Performance of Extremely Low Birthweight Children at 5 Years of Age on the Miller Assessment for Preschoolers

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ABSTRACT. The purpose of this geographically defined national study was to evaluate the performance of extremely low birthweight children (ELBW < 1000g) born in Iceland in 1991-1995 and compare them to a cohort of matched control children born full term. The Miller Assessment for Preschoolers (MAP) was used to provide an overall profile of 32 ELBW children and 55 control children at 5 years of age. The results indicated that score patterns on the MAP between ELBW and normal birthweight children differ. The differences were significant on the Total Score, and the Foundations, Coordination, and Complex-Tasks Indices. This study found that the ELBW group had specific problems in basic motor tasks, coordination, and fine motor skills. The results validate the need for early assessment, regular follow-up, and consultation to promote optimal task performance and social participation of children born prematurely. *[Article copies available for a fee from The Haworth Document Delivery Service: 1-800-HAWORTH. E-mail address: <docdelivery@haworthpress.com> Website: <http://www.HaworthPress.com> © 2005 by The Haworth Press, Inc. All rights reserved.]*

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Advances in perinatal care over the past two decades have led to an increase in the number of very low (VLBW < 1500 g) and extremely low (ELBW < 1000 g) birthweight infants (Georgsdottir & Dagbjartsson, 2003; Sutton & Bajuk, 1999; Finnstrom et al., 1997; Doyle, 2001). Decrease in cases of severe central nervous system damage in neonates has been reported, but mild to moderate impairment is more frequent. Although subtle, these impairments can still prevent a child from achieving his or her full potential, and can be an indication of later learning and behavioral difficulties. The majority of studies have found that despite the fact that most ELBW and VLBW children possess average intelligence, a significant number exhibit learning and behavioral difficulties at school (O'Callaghan et al., 1994; Hall, McLeod, Counsell, Thomson & Mutch, 1995; Aylward, 2002; Saigal, den Ouden et al., 2003). Recent studies of ELBW children have found deficits in all motor functions, and perceptual and visual-motor skills (Goyen & Lui, 2002; Goyen, Lui & Woods, 1998; Whitfield, Eckstein-Grunau & Holsti, 1997). Moreover, these problems exist in children whose cognitive outcomes are in the average range. According to Aylward (2002), most studies to date indicate that the lower the birthweight, the greater the likelihood of these problems. However, Foulder-Hughes and Cooke (2003) could not find evidence to suggest that younger gestational age or lighter babies were at an increased risk of Developmental Coordination Disorder (DCD). DCD is characterized by impairments in motor performance expressed in movement and spatial-temporal organization problems, which cannot be explained by the child's age or intellect, or by other diagnosable neurological or psychiatric disorders (Polatajko, Fox & Missiuna, 1995; American Psychiatric Association, 1994). Foulder-Hughes and Cooke investigated motor outcome in 280 preterm children born at or below 32 weeks of gestation and 210 controls, at 7 and 8 years of age, with the Movement Assessment Battery for Children (M-ABC) (Henderson & Sugden, 1992), and the Developmental Test of Visual Motor Integration (VMI) (Beery, 1997). Using the 5th percentile on the M-ABC as an indicator, 30.7% of the preterm group was found to be impaired compared to 6.7% of the controls. The preterm group also scored considerably poorer than the full-term children on the VMI.

Dewey, Crawford, Creighton and Sauve (1999) found motor and visual motor function deficits at school age in VLBW children who ap-

peared to be developing normally at age 3. Roberts, Marlow and Cooke (1989) assessed a cohort of very low birthweight children at 6 and 8 years of age. Their second study (Marlow, Roberts & Cooke, 1993) suggested that the VLBW children's clumsiness would improve, as the children got older. When Powls, Botting, Cooke, and Marlow (1995) traced the original cohort and assessed the children at 12-13 years of age with the M-ABC, they found that the poor motor skills in the VLBW children persisted as the children grew older, and altogether 51% of the group had borderline scores. The most significant differences between the cohort and classroom-matched controls were seen in the tests of manual dexterity. Goyen et al. (1998) found a significant correlation between fine motor scores on the Peabody Developmental Fine Motor Scale (Folio & Fewell, 1983) and visual motor skills in a group of VLBW children. The authors suggested that these visual motor deficits might be more influenced by fine motor performance than by visual motor skills. This is in accordance with the findings of Luoma, Herrgård, and Martikainen (1998) who assessed 46 children born at or below 32 weeks gestation and matched full-term controls. Their analysis revealed that the preterm children had problems in voluntary control of their hand movements, which was associated with impaired precision of kinesthetic and tactile perception of the upper limbs, together with the inability to move fluently from one task to another.

