Outcome at 8 years for children with birth weights of 1250 g or less

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Abstract

The educational, motor, and behavioural performance of a hospital based cohort of 51 children aged 8 years with birth weights of 1250 g or less is reported, as part of a longitudinal study. Compared with age, race and sex matched classmates, who were examined at school at the same visit, the very low birthweight (VLBW) group performed less well on the basic mathematics test A, the Schonell spelling test, and the test of motor impairment. Reading performance was also poorer in this group. Twenty three (45%) VLBW children were having difficulty with one or more school subjects compared with 11 (19%) controls, and 15 (26%) had difficulties in two or more areas, compared with three (5%) controls. Parents of VLBW children reported a similar frequency of behavioural problems to controls but teachers identified characteristics typical of emotional disorders and overactivity more frequently among the VLBW group. Motor testing at 6 years of age was the best predictor of school problems at 8 years, correctly identifying 15/16 children with multiple problems with a low (33%) positive predictive value but a high (98%) negative predictive value. Children with birth weights of 1250 g or less and no major impairment have a high frequency of learning difficulties that become more apparent with advancing age. Such problems may be predicted at an earlier age by detailed motor testing.

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As mortality and the frequency of major handicap fall among very preterm children, attention has been directed at the quality of survival for the remaining children. Several recent studies have evaluated outcome for very low birthweight (VLBW) children at early school age (5–6 years).^{1–5} Impairment of cognitive, behavioural, visuospatial, language, and motor performance has been described, although many studies have not related performance to that of control populations. There is often a wide overlap in performance between VLBW and control children, and caution is needed in the interpretation of such data as learning difficulties may appear as greater demands are made of the child as education proceeds.

Rather fewer studies have evaluated perfor-

mance at junior school age,^{3 6–8} although several studies have included children of this age within a broad age range of children studied.^{9–12} A significant proportion of children with learning difficulties has been described in addition to the problems noted above. Only one other study has reported school performance between 5–9 years of age in a UK population and then only using teacher ratings.⁹

We have studied a hospital based cohort of 72 surviving children with birth weights ≤ 1250 g, born during the 18 months after January 1980 and exposed to full neonatal intensive care. Fifty eight (80.5%) were known to be in mainstream school, although two had cerebral palsy. In order to study the associates and antecedents of motor skills, we reported the outcome at 6 years for 53 of this cohort who were free of cerebral palsy or sensory impairment.¹ These VLBW children performed less well than age and sex matched controls over a range of tests of motor performance, intelligence, behaviour, and neurological function. Motor scores at 6 years were associated with both perinatal and environmental variables. Tests of educational proficiency are, however, difficult to evaluate so soon after entry into the educational system and may not correlate closely with measures of intelligence quotient (IQ). We now report further on this cohort at the age of 8 years, with particular regard to their school performance, behaviour, and maturing motor skills.

Population and methods

The derivation and demography of the study population has been described previously.¹ Of the 53 children without cerebral palsy seen at 6 years, one had emigrated to Nigeria and the parents of one further child declined his re-examination. This child had marked motor problems, being in receipt of special educational provision at 6 years, and his parents had not taken up an opportunity for further occupational therapy. All the remaining 51 children were visited at school by LR where they were examined at the same time as an age and sex matched control. For 36 children this was the same control as had been used at the previous examination. Eight further controls from the study at 6 years were visited and examined at their new school. The remaining seven were untraceable or had moved out of the area. Fifteen new controls were recruited, being the child of the same race and sex to the index child with the nearest birthday on the

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class register, so that each index child had a school matched control and 44 index children had the control used at 6 years.

