The reliability of the Molteno Adapted Scale in predicting developmental outcomes at 2 years, in prematurely born very low birth weight infants.

Author: Barbara Laughton Student No: 0208438 K
MSc Child Health (Neurodevelopmental Option)

Supervisor: Prof L B Jacklin MB BCh M Med MSc FCPaed
Department of Paediatrics and Child Health
University of the Witwatersrand

Co-Supervisor: Prof J F Schoeman MBChB MMed(Paed) FCPaed MD
Department of Paediatrics & Child Health, Stellenbosch University

Ethics Approval: M 060439

A research report submitted to the Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, in partial fulfilment of the requirements for the degree of Master of Science in Child Health (Neurodevelopmental Option).

CANDIDATES DECLARATION:

I, Barbara Laughton declare that this research report is my own work. It is being submitted for partial fulfilment for the degree of Master of Science in Child Health (Neurodevelopmental option) at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at this or any other university.

Signed: B. Laughton

.....7th..... day of ...November....., 2010.

ABSTRACT:

Background:
Prematurely born very low birth weight (VLBW) infants are at high risk for neurodevelopmental problems and require regular follow up. Within the South African context, one needs a reliable and user-friendly screening tool to identify those who require intervention. The Molteno Adapted Scale (MAS) is used for this purpose in many clinics, but it has never been validated.

Aim:
To assess if the MAS performed on young prematurely born infants reliably predicts the neurodevelopmental outcome at 2 years of age as determined by the Griffiths Mental Development Scales (GMDS).

Methods:
A retrospective study of records of VLBW infants between 1998 and 2006, from the Panorama Medi-Clinic Neonatal Intensive Care Unit follow up clinic. Infants with birth weights < 1500g and accurately assessed gestation < 34 weeks were included. Those who suffered brain insults e.g. meningitis, between the early assessments and the GMDS were excluded. For each child, quotients obtained from the MAS at early assessments were compared to quotients obtained on the GMDS after 2 years of age using Spearman correlations.

Results:
Fifty-two (27 boys) VLBW infants were included in the study, with a mean birth weight of 981.2 ± 225.5 g and mean gestation of 27.7 ± 1.9 weeks. Thirteen (25%) infants had cerebral palsy and two had visual impairment. MAS assessments were performed at mean ages of 5.1, 10.1 and 16.8 months and the GMDS at a mean age of 28.8 months. Correlations between the MAS and the GMDS ranged from 0.1 - 0.43 at the first assessment, 0.29 - 0.46 at the second assessment and 0.52 - 0.63 at the third assessment. Correlations were statistically significant for the Fine Motor quotient on the MAS at the first assessment, the General quotient and Personal Social quotient at the second assessment, and all quotients except Personal Social at the third assessment.

Conclusion:
Developmental quotients on the MAS at 5.1 and 10.1 months have a weak positive correlation with the GMDS at 28 months. The MAS at 16.8 months significantly correlated with the developmental outcome as assessed on the GMDS at a mean age of 28 months in prematurely born VLBW infants.

ACKNOWLEDGEMENTS

I would like to acknowledge the assistance from Mrs Debbie Grové for assistance with statistical analysis and Professor Martin Kidd for advice and performing the statistical analysis for correlations between the scores. To my supervisors, Professor Lorna Jacklin and Professor Johan Schoeman for their invaluable advice and guidance.

TABLE OF CONTENTS:

LIST OF TABLES

LIST OF APPENDICES

LIST OF ABBREVIATIONS USED

CP – Cerebral Palsy

GMDS – Griffiths Mental Development Scales

NDT – Neurodevelopmental Treatment

NICU – Neonatal intensive care unit

MAS – Molteno Adapted Scale

INA – Infant Neuromotor Assessment

IQ – Intelligence Quotient

SD – Standard deviation

VLBW – Very low birth weight

1. INTRODUCTION

Very low birth weight (VLBW) prematurely born infants are a select group of infants at high risk for neurodevelopmental problems. Major disabilities range from 20 – 50% in the first few years of life.[1-4] As a result these infants require regular neurodevelopmental follow up.[2] These assessments aim to:

1) Identify deficits that need intervention,
2) Monitor the effects of intervention for these deficits,
3) Answer parent's questions about predicting future function and,
4) Audit the neonatal services provided. [3-7]

Many neurodevelopmental assessment tools have been developed to fulfil these aims, which may be either comprehensive assessments, screening tools, or aimed to assess a specific area of function e.g. only motor or language[8]. However, it is difficult to accurately predict long term outcomes from assessments performed in the early years, especially in children with milder problems.

In South Africa, and in the high risk group of VLBW infants, there is a need for a user-friendly, quick and reliable predictor of neurodevelopmental outcome in young infants in resource-limited settings.

The Molteno Adapted Scale (MAS) (appendix 2) is used as the preferred developmental assessment tool in many centres in the Western Cape. It is quick and easy to administer and is perceived to be accurate. However, it has never been

standardised and normative studies have not been performed, neither has its predictive validity been assessed in the cohort of children for which it is intended.

It is the intention of this study to conduct a pilot study to assess the predictive value of the MAS and to assess the appropriateness for further studies.

2. LITERATURE REVIEW

VLBW infants are a select group of infants who are at high risk for neurodevelopmental problems. Infants born before 32 weeks gestation are at increased risk when compared to term infants, with those born before 28 weeks or with birth weights <1000g at highest risk for neurodevelopmental problems.[2] Major disabilities range from 20 – 50% in the first few years of life.[1-4] It is estimated that 5 – 20% of prematurely born infants develop cerebral palsy (CP), but even in the absence of CP, motor performance may be affected in 20 – 40 % of infants.[3] These infants are also at higher risk for cognitive impairment, with their mean intelligence quotient (IQ) 4 – 10 points lower than controls, with 15% performing in the borderline range (IQ 70-85) and 10-25% with IQ below 70.[3,4] In extremely low birth weight infants, visual impairment may be as high as 9% and hearing impairment 11%.[2]

It is well recognised that VLBW infants require regular follow up from a neurodevelopmental perspective.[2,5] Early assessments may identify problems that need intervention while there is still chance for a positive effect on the developing brain. Often parents and care-givers would like to know the potential outcome and problems they will face with their child. Measuring the quality of outcome is also important for management policies within the neonatal unit. [3-7]

Many neurodevelopmental assessment tools have been developed and may be either comprehensive or screening tools, or aimed to assess a specific area of function e.g.

only motor or language. The most well recognised developmental assessments in young infants are the Bayley Scales of Infant Development[7,9] or the Griffiths Mental Development Scales.[10,11] These are comprehensive assessments and results from these assessments are expressed as quotients. They take approximately one hour per patient to perform and are not always feasible in overloaded high-risk follow-up clinics. For this reason, screening tools have also been developed[9,12-15] and these may be performed in 15 – 30 minutes. Results are expressed by putting infants into "High" or "Low Risk" categories.

