2 months and 10 months and the motor subtests between 2 months and 7 months. However despite these differences, the Bayley-III is a valid test to use on black urban African infants in Gauteng and local norms do not need to be created to be used with the test. This is because the overall SA scores still fall within 1 SD of the USA mean and since development varies considerably between children.

These findings support the results of previous studies that suggest that different populations have different developmental profiles. In particular its findings are similar to those of Richter (1988) et al and Aina (2005) et al, who found that African infants perform better than USA infants on developmental tests such as the BSID, especially in the earlier months.

Further the study has found that:

Differences exist between male and female performance on the Bayley-III. However these differences are small and need further investigation. The formulation of gender specific norms may be necessary.

Finally growth parameters did not have an effect on scores on the Bayley-III and hence on development. This may only be true for healthy infants.

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Appendix A-Research protocol

A STUDY TO EVALUATE THE PERFORMANCE OF BLACK SOUTH AFRICAN URBAN INFANTS ON THE BAYLEY SCALES OF INFANT DEVELOPMENT III.

Vanessa Rademeyer- BSc (Physiotherapy)

Supervisors: Nicole Baillieu MSc (Physiotherapy)

Joanne Potterton PhD

INTRODUCTION:

In humans the first few years of life are an extended transition period allowing helpless infants requiring total care to become independent individuals. This process of normal development refers to an average rate of mental and motor development in children as they reach predictable stages known as milestones (Aina et al, 2005). Neural maturation occurs spontaneously due to brain growth, myelination and synapse formation, but is influenced by many factors including experience (Campbell et al, 2006), environment, culture, race and geographical location (Aina et al, 2005). An understanding of normal development is essential to assessment and treatment of infants and children. However since there is such variation in rates of normal development (Aina et al, 2005) caution must be exercised when comparing infants across different populations.

Infants need to be assessed developmentally in the first few years of life so that potential problems may be identified and the appropriate treatment started early. Early intervention is essential since brain development during this time is extensive and easily influenced (Grantham-McGregor et al, 2007). Although evidence of the efficacy of early intervention is inconclusive (Campbell et al, 2006), research has demonstrated that children developing in a stimulating environment have higher cognitive function than those growing up in less stimulating environments. (Grantham-McGregor et al, 2007; Walker et al, 2007).

The Bayley Scales of Infant Development II (BSID II-2nd Edition) is a widely used standardised assessment tool for clinical and research purposes and is known as the gold standard of infant assessment (Harris et al, 2005). It is a reliable and valid tool used to assess infants' mental and motor development from 0-42months of age (Campos et al 2006; Gauthier et al 1999). It was designed and normed on Infants in the USA. The BSID (1st Edition) and BSID II released in 1969 and 1993 respectively have been followed by the Bayley Scales of Infant Development III (BSID III Tech report 2, 2007), released in 2006.

The BSID III is a revised edition of the BSID II. It measures cognitive, language (expressive and receptive), motor (gross and fine), social-emotional, and adaptive behaviour (Bayley III Tech report 2, 2007). During its development, research showed the BSID III mean scores were about 7 points higher than those of the BSID II. The reason suggested for this was due to changes in the demographics of the population in America.

These changes included changes in proportions of children from different racial and ethnic backgrounds and regions of the country and changes in parent educational levels. Other differences between the BSID II and III were that the BSID III included clinical cases in its normative sample whereas the BSID II did not. This was done to make the BSID III more representative of the population and its range of abilities. The BSID III's precision as an assessment tool has improved compared to the BSID II. This is the result of improvement in the methodology of norms development, which was used to develop norms for the BSID III. The BSID III has been shown to have a high discrimination and good sensitivity in discriminating clinical cases from normal cases. Therefore, in clinical cases such as Down syndrome, the sample means were two or more standard deviations below those means of the normative sample, which met with theoretical expectations (Bayley III Tech Report 2, 2007).

As mentioned earlier there is wide variation in rates of normal development, which can be influenced by a number of issues including environment, genetics, poverty, and nutrition and parenting practices (Walker et al, 2007; Aina et al, 2005; Lindsey et al 1999).