The test protocol comprised the test of motor impairment,¹³ the Suffolk reading test (NFER Nelson), the basic mathematics test A (NFER Nelson), the Schonell S1 graded word spelling test,¹⁴ and a handwriting assessment (see below). Parts of the tests which were given verbally were given simultaneously to each child and the remaining tests given in parallel over the school day, with index and control being taken in random order. The class teachers were asked to grade each child's performance on a five point scale for mathematics, reading and spelling, and to complete a behavioural questionnaire (Rutter B(2)), supplemented with 10 items from the Connors hyperactivity scale. Parents completed a Rutter A(2) questionnaire. Teachers and examiners were aware of the index/control pairing, but the educational scales were scored blind to the child's identity.

HANDWRITING ASSESSMENT

The child was asked to write a story about their favourite person over a 15 minute period, being directed that neat handwriting was the goal. Standard paper (8"×7" with 8 mm spaced lines) and pencils (HB) were used. The text was scored blind to the child's study group over a range of motor (grasp, pressure, orientation) and spatial (letter size, spacing, relation to line) items after Alston and Taylor.¹⁵

Data were coded for analysis with the SPSS-PC+ statistical software package and merged with the data obtained from the previ-

ous study.¹ Socioenvironmental variables were identical to the previous dataset. Results are expressed as medians with range or quartiles as appropriate. Because of the excess of controls, populations were compared using unpaired ranking tests although, using Wilcoxon paired tests, the pairings from the six year study (n=44) and the comparisons for controls at the same school (n=51) showed essentially similar results. Results are thus quoted for all 59 controls (between group eight year comparisons) or for the 44 original controls (comparisons between six and eight year studies).

Results

Data were collected on all children, excepting one parental questionnaire and one teacher's assessment: 51 index children and 59 controls (44 controls from the previous study). The median ages at examination were index children 96 months (range 85–117) and controls 97 months (range 81–106).

The index children performed less well over the whole range of educational tests (table 1). Although the summary reading scores were similar in the two groups, 16 index children were excluded because they did not achieve a reading age of 6.5 years, compared with only six controls. There was a four point discrepancy in raw reading scores (95% confidence interval (CI) –6 to 11), an eight month discrepancy in spelling age (95% CI 1 to 14), and a seven point discrepancy in maths scores (95% CI 5 to 10). Defining acceptable performance as scores over 10th centile for controls, three times as many index as control children performed poorly in reading, maths and spelling, respectively (table 2). Twenty four (48%) index children were having problems in one or more subject compared with 11 (19%) controls. Nine (18%) index children had problems in two areas and a further six (12%) problems across all areas. The teacher's own subjective assessments correlated very closely with the objective testing in all three subjects. Results of IQ testing at 6 years (all within the normal range: >80) correlated with the results of all three educational tests ($p < 0.001$ for each comparison). Four subscales of the Wechsler preschool and primary scales of intelligence (WPPSI) correlated with all three educational measures: information, vocabulary, arithmetic and comparisons. Despite this association, there was a wide scatter of results and both overall IQ and subscales at 6 years proved poor predictors of school difficulties as defined above. There was much overlap in the IQ scores of children experiencing no difficulty (median 117, range 84–139), difficulty with one subject (105, 82–129), two subjects (105.5, 91–130), or three subjects (101, 97–122).

Fewer index than control children achieved more than 20 words on the handwriting test (table 1) and although there was a trend towards poorer performance by the index children, especially among the 'motor' items, the test was not a good discriminator.