It should be noted that neurodevelopmental assessments are not IQ tests, and Rose et al[7] aptly describes them as excellent descriptive instruments, capturing a developmental level and evaluating it against well-normed population values.

While it is ideal to identify deficits early to initiate appropriate intervention, not all deficits are evident in the first year of life due to the nature of the rapidly developing brain and the varying nature and severity of insults.[5-7,16,17]

A number of studies have evaluated the predictive value of various assessment tools for early outcome before 2 years or later outcome at school age. These have shown that neurodevelopmental assessments have little predictive ability before 1 year of age.[4,11,18,19] Voss et al shows that neurological assessments at term age are a poor predictor of neurodevelopmental outcome with only 49% of infants correctly categorised[16]. Rose et al reports that the median correlation between developmental tests administered in the first 6 months of life and IQ scores at 2 to 4 years is only

0.21 for unselected groups of normal children.[7] Most moderate and severe deficits are evident by 18 months, but some may only become evident at 6 years of age or older.[5-7,16,17] Neurodevelopmental problems may also improve over time.[1,4] One should therefore be cautious about predicting long term outcomes of VLBW infants using early neurodevelopmental assessments. Despite these limitations, early neurodevelopmental assessments are important for early detection of problems and early intervention where necessary, as well as for outcome studies and obtaining some idea of a child's future functioning and special needs.

There are many publications on the neurodevelopmental outcome of very low birth weight infants corrected for gestational age.[1,4,13,16,20,21] Den Ouden et al's[22] findings support this by comparing 555 'normal' preterm infants with term infants and showed that without correction all developmental milestones were reached later than in term children during the first year, whereas these children would be considered "normal" if corrected age had been used. However, even without correction at 2 years of age development was equal to or better than fullterm children . They recommend full correction for the first year of life to avoid over-referral and unnecessary parental anxiety. However, one needs to be aware that Miller et al[23], showed that over correction may occur when using the Griffiths score at an early age and children who have, or are at risk of developmental disability, may be missed. They therefore recommend that both corrected and uncorrected developmental quotients should be considered.

The Griffiths Mental Development Scales (GMDS) is widely accepted as a reliable tool[24] and has been validated for use in the South African context.[25-27] The GMDS was developed in Great Britain and has been standardised on British children.[24] The psychology department at the University of Port Elizabeth has produced many research projects assessing the relevance of the scales for South African children, which show good correlation between the different South African race and language groups and British children.[28] The GMDS is a comprehensive assessment, requires trained and registered personnel, and takes at least an hour to administer, which prevents it from being used in busy and under resourced developmental clinics in South Africa.

There are a number of screening tools used in South Africa, some of which have been validated in certain South African population groups. The Denver Screening Test[9] is used in South African studies. [29-31] The Infant Neuromotor Assessment is used in the Western Cape, but is limited to predicting motor outcome.[13] The Molteno Adapted Scale (MAS) is used routinely as an assessment tool in neurodevelopmental clinics in secondary and tertiary hospitals in the Western and Eastern Cape Provinces of South Africa. It takes approximately 10 – 15 minutes to perform, is easy to administer and is thought to be accurate. It is based on the work on the developmental milestones of the young child of Mary Sheridan[32] and Ruth Griffiths[33] and uses well recognised developmental milestones that are used in many developmental tests.[9,12,14] An extensive literature research has not revealed any publications using the MAS. Research papers on the standardisation or normative studies have also not been found.

In the context of overburdened clinics in South Africa, the MAS is a tool that requires minimal apparatus and training, and can be used in resource poor settings. In the high risk group of VLBW infants, there is a need for a user-friendly, quick and reliable predictor of neurodevelopmental outcome in young infants. It is best to use a tool that everyone knows and trusts, than to introduce a new tool that still needs to be learnt and accepted by the staff as well as validated and adapted for our cultural groups. However, the MAS also should be assessed critically in the setting where it is used as to its appropriateness.

3. AIM OF STUDY

To assess the reliability of the MAS as an instrument to predict neurodevelopmental outcomes in VLBW infants, by comparing the early scores as assessed using the MAS, to the developmental scores as assessed by the gold standard – the GMDS, at 2 years of age. Thereby to determine whether the MAS has any value in clinical practice.

4. STUDY HYPOTHESIS

The Molteno Adapted Scale (MAS) performed at a young age in VLBW infants, will reliably predict the neurodevelopmental outcome at 2 years, or alternatively the MAS will not reliably predict the neurodevelopmental outcome at 2 years of life in VLBW infants.

4.1 Study Objectives

4.1.1 Primary Objective:

To demonstrate whether the MAS performed at 4½ months, 9 months, 12 months and 18 months, is a reliable predictor of the neurodevelopmental status in VLBW infants at 2 years of age as measured by the Griffiths Mental Development Scales.

4.1.2 Secondary Objective:

To determine if the MAS has value in clinical practice and future research.

