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Low birthweight children: coping in school?

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Aim. To describe and compare school performance and IQ at 11 y of age in a population of 130 children weighing less than 2000 g at birth without any major handicaps (low birthweight) and a random control sample of 131 children born at term weighing over 3000 g (normal birthweight); and to evaluate the relative strength of parental factors versus child birthweight in predicting IQ. *Methods*. The mothers and teachers completed validated questionnaires addressing school performance and the child's IQ was evaluated by WISC-R, prorated. In addition, socioeconomic status was investigated using different questionnaires. *Results*. According to maternal reports, twice as many low birthweight children had school problems and three times as many of these children were referred to the School Psychological Service. Mean prorated IQ was 5 points lower in the low birthweight group. No statistically significant difference was found for mean IQ between the groups with birthweights of less than 1500 g vs 1500–2000 g. In a multivariate linear regression analysis, parental factors accounted for 13% of the variance in child IQ compared with only 3% accounted for by child birthweight.

Conclusion. Low birthweight significantly increases the risk of school problems.

Key words: *Cognitive, low birthweight children, school performance, socioeconomic status*

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There is a strong association between low birthweight and cerebral palsy. In populations born in the 1980s the prevalence of cerebral palsy in very low birthweight children was estimated as 6–10% (1–2). In many studies, researchers have found a 5–10-points lower mean IQ among low birthweight and very low birthweight children than that of normal birthweight controls, when those with major handicaps such as cerebral palsy, blindness and deafness are excluded (3–6). Furthermore, some studies indicate that low birthweight children, in addition to having a lower mean IQ, are more likely to have learning disabilities/school problems and behavioural problems (4). However, long-term controlled and population-based studies assessing school performance are scarce (7). We have previously reported on the behavioural, motor and neuropsychological outcome at 5 y of age in a regional cohort of low birthweight children with birthweights of less than 2000 g, compared with normal birthweight controls (8–11). The aims of our study of the same cohort at 11 y of age were: (i) to compare school performance and IQ in low versus normal birthweight children, and (ii) to evaluate the relative strength of parental factors such as socioeconomic status and child-rearing style versus child birthweight in predicting cognitive abilities and school performance.

Methods

The study and control groups have been described in detail elsewhere (8–9). The low birthweight survivors, with birthweights of less than 2000 g, and without major handicaps, were born in the county of Hordaland, Norway, between April 1st 1986 and August 8th 1988 (Table 1). The control group was randomly selected from a population of non-disabled, 5-y-old children with birthweights above 3000 g and a gestation period of more than 37 wk, and in no need of transfer to the neonatal unit. Of the 130 low birthweight children who participated in the study at 11 y of age, 120 were born in the same regional hospital, Haukeland Sykehus. The remainder were born in smaller hospitals in the region and then transported to the regional hospital shortly after birth. The Regional Ethics Committee on Medical Research approved the project protocol, and written consent was obtained from all the children and parents. The investigators had not previously been involved in the treatment of the children, and were unaware of birthweight status.

Demographic measures regarding parental education, family income, parental school problems, such as learning disabilities/attention problems, and family and marital status were obtained through a question-

Table 1. Survival and handicaps among liveborn children with birthweight under 2000 g born during the study period (number %).

Birthweight group	Total	<1000 g	1000–1499 g	1500–1999 g
Total liveborn	217	33	60	124
Multiple malformation/ chromosomal abberation[1]	8 (4)	2	1	5
Cerebral palsy[2]	12 (6)	1	6	5
Blind	0	0	0	0
Deaf	1	1	0	0
Eligible, intact survivors[3]	174 (80)	16 (48)	46 (77)	112 (90)
Assessed at age 11[4]	130 (75)	14 (88)	36 (78)	80 (71)
Teacher assessment[5]	111 (85)	11 (79)	32 (89)	68 (85)
Gender: boy/girl	67/63			

[1] Six of these children died before 5 y of age.
[2] Nine children had spastic diplegia, one had spastic hemiplegia and two had spastic quadriplegia.
[3] Infants living at 11 y of age without cerebral palsy (by 2 y of age), deafness, chromosomal aberration, or multiple malformation.
[4] Percentage calculated from number of intact survivors.
[5] Percentage calculated from number of assessed children.