The results of the test of motor impairment

Table 1 Results of educational and handwriting tests

	VLBW group (n=51)	Control group (n=59)	p Value
Mathematics (score)	25 (18–30)	32 (27–36)	0.001*
Spelling age (months)	91.5 (84–114)	102 (94–115)	0.016*
No correct	26 (19–46)	34 (28–46)	0.014*
Reading age (months)	101 (93–119)	106 (97–121)	0.610*
Not scored (<78 months)	16 (31%)	6 (10%)	
Raw score	41 (23–50)	44 (35–52)	0.106*
Handwriting test:			
Complete <20 words	9	1	0.010†
Motor items:			
Non-tripod grasp	6	2	0.187†
Loose grasp	4	0	0.093†
Paper not square to table	5	0	0.045†
Trunk not square to table	4	1	0.278†
Normal writing pressure	49	44	0.840†
Spatial items:			
Letter size inappropriate	26	21	0.151†
Letter spacing irregular	13	7	0.110†
Word spacing irregular	24	8	0.003†
Relation to line poor	7	4	0.372†
Poor school performance (score <10th centile):			
Spelling (score ≤20 correct)	14 (27.5%)	5 (8.5%)	0.018†
Reading (raw score ≤21)	15 (29.4%)	5 (8.5%)	0.010†
Mathematics (score < 27)	15 (29.4%)	5 (8.5%)	0.010†

* Mann-Whitney U test; † χ^2 test with Yates's correction.

Table 2 Schooling difficulties at 8 years (scores <10th centile for controls)

	VLBW group (n=51)				Control group (n=59)			
	No	Reading	Mathematics	Spelling	No	Reading	Mathematics	Spelling
No difficulties	28	0	0	0	00	0	0	0
Difficulties:								
In 1 subject	10	3	5	2	8	2	3	3
In 2 subjects	5	4	2	4	2*	2	1	1
In 3 subjects	8	8	8	8	1*	1	1	1

* All three among controls recruited at 8 years.

are shown in table 3. As at 6 years, the VLBW group showed higher (poorer) impairment scores. They performed less well over the whole range of individual items, except jumping. Although median scores were often similar, there was a greater proportion of poor scores among the VLBW group, which reached statistical significance when corrected for ties or analysed as control/index pairs. There was a significant fall in impairment score between 6 and 8 years (paired Wilcoxon: $Z = -4.566$; $p < 0.001$) which was more marked in the VLBW group (median change -2.5 , interquartile range -3.5 to -0.5) compared with the controls (-0.5 , -1.5 to 1.0 ; $p = 0.008$; paired Wilcoxon test), implying that the index children had caught up some of the motor disadvantage noted at six.

Nine VLBW children were considered by their parents to have a significant behaviour disorder (score above 12 on the Rutter A(2) scale) compared with one control child, but generally similar scores were obtained over the range of measures (table 4). On only two items did parents score the VLBW children consistently higher than controls: restlessness ($p = 0.047$) and inability to settle ($p = 0.049$). In contrast teachers recorded similar proportions of both groups with behaviour disorder (score above 8) but scored more adverse items for index children. These tended to indicate 'emotional problems' and 'hyperactivity' rather than conduct disturbances as indicated by the subscore analysis. On univariate analysis two items were over-represented in the VLBW group: 'fearful/afraid of new situations' ($p = 0.01$) and 'unresponsive/apathetic' ($p = 0.001$). On the Connors hyperactivity items the index children scored higher overall, being particularly considered to have poor coordination ($p = 0.001$), to be inattentive ($p = 0.003$), and lack leadership ($p = 0.003$).

Social and demographic associates of poor school performance were sought. The parents of VLBW children who were failing in two or three separate subjects ($n = 13$) were more likely to live in rented accommodation and have a manual occupation. Other variables did not vary significantly between the two groups (table 5).

Table 3 Results of the test of motor impairment (revised) (data expressed as median (interquartile range) or number as appropriate)