Most studies suggest that ELBW children often perform poorly on motor tasks, many of which are part of their everyday life. Restrictions in ability to engage in typical childhood activities can easily interfere with socio-emotional development, school performance, activity preferences, and overall well-being. Neuromotor deficits can cause children to be more cautious in peer interactions, thus influencing their social participation (Chen & Cohn, 2003; Saigal, Pinelli, Hoult, Kim & Boyle, 2003; Saigal, Lambert, Russ & Hoult, 2002). According to Aylward (2002), many ELBW children display a tendency to withdraw from challenging tasks, thus not fully using their own potential.

Palta, Sadek-Badawi, Evans, Weinsten, and McGuinnes (2000) used the Pediatric Evaluation of Disability Inventory (Haley, Coster, Ludlow, Haltiwanger & Andrellos, 1992) to examine self-care, mobility function and social-communicative skills in a VLBW group of 425 children at age 5. Although most of the children functioned within the normal range in everyday tasks, the authors found functional limitations within all domains among children without cerebral palsy. Msall and Tremont (2002) described functional outcomes in various age groups after prematurity. They criticized the exclusive use of discriminative in-

struments to compare a child's performance with normative samples, and claimed that in order to understand the impact of neurological or developmental impairments, functional assessment is required. These authors stressed the importance of enhancing functional outcomes, optimizing community participation, and providing quality family support.

The present study was prospective and case controlled with focus on the overall development of perceptual, sensory, and motor skills of ELBW children at 5 years 3 months to 5 years 7 months of age. It was a part of a geographically defined national study on survival, health, development, and long-term outcome of ELBW children in Iceland. Other results on health and development in the Icelandic ELBW children have been reported (Georgsdottir & Dagbjartsson, 2003; Georgsdottir et al., 2003, Georgsdottir et al., in press). In accordance with other studies and our clinical experience, we hypothesized that the Icelandic ELBW children would demonstrate significant sensory and motor deficits that might affect their performance in daily occupations in comparison with normal birthweight, typically developing children.

METHOD

Participants

The sample in the study consisted of 35 ELBW children, aged 5.3-5.7 years (mean age 5.4 years), weighing 500-999g, and born in 1991-1995. This is the total population of ELBW children born in Iceland during the period. The ELBW children were matched with controls in regard to date of birth and gender, according to information provided by the National Birth Registry and Statistics Iceland. Each ELBW child was matched with one or two control children. The control group consisted of 55 children, 12 boys and 43 girls. The criteria for their selection was gestational age of $\geq$ 37 weeks; birthweight of $\geq$ 2500 grams; Apgar score of $\geq$ 7 within one and five minutes, and no known developmental impairments when enrolled in the study. Three ELBW children from the original population of 35, who had major neurological or physical impairments, were excluded from the study. Hence, the ELBW group consisted of 32 children, six boys and 26 girls.

Instrument

The Miller Assessment for Preschoolers (MAP) (Miller, 1988; 1982) was selected to provide an overall profile of the children's strengths and

limitations with emphasis on abilities involving basic motor tasks, sensation, perception and problem solving. The MAP is a standardized instrument that identifies children between the ages of 2 years 9 months to 5 years 8 months, who may be at risk for mild to moderate pre-academic problems. It is designed to provide a comprehensive overview of a child's developmental status, and to indicate specific areas of development in need of remediation (Miller, 1988, 1982). The 27 subtests of the MAP are divided into five subgroups or Performance Indices: *Foundations* (basic sensory and motor abilities), *Coordination* (oral motor, fine motor and gross motor performance), *Verbal* (cognitive aspects of language), *Non-Verbal* (non-spoken items, visualization and mental manipulations), and *Complex Tasks* (integration of sensorimotor and cognitive abilities). The norms for the MAP Total Score and Performance Indices Scores are expressed by percentiles on a three-level nominal scale. A color-coded system is used to indicate whether a child is at risk for developmental deficits. A Total Score in the red range (< 5% of the normative sample) indicates likelihood for the child to be at risk of a developmental problem. The yellow range (6-25% of the normative sample) indicates a risk of delayed development, while the green range (26-99% of the normative sample) indicates average performance or above. The instrument has a large number of items that discriminate between mild and severe delays, but do not distinguish between high-scoring examinees (Miller, 1988).