5. PATIENTS AND METHODS

5.1 Study sample and setting

Patient records from the high risk neurodevelopmental clinic at Panorama Medi-Clinic Hospital, Cape Town were reviewed. The clinic follows up graduates from the Panorama Medi-Clinic Neonatal Intensive Care Unit (NICU) which is a Quaternary Referral Centre for patients with private medical aid insurance. Neonates with a gestational age of greater than 24 weeks are admitted to the NICU. The NICU has an average of 350 admissions per year, including approximately 60 infants with birth weights < 1500g. The NICU contributes to the Vermont Oxford Network database.[34]

Neurodevelopmental therapy care is routine practice in the NICU. The nursing staff are trained in the correct positioning and handling of the VLBW prematurely born infants, and a Neurodevelopmental Treatment (NDT) trained physiotherapist with a special interest in prematurely born infants oversees this. Parents are encouraged to handle infants as they become more stable and to attend a training session on appropriate handling and positioning of their infants. Parents are also given an instruction booklet on handling and positioning their child before discharge.

High risk neurodevelopmental assessments of NICU graduates are recommended at 4½ months, 9 months, 12 months, 18 months and 24 months corrected age. Assessments are performed by a Developmental Paediatrician and an NDT trained Physiotherapist. At 4½ months, 9 months, 12 months corrected age, the Infant

Neuromotor Assessment[13] and the MAS are used as assessment tools, and at 18 months corrected age a formal neurological examination and the MAS are used. At 24 months corrected age the GMDS and a neurological examination are performed.

At the high risk neurodevelopmental follow up, further advice is given on handling and positioning depending on the problems identified at the assessment. If deemed necessary, infants are referred to weekly NDT physiotherapy. Fussy and irritable infants are referred to occupational therapy for sensory integration assessment and infants with feeding difficulties or speech delay are referred to an NDT speech therapist.

5.2 Sampling method

Patient records from the High Risk Neurodevelopmental Clinic at Panorama Medi-Clinic Private Hospital, Cape Town were reviewed. All records were reviewed from the inception of the clinic in 1998 until the end of December 2006. Patients were only included in the study if they met the inclusion criteria.

5.2.1 Inclusion criteria

Included in the study were those infants with birth weights less than 1500g, born before 34 weeks gestation and who had had both the MAS used as a neurodevelopmental assessment at an early age, and the GMDS performed after 2 years of age. Only infants with accurately known gestational ages at birth, calculated

using mother's dates and antenatal ultrasounds during the first trimester, or dates of conception for mothers who were on assisted fertility programs were included.

5.2.2 Exclusion criteria

Infants whose gestational age could not be reliably determined and infants who had sustained brain insults e.g. meningitis, between the Molteno assessments and the Griffiths Assessment were excluded. Children assessed on the Revised GMDS (2004) or the Extended Revised version (2006) were excluded.

5.3 Assessments

All assessments were performed by a single examiner.

5.3.1 The Molteno Adapted Scale

The MAS (appendix 2) assesses the four basic areas of child development: Gross Motor, Fine Motor, Personal Social and Communication, listing items from 1 – 72 months. The MAS takes approximately 10 – 15 minutes to perform and requires minimal apparatus. In contrast to other developmental screening tools where a pass or fail result is obtained, the MAS enables the examiner to ascertain the developmental age equivalent of the child for each of four main areas. A quotient may then be calculated for each area using the developmental age equivalent expressed as a percentage of the chronological age.

The benefit of calculating quotients is that they may give an indication of the severity of disability. The use of quotients also allows the comparison of results in testing the same child at different ages; and in research the use of quotients enables the calculation of mean scores when comparing different groups.

5.3.2 The Griffiths Mental Development Scales

The Griffiths Mental Development Scales (GMDS) is widely accepted as a reliable tool[24] and has been validated in the South African context.[25-27] The GMDS takes at least an hour to administer and requires trained and registered personnel.

The GMDS assesses a child's development on 6 subscales: Locomotor, Personal-Social, Hearing & Speech, Eye & Hand Co-ordination, Performance and Practical Reasoning. For each subscale, raw scores are obtained and an age equivalent is calculated in months, from which a quotient may be calculated by comparing the developmental age equivalent with the child's chronological age. A General Griffiths Quotient is obtained by calculating the average of the quotients obtained on the subscales.

There are difficulties in accurately calculating the Practical reasoning subscale in the third year: if a child does not pass any items on the Practical Reasoning subscale, the scores are calculated as an average of the other 5 subscales, which is not a true reflection of performance on the Practical reasoning subscale. For these children, the General Griffiths Quotient was calculated as an average of the 5 subscales without

the Practical Reasoning contributing to the average. For the purpose of this study, the Practical Reasoning subscale was not included in the analysis.

5.4 Correcting Age for Shorter Gestation

Routine practice in the High Risk Neurodevelopmental Clinic at Panorama Medi-Clinic Private Hospital is to calculate prematurely born infant's corrected age using expected due date for delivery as zero time. The due date for delivery is determined from the date of conception or early neonatal ultrasound during the first trimester of pregnancy.

It is standard practice to correct prematurely born infants' ages until 2 years. Since the GMDS was performed after 24 months, results were calculated according to chronological age.

5.5 Data Collection

Data from patient records was recorded on the data record sheet (Appendix 1). This was transferred to a data base on and Excel spread sheet on a private computer requiring a password for entry.

Raw data (often recorded as an age equivalent on the patient records) for Gross Motor, Fine Motor, Personal Social and Communication from the MAS was converted

into quotients by dividing the developmental age equivalent obtained on the MAS by the corrected age of the patient. The General Quotient for the MAS was obtained by calculating the average of the four quotients. In the case where data was missing for one area on the MAS the general Quotient on the MAS was not calculated, but values for the other developmental area were included as they could still be used to correlate scores with the Griffiths subscales. GMDS results are expressed as Quotients and these were recorded on the data sheet.

Patients' records were reviewed as to whether the child was referred to, or had attended physiotherapy, occupational therapy or speech therapy.

5.6 Human Subjects protection

Ethics Approval was obtained from the Human Research Ethics Committee (Medical) of the University of the Witwatersrand, Johannesburg (appendix 3). As the assessments were part of routine medical care, patients or their parents have not been consented. It was not necessary to obtain consent from hospital authorities as only the private practice notes were reviewed. Since the study consists of reviewing records, there is no threat or danger to the patient.

5.7 Statistics

5.7.1 Sample size

This is a retrospective study, and the sample size was determined by the number of children who were assessed on the GMDS, before the revised GMDS came into use in the clinic. All infants who met the criteria were included.