Recent studies have shown that at least 200 million children in developing countries are not reaching their developmental potential due to poverty and its associated health, nutrition and social factors (Grantham-McGregor et al 2007). The four major risk factors for this are stunting, inadequate cognitive stimulation, iodine deficiency and iron deficiency anaemia (Walker et al, 2007). Other factors include infectious diseases, intra-uterine growth restriction, and environmental exposure to toxins, decreased cognitive stimulation, maternal depression, and exposure to violence (Walker et al, 2007). These affect a child's development through changes in brain structure, function and behaviour. In developing countries children are often exposed to a combination of these risks (Walker et al, 2007).

The HIV/Aids epidemic, which in Sub-Saharan Africa constitutes two thirds of the global population of adults and children living with HIV (Aids Epidemic update, 2006) poses a risk factor for child development, directly due to its effects on the brain and indirectly due to maternal illness and poverty associated with the burden of illness and loss of income (Walker et al, 2007). Neurological and developmental signs are common in children with HIV and are often early markers of disease progression (Van Rie et al, 2007).Neuro-developemental assessments are rarely performed in developing countries due to lack of skilled assessors and standardized/validated tools. This results in 'missed opportunities' timely initiation of ART (Van Rie et al, 2007).

The impact of nutrition on development and growth has been well documented. Breastfeeding is said to have a beneficial effect on the attainment of gross motor milestones (Sacker et al, 2006) and there is evidence to suggest it may affect cognitive development too (Walker et al, 2007). The WHO Child Growth Standards based on length, height, weight and age were developed to document how children should grow under optimal conditions. These standards allow for comparisons of children's' growth and determination of its adequacy (WHO MGRS, 2006-2). Stunting (height for age<2SD below the mean) by 2-3yrs age is significantly associated with later cognitive deficits, poor school achievement and dropout. Stunting is caused by poor nutrition and is a common problem in developing countries. Weight for age, which combines weight for height and height for age has also been linked to development and is used instead of stunting to measure nutritional status in children (Grantham-McGregor et al 2007).

The WHO Multi-centre Growth Reference study found that significant associations exist between gross motor development and some physical growth indicators. Increases in weight for age/weight for length or BMI tended to reduce the age of achievement of sitting without support while increases in length for age tended to increase the age of achievement of sitting without support, crawling, standing with assistance, standing alone and walking with assistance. The milestone most strongly associated with growth was sitting without support (WHO MGRS 2006). Head circumference (HC) measurements are included in these growth references and are an indicator of nutritional status and brain growth. Microcephaly (HC<2SD below the mean) and macrocephaly (HC>2SD above the mean) are assumed to be indicators of brain pathology. Microcephaly is commonly associated with decreased brain volume, decreased IQ and poor academic ability (Ivanovic D et al, 2004). Macrocephaly has been associated with above average intelligence but more often with a range of neurological disorders namely; enlarged brain, skull or subarachnoid spaces, neurofibromatosis, tuberous sclerosis, metabolic disorder, cognitive impairment, mental retardation, learning problems, seizures and pervasive developmental disorders. Macrocephaly can be familial and non-symptomatic but most cases result in hydrocephalus with its associated neurological affects (Nevo et al, 2002).

Ethnic differences may also influence development. In a study of infants at 9 months age, ethnic differences were found in the achievement of gross motor milestones. Black Caribbean and Black African infants were found to be less likely to have gross motor delays at 9 months age compared to white infants (Kelly et al, 2006). These differences could not be explained by other factors. Differences found, which could be explained, were thought to be due to socio-economic factors, such as mother's education, household income, overcrowding and dampness in the home as well as possible cultural traditions (Kelly et al, 2006). Whether differences amongst different races/cultures/peoples are explained or unexplained they still remain and pose a problem when comparing populations to one another. Therefore the question remains whether the use of a standardized test with American norms is appropriate for all populations especially the South African one. Differences in normative scores for the American population from the BSID II to III have been suggested to be due to changes in demographics (Bayley III Tech report 2, 2007), so one could assume that populations with different characteristics could also have different scores.