naire given to the parents at the time of the present investigation. Mother's non-verbal problem-solving abilities were assessed using the Raven Progressive Matrices at the time of the 5-y follow-up (12). Maternal child-rearing attitudes were assessed using a 65-item version of the Child Rearing Practices Report (CRPR) (8, 13–15). Assessment of parental stress (such as competence, social isolation, spousal relationships, role restriction, attachment, health) and total parental stress, which included areas of the child's behaviour (such as adaptability, how demanding the child is) and family life events were obtained from the Parental Stress Inventory (PSI), translated from the original version (16). We evaluated maternal psychological distress, such as depression, anxiety and psychosomatic symptoms using a Norwegian version of the Symptom Check List–Revised (SCL-90R) (8, 17). To facilitate interpretation of the analyses, the maternal Raven score, child-rearing factor scores, parental stress index, total parent stress index, maternal psychological distress score were z-transformed to yield standardized variables with means of 0 and standard deviations (SD) of 1. The Raven Progressive Matrices test was completed by 105 (80%) mothers of the low birthweight children (in the study at 5 y of age) compared with 115 (88%) of the control mothers. All mothers of low birthweight children and 130 out of 131 control mothers completed the Child Behaviour Checklist (CBCL). The PSI was completed by 122 (93%) mothers of low birthweight children compared with 119 (91%) mothers of controls. The SCL-90-R was completed by 115 (88%) of the low birthweight mothers and 119 (91%) of the control mothers, and 115 (88%) of the low birthweight mothers and 122 (93%) of the control mothers completed the CRPR.

Psychometric intelligence was assessed using the Norwegian version of the Wechsler Intelligence Scale for Children–Revised (WISC-R) (18). The subscales for word comprehension, similarities, block design and object assembly were assessed, and a prorated IQ was calculated. Arithmetical abilities (mathematics) were assessed using a Norwegian screening test with a maximum of 27 tasks to be completed in 10 min (Myhre 1988).

Each child's school performance was assessed using the CBCL (Achenbach 1991, maternal report) and the Teacher's Report Form (TRF, Achenbach 1991). In addition to the TRF subscales for reading and mathematics, the CBCL scale for school performance and the TRF scale for academic performance were used (19, 20). Teachers were not aware of birthweight status. A lower score on school performance from the CBCL and academic performance from the TRF indicated more problems. A score lower than the 10th percentile for the control children of the same sex was classified as a school problem (Table 3). None of the children were in special classes or had to repeat grades. Under the Norwegian educational system, most children with severe learning disabilities do not attend special classes or have to repeat grades, but are referred to the School Psychological Service. Pure-tone audiometry and visual acuity assessment with Snellen letters were used to diagnose hearing/visual deficits, which could affect test results.

All eligible children from the study at 5 y of age were still eligible at 11 y of age according to the stated criteria. A total of 130 out of 174 (75%) eligible low birthweight children (Table 1) and 131 out of 170 (77%) eligible control children were examined at a mean age of 11 y and 3 mo (SD 1.5 mo). One of the controls did not take part in the study but the mother participated through answering the questionnaires. Of the 43 out of 174 low birthweight children missing, 19 did not want to participate, 12 did not answer, 7 had moved away, and 5 were untraceable. Of the 40 out of 170 controls missing, 17 did not want to participate, 11 did not

Table 2. Demographic data for low and normal birthweight families.

Birthweight group	<2000 g ($n = 130$) Mean (SD)	>3000 g ($n = 131$) Mean (SD)	Difference of means	95% CI of difference	P (t-test)
Paternal education (y)	12.1	13.3	1.3	0.5 to 2.1	0.002
Average income (in NOK 1000)	40.9 (2.8)	45.5 (4.1)	4.6	−1.4 to 5.3	0.36
Maternal education (y)	12.3	13.3	1.0	0.4 to 1.7	0.002
Maternal age (y)	31.7 (5.2)	32.6 (4.5)	0.9	−0.4 to 2.2	0.15
Maternal psychological distress[1,2]	0.34 (0.33)	0.27 (0.24)	0.07	−0.14 to 0.007	0.07
Maternal Raven Score[2,3]	−0.08 (1.0)	0.14 (1.0)	0.21	−0.48 to 0.05	0.11
Number of siblings	1.8 (1.06)	1.8 (0.87)	0.01	−3.1 to 0.18	0.59
Childrearing practices[2,4]					
Nurturance	−0.13 (0.09)	0.14 (0.08)	−0.27	−0.51 to −0.03	0.03
Restrictiveness	0.08 (0.10)	−0.07 (0.08)	0.15	−0.09 to 0.40	0.27
Permissiveness	0.03 (0.09)	−0.03 (0.08)	0.06	−0.19 to 0.31	0.63
Overruling	0.08 (0.09)	−0.09 (0.08)	0.16	−0.08 to 0.41	0.19
Parent Domain stress[2,5]	0.08 (0.1)	−0.07 (0.09)	0.15	−0.12 to 0.42	0.28
Total Parental Stress[4,5]	0.18 (1.0)	−0.15 (1.0)	0.34	0.06 to 0.62	0.02
Family life event[4,5]	1.3 (1.4)	1.2 (1.4)	0.03	−0.33 to 0.39	0.87
	Proportion		p (χ^2)		
Single parent family	15/125	10 /125	0.3		
Maternal smoking in pregnancy	55/111	38/125	0.04		
Parental school problems	26/124	18/120	0.2		