5.7.2 Statistical analysis

Descriptive statistics were used to describe and compare the cohort at the different assessments. The number and percentage of qualitative variables, and the mean and standard deviation of quantitative data were calculated using the Statistical Package for the Social Sciences (SPSS) version 14. Comparison between the mean values of quantitative variables was calculated using the Student's t-test. Statistical significance was set at <0.05.

To determine the associations between the MAS scores at each assessment and the GMDS scores at 2 years for each participant, Spearman's rank correlation coefficients were calculated, using Statistica 9.[35] Correlation is significant at the 0.01 level.

The correlation between the developmental quotient and subquotients of the MAS performed at 4½ months, 9 months, 12 months, 18 months, and the general quotient and the sub-quotients of the GMDS at 2years was determined as follows:

a) The Developmental Quotient with the General Griffiths Quotient
b) The Gross Motor Quotient with the Locomotor subquotient
c) The Personal Social Quotient with the Personal Social subquotient
d) The Communication Quotient with the Hearing & Speech subquotient
e) The Fine Motor Quotient with the Performance subquotient
f) The Fine Motor Quotient with the Eye & Hand Coordination subquotient
g) The Fine Motor Quotient with the average of the combined Performance and Eye & Hand Coordination subquotients

6. RESULTS

6.1 Participants data

Fifty-two Infants (27 boys and 25 girls) met the criteria and were included in the study. Their demographic and clinical data are shown in table 1.

Table 1: Demographic and clinical data of infants on study	
Gender: male Female	27 (51.9%) 25
Mean birth weight ± SD in grams (range)	981.2 ± 225.5 (410 – 1460)
Mean gestational age ± SD in weeks (range)	27.7 ± 1.9 (24-32)
Race: Caucasian Mixed African	41 (78.8%) 10 (19.2%) 1 (2%)
Problems Identified: Spastic Diplegia Spastic Quadriplegia Left hemiplegia Autistic spectrum Disorder Visual Impairment Dysmorphic	 7 (1 minimal functional impairment) 4 2 (both minimal functional impairment) 1 2 1

6.2 Age at assessments

The age at assessments on the MAS varied and did not comply with the expected ages as recommended by the high risk follow up clinic. In addition, not all infants had all 3 early assessments. The assessments were therefore grouped into 3 ranges as set out in table 2, which were the most common ages for the children who had 3 assessments.

The age at which the GMDS was performed also varied widely. In order to include an adequate sample size, assessments performed between 25-37 months were included.

6.3 Assessments on the MAS

In some instances, the results of all four parameters were not recorded. The incomplete assessments were included in the analysis, as they were still useful to correlate with the Griffiths Subquotients, but General Scores were not calculated on these patients. The number of assessments performed using the MAS is described in table 2 below.

Table 2: Description of the three assessments performed on the MAS: Age range and number assessed at the three assessments

	First assessment	Second Assessment	Third Assessment
Mean corrected age at assessment ± SD in months (range)	5.1 ± 1.1 (3 – 7)	10.1 ± 1.3 (8 – 12.5)	16.8 ± 1.8 (13 – 20)
Number of infants assessed			
Total	39	40	38
Gross Motor	34	38	34
Fine Motor	37	40	37
Personal Social	37	40	37
Communication	39	40	38
General	31	38	33

Scores obtained on the Molteno Adapted Scale at the three assessments are summarised in Tables 3, 4 and 5.

Table 3 : Summary of scores obtained at the first assessment on the MAS at a Mean corrected age of 5.1 months (n = 39)						
	Number Assessed	mean	Median	Maximum	Minimum	SD
Gross Motor	34	93.6	91	171	43	29.3
Fine motor	37	95.6	100	150	44	27.0
Personal social	37	107.6	107	177	59	25.6
Communication	39	112.6	111	156	59	22.3
General Developmental Quotient	31	102.2	103	150	52	22.4

Table 4: Summary of scores obtained at the second assessment on the MAS at a mean corrected age of 10.1 months (n = 40)						
	Number Assessed	mean	Median	Maximum	Minimum	SD
Gross Motor	38	85.8	89	129	20	24.0
Fine motor	40	98.1	100	120	40	18.6
Personal social	40	107.9	109	141	40	24.1
Communication	40	99.9	100	129	50	19.5
General Developmental Quotient	38	97.3	104	120	38	19.4

Table 5: Summary of scores obtained at the third assessment on the MAS at a mean corrected age of 16.8 months (n=38)						
	Number Assessed	mean	Median	Maximum	Minimum	SD
Gross Motor	34	91.9	92	124	38	20.0
Fine motor	37	100.9	100	152	56	20.2
Personal social	37	97.3	98	131	25	18.0
Communication	38	97.0	100	129	44	17.1
General Developmental Quotient	33	97.2	103.5	119	44	10.0

6.4 Griffiths Assessments

The mean age at Griffiths assessment was 28.8 months with a standard deviation of 2.5 months and a range of 25.5 – 36.4 months.

Only 28 (53.8%) had scores calculated for the Practical Reasoning subscale. For these children, the General Griffiths Quotient was calculated as an average of the 5 subscales without the Practical Reasoning contributing to the average. For the purpose of this study, the Practical Reasoning subscale was not analysed further.

The scores obtained on the Griffiths Mental Development Scales for the study cohort are summarised in Table 6

Table 6: Scores obtained on the Griffiths Mental Development Scales for the study cohort (n=52)

Griffiths Scale	Mean Quotient	Median Quotient	Standard Deviation	Maximum Quotient	Minimum Quotient
Locomotor	91.9	96	24.3	132	15
Personal- Social	103.2	108	21.8	139	43
Language	97.9	98	24.0	141	42
Eye & Hand Coordination	95.6	100	16.2	126	47
Performance	98.0	94	22.1	163	56
General Quotient	96.2	97	18.5	127	40.6

6.5 Comparison between the MAS and the GMDS

6.5.1 Demographics

A comparison of the demographics of the infants at the different assessments is shown in Table 4.