In 1992 a study was published on the use of the BSID (first edition) on black South African infants (Richter et al, 1992). The results of this study showed that South African infants scored significantly higher than the American standardization sample and was more marked in the motor scale from 2-10 months and the mental scale from 4-15 months. This highlighted the issue of "African infant Precocity" and made it necessary to question the validity of using western normed assessment tools on different populations (Richter et al 1992). The researchers of this study formulated a set of norms for black

South African Infants as a supplement to the BSID to assist with interpreting scores for this specific population. These Norms would assist with comparison of an Infant in this population with his peers rather than with American Infants *(Richter et al, 1988).* A similar study done in 2005 on the BSID II on Nigerian children found that the Nigerian children scored above the normal values for the American Infants especially in the lower age groups up to two weeks (Aina et al, 2005). Many previous studies have found that African infants are precocious in development when compared to American infants. Generally it is suggested that cross- cultural differences exist in rates of infant development. Further research in this area is needed to confirm or refute these suggestions. Until then caution needs to be exercised when comparing culturally/demographically different infants to what is considered 'normal' in the USA.

In light of this, it is possible that black South African urban infants may develop at different rates to American Infants due to cultural, ethnic, socio-economic and environmental/geographic differences. Since there have been no studies done on the validity of the BSID III on different populations as yet, the results of this study will determine whether the BSID III is a valid tool for practitioners to use to assess this population.

PROBLEM STATEMENT:

The BSID III was designed and normed in the USA. No research has been carried out regarding its validity for use on different populations including the South African population.

RESEARCH QUESTION:

How do black South African urban Infants perform on the BSID III?

AIM:

To Evaluate the Performance of Black South African Urban Infants in Gauteng on the BSID III.

OBJECTIVES:

-To compare the scores achieved on the BSID III of Black South African Urban Infants to those of American Infants and to analyse any differences found.

-To determine whether height, weight or head circumference have any correlation to infant scores.

-To determine whether the BSID III is a valid test to use on the Black Urban South African population in Gauteng.

-To determine whether sex affects performance on the BSID III

HYPOTHESIS:

The Null Hypothesis is that the South African and American scores do not differ while the alternative hypothesis is that the two scores are different. A directional alternative hypothesis is not possible as there is no indicator of what to expect for this recently published/revised tool.

RESEARCH DESIGN: Cross sectional study

SUBJECTS:

Population:

For the purposes of this study it was decided to focus on Black South African Urban Infants in the Gauteng area. This would include the lower and middle class black population attending Municipal Clinics in the Gauteng area. Thirty infants in each of the following age groups 3, 6, 9 and 12 months would be recruited.

Inclusion criteria:

-Clinically/apparently normal infants

-Infants aged 3, 6, 9 and 12 months or within 15 days of these months

-African Black South African Infants

-Infants resident in Gauteng (ie: living in Gauteng since birth)

Exclusion criteria:

-Infants with any apparent clinical abnormality

-Infants with Cerebral Palsy, any syndromes or other obvious disability

-Premature Infants (Born less than 37 weeks gestation)

-Infants who are non-South African and any race other than Black African.

Sample size determination:

Sample size is limited to resources which will restrict the study to 120 subjects which will be distributed over 4 time periods so as to measure a required 30 subjects in each age group in order to acquire enough scores to draw conclusions from. From a statistical point of view a sample size of 30 subjects per group, is the minimum required for estimation of a mean and Standard Deviation and a Confidence Interval, which is based on a normal (Gaussian) distribution (z).

METHODS:

Measurement instruments:

The Bayley Scales of Infant Development III will be administered to each child. Scores obtained will fit into the following categories: Cognitive, gross motor, fine motor, expressive language and receptive language. A Pilot study will be done on 12 children.

The Bayley III provides four types of norm-referenced scores: scaled scores, composite scores, percentile ranks and growth scores. Confidence intervals are available for the scales and developmental age equivalents are available for the subtests.

A research assistant will assist the researcher with data collection. This assistant will be trained in the administration of the BSIDIII Reliability will be ensured through consistent use of the BSID III. Inter-rater reliability will be ensured by ensuring assessors derive the same scores when testing the same children at different times.

Each infant's height, weight and head circumference will be recorded from their clinic card. Body mass index will then be calculated from this as will weight for age, height for age and weight for height. These will be compared to the WHO z-scores. Comparisons between growth and development can then be made.

PROCEDURE:

Recruitment:

Subjects taking part will be recruited from Municipal Vaccination Clinics in Gauteng. Written permission from the head of each Clinic will be obtained. Municipal clinics would include Parkhurst, Brixton, Garden City and Malvern. Subjects will meet the inclusion and exclusion criteria as described. The parent/caregiver will be given a letter stating the purpose of the study, and asking their permission to have their child take part in the study. Written consent will be gained. They will be randomly assessed when they attend the clinic for vaccination or screening, preferably prior to vaccination or shortly after when the mother has pacified the child. Each child's height, weight and head circumference will be measured.