[1] Symptom Check List–Revised (SCL-90R).
[2] Factor scores z-transformed to a mean of 0 and a standard deviation of 1 were used.
[3] Raven Progressive Matrices test. The age corrected score, z-transformed to a mean of 0; a standard deviation of 1 is used.
[4] Child Rearing Practices Report (CRPR).
[5] Parental Stress Index, Norwegian translation. Parental Domain score reflects area in general parenting. Total parental stress includes area of the child's behaviour.

answer, 4 had moved away, and 8 were untraceable. Among the 19 low birthweight children who did not want to participate, the mothers reported that 18 children were doing well in school and had no behavioural problems. For the 131 controls, 108 (82%) teachers answered the TRF. Mean birthweight of the low birthweight children was 1537 g (SD 367) and mean gestational age was 32 wk (SD 3). Compared with the control group, the low birthweight children were raised in families where the fathers and mothers had a lower mean education, mean total parental stress was higher, child rearing tended to be less nurturing, and maternal smoking during pregnancy was more common (Table 2). All low birthweight children and 128 of the 131 controls completed the audiometry tests, and 38 low birthweight children as compared with 23 controls had deficits of 40 decibels or more at 1000 and/or 2000 Hz in both ears giving an OR of 1.9 (95% CI, 1.1 to 3.4). However, these children did not have a lower mean IQ than the rest of the children and were therefore retained for analysis. All the children completed the visual examination, but, allowing for the use of glasses, all the children were without visual deficits defined as visus lower than 6/9.

Statistical analyses

First, mean group differences between the low birthweight and control groups for parental risk factors and outcome variables were compared using t-tests and differences in proportions using the χ^2 test (Tables 2 and 3). Second, the odds ratios for the outcome variables were adjusted for confounding by parental factors using multiple logistic regression analyses with forward stepwise selection of variables. Only those parental variables that were significantly different for the two groups were made available to the analyses. Cases with missing parental variables were excluded from these analyses. Third, the parental factors presented in Table 2 were subjected to hierarchical, stepwise, multiple linear regression analysis with prorated IQ as the dependent, continuous variable (Table 4). An identical analysis was repeated with academic performance as the dependent variable. Fourth, we investigated interactional effects for the strongest parental predictors of child IQ from the multiple regression analyses. This was done by computing a new variable, a product of the parental variable in question and the birthweight group status variable. The new variable was forcibly entered into the model with prorated IQ as the dependent variable. Similar procedures were repeated using the other strong parental variables. SPSS for Windows, version 10.0, was used for the statistical analyses (21).

Results

Twice as many low birthweight children had a school

Table 3. Child IQ and school performance for low and normal birthweight children.

Birthweight group	<2000 g ($n = 130$) Mean (SD)	>3000 g ($n = 131$) Mean (SD)	Difference of means (95% CI of difference)	P (t-test)
Prorated IQ	96 (13)	101 (10)	4.9 (2.1 to 7.7)	$p = 0.001$
Mathematics[1]	16 (5)	18 (4)	2.6 (1.5 to 3.6)	$p = 0.001$