Table 7: Demographics of infants included at different assessments				
Assessment	First MAS	Second MAS	Third MAS	GMDS
Number	39	40	38	52
Gender: Male Female	21(53.8%) 18	18 (45%) 22	19 (50%) 19	27 (51.9%) 25
Mean age at assessment ± SD in months (range)	5.1 ± 1.1* (3 – 7)	10.1 ± 1.3* (8 – 12.5)	16.8 ± 1.8* (13-20)	28.8 ± 2.5** (25.5-36.4)
Mean birth weight ± 1SD in grams (range)	952.3 ± 207.0 (410 – 1290)	964 ± 239.2 (410 – 1460)	959.2 ± 243.3 (410 – 1460)	981.2 ± 225.5 (410 – 1460)
Mean gestational age ± SD in weeks (range)	27.8 ± 1.9 (25 – 32)	27.4 ± 1.9 (24 – 32)	27.5 ± 25.3 (25 – 32)	27.7 ± 1.9 (24-32)

***Corrected age**

**** Chronologial age**

6.5.2 Time period between MAS and GMDS

The time between the MAS and the GMDS for each individual participant was calculated, and the mean and range for each group is shown in table 5.

Table 8: Mean time period between the MAS assessments and the GMDS in months (range)	
First Assessment	23.6 (19.1 – 32)
Second Assessment	19.2 (14 – 28.7)
Third Assessment	12.1 (5.5 – 18.4)

6.5.3 Correlation studies

Tables 6, 7 and 8 describe the correlation of scores on the MAS at early assessment with the GMDS at a mean age of 28.8 months.

Table 9: The relationship between the first MAS assessment at a mean corrected age of 5.1 months and the GMDS at a mean chronological age of 28.8 months for each individual patient

Scales		Spearman	
MAS	**GMDS**	**R**	**P**
Developmental Quotient	General Griffiths Quotient	0.15	0.42
Gross Motor Quotient	Locomotor subquotient	0.23	0.18
Personal Social Quotient	Personal Social subquotient	0.23	0.16
Communication quotient	Hearing & Speech sub quotient	0.10	0.54
Fine Motor Quotient	Eye & Hand Coordination subquotient	0.22	0.19
Fine Motor Quotient	Performance subquotient	0.43	<0.01
Fine Motor Quotient	Combined Performance and Eye& Hand Coordination	0.41	0.01

Table 10: The relationship between the second MAS assessment at a mean corrected age of 10.1 months and the GMDS at a mean chronological age of 28.8 months for each individual patient

Scales		Spearman	
MAS	**GMDS**	**R**	**P**
Developmental Quotient	General Griffiths Quotient	0.46	<0.01
Gross Motor Quotient	Locomotor subquotient	0.38	0.02
Personal Social Quotient	Personal Social subquotient	0.4	0.01
Communication quotient	Hearing & Speech subquotient	0.27	0.09
Fine Motor Quotient	Eye & Hand Coordination subquotient	0.29	0.07
Fine Motor Quotient	Performance subquotient	0.42	<0.01
Fine Motor Quotient	Combined Performance and Eye& Hand Coordination	0.33	0.03

Table 11: The relationship between the third MAS assessment at a mean corrected age of 16.8 months and the GMDS at a mean chronological age of 28.8 months for each individual patient			
Scales		Spearman	
MAS	**GMDS**	**R**	**p**
Developmental Quotient	General Griffiths Quotient	0.6	<0.01
Gross Motor Quotient	Locomotor subquotient	0.58	<0.01
Personal Social Quotient	Personal Social subquotient	0.32	0.06
Communication quotient	Hearing & Speech subquotient	0.52	<0.01
Fine Motor Quotient	Eye & Hand Coordination subquotient	0.63	<0.01
Fine Motor Quotient	Performance subquotient	0.63	<0.01
Fine Motor Quotient	Combined Performance and Eye& Hand Coordination	0.58	<0.01

6.6 Therapeutic intervention for problems

There were 13 children identified with the diagnosis of CP as described in table 1. Eleven of these children received regular physiotherapy. The time period and intensity of physiotherapy treatment were not documented in the notes. Two children had no intervention: one child with a mild left hemiplegia who did not attend physiotherapy, and another child with spastic diplegia who lived in a rural area and her family were not convinced that she had any problems.

One child who had problems with the quality of non-verbal communication, but did not meet the criteria for Autism, was identified early and referred to speech therapy.

In the two children with visual impairment, the severity was not sufficient to prevent reliable developmental assessments being performed. One child (also with spastic

quadriplegia) had a squint that was repaired after the GMDS and the other child (also spastic diplegia) had retinopathy of prematurity and she had cryotherapy before the first MAS assessment.

According to the records, a further 13 children were referred to physiotherapy but there is no record of their attendance.

7. DISCUSSION

The variation in age of assessments did not fit the assumption that patients would attend assessments at ages recommended on discharge from the NICU. This is a retrospective study with case record review and different to a prospective study with planned study visits. There was enough variation in the individual scores within the groups, and there was a sufficient number of assessments at each time point, to make the comparisons meaningful despite the fact that not all infants had all assessments. The Griffiths assessments were also performed at a mean age of 28.8 months, which does not fit with the hypothesis of the scores on the MAS predicting the GMDS scores at 2 years.

This study shows that early assessments on the MAS have a positive correlation with the GMDS at a mean age of 28.8 months. However, the correlations in earlier assessments are weak, but they strengthen as the time between the MAS and the GMDS shortens.

At the first assessment at a mean corrected age of 5.1 months (range 3-7) there is a weak correlation (range 0.10 -0.43), with only the Fine Motor Quotient on the MAS reaching significant correlations with the Performance and the Eye & Hand Coordination/Performance combined subquotients on the GMDS.

At the second assessment at mean corrected age of 10.1 months (range 8-12.5 months) correlation improves (ranging from 0.29 – 0.46) with the Developmental Quotient and the Personal Social Quotients reaching significance.

Correlation is the strongest in 3rd assessment (ranging from 0.32-0.63) where all, except the Personal Social, reach significance.