	VLBW group (n=51)	Control group (n=59)	p Value (Mann-Whitney U test)
Manual dexterity:			
Pegboard (sec) preferred	24 (21–25)	22 (21–24)	0.050
Other	26 (23–30)	25 (22–27)	0.132
Threading beads (sec)	18 (14–22)	15 (13–18)	0.013
Flower trail (No of errors)	3 (2–4)	2 (1–3)	0.022
Subscore (/6)	1 (0.5–2)	0.5 (0–1.5)	0.050
Ball skills:			
Catch (/10) preferred	9 (7–9)	9 (8–10)	0.017
Other	7 (5–9)	9 (7–9)	0.003
Throw (/10)	6 (4–8)	7 (6–8)	0.029
Subscore (/4)	1.5 (0.5–2.5)	0.5 (0–1.5)	0.001
Balancing skills:			
Stork balance (sec) preferred	13 (8–20)	20 (12–20)	0.002
Other	12 (6–18)	19 (12–20)	0.001
Jump cord (No failing test)	5	5	0.900*
Heel-toe walking (/15)	15 (15–15)	15 (15–15)	0.009
Subscore (/6)	1.5 (0.5–2)	0.5 (0–1)	0.001
Impairment score (/16)	3.5 (3–5)	2.0 (1–4)	0.0002

* χ^2 test.

Table 4 Results of Rutter A(2), B(2) and Connor behavioural questionnaires (data expressed as median (interquartile range) or number as appropriate). Items scored as 0, 1, or 2 as per questionnaire

	VLBW group	Control group	p Value
Parental questionnaire (A(2))			
No of questionnaires	51	58	
Health items	3 (1–3)	2 (1–3)	0.911*
Habits items	2 (1–2)	1 (1–2)	0.407*
Statements (total)	5 (3–9)	4 (3–8)	0.229*
Behaviour disorder (n)	9	1	0.010
Emotional disorder (n)	5	0	0.019
Conduct disorder (n)	4	1	0.181
Teachers' questionnaire (B(2))			
No of questionnaires	50	59	
Statements (total)	4.5 (1–7)	2 (0–5)	0.028*
Behaviour disorder (n)	9	7	0.391
Emotional disorder (n)	6	1	0.047
Conduct disorder (n)	3	6	0.500
Emotional scale	2 (0–4)	0 (0–2)	0.017*
Conduct scale	1 (0–3)	0 (0–3)	0.353*
Hyperactivity (A(2) and B(2))	2.5 (1–5)	1.5 (0–3)	0.014*
Hyperactivity (Connors)†	5 (2–9)	2 (0–6)	0.001*

† Scored as 0 ('not at all') up to 3 ('very much').

* Mann-Whitney U test; others χ^2 .

Table 5 Poor school performance among VLBW children. Results are number (%) except where otherwise stated

	School difficulties (in 2–3 subjects) (n=13)	No difficulties or in 1 subject only (n=38)	p Value
Rented house	10 (77)	14 (37)	0.029
Own house	3 (23)	24 (63)	
Social group:			
Non-manual	2 (15)	14 (37)	0.036
Manual	9 (69)	16 (42)	
Unemployed	2 (15)	3 (8)	
Biological parents	8 (62)	29 (76)	0.503
Only child	6 (46)	9 (24)	0.237
Older sibling	2 (15)	10 (26)	0.716
Median (range) maternal age in years	32 (24–37)	31 (24–40)	0.240*
Median (range) time in school in months	39 (27–48)	43 (32–52)	0.220*
Active problems:			
Medical problems	8 (62)	15 (39)	0.290
Squint/refractive error	3 (23)	11 (29)	0.961
Hearing problem	0	5 (13)	0.403
Male gender	6 (46)	26 (68)	0.271
Left hand preference	4 (31)	13 (34)	0.999

* Mann-Whitney U test; others χ^2 .

Table 6 Perinatal variables and school difficulties. Results are number (%) except where otherwise stated