Birthweight group	<2000 g n (%)	>3000 g n (%)	OR (95% CI) Unadjusted	OR (95% CI) Adjusted for demographic factors[2]
Total no. of children	$n = 130$	$n = 131$		
Low IQ[3]	24 (19)	7 (6)	3.9* (1.8 to 7)	1.8 (0.9 to 3.0)
Mental retardation[3]	3 (2)	0		2.0 (0.4 to 6.0)
Mother's report				
School performance[4]	22 (17)	9 (7)	2.7* (1.2 to 6)	2.2* (1.2 to 4.3)
Mathematics	29 (23)	10 (8)	3.4* (1.6 to 7.3)	1.8* (1.0 to 3.2)
Norwegian	29 (23)	18 (14)	1.8 (0.8 to 2.9)	
Special education/ assistance	41 (32)	29 (23)	2.6 (0.4 to 1.1)	
School psychological service	36 (29)	16 (13)	2.7* (1.4 to 5.2)	2.5* (1.6 to 4.2)
Teacher's evaluation				
Total no. of children	$n = 111$	$n = 108$		
Academic performance[5]	12 (11)	9 (9)	1.3	
Mathematics	30 (31)	9 (11)	3.9* (1.7 to 8.8)	2.5* (1.2 to 4.8)
Norwegian language	21 (21)	30 (29)	1.5	

* $p < 0.05$.
[1] A Norwegian mathematical screening test (Myhre 1988).
[2] Adjusted for paternal/maternal education, child-rearing practice (nurturance), total parental stress and maternal smoking in pregnancy.
[3] Low IQ defined as a score lower than 85 points and mental retardation a score lower than 70 points.
[4] Achenbach, CBCL: School performance scale, with problem defined as score poorer than 10th percentile for the control children of same sex.
[5] Achenbach,TRF: Academic scale, with problem defined as score poorer than 10th percentile for the control children of same sex.

problem compared with controls according to the maternal report, when confounding factors were controlled for. Mathematical problems reported by mothers and teachers were twice as common in the low birthweight group; teachers reported on 16 of the 23 low birthweight children with mathematical problems reported by the mothers compared with 5 of the 7 controls. Two to three times as many low birthweight children were referred to the School Psychological Service (Table 3). The mean prorated IQ was 5 points lower in the low birthweight group (Table 3). No significant difference was found for mean IQ between children with birthweights of less than 1500 g ($n = 50$) and those with birthweights between 1500 and 2000 g ($n = 80$). In these two groups, mean IQ was 96 (SD 12) (<1500 g) vs 95 (SD 13) (1500–2000 g). There were no significant gender differences in mean IQ in either the low birthweight group or the control group. The 13 children with cerebral haemorrhage detected on ultrasound scan in the neonatal period had a similar mean IQ to those without haemorrhage.

Among the 22 low birthweight children with school problems (mothers' report, CBCL), we found that 10 had a low IQ, and 21 had been referred to the School Psychological Service. The teacher reported 10 of the 22 to be without academic problems compared with 2 out of 7 controls (OR: 4.3; 95% CI, 0.04 to 1.5). Among the 36 low birthweight children referred to the School Psychological Service, 13 had no school problems (mothers' report, CBCL). Among the 29 low birthweight children with problems in mathematics, 17 also had language problems. No statistically significant difference was found in the number of children with school problems for those with birthweights of less than 1500 g ($n = 50$, 10%) compared with those with birthweights between 1500 and 2000 g ($n = 80$, 18%), OR 2.1 (95% CI, 0.6 to 6.9, $p = 0.23$).

In the hierarchical, stepwise, multiple linear regression analysis, the final model explained 16% of the variance in child IQ. Removal of the birthweight group status variable from the last block reduced the explained variance by 3%, indicating that approximately 3% of the variance in child IQ was attributable to birthweight and 13% to demographic factors. Paternal education was the strongest predictor of child IQ in addition to maternal IQ (Table 4). No statistically significant interactional effects were found for any of the investigated demographic variables. A similar hierarchical, stepwise, multiple regression analysis with school

Table 4. Child prorated IQ according to birthweight adjusted for demographic factors. Hierarchical stepwise multiple linear regression analyses in combined low and normal birthweight children that had complete data sets for the variables analysed ($n = 208$).

Analysis block	Adjusted R^2	Independent variables	B 95% (CI of B)	β	p
Dependent variable: child prorated IQ					
Block 1					
Birthweight group	0.05	Birthweight group	−5.0 (−7.8 to −2.1)	−0.21	0.001
Block 2					
Addition of socioeconomic variables and maternal IQ	0.14	Paternal education	0.8 (0.3 to 1.3)	0.23	0.001
		Birthweight group	−3.9 (−6.7 to −1.0)	−0.17	0.009
		Raven score	3.7 (0.8 to 6.6)	0.16	0.01
Block 3					
Addition of child rearing	0.16	Paternal education	0.8 (0.3 to 1.3)	0.21	0.002
Maternal well-being		Birthweight group	−4.0 (−6.9 to −1.1)	−0.18	0.008
		Maternal Raven score	4.0 (1.0 to 6.9)	0.17	0.009
		Permissiveness (CRPR)	−1.5 (−3.0 to −0.1)	−0.14	0.04

In *block 2* birthweight group, monthly income, paternal education, maternal education, maternal Raven score, parental school problems, maternal age, single parent family status and mothers smoking during pregnancy were subjected to analysis as independent variables.