These results confirm the hypothesis that the MAS is a reliable predictor of neurodevelopmental outcome in VLBW infants, but not when done below 7 months of corrected age. This concurs with the literature about the limitations of using early tools for prediction of outcome in later childhood.[3,5,7]

A more suitable assessment tool should be chosen for the younger age group. It is interesting that the most significant correlation at a mean age of 5 months is the Fine Motor Quotient. In a situation where the Infant Neuromotor assessment is already found to be sensitive and used to assess Gross Motor outcomes,[13] it may be pertinent to add the Fine Motor component of the MAS.

It is important to note that this analysis is not an assessment to gauge the severity of disabilities. Further studies need to be conducted to compare the predictability of mild or severe problems using the MAS but it was not within the scope of this study.

8. LIMITATIONS

This study has several limitations:

First, as a retrospective study reviewing patient records, data is not as complete as one would have liked.

Second, the age range for the MAS assessments and the GMDS assessments are wide, but this could also be a strength as we know that the correlation spans the age range of young infants.

Third, interventions like physiotherapy, speech therapy and occupational therapy were poorly documented. There may have been patients who were identified with problems on early MAS assessments and referred for interventions, mostly physiotherapy. This may have affected the Griffiths score at 2 years by improving outcome, but at the same time there may be patients who required intervention who did not receive this and their scores may have deteriorated over time, due to their deficits preventing further developmental progress. Hopefully these two will balance each other out.

Fourth, these results are all calculated from assessments by a single examiner, who may have a slight bias or difference in a marking style, and the results may be rather specific to this particular examiner. These results may not necessarily transfer to a variety of examiners with differing skills, in particular persons using the MAS with little experience of developmental paediatrics. The advantage is that there was

consistency in this sample which could be viewed as a pilot study to assess the feasibility of further studies, as these assessments should have been performed with the same consistent standards. Since the MAS has shown some reliability in predicting developmental scores, this should allow for further studies using different examiners.

Fifth, the General Griffiths Quotients were also skewed upwards due to the examiner excluding the Practical Reasoning subscale and calculating the General Quotient without the Practical Reasoning Subquotient.

Sixth, we do not know how the MAS will correlate with the newly revised GMDS.[36] The GMDS has recently been updated, but there has been little research in South Africa using the revised scales. The revised version also does not allow for comparisons of quotients as results are expressed as z-scores and percentiles and will therefore not be appropriate for this study.

Seventh, while the correlations appear acceptable, especially in the older child, this analysis does not assess whether the MAS can identify all children correctly within a developmental category e.g. normal development or mild, moderate or severe delay. This assessment did not calculate the false positives and false negatives and the ability of the MAS to identify all children requiring intervention. This is out of the scope of this thesis and was not in the specific aims, but should be a subject of future research.

Eighth, other factors which also have an influence on the neurodevelopment of the young child were not measured in this study, in particular the stability of the family, parental education, socioeconomic factors, and the cultural environment in which the child is reared.[37]

9. CONCLUSION

In this select group of VLBW infants, the MAS shows a weak correlation at a mean age of 5.1 months, a moderate correlation at a mean age of 10.1 months, a moderately strong correlation at a mean age of 16.8 months with the GMDS at a mean age of 28.8 months. These results are encouraging, and there is sufficient evidence to suggest further studies for the use of the MAS for multiple users and in different high risk groups.

10. REFERENCES

1. Ment LR, Vohr B, Allan W, et al: *Change in Cognitive Function Over Time in Very Low-Birth-Weight Infants.* JAMA 2003;289(6): 705-711

2. Colvin M, McGuire W, Fowlie PW: *Neurodevelopmental outcomes after preterm birth.* BMJ 2004;329:1390-1393

3. Latal B*: Prediction of Neurodevelopmental Outcome After Preterm Birth.* Pediatr Neurol 2009; 40: 413 -419

4. Kohlhauser C, Fuiko R, Panagl A, Zadra C, Haschke N, Brandstetter S, Weninger M, Pollak A: *Outcome of Very-Low-Birth-Weight Infants at 1 and 2 Years of Age. The importance of Early Identification of Neurodevelopmental Deficits.* Clin Pediatr. 2000; 39:441-449.

5. Vohr BR: *Progress in predicting outcomes for extremely low birth weight infants: baby steps.* Acta Paediatrica 2007: 96; 331-332.

6. Marks K, Glascoe FP, Aylward GP, Shevell MI, Lipkin PH, Squires JK: *The Thorny Nature of Predictive Validity Studies on Screening Tests for Developmental-Behavioral Problems.* Pediatrics 2008; 122 (4): 866 – 868.

7. Rose SA, Feldman JF, Jankowski JJ: *The Building Blocks of Cognition.* J Pediatr 2003;143: S54-S61.

8. Glascoe FP, Martin ED, Humphrey S: *A Comparative Review of Developmental Screening tests.* Pediatrics 1990; 86(4): 547 – 553.

9. Bayley N: *Bayley Scales of Infant and Toddler Development*, Third Edition (2005), Psych Corp, Pearson.

10. Griffiths R: *The abilities of Young Children,* Child Development Research Centre , London (1970)

11. Bowen JR, Gibson FL, Leslie GI, Arnold JD, Ma PJ, Starte DR: *Predictive value of the Griffiths assessment in extremely low birthweight infants.* J Paediatr Child Health 1996; 32 (1): 25-30.

12. Frankenburk WK, Dodds J, Archer P, Bresnick B, Maschaka P Edelman N , Shapiro H: *Denver II screening manual.* Denver Developmental Materials Incorporated (1990)

13. Magasiner VA, Molteno CD, Lachman P, Thompson C, Buccimazza SS, Burger E: *A Neuromotor Screening test of High-Risk Infants in a Hospital or Community Setting,* Pediatric Physical Therapy 1997: 9 (4) 166 - 172

14. Capute AJ, Pasquale AJ: *The infant neurodevelopmental assessment: a clinical Interpretive manual for CAT-CLAMS in the first 2 years of Life; Part 2.* Current Problems in Paediatrics 1996; 26(8): 265-306.

15. Haataja L, Mc Gready R, Arunjerdja R, Simpson JA, Mercuri E, Nosten F, Dubowitz L. *A new approach for neurological evaluation of infants in resource-poor settings.* Annuals of Tropical Paediatrics 2002: 22, 335 -368.