	School difficulties (in 2–3 subjects) (n=13)	No difficulties or in 1 subject only (n=38)
Multiple pregnancy	3 (23)	9 (24)
Antenatal steroids	0	13 (34)
β_2 agonists	2 (15)	18 (47)
Fetal distress	4 (31)	9 (24)
Vaginal delivery	11 (85)	30 (79)
Caesarean section	2 (15)	8 (21)
Intubated at birth	8 (62)	20 (53)
Median (interquartile range) Apgar score		
1 min	4 (2–7)	4 (2–7)
5 min	8 (7–9)	9 (7–10)
Median (range) birth weight in g	1050 (620–1240)	1050 (630–1250)
Median (range) gestation in weeks	27 (24–33)	28 (25–35)
Small for dates	2 (15)	11 (29)
Median (range) days ventilated	1 (0–18)	2 (0–28)
Bruised at birth	2 (15)	11 (29)
Septicaemia	2 (15)	4 (11)
Abnormal movements	0	2 (8)
Fits	2 (15)	5 (13)
Abnormal early scan	1 (8)	17 (45)
Abnormal late scan	1 (8)	5 (13)

All comparisons not significant bar antenatal steroids ($p = 0.038$).

Univariate assessment of perinatal factors identified that VLBW children failing at school were less likely to have received antenatal steroid treatment ($p=0.038$) than those achieving adequate scores in two or three subjects. This apart no differences were identified in 19 other perinatal variables (table 6). This difference may therefore have arisen by chance. Eighteen children had had intraventricular haemorrhages detected in the neonatal period, classed as subependymal ($n=9$), intraventricular ($n=7$), or parenchymal ($n=2$). Of these only one, with a unilateral intraventricular haemorrhage, was having difficulties at school. Six children had abnormal late scans classed as persistent ventricular enlargement ($n=2$) or cystic periventricular leucomalacia with small ($n=3$) or large ($n=1$) cysts. Of these, only one with persistent ventricular enlargement was having difficulty at school. The presence of abnormal neonatal neurological signs (fits or abnormal movements: eight children) was associated with later schooling difficulties in only two.

The longitudinal performance between 6 and 8 years may be compared in several ways. Discriminant function analysis, using poor performance in two or three subjects as the dependent variable, identified that the impairment score at 6 years was the best discriminant of all the six year measures, followed by the verbal quotient of the WPPSI, and finally the class teacher's assessment at six. The latter variable, however, identified only four (33%) of the children with poor performance at 8 years and incorrectly allocated a further 11 children to this group. In contrast, an impairment score of 5 or more at 6 years correctly identified 15 (94%) children with school problems in two or more areas, with a low positive predictive value of 33%, but a high negative predictive value of 98% (table 7).

Discussion

Although 80% of VLBW children now receive mainstream education,¹⁶ since the early UK studies of Drillien¹⁷ it has been apparent that even in the presence of IQ scores in the normal range VLBW children are more likely to underachieve at school. In a study of 28 survivors with birth weights less than 1000 g from Seattle, despite IQ scores in the low normal range (mean 90.5), 64% were in receipt of special educational provision and only one

quarter were performing satisfactorily at school.¹⁸ In a more recent study VLBW children were compared with normal birthweight sibling controls.¹⁹ Despite only small differences in IQ, 28% were considered to be performing poorly at school, compared with only 3% siblings. In a further study of the same population at between 5 and 9 years of age, 53% of 45 VLBW children were performing below average, including 10 (22%) with poor overall performance, compared with figures of 22% and 2% respectively for control children.⁹ In these contexts, the results of this study are in broad agreement: IQ scores measured at 6 years were all in the normal range but only 43% and 55% of VLBW children were performing satisfactorily at junior school on subjective and objective measures, respectively, compared with 71% and 81% controls. Of concern is the observation that our previous examination had failed to identify accurately the subgroup of children with educational difficulties, and that the proportion of children causing concern had increased over the intervening two years. Similar proportions of educational problems have been reported by other recent studies.^{2 3 6 10-12}

The spectrum of problems observed in this study covers all the mainstream areas of educational assessment, including motor skills and behaviour. There is also a wide variation in the type of educational problem from child to child with no particular pattern of deficits, in line with some studies,¹⁸ but at variance with other studies that have implicated primarily visuospatial²⁰ or language problems.⁵ It is clear that the spectrum of problems alters with development, and longitudinal studies are necessary to chart this, but local socio-environmental and educational factors may interact to produce differing outcomes in differing populations.