The MAP has been subjected to numerous critical reviews by experts in the areas of psychometrics and child development. It has strong internal reliability (r = .79-.82) and interrater reliability (r = .98) (Daniels & Bressler, 1990; Miller, 1988). Recent studies support the notion that the MAP is a valid tool to identify developmental delays in children with moderate to severe developmental problems (Daniels, 1998; Parush, Winokur, Goldstand & Miller, 2002; Parush, Yochman, Jessel, Shapiro, & Mazor-Karsenty, 2002). According to Daniels (1998), the Total Score and the Complex Tasks Index distinguish best among children with various developmental disabilities but the Verbal and Non-Verbal Indices are the least accurate discriminators.

The MAP has been in use in Iceland for several years. A cross-cultural comparison of the performance of Icelandic children to the norms of U.S. children on the MAP revealed less range on several of the subtest scores for the Icelandic sample than was obtained within the U.S. standardization sample (Egilson, 1994). Furthermore, significant differences were obtained on the Foundations Index for age group VI, favoring the performance of the Icelandic children. Parts of the instru-

ment were translated into Icelandic prior to the study, and the subtests in the Verbal Index were adjusted with a consultation from a speech pathologist, and a back-translation performed.

Procedure

The instrument was individually administered according to standard procedures. Results were recorded on the score sheets, and qualitative and behavioral observations were also noted. All the children were tested at the same time in the morning, within the same setting, and following the same order. Testing time per child was approximately one hour. All the children in the study fell into age group VI on the MAP.

Data Analysis

The data was entered into a database using the SPSS, Version 11.0 for Windows. Descriptive data was computed. An analysis of the differences between the two samples on the MAP Total Score and the five Performance Indices was performed using the Mann Whitney *U* Procedure. Measures of clinical significance were calculated using Cohen's d which compares the mean rank scores of the two groups (Kraemer, Morgan, Leech, Gliner, Vaske & Harmon, 2003; Cohen, 1988). To analyze the differences on each of the 27 subtests, the percentile scores of the ELBW children were compared with the scores of the control group using a Chi-Square Test.

RESULTS

Table 1 presents the frequency of definite scores categorized for the two groups according to the instrument's color coding system. Within the no problem range (Green), the scores of the ELBW children were all in the lower percentiles, only reaching as high as the 47th percentile for one child, while the control children had a varied range to up to 92nd percentile (Table 2).

Figure 1 shows differences in performance between the two groups on the Total and Indices Scores. Since MAP scores are presented as percentiles, medians are the appropriate measure of central tendency. The median percentile Total Score for the ELBW group was 9 but 47 for the control group. The median scores differed on all of the Indices Scores except for the Non-Verbal Index.

TABLE 1. Frequency of Total Scores on the MAP

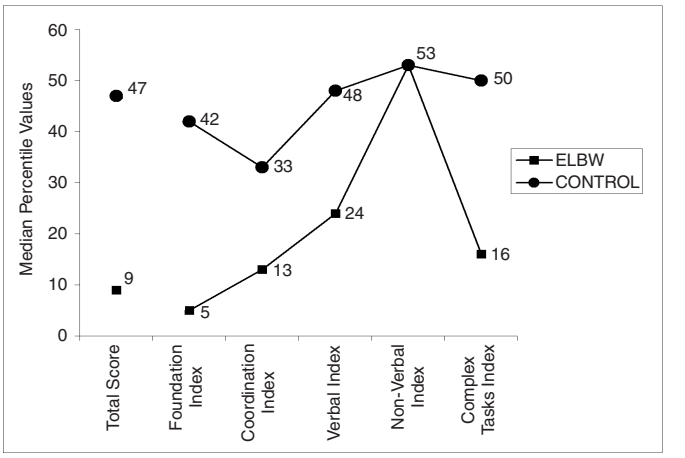
Color range	ELBW (n = 32)	Control (n = 55)
Green > 26. percentile	7 (22%)	44 (82%)
Yellow 6. - 25. percentile	12 (38%)	8 (14%)
Red < 5. percentile	13 (40%)	2 (4%)