16. Voss W, Neubauer A, Wachtendorf M, Verhey JF, Kattner E: *Neurodevelopmental outcome in extremely low birth weight infants: what is the minimum age for reliable developmental prognosis?* Acta Paediatrica 2007; 96: 342-347.

17. Jobe AH: *Predictors of outcomes in preterm infants: Which ones and when?* J Pediatr 2001; 138: 153-6.

18. Elliman AM, Bryan EM, Elliman AD, Palmer P, Dubowitz L: *Denver developmental screening test and preterm infants.* Arch Dis Child 1985; 60: 20-24.

19. Paro-Panjan D, Neubauer D, Kodric J, Bratanic B: *Amiel-Tison Neurological Assessment at term age: clinical application, correlation with other methods, and outcome at 12-15 months.* Dev Med Child Neurol 2005; 47:19-26

20. Grimmer I, Metze BC, Walch E, Scholz T, Brűhrer C: *Predicting neurodevelopmental impairment in preterm infants by standardized neurological assessments at 6 and 12 months corrected age.* Acta Paediatr 2010; 99: 526 – 530.

21. Sonntag J, Grimmer I, Scholz T, Metze B, Wit J, Obladen M: *Growth and neurodevelpmental outcome of very low brithweight infants with necrotizing enterocolitis.* Acta Paediatr 2000; 89: 528 – 532

22. Den Ouden L, Rijken M, Brand R, Verloove-Vanhorick SP, Ruys JH: *Is it correct to correct? Developmental milestones in 555 "normal" preterm infants compared with term infants.* J Pediatr 1991; 118: 399 – 404

23. Miller G, Dubowitz LMS, Palmer P: *Follow-up of preterm infants: is correction of the developmental quotient for prematurity helpful?* Early Human Development 1984; 9: 137 – 144.

24. Griffiths R: *The Abilities of Young children.* (1984). ARICD, Amersham.

25. Luiz DM, Foxcroft CD and Stewart R: *The construct validity of the Griffiths Scales of Mental Development.* Child: Care health and development 2001; 21 (1): 73 – 83

26. Mothuloe VB, Richter LM, Barnes CJ, Schoeman M. *Griffiths Scales of Mental Development: A South African validation study.* S Afr J Educ 1994: 14 (1) 38-43

27. Allan MM, Luiz DM, Foxcroft CD. *A Comparison of the performance of normal preschool South African and British children on the Griffiths Scales of Mental Development.* University of Port Elizabeth, Research papers presented, Unpublished.

28. Luiz DM: *Children of South Africa: In search of a developmental profile.* Inaugural and Emeritus Addresses D34, 1994. University of Port Elizabeth

29. **Pregnancy, Efavirenz, and Birth Outcomes in Johannesburg**
Daniel Westreich*[1], D Rubel[2], P MacDonald[2], P Majuba[2], M Maskew[2], S Nagar[2], I Jaffray[2], P MacPhail[2], S Cole[1], and I Sanne[2] CROI Paper 922

30. Human Sciences Research Council: African early child development measures resource: *http://www.hsrc.ac.za/EDC-Measure-143.phtml*

31. Oelofse A, Van Raaij JM, Benadé AJ, Dhansay MA, Tolboom JJ, Hautvast JG:*Disadvantaged black and coloured infants in two urban communities in the Western Cape, South Africa differ in micronutrient status*. Public Health Nutr. 2002;5 (2) :289-94.

32. Sheridan MD: *From Birth to Five Years, Children's Developmental Progress* NFER-Nelson Publishing Co. 3rd edition 1975

33. Griffiths R: *The abilities of Babies*, London University Press (1954)

34. Vermont Oxford Network website: www.vtoxford.org

35. StatSoft, Inc. (2009). STATISTICA (data analysis software system), version 9.0. www.statsoft.com.

36. Luiz D, Faragher B, Barnard A, Knoesen N, Kotras N, Burns L E, Challis D: *Griffiths Mental Developmental Scales – Extended Revised, 2 - 8 years Analysis manual*, ARICD Hogrefe Test Agency (2006)

37. Gross SJ, Mettelman BB, Dye TD, Slagle TA: *Impact of family structure and stability on academic outcome in preterm children at 10 years of age.* J Pediatr 2001;138: 169-75

Appendix 1: Data record Sheet.

Study number: Category:

Patients Name: M / F
Birth weight:

Date of Birth: Gestation:
EDD:

Griffiths: Date:

Age at testing in Months;	
General Quotient	
Locomotor	
Personal Social	
Speech and Hearing	
Eye & hand coordination:	
Performance:	
Eye & Hand and Performance combined:	
Practical Reasoning:	

Molteno Assessment:

Age in months	Gross Motor	Fine Motor	Personal social	Communication	General Quotient

Other notes or problems:

Intervention:

Appendix 2: The Molteno Adapted Scale: GROSS MOTOR

Mths			
1		1	Lifts head when prone
2		2	Supported sitting - head vertical
3	{	3	Supine – symmetrical
		4	Prone elbow support
4		5	Pull to sit - no head lag
5		6	Rolls from prone to supine
6	{	7	Rolls from supine to prone
		8	Prone - extended arm support
7		9	Sits alone = 1 minute
8	{	10	Prone - pivots in circle using arms
		11	Sits alone = 1 minute
9	{	12	Pulls to stand
		13	Crawls
10		14	Sitting - can recover toy behind him
		15	Creeps - like a bear
11	{	16	Cruizes around furniture
		17	Stands at furniture - lifts one foot at a time
12	{	18	Walks with one hand held
		19	Walks alone - 10 steps (high guard)
15	{	20	Walks - reciprocal arm movements
		21	Walks backwards
18	{	22	Throws a ball
		23	Kicks a ball
21		24	Climbs on and off adults sized chair without help
24	{	25	Jumps off step - two feet together
		26	Stands on one (either) leg – briefly
30		27	Pedals tricycle
36		28	Up stairs one foot per step, down two feet per step
42		29	Hops on one (either) foot 3 - 5 times
48		30	Stands on one leg - 10 secs.
54	{	31	Hops on one leg - 20 times
		32	Catches ball 2/3
60		33	Hops on each foot - 20 times
66		34	Walks along straight line (10 paces)
72	{	35	Sits up without help of hands
		36	Walks backwards along straight line (10)