Data Collection:

This will take place on a Monday and Tuesday. Ideally 4 children a week would be assessed and data collection would take 20-30 weeks. Each assessment will take 60-90minutes. Each child's height, weight and head circumference will be recorded. This study will also assess whether there is any correlation between growth (height for weight) in infants and their scores on the BSID III. Infants who are found to score less than 1 SD below the norms (composite scores less than 85) will be referred for appropriate therapy or investigation.

STATISTICAL CONSIDERATIONS:

DATA ANALYSIS:

Descriptive statistics inclusive of 95% confidence intervals will be determined for each of the four age groups. A comparison of South African (RSA) and Bayley III norms will be done for each age group using the students - t test. The latter is done since for the USA only summarised data for example mean and SD are available. Testing will be done at the 0.05 level of significance. Infants scoring one or more standard deviations below or above the norms will be considered to have significant delay or advancement.

Scaled scores will be calculated for the subtests, and are derived from the total raw score. They range from 1 – 19, with a mean of 10, and a SD of 3.

Composite scores will be calculated from the scaled scores. They range from 40 – 160, with a mean of 100, and a SD of 15. These scores can be used to compare a child's performance across all the scales.

Percentile ranks will be calculated, and indicate the standing of a child relative to that of the children in the standardisation sample. They range from 1 - 99, with a mean and median of 50.

Confidence intervals will be determined for all subtests, and express the precision of test scores.

Developmental age equivalents will be determined, which represent the age at which a given raw score is typical.

<u>Statistical tests</u>: Students t test

<u>Budget:</u>

Printing costs for assessment forms (45 pages), information forms, consent forms, assessment forms and questionnaires:

= 50 pages x 155 x 60c per page

= R4650.

Transport to Clinics -R1, 92 per km, R10 km per day for 30 days x 2 (researcher and assistant)

= R1152, 00

Paying research assistant at R85 per hour x 1,5hrs per child x 60:

= R7650.

TOTAL = R13 452.

Time Line: Proposal submitted August 2007. Data collection will start in October 2007 and continue until May 2008. Write up of research report will be completed by June 2008.

ETHICS:

Ethical clearance has been applied for and is pending. Using numbers instead of patient names on assessment forms will ensure confidentiality. Informed consent from the parents and verbal assent from the child will be attained.

CONCLUSION:

This study will assess the performance of a specific sector of the South African population's performance on the BSID III. Since age groups up to 12 months only will be assessed there may be a need for further research to assess performance of children from 12-42 months of age. The results of this study will be useful for practitioners who will be using the BSID III on this specific population for assessment or research purposes.

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Appendix B- Ethical clearance

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Division of the Deputy Registrar (Research)

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)
R14/49 Rademeyer

CLEARANCE CERTIFICATE	**PROTOCOL NUMBER M070815**
PROJECT	A Study to Evaluate the Performance of Black South African Urban Infants on the Bayley Scales of Infant Dvelopment III
INVESTIGATORS	Miss V Rademeyer
DEPARTMENT	Department of Physiotherapy
DATE CONSIDERED	07.08.31
DECISION OF THE COMMITTEE*	APPROVED UNCONDITIONALLY

Unless otherwise specified this ethical clearance is valid for 5 years and may be renewed upon application.

DATE 07.09.03 **CHAIRPERSON** ....
(Professors PE Cleaton-Jones, A Dhai, M Vorster, C Feldman, A Woodiwiss)

*Guidelines for written 'informed consent' attached where applicable

cc: Supervisor : Ms N Baillieu

DECLARATION OF INVESTIGATOR(S)

To be completed in duplicate and **ONE COPY** returned to the Secretary at Room 10005, 10th Floor, Senate House, University.
I/We fully understand the conditions under which I am/we are authorized to carry out the abovementioned research and I/we guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to resubmit the protocol to the Committee. **I agree to a completion of a yearly progress report.**

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

Appendix C-Information sheet and informed consent

Dear Parent/Care giver

My name is Vanessa Rademeyer and I am a Masters student in Physiotherapy at WITS University. We are currently looking at normal development in Black South African children. We would be most grateful if you and your child would consider participating in this study.