TABLE 2. Central Tendency for the MAP Total Score and Indices Scores

	ELBW (n = 32)				Control (n = 55)						
	Mean	Median	SD	Range	Mean	Median	SD	Range	*U*	p - value	d
Total Score	14	9	13.78	1-47	45	47	22.1	1-92	219.000	*p < .001*	1.7
Foundations Index	12	5	15.23	1-63	39	42	22.04	3-99	247.500	*p < .001*	1.4
Coordination Index	20	13	22.95	1-99	40	33	27.12	1-99	437.000	*p < .001*	0.8
Verbal Index	46	24	33.71	7-99	65	48	33.9	7-99	604.000	*p < .05*	0.6
Non-Verbal Index	52	53	33.89	7-99	67	53	29.4	7-99	644.000	*p < .05*	0.5
Complex Tasks Index	21	16	18.81	1-50	59	50	33.52	1-99	305.500	*p < .001*	1.5

Note. Descriptive information is presented in percentile scores.

FIGURE 1. Total Score and Profiles of Indices Scores



Means, distribution and significance tests are displayed in Table 2. Analysis of the differences between the two groups revealed significant differences at $p < .001$ between the groups on the Total Score, the Foundations, Coordination and Complex Tasks Indices. Differences at $p < .05$ were found on the Non-Verbal and Verbal Indices. The *d*-values, much larger than typical support the clinical significance of the findings (Cohen, 1988). The range was less and the maximum percentile score lower for the ELBW group on the Total Score and three of the Indices: the Foundations, Coordination and Complex Tasks Indices, than for the control group.

The Chi-Square analysis of the difference for each of the 27 subtests revealed statistically significant differences between the two groups on *Block Designs (.000)*, *Draw a Person (.001)*, *Vertical Writing (.007)* and *Maze (.018)*. Significant differences were also obtained on *Block Tapping (.013)*, *Finger Localizations (.002)*, *Motor Accuracy (.003)*, *Romberg (.001)*, *Stepping (.013)*, *Walks Line (.000)*, *Kneel Stand (.006)*, *Rapid Alternating Movements (.006)*, and *Digit Repetition (.031)*. However, since the expected frequencies were not balanced across categories for these subtests due to the narrow range of scores of the ELBW children, the assumptions for the Chi-Square test were violated. Modest or no differences were obtained between the two groups on *Tower, Stereognosis*, *Sequencing*, *Object Memory*, *Figure Ground*, *Hand to Nose*, *Tongue Movements*, *Sentence Repetition*, *Articulation*, and *General Information*.

In sum, the results of this study indicate that score patterns on the MAP between ELBW and normal birthweight children differ. The differences are significant on the Total Score, and the Foundations, Coordination and Complex-Tasks Indices.

DISCUSSION

Despite individual differences among the ELBW group, a fairly homogeneous profile emerged on the MAP in comparison to the control group. In addition to the difference in the Total Score, significant differences were found on the Foundations, Coordination, and the Complex Tasks Indices, clinically strengthened by *d*-values much larger than typical. Significant differences at $p < 0.05$ were obtained on the Verbal and Non-Verbal Indices. Some subtests in these two Indices appeared to be too easy for the Icelandic children in this study, which is in accordance with the findings of Egilson (1994). It should be noted that although sig-

nificant differences at $p < 0.05$ were obtained between the two groups on the Non-Verbal Index, the median scores were the same, reflecting the skewed distribution of the sample scores. Subtest analysis further revealed that the ELBW children achieved their lowest scores on items that call for visual-motor precision, kinesthesia, and praxis. This was especially evident where processing, planning, and execution of actions were required. However, there were modest or no differences between the two groups on items that involve simple visual and perceptual skills. This is in line with the findings of Goyen (1998) and Luoma et al. (1998) who suggested that the visual-motor deficits found in VLBW children may be highly influenced by fine motor performance. Although the Icelandic ELBW group had problems with a few subtests that do not require multiple skills to accomplish, such as Digit Repetition and Block Tapping, it appeared to be mainly due to their lack of attention, organization, and concentration.