In *block 3* birthweight group, child sex, maternal psychological distress, family life-events and parental social support/stress (PSI), the four child-rearing practices factor variables (CRPR) were subjected to analysis as independent variables.

The independent variables in the table were those that made significant independent contributions to explaining variance in child IQ. β is the unstandardized regression coefficient.

performance (CBCL) as the continuous variable showed that 2% of the variance in school performance was attributable to birthweight and 12% to demographic variables.

Discussion

The major findings of the present study were that twice as many low birthweight children had school problems compared with normal birthweight controls, although mean IQ was only 5 points lower. Furthermore, parental/demographic factors were much stronger predictors of child outcome than birthweight.

The present study was population based and loss to follow-up was 25%. However, mean birthweight and gestational age for those lost to follow-up were comparable with those who were assessed. Demographic characteristics of the population can be assumed to be similar to those of Norway as a whole. The distribution of birthweights and prevalence of malformations and chromosomal aberrations in the low birthweight group studied were also representative (22).

The parents of low birthweight children in our study were somewhat disadvantaged, compared with the parents of control children, with regard to demographic factors. This finding is similar to reports from countries with a higher proportion of residents of low socioeconomic status (23, 24). However, the differences were small and limited to only some of the variables studied.

A somewhat lower mean IQ in low birthweight children, typically approximately one-third of a standard deviation as in the present study, has been found in many previous studies (6). A major concern has been that, although mean IQ in low birthweight children has been one-third of a standard deviation lower, academic school problems may be a greater problem (7, 25–26). In the present study, this concern was confirmed with a twofold increase in school problems for the low birthweight children. One could argue that demands in school on intellectual capacity are still moderate at the age of the children in the present study. If so, a further follow-up could disclose a higher proportion of academic school problems. Saigal et al. (26) reported a twofold increase in the need for special education in extremely low birthweight children at 8 y of age compared to controls (25). However, at 12–16 y of age they found an eightfold increase (26). In the Norwegian school system the teacher does not give grades at the class level of the children in the present study and exams are only given in mathematics and Norwegian language. In other words, teachers may have an incomplete insight into the children's academic abilities. On the other hand, in the two main subjects, mathematics and Norwegian language, with a two to threefold increase in academic problems, there seemed to be accordance between mothers' and teachers' reports. In a large hospital-based study of low birthweight children at 9 y of age, and with similar birthweights to those in the present study, Klebanov et al. found a twofold increase in school difficulties over controls in the two groups with birthweights of 1000–1500 g and 1500–2500 g, respectively. Those with extremely low birthweights had a fourfold increase (7). In our study there were only 14 extremely low birthweight children, excluding reliable analyses for that subgroup.

In the present study every third low birthweight child received special education, which might lead one to conclude that a special intervention programme for low birthweight children would be appropriate. However, as many as every fourth control child received special education, which puts the finding into the proper perspective. Such findings underscore how important it is to include a large random control sample in follow-up studies. Two to three times as many low birthweight children compared to control children were referred to school psychological services. This may be due to the academic school problems discussed previously or to behavioural problems such as attention deficits (27, 28). Behavioural outcome at 11 y of age in the present cohort will be reported separately.

Small group differences were found between the low birthweight and the control families regarding the investigated parental factors. However, these factors were much more important than birthweight in predicting child outcome, as has been found in our previous studies (8, 27). Since no interactional effects were found, this strong predictive power of parental factors was equal for low birthweight children and controls. The dominant role of parental factors related to socioeconomic status over assessable parental stress and maternal well-being in predicting child IQ was also seen in our study at 5 y of age (8). In Hack's review of outcome of intrauterine growth-retarded (IUGR) children, it was found that ongoing detrimental effects of socioenviromental deprivation throughout the lifespan play a much greater role in determining outcome than any potential effect of intrauterine growth failure on the developing nervous system (29).

We conclude that low birthweight is associated with an increase in school problems at 11 y of age. The present study adds to an increasing body of literature that undermines the hypothesis originating in the 1960s and 1970s stating that infants with biological risk factors such as low birthweight are especially vulnerable to environmental risk factors.

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