Study: To Evaluate the Performance of Black South African Urban Infants in Gauteng, on the Bayley Scales of Infant Development III

Why are we doing this?

We would like to find out whether an American test looking at Normal Development in Children can be used on Black South African children.

What do we expect from the participants and their parents?

We would like to assess your child just before their Vaccination. The assessment will take 30minutes-1 hour.

Are there any benefits to participants?

Yes. This is a free assessment of your child's development.

Are there any risks/side effects to the participants?

No.

May I withdraw my child from this study?

Yes. You can withdraw from this study at anytime without giving a reason.

What about confidentiality?

Your child's name will be separated from their assessment form and no one will have access to it except me. All details will be kept confidential.

If you have any queries please contact me, Vanessa Rademeyer on 011 646 0131.

If you are happy to allow your child to take part in this study, please read and sign the attached consent form.

Thank you

Vanessa Rademeyer

Consent form:

I **…………………………………….** Parent/Guardian of**……………………………………** have read and understood the information sheet and agree to allow my child to participate in the above mentioned study.

Date:

Signed:

Appendix D-Bayley-III Assessment Form

Bayley
Scales of Infant and Toddler Development™
THIRD EDITION

Record Form

Child's name: ______________________
Sex: ☐ M ☐ F ID #: ______________________
Examiner's name: ______________________
School/Child care program: ______________________
Reason for referral: ______________________

Subtest Summary Scores

Subtest	Total Raw Score	Scaled Score	Composite Score	Percentile Rank	Conf. Interval (___%)
Cognitive (Cog)			Use Table A.5		
Language (Lang)					
Receptive Communication (RC)					
Expressive Communication (EC)					
Sum			Use Table A.4		
Motor (Mot)					
Fine Motor (FM)					
Gross Motor (GM)					
Sum			Use Table A.4		
Social-Emotional (SE)			Use Table A.5		
Adaptive Behavior					
*Communication (COM)					
Community Use (CU)					
Functional Pre-Academics (FA)					
Home Living (HL)					
*Health and Safety (HS)					
*Leisure (LS)					
*Self-Care (SC)					
*Self-Direction (SD)					
*Social (Soc)					
*Motor (MO)					
Sum			(GAC) Use Table A.6		

*For children younger than one year, the GAC is calculated using only those skill areas indicated by an asterisk.

Calculate Age and Start Point

	Years	Months	Days
Date Tested			
Date of Birth			
Age			
Age in Months and Days	Years × 12 + months		
Adjustment for Prematurity	Adjust through 24 months		
Adjusted Age			
Start Point	Calculate start point according to chart below		

Age	Start Point
16 days–1 month 15 days	A
1 month 16 days–2 months 15 days	B
2 months 16 days–3 months 15 days	C
3 months 16 days–4 months 15 days	D
4 months 16 days–5 months 15 days	E
5 months 16 days–6 months 15 days	F
6 months 16 days–8 months 30 days	G
9 months 0 days–10 months 30 days	H
11 months 0 days–13 months 15 days	I
13 months 16 days–16 months 15 days	J
16 months 16 days–19 months 15 days	K
19 months 16 days–22 months 15 days	L
22 months 16 days–25 months 15 days	M
25 months 16 days–28 months 15 days	N
28 months 16 days–32 months 30 days	O
33 months 0 days–38 months 30 days	P
39 months 0 days–42 months 15 days	Q