The motor skills of our index population have shown improvement with time. Motor and neurological immaturity are features of the preschool VLBW population.^{1 21} In our population motor performance was the best indicator of later school performance. The high negative predictive value indicates that low motor impairment scores at school entry are associated with satisfactory school performance, whereas high scores carry a 33% risk of learning difficulties. Early educational intervention is therefore possible, as has been indicated in other studies.⁵ In a population study from Manchester, subjectively ascertained motor skills at school entry were found to indicate later arithmetic and motor performance.²² Indeed the best discriminator between index and controls at 8 years in this study was the mathematics test, a particular distinguishing feature of preterm children in two previous studies.^{19 23}

Socioenvironmental influences will comprise relatively greater influences on outcome as the child grows older. Of the small series of markers of family structure and social status used in this study, two (social group and home ownership) are significantly associated with school performance as anticipated.

Table 7 Predictive value of 6 year examination. Results are number (%)

	Assessment at 8 years	
	No difficulties or in 1 subject only	School difficulties (in 2-3 subjects)
Findings at 6 years		
Teachers' assessment:		
Good	21 (100)	0
Average	46 (85)	8 (15)
Poor	11 (73)	4 (27)
Revised test of motor impairment score:		
<5	49 (98)	1 (2)
≥5	31 (67)	15 (33)
VLBW group only:		
<5	15 (40)	1 (8)
≥5	23 (60)	12 (92)

Within each grouping, however, VLBW confers excess disadvantage. Whether this is the result of poor matching at the family level²⁴ or related to biological factors and premature birth cannot be ascertained.

As infants, preterm children are often considered to be more irritable, with more 'difficult' behaviour patterns. At 8 years, the spectrum of behaviour reported by parents of VLBW children differs little from that of control parents. Teachers, however, scored the index group higher and consistently on items relating to emotional problems (worries, fears, unhappiness, tics, fussiness) and overactivity (fidgeting, restlessness, inattention). These differences were similar to the differences noted at 6 years on a simpler questionnaire. Studies of children with an excess of soft neurological signs have demonstrated that anxiety traits are common, even though the physical signs regress as the child grows.²⁵ In the Vancouver study the small group followed up to 13 years also demonstrated an excess of behavioural problems that appeared to follow on from their syndrome of 'minimal brain dysfunction' at 6 years.²⁶ It is important to follow up this cohort further to determine the significance of these differences into teenage years.

Outcome at 6 years could not be associated with neonatal ultrasound scan findings but motor scores were associated with three perinatal variables.¹ This association is lost when outcome measures at 8 years are considered, and it is of note that abnormal scan findings are not necessarily associated with school problems. This may not be surprising as ultrasound usually detects only relatively large white matter lesions and may not identify more subtle changes in grey matter²⁷ or white matter.²⁸ No other perinatal variables were associated with 8 year outcome in line with most other studies that have used individual perinatal factors, although a few studies have associated summary neonatal scores with outcome.⁹ Those children with poor head growth over the first 8 months may be particularly at risk for later school problems.⁷ Other groups have studied the outcome for preterm small for gestational age children with conflicting results.²⁹ No association between conventional (10th centile) measures or SD scores of birth weight for gestational age was seen in our study. Other factors not assessed in this study, such as the quality of neonatal nutrition,³⁰ may have a significant effect on outcome.

Thus, of children weighing ≤ 1250 g at birth born in 1980–1, 20% of survivors have a major impairment sufficient to warrant special schooling. Only half of the remainder were free of problems at 8 years with a further quarter performing poorly at school. Few of these children were receiving remedial teaching, although studies from North America would indicate that they may need it. VLBW children at junior school demonstrate an excess of motor, behavioural, and educational problems that appear to persist despite the

improvements in care and major morbidity that have occurred over the past 20 years.

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