Original Articles

Pune Low Birth Weight Study – Cognitive Abilities and Educational Performance at Twelve Years

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Objective: *To assess the intelligence, visuo-motor perception, motor competence and school performance of children with birth weight less than 2000grams, at the age of 12 years.* ***Design:*** *Prospective cohort study.* ***Setting:*** *Infants discharged from a Neonatal Special Care Unit of a referral hospital with birth weight less than 2000g between 1987-89 and followed up in the High Risk Clinic.* ***Methods:*** *The children were assessed by the Weschler's Intelligence Scale, Bender Gestalt test for visuo-motor perception, Wide Range Achievement Test for specific learning disability, Draw-a-Person screening test for emotional problems and Movement Assessment Battery for motor competence. Academic achievement was also scrutinised.* ***Results:*** *One hundred and eighty children weighing less than 2000grams at birth and ninety control children were assessed. The mean IQ of the study group was normal (89.5 ± 16.9), though significantly lower than that of controls (97.2 ± 14.1; p <0.05). Pre term SGA children had the lowest mean IQ (85.4 ± 17.7). In the 78 VLBW children, there were 12 (15.4%) mentally retarded children as compared to only 3 (3.3%) amongst controls (p <0.00I). There were only 3 (3.8%) 'bright' children among the VLBW group, as compared to 20 (22.2%) in the control group (p <0.001). Visuo-motor perception and motor competence of the study group was poor, and they had writing and mathematics learning disability, especially the preterm SGA and VLBW group. Academic achievement was poor and the incidence of borderline intelligence was 24.4%, which has increased from 13.4% at 6 years.* ***Conclusions:*** *The intelligence and academic performance of the children weighing less than 2000 grams is significantly lower than that of controls, though within normal limits. They also have poor visuo-motor perception, motor incompetence, reading and mathematics learning disability. The preterm SGA and VLBW children had the poorest cognitive abilities.*

Key words: *Congnitive development, Low birth weight infants, School performance.*

THERE has been tremendous improvement in neonatal care in the last two decades. The technological advances in neonatology, the close obstetric-neonatal collaboration, better understanding of neonatal physiology, have steadily improved the survival of the low birth weight infant. In fact, neonates are surviving after insults, which were previously thought to be fatal(1), and a whole new generation of Neonatal Intensive Care Unit (NICU) graduates is emerging.

In the Western countries, inspite of increased survival of extremely low birth weight (less than 1000g) infants, the cerebral palsy rate has remained constant(2). However, these positive findings are also accompanied by reports of increasingly higher incidence of learning difficulties(3). Although these children look normal, have age appropriate adaptive skills and activities of daily living, they often have poor school achievement. The demands for academic learning and

achievement suddenly increase around the age of 12 years. According to Piaget's theory(4), this is the phase of 'concrete operation' in which the conceptual skills and abstract thinking develop and also the thought process becomes more organized and logical. The emphasis in this study was mainly on the detection of these subtle learning problems in children who weighed less than 2000 g at birth, who otherwise looked and behaved normally.

This long term follow up study started in 1987-89. In the first phase of the study, major handicaps and neurologic sequelae were identified at the end of 3 years(5). In the second phase of the study, problems with cognition, visuo-motor perception and fine motor co-ordination, skills which are needed for reading and writing were assessed at school entry(6). In the present study, the children had a battery of tests to assess their intelligence, visuo-motor perception, motor co-ordination and specific learning disabilities in reading, writing and mathematics. Their school performance was also scrutinized. The main aim was to identify children with "borderline intelligence", who may not be able to cope in a normal school.

Subjects and Methods

The cohort consisted of infants weighing less than 2000g discharged from the Neonatal Special Care Unit from October 1987 to April 1989. Full term neonates, with a normal antenatal, natal and postnatal course, weighing more than 2500 g, were enrolled as controls. They were followed up prospectively till the age of 12 years.