PsychCorp
To order, call: 1-800-211-8378

4 5 6 7 8 9 10 11 12 A B C D E

ISBN 015402723-5
9 780154 027238

Appendix E 1-Sample data

SUBJECT	AGE MONTHS	DAYS	SEX	HEIGHT CM	WEIGHT KG	HEAD CIRCUMFERENCE CM	COG COMPOSITE SCORE	LANG COMPOSITE SCORE	MOT COMPOSITE SCORE
1	3	5	M	59	8	43	120	100	121
2	3	1	F	59.5	6,5	42	95	100	103
3	3	10	M	58	6,9	43	120	129	103
4	3	7	F	60	5,7	40	110	115	107
5	3	11	M	61	5,9	42	80	100	118
6	3	8	F	62	6,3	42	95	109	110
7	3	9	F	61	7,3	41,5	105	124	115
8	3	10	M	41	5,9	43	85	106	107
9	3	13	M	69,5	7,6	44	105	86	112
10	3	5	F	61	6,35	42,5	110	86	103
11	3	13	M	63	6,3	42	115	103	121
12	3	12	M	61	6,39	42	80	109	103
13	2	19	F	62,5	6,3	40,5	110	103	115
14	3	6	F	60	5,7	40	95	97	79
15	2	25	M	54	6,2	40	90	91	112
16	3	9	M	59	6,9	41	125	106	127
17	2	17	M	61	5,9	42	100	129	112
18	2	29	M	58	6	40.5	120	127	118
19	3	9	M	63	7,3	43,9	110	109	100
20	3	6	F	61	6,5	39	115	121	110
21	3	7	M	59	6,4	40	120	115	110
22	3	16	F	62	6,5	42	95	94	103
23	3	9	M	54	4,9	39	70	77	91
24	3	3	M	64	8,3	44	100	106	121
25	3	6	F	58	5,2	40	85	100	107
26	3	1	F	56	5,3	41,5	90	106	103
27	3	7	F	61	5,7	40	110	103	97
28	3	14	M	62	6,8	42,5	105	97	112
29	3	7	F	52,5	5,5	40,5	120	97	127
30	3	3	F	56	5,7	39,5	110	100	121
31	2	15	M	62	8,15	44	135	106	121
31	6	10	F	68	8,3	43	105	135	121
32	6	0	M	65	7,75	45	95	153	121
33	6	12	F	64	6,9	43,5	105	150	133

SUBJECT	AGE MONTHS	DAYS	SEX	HEIGHT	WEIGHT	HEAD CIRCUMFERENCE	COG COMPOSITE SCORE	LANG COMPOSITE SCORE	MOT COMPOSITE SCORE
35	6	0	F	62,5	6,9	44	105	127	103
36	6	0	F	62	7,2	46,5	85	106	103
37	6	3	M	62,5	6,21	43	100	121	88
38	5	24	M	69	8,3	43	80	100	88
39	6	4	M	86	8	45	80	106	73
40	6	1	M	63	6,9	43	115	115	107
41	6	6	M	65	8,4	43,9	85	112	110
42	5	22	M	64	8,2	43	85	112	88
43	5	29	M	66	7	45	95	94	110
44	6	2	M	69	8,4	45,5	115	103	115
45	6	10	F	65	7,3	44	110	115	115
46	6	0	M	63	7,9	44	100	106	91
47	6	0	M	67	8	45	105	115	103
48	6	13	F	62	7,5	44	110	91	115cm
49	6	10	M	63	7,5	44	80	127	88
50	6	10	M	68	7,7	45	85	97	107
51	6	0	F	61	5,85	42	110	115	112
52	6	12	F	64	5,2	44	95	106	103
53	6	16	M	69,5	9,2	45,5	85	121	79
54	6	2	F	66	7	43,5	105	127	118
55	6	3	F	66	7,1	42,5	105	127	115
56	6	0	F	66	8,7	43,5	110	115	130
57	6	0	F	68	7,8	44	110	106	107
58	6	0	M	63	6,6	43	105	100	112
59	6	9	F	62	8.2	42,5	115	115	121
60	6	11	M	70	8	45,5	115	121	107
60a	6	6	F	58	6,4	41	90	132	121
61	9	16	M	67	9,4	44,5	95	79	100
62	9	2	M	68	9,4	46	90	97	91
63	8	29	F	68	8,1	47	105	118	103
64	8	29	M	66,5	8,5	46	100	100	91
65	8	27	F	67,5	16	46	105	118	110
66	9	1	M	70,5	7	44	85	89	88
67	9	3	M	70	10.5	47,5	95	97	110
68	9	14	M	68	9,5	46,5	100	97	100
69	9	10	F	69	9,35	47,5	105	106	97
70	9	7	M	69	7,1	44	95	112	91