Daniels (1998) implied that the cut-off scores for the problem categories suggested by the author of the MAP may be too stringent. Use of the possible problem category (yellow) may result in overidentification of developmental problems since the range is from the 6th-25th percentile. On the other hand, the definite problem score (red < 5th percentile) is rather narrow and can result in children with later problems being identified as not at risk. It may be appropriate to use the 16th percentile as the cutpoint because it represents one standard deviation below the mean. Since the 16th percentile is not an attainable score on the MAP, use of the 14th percentile is recommended, as suggested by Fulks (1995) and Daniels (1998). Seventy-two percent of the ELBW children's Total Scores in this study were at or lower than the 14th percentile cutpoint, or one standard deviation below the mean, while only 11% of the control children scored at that range.

The ELBW children in this study were far more likely to experience sensory and motor difficulties at age 5.4 than their controls who were born full-term. This is in accordance with the findings described in the literature (Goyen, 1998; Luoma et al., 1998; Aylward, 2002; Foulder-Hughes & Cooke, 2003). Several of the Icelandic ELBW children presented with overall low muscle tone, resulting in difficulties maintaining a good sitting position during the evaluation. Poor quality of performance of basic motor skills and coordination was common, as well as diminished awareness of sensation, especially proprioception. A dyspraxic element was not uncommon, most noticeable on the subtests in the Complex Tasks Index. The profile present in a number of the ELBW children appeared to be similar to the characteristic features outlined in

many studies of children with DCD (Missiuna & Polatajko, 1995; Willoughby & Polatajko, 1995; Holsti et al., 2002). The deficits incorporate movement, spatial-temporal organization problems, and lack of kinesthetic awareness.

As stated earlier, three ELBW children who had major neurological impairments were excluded from the study. However, mild neurological abnormalities with increased tonus and reflex activity on one side of the body were found in several children. No formal measure of attention was performed, but the ELBW group appeared to be more distractible, and to have shorter attention span during the evaluation & than the control group.

IMPLICATIONS

It is accepted that impairment in one area may affect other areas of child development. As a result, the deficits found in the ELBW children in this study can affect their overall development and well-being. These impairments may have implications for the children's participation in and choice of daily occupations, in play, self-care, or academic activities (Saigal & den Ouden et al., 2003; Msall & Tremont, 2002). In the classroom and on the playground the children will be compared with their peers. Failure and feelings of inferiority may lead to low self-confidence and self-esteem that can trigger a vicious circle (Aylward, 2002; Saigal et al., 2002). Some studies indicate that the problems of ELBW children may be underestimated by caregivers and professionals, and the children felt to be little miracles having survived extreme danger. The literature indicates that preterm children may exhibit functional problems as they grow older in terms of their daily occupations and social participation (Msall & Tremont, 2002). The environment may play a crucial role in how the children succeed. The International Classification of Function, Disability and Health (WHO, 2001) can be a useful framework to understand how environmental factors interact with developmental and health conditions in ELBW children, and whether various factors act as a facilitator or a barrier to their participation. It is therefore of great importance to include evaluation tools that emphasize participation, activity performance and contextual elements in assessment of children born prematurely.

Our results show that the ELBW group differs significantly from the normal birthweight peer cohort. The results validate the need for early assessment and regular follow-up. Effective intervention strategies should

be developed with emphasis on consultation with parents and teachers to help the children succeed with their daily occupations at home, in school and in the community. A follow-up at age 10-12 is recommended with a broader focus on adaptive skills as they are used in the community, for scholastic achievement and social participation. It is of utmost importance to focus on the children's strengths as well as challenges. Thus, developmental and educational interventions should optimize learning, community participation, and family understanding. Furthermore, the findings of this study support the notion that the MAP is a useful tool to identify sensory and motor developmental deficits in ELBW children at preschool age.

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