All these children were called for a thorough assessment soon after their twelfth birthday by sending a letter. The social worker made a home visit if the parents did not respond to the letter. When the child came to the hospital, anthropometric measurements were taken and a medical examination was done. Treatment was given for any medical problems and appropriate referrals were done. The mother was questioned regarding scholastic problems or failures. Children with seizure disorders were counseled and EEGs were done whenever necessary. Children with hearing impairment were encouraged to use the hearing aid throughout the day.

The following tests were done on every child for an in-depth assessment of cognitive development at 12 years.

Weschler's Intelligence Scale - Revised (WISC-R)(7)*:* The Weschler's Intelligence scale is the most commonly used intelligence scale all over the world for school age children. It assesses the abilities and processing skills across a wide range of verbal and non-verbal domains. An Indian version by M. C. Bhatt is available(7). One of its main advantages is that it gives a separate verbal and performance IQ. It has 11 subtests-information, comprehension, arithmetic, similarity, vocabulary, digit span, picture completion, picture arrangement, block design, object assembly and coding. It must be administered in a quiet room by a trained psychologist and takes about one and a half hours. An intelligence quotient below 70 is considered as mental retardation, between 70-84 as "borderline intelligence", between 85-109 as average and 110 or more as above average intelligence.

Bender Gestalt Test (BG)(8)*:* This assesses the visuo-motor perception, which is very important for reading and writing. It consists of nine figures characterized chiefly by their patterning (that is their Gestalt). The child is simply instructed to copy each figure, there being no time limit. The results are divided as age appropriate, below normal (9-11 years) and poor (below 9 years).

Wide-Range Achievement Test (WRAT)(9)*:* This test assesses the basic codes of reading, writing and mathematics. When used in conjunction with an IQ test like WISC, it is valuable for determining specific learning disabilities.

Draw-a-person Screening Procedure for Emotional Disturbance (DAP-SPED)(10)*:* This is a screening test to identify children and adolescents with emotional or behavioral problems. A prescribed size of paper is given to the child and he is asked to draw a full human figure. The test has in all 55 signs of emotional disturbance and each one gets a score of emotional disturbance.

Movement Assessment Battery for Children (ABC)(11)*:* This test assesses motor skills in children and consists of body balance, ball skills and manual dexterity. The results are described as an impairment score, where zero score indicates no impairment.

The entire assessment was spread over two days and took approximately 5 hours.

School Performance: Parents were asked to bring in the progress card with marks of the previous final examination. Performance was graded as below average (less than 50% marks), average (50-70% marks) and above average (>70% marks).

Statistical Analysis

Analysis was done using statistical package for social science (SPSS) for windows (version 10.0). The linear association between the normally distributed variables was assessed by Pearson's correlation coefficient, otherwise Spearman correlation coefficient was used. The non-parametric tests like Mann Whitney U test were performed to test the significance of difference between the means of non- normally distributed variables. A two-way multivariate analysis (MANOVA) was performed to test for difference in groups. The test for trend was performed to look for linear trends in the means of some major outcome variables. Simple chi-square test was used to explore the difference between groups. $p < 0.05$ was considered as significant.

Results

We have previously reported the cognitive development of 201 children with birth weight <2000g at the age of 6 years. The cohort has been described in detail in the previous publication(6). Ten children with cerebral palsy / mental retardation were deleted at the beginning of the six year study, as they could not do the complicated tests of cognition. This is a continuation of the same study, and no new enrollment or deletion has been done. One child died due to gastroenteritis in the interim period. Two parents refused permission for further assessment and eighteen families had moved away during this six-year period. So this communication describes the cognitive development of 180 children with birth weight less than 2000 g and 90 normal birth weight controls, who have been prospectively followed up since birth for 12 years.

Baseline Data

The birth weight of the study group ranged from 860 to 1999 g with the mean of 1549 ± 242.3. There were 78 children (43.3%) with birthweight <1500g (henceforth referred to as VLBW). There were 102 (56.7%) children with birthweight between 1500-1999g. The study group had 73 females and 107 males and the control group had 35 females and 55 males.