SUBJECT	AGE MONTHS	DAYS	SEX	HEIGHT	WEIGHT	HEAD CIRCUMFERENCE	COG COMPOSITE SCORE	LANG COMPOSITE SCORE	MOT COMPOSITE SCORE
72	9	1	M	66	10	46	95	94	107
73	9	7	M	67	9,8	46	95	97	112
74	9	9	F	72	8,9	46	100	121	110
75	9	0	F	66	7,5	43	85	124	79
76	9	1	M	74	10,3	48	90	100	103
77	8	27	M	67	8,8	46	95	118	88
78	9	5	M	67	7,5	43	115	115	100
79	9	4	F	68	9,2	45	90	121	107
80	9	0	F	68	8,9	45,8	95	112	100
81	9	1	F	68	8,5	46	105	112	106
82	9	11	F	66	6,9	43	80	127	88
83	9	3	F	71	8,1	46,5	95	94	94
84	9	4	F	67,5	7	44	105	103	97
85	9	3	F	68,5	7,9	47	105	94	97
86	9	1	M	76	9,6	45	95	97	97
87	9	6	F	69,5	9,9	45,5	115	132	107
88	9	0	F	72	8,7	45	105	118	94
89	9	0	F	69,5	10,2	46,5	95	103	85
90	9		M	66	7,9	46	80	91	82
91a	9	0	F	66	9	46	95	109	100
91	11	19	F	60	7,55	44	65	86	82
92	12	0	F	72,5	8,7	43	70	91	97
93	12	0	F	72	8,7	46	85	97	85
94	12	0	F	76,5	8,8	47,5	95	97	94
95	12	9	M	73	9,5	47	80	86	97
96	12	1	F	74	11,5	44	90	91	103
97	12	0	F	76	9,2	44,5	90	79	85
98	12	0	M	75	10	46	100	112	112
99	12	7	F	74	9,9	48	110	91	103
100	11	29	M	75	11	48	120	91	132
101	12	0	F	74	10,1	46	100	121	97
102	12	9	M	74	7,6	44	130	97	136
103	12	4	M	70	9,4	45,5	110	94	118
104	12	3	M	78	9	48	95	89	89
105	12	0	F	72	9	46	120	112	112
106	11	16	F	76	10,9	46	90	103	91
107	11	17	F	71,5	9,6	45	100	106	91
108	11	21	F	76	10,3	48,5	80	97	97
109	12	3	M	76	9	48	90	94	91

SUBJECT	AGE MONTHS	DAYS	SEX	HEIGHT	WEIGHT	HEAD CIRCUMFERENCE	COG COMPOSITE SCORE	LANG COMPOSITE SCORE	MOT COMPOSITE SCORE
110	12	4	F	76	10,4	46,5	95	94	88
111	12	5	F	71	9,1	47	120	118	127
112	12	1	F	73	,9,4	47	100	100	85
113	12	1	M	76	10,1	46	90	94	88
114	12	13	M	71	8.8	48	85	106	91
115	12	4	M	72	9,7	47	110	118	100
116	12	8	M	75	9.8	48	100	115	91
117	12	1	M	76.5	10.8	47	125	97	100
118	12	1	M	77	9.5	47	140	115	112
119	12	9	F	79	13.7	47	130	112	94
120	12	4	M	79	11.8	50	100	109	103

Appendix E 2-Gender differences in subtest scores overall.

Subtest	Males (62)	Females (60)	P-value
Cognitive	100.1	99.3	0.83
Language	105.1	108.7	0.06 *
Motor	103.6	103.5	0.69

Appendix F- Approval from Health Department

Joburg

a world class African city

ENQUIRIES: C. Fraser
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11 January 2008

Dear Ms Rademeyer

APPROVAL TO CONDUCT RESEARCH WITHIN HEALTH IN THE CITY OF JOHANNESBURG

Permission has been granted to you to conduct research in the Health Department within the City of Johannesburg.

Topic:

A Study to Evaluate the Performance of Black South African Infants on the Bayley Scales of Infant Development III

Please contact the following person(s) before you commence with your project and to gain access to the clinics:

Region B: Parkhurst: Regional Health Manager Ms Paulinah Maepa Tel.: 011-718-9657
Cell: 082-551-5804
Region E: Bez Valley Regional Health Manager Ms Ncumisa Mehana Tel.: 011-881-6456
Cell: 082-467-9565
Region F: Malvern Regional Health Manager Mr Oupa Montsioa Tel.: 011-681-8129
Cell: 082-467-9423

Should you have any queries please do not hesitate to contact our department.

We look forward to your Final Research Report.

Thank you

11/1/08

DR. R. BISMILLA
Executive Director
City of Johannesburg
Health Department