Appendix 2 cont: The Molteno Adapted Scale: PERSONAL-SOCIAL

Mths			
1	**{**	1	Watches mother when feeding
		2	Sucks well
2	**{**	3	Smiles at mother
		4	Enjoys bath
3	**{**	5	Excited when sees bottle
		6	Obvious pleasure at being handled
4	**{**	7	Tries to hold bottle
		8	Friendly towards strangers
5		9	Holds bottle
6	**{**	10	Chews solids
		11	Smiles, pats mirror image
7		12	Drinks from a cup
8		13	Plays peek-a-boo (Waar's hy)
9	**{**	14	Holds and eats biscuit
		15	Stranger anxiety
		16	Pulls off hat
10	**{**	17	Pushes arm into sleeve
		18	Deliberate casting
11		19	Finger feeds
12		20	Holds spoon
		21	Uses spoon - spills most
15	**{**	22	Pulls off socks
		23	Domestic mimicry
		24	Uses spoon - spills very little
18	**{**	25	Pulls up pants
		26	Indicates wet/dry nappy
21	**{**	27	Handles cup very well
		28	Sits on parent's knee and looks at books
24	**{**	29	Clean and dry by day
		30	Jealous of other children
30	**{**	31	Parallel play
		32	Washes and dries hands
36	**{**	33	Dresses - needs help with buttons
		34	Dry at night
42		35	Manages buttons
		36	Dresses with supervision
48	**{**	37	Likes to dress up
		38	Play - group of 2 – 3
60		39	Play - group of 4 – 5
72		40	Co-operative play - leadership and division of labour

Appendix 2 cont: The Molteno Adapted Scale: FINE MOTOR

Mths			
		1	Follows to midline
2	**{**	2	Hand to mouth as a voluntary act
		3	Follows past midline
3	**{**	4	Fingers one hand with other when lying quietly
		5	Follows through 180°
4		6	Four - part sequence - reach, grasp, retrieve mouth
5	**{**	7	Crumples paper
		8	Grasps ring
6	**{**	9	Grasps ring, mouth and transfer
		10	Shakes waves and bangs object
7		11	Retains only one cube in hand at a time
8	**{**	12	Grasps ring by the string
		13	Retains one cube in each hand
9	**{**	14	Mouthing exploratory (not obligatory)
		15	Removes pegman from car
10	**{**	16	Clicks two cubes together
		17	Throws objects
11	**{**	18	Thumb (index finger) opposition
		19	Holds care and “explores” with index finger
		20	Replaces pegman
12	**{**	21	Simple formboard - replaces large circle
		22	Retains three cubes
		23	Retains four cubes
15	**{**	24	Simple formboard - replaces both circle
		25	Two cube tower
18	**{**	26	Three - four cube tower
		27	Completes simple formboard with reversal (trial and error)
21	**{**	28	Three pieces formboard - two shapes in
		29	Simple formboard with reversal
24	**{**	30	Three pieces formboard - replaces three shapes
		31	Six cubes tower and train
30	**{**	32	Three piece formboard with reversal (trial and error)
		33	Train with chimney
		34	Three piece formboard - with reversal (no trial and error)
36	**{**	35	Copies O
		36	Nine cube tower and bridge
42	**{**	37	Coloured formboard five out of five
		38	Copies +
48	**{**	39	Coloured formboard five out of five
		40	Gate
54		41	Copies □
60	**{**	42	Steps (six cubes)
		43	Copies Δ
66		44	Copies ◊
72	**{**	45	Steps (ten cubes)
		46	Copies

Appendix 2 cont: The Molteno Adapted Scale: COMMUNICATION

Mths			
		1	Startles to sounds
1	**{**	2	Throaty sounds
		3	Cries when hungry
2		4	Vowel sounds
3		5	Coos, chuckles, squeals
		6	Initiates vocalisation
4	**{**	7	Giggles and laughs
5		8	Combines sounds eg. ah-goo
		9	Object permanence - looks after dropped object
6	**{**	10	Makes “m” sound
		11	Response when called
7	**{**	12	Shouts for attention
8		13	Combines syllables, eg. ba-ba, ma-ma
		14	Waves bye-bye
9	**{**	15	Babbles tunefully
		16	Says mama, dada
		17	Object permanence find cube under cover
10	**{**	18	Shakes head for no
		19	One word with meaning
		20	Two - three words with meaning
11	**{**	21	Imitates one or two words
		22	Where is daddy - looks at father
12	**{**	23	Reacts with expression
		24	Definition by use
15	**{**	25	Uses five words
		26	Points to one picture
18	**{**	27	Points to one body part
		28	Two word utterance
		29	Points to three body parts
21	**{**	30	Names six familiar objects
		31	Points to five body parts
24	**{**	32	Uses pronounce - I, you, me
		33	Combines three words
30		34	Names eight picture cards
		35	Names 10 picture cards
36	**{**	36	Digit repetition (3)
42		37	Names 12 picture cards
		38	Knows name age and sex
48	**{**	39	Sentence repetition
54		40	Comprehends cold, tired, hungry
		41	Opposites lady, bit, hot
60	**{**	42	Knows address, birthday
66		43	Word definition (5)

APPENDIX 3: Ethics approval certificate

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Division of the Deputy Registrar (Research)

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)
R14/49 Laughton

CLEARANCE CERTIFICATE	**PROTOCOL NUMBER M060439**
PROJECT	TheReliability of the Molteno Adapted Developmental Scale in Predicting Developmental Outcomes at 2 Years,.....
INVESTIGATORS	Dr B Laughton
DEPARTMENT	Department of Paediatrics
DATE CONSIDERED	06.05.05
DECISION OF THE COMMITTEE*	Approved unconditionally

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

DATE 06.05.08 **CHAIRPERSON** .....
pp (Professor PE Cleaton-Jones)

*Guidelines for written 'informed consent' attached where applicable

cc: Supervisor : Prof LB Jacklin

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