The group had 33 (18.8%) full term children. whereas the rest of 147 (81.2%) were preterm. There were 27 (15%) children with gestational age £ 32 weeks, 70 (38.8%) with a

gestation of 33-34 weeks, 50 (27.7%) children with a gestation of 35 -36 weeks. Out of the 147 preterm infants, almost half (*n* = 74) were appropriate for gestational age (AGA) and the rest (*n* = 73) were small for gestational age (SGA). Five children had hearing impairment and three children had seizure disorder. One child had stuttering speech and one had dyslalia. One child was operated for congenital cataract, three had myopia and five children had squint. The study and the control group was well matched for socio-economic status.

Cognitive Assessment

Weschler's Intelligence Scale (R): The frequency distribution of the mean intelligence quotients of the study group and controls is shown in *Table I and Fig. 1*. The verbal IQ was uniformly poor in the whole study group. The preterm SGA group had the lowest mean IQ score (85.4 ± 17.7),which was significantly less than that of controls (p <0.001). The preterm AGA and full term SGA children performed much better and had IQs in the nineties. In the 78 VLBW children, there were 12 (15.4%) children who were mentally retarded (IQ <70), compared to only 3 (3.3%) in the control group and this difference was highly significant (p <0.001). There were only 3 (3.8%) 'bright' (IQ >110) children compared to 20 (22.2%) in the control group and this difference was highly significant (p <0.001). The study group had poorer scores on all subtests (p <0.05), except picture completion test when compared with controls.

Bender Gestalt Test: The study group had 84 (46.6%) children with visuo-motor age less than 9 years as compared to 27 (30%) in the control group (p <0.001). There were 42 (23.3%) children with age appropriate visuo-motor perception, compared to 43 (47.8%) in the control group (p <0.000).

TABLE I– *Distribution of IQ (WISC-R) at 12 years*

Intelligence quotient		Study group (n = 180) n (%)	Controls (n = 90) n (%)
50-69	(Retarded)	24 (13.3)**	3 (3.3)
70-84	(Borderline)	44 (24.4)	14 (15.6)
85-109	(Normal)	93 (51.8)	53 (58.9)
³110	(Bright)	19 (10.5)**	20 (22.2)

** P = < 0.001

Wide Range Achievement Test (WRAT): The reading skills did not show any significant difference between the two groups. On the whole, the writing skills of the study group were poorer than that of the controls. Out of 180 children, 33 had (18.3%) poor writing skills, compared to 6 (6.7%) among controls (p <0.01). Amongst the VLBW children, twenty five percent of the children had poor writing skills (p <0.001). Preterm (22.7%) children with gestation <32 weeks showed difficulty in writing compared to controls (p <0.05).

The mathematics skills of the study group and control group were compared (*Table II*). The study group had a mean score of 82.7 ±

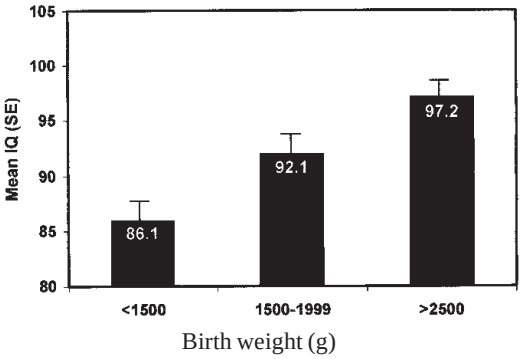

Fig. 1. Intelligence quotients (IQ) according to birth weight.

TABLE II–*Comparison of mathematics score (WRAT)*

Group	N	Mathematics Score Mean (SD)
All LBW	180	82.7 (16.9)*
Birthweight <1500g	78	80.4 (15.1)**
Birthweight 1500-1999g	102	84.4 (17.9)
Preterm SGA	73	81.6 (18.0)*
Full term SGA	33	82.7 (16.2)
Preterm AGA	74	83.7 (16.1)
Controls	90	87.8 (15.8)

* $p < 0.05$, ** $p < 0.001$;
AGA - Appropriate for gestational age;
SGA - Small for gestational age.

16.9, which was significantly less ($p < 0.05$) than that of the control group (87.8 ± 15.8). When the scores were compared according to birth weight categories, the VLBW children had a significantly ($p < 0.01$) lower score of 80.4 ± 15.1. Similarly, when weight for gestation categories were compared, the preterm SGA children had a score of 81.6 ± 18.0, which was significantly lower than that of controls ($p < 0.05$).

Movement Assessment Battery for Children (ABC Test): The motor impairment score was expressed as median impairment score (interquartile range). The whole study group had a median score of 9.8 (0-18) compared to a median of 7.3 (0-17.5) in controls. This difference was significant ($p < 0.001$). When the boys from the study group (median 8, range 0-30) were compared with boys from the control group (median 6, range 0-17.5), the difference was significant. Similarly, when girls from the study group (median 12, range 0-31) were compared to those from the control group (median 9.5, range 0-18), the difference was significant (0.019).

The performance of girls and boys was compared in the three subtests of body balance, ball skills and manual dexterity. In ball skills and body balance, the girls performed very poorly ($p < 0.000$). It was only in manual dexterity, that the girls seemed to perform better, with borderline difference ($p < 0.052$) compared to boys.

Draw a person test for emotiona1 disturbance: Amongst the control children, 30 (32.7%) children showed emotional instability as compared to 70 (42.9%) in the study group. However, this difference was not statistically significant.

School Performance: Most of the children were studying in the seventh standard and marks obtained in the previous year's final examination were considered. Amongst the study group, seven children gave a history of repeating a grade, whereas one control child had a failure. The academic performance of the two groups is shown in *Table III*.

The number of children with below average academic performance were significantly more in the study group ($p < 0.05$). A good academic performance was seen in significantly higher number in the control group. There was a strong association between academic performance and IQ. The mean IQ rose from 82.4 ± 14.2 in those obtaining <50% marks to 103.0 ± 14.9 in those with >70% marks.

Discussion

This study is a continuation of the six year follow up study with no additions or deletions. As reported earlier(6), ten children with cerebral palsy / mental retardation had already been excluded at the beginning of the 6 year study, as they could not perform the complicated tests of cognition.

Attention has recently been focussed on the long term outcome of VLBW children. There is evidence that despite their lack of

TABLE III–*Academic performance of LBW children*

	Grade repetititon	Below average (< 50% marks)	Average (50-70% marks)	Above average (>70% marks)
LBW (n= 166)	7 (3.8%)	36 (21.5%)*	90 (54.9%)	33 (19.8%)*
Controls (n = 90)	1 (1.2%)	9 (10.8%)	44 (53.0%)	29 (34.9%)

* $p < 0.05$

major neurodevelopmental problems, they are failing to match the performance of their peers in a number of areas(12). These areas include educational achievement, particularly reading and mathematical skills, social integration and motor skills.

This study began in 1987, when we were not ventilating neonates. Hence there are only three infants weighing <1000 g. However, we had 78 VLBW neonates, out of which 53 were small for gestational age. The mean IQ of the entire LBW group was much lower (89.5 ± 16.9) than the control group (97.2 ± 14.1), though it was within normal limits. This finding has been reported by several authors(13-15), especially in VLBW children. Our VLBW children had a mean IQ of 86.1 ± 14.5, which was just within normal limits, but significantly lower than that of controls and that of children with birth weight between 1500 to 1999 g. The preterm SGA children fared the worst with a mean IQ of 85.4 ± 17.7, which was much lower than that of preterm AGA and full term SGA group. The double biological risk factors of prematurity and intrauterine growth retardation seemed to have the worst effect on intelligence. The incidence of "borderline intelligence" was 24.4%. In the Scottish low birth weight study, the incidence was 28.5%(16). There are no Indian figures available to compare this incidence. This has risen from our previous reported figure of 13.4 at 6 years(6). The number of children with mental retardation (IQ <70) has also risen from the previous reported incidence of 3.5% to 13.3%(6). Also, there were less number of children with above average intelligence or "bright" in the low birth weight population compared with controls. The subtests of WISC showed that children from the study group showed low scores in all areas except the picture completion test, a test, which needs a low level of intelligence.

Visuo-motor perception was poor in the study group. Visuo-motor perception is very important for reading and writing. In these children, the letters tend to collide with one another and they are formed in strange ways. They cannot write on a straight line, cannot color within a figure, cut and paste. All these problems affect their academic performance. Poor visuo-motor perception has been reported in ELBW children by Saigal(17). The Wide Range Achievement test was done to identify specific learning disabilities. The reading skills did not show any difference between the study and control group. Reading problems have been reported by other authors (18). The writing skills of VLBW children and preterm children with gestation less than 32 weeks were particularly poor. The mathematical skills of all the 190 children were poor when compared with controls, the VLBW and preterm SGA group fared the worst ($p < 0.05$). Poor mathematical skills in VLBW children has been reported by Low(19).

The ABC movement test assesses the qualitative aspect of the child's motor

Key Messages

- The mean intelligence quotient of children with birthweight less than 2000 grams was significantly less than that of controls (birth weight > 2500grams), though within normal limits.
- This group had poor visuo-motor perception, poor motor competence, and writing and mathematics disability.
- Academic achievement was poor compared to controls and 24.4% of the children had "borderline intelligence".
- Preterm small for gestational infants and very low birth infants had the poorest cognition.

performance. It gives a clear assessment of everyday motor competence as there is a complex interaction between cognitive, affective and motor factors. The study group showed motor incompetence compared to controls, when boys were compared with boys and girls were compared with girls. In the subtests, girls fared poorly compared to boys in body balance and ball skills. This is quite understandable, as sports are hardly encouraged in girls in our Indian society. Their performance was somewhat better in manual dexterity, when compared with that of the boys, Powls *et al*.(20) have shown significantly impaired motor performance in VLBW children at 8 years.

The 'Draw a person' test showed no significant difference between the two groups. More emotional problems have been reported in VLBW children by Horwood(13).

The academic performance of the study group was poor compared with controls. There were more failures and more children with below average marks in their examination, and less number of children with a good academic performance. Drillen(12) reported that 50% of children weighing <1360 g were not educable in the normal school system. More recently, Saigal(21) has also reported that a large number of ELBW children needed special education. In India, there is no awareness amongst the school authorities and also parents regarding special education. The city of Pune with a population of 30 lakhs has only two special education schools. Integration in normal schools with special assistance is also not known. Thirty eight percent of children in our cohort had subnormal IQ and will not be able to sustain themselves in the normal school system.

As the children get older, the impact of biological risks at birth decreases and the impact of social and environmental factors assume more importance(22). This aspect of cognitive development will be discussed in another article.

In conclusion, we have shown that children weighing <2000 g have lower IQs compared to controls, though just within normal limits. They have poor visuo-motor perception, poor writing and mathematical skills and motor incompetence. Children with double biological risk factors of prematurity and intrauterine growth retardation and very low birth weight children have poor cognition.

Contributors: SC conceived the project, supervised it and wrote the paper. MO did medical checkups and analysis of data. AC did all the psychological tests. AP supervised the project. MH made home visits and ensured all appointments.

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Competing interests: None.

REFERENCES

1. Laroche J C, Bethmann O, Couchard M. Brain damage in the premature infant: Early lesions and new aspects of sequelae. ltal J Neur Sci 1986; 5 (suppl) : 43-52.
2. Stewart A, Turcan D, Rawlings G. Outcome of infants at high risk of major handicap. Ciba Foundation Symposium 1978; 59: 151-164.
3. Hack M, Fanaroff AA, Merkatz IR. The low birth weight infant: Evolution of changing outlook. N Eng J Med 1979; 301: 1162-1165.
4, Morgan CT, King RA, Weisz JR, Schopler J. Introduction to Psychology. 7th ed New Delhi: Tata Mc-Graw Hill Publishing Co., Ltd, pp 425-426.
5. Chaudhari S, Kulkarni S, Barve S, Pandit A, Sonak U, Sarpotdar N. Neurologic sequelae in high risk infants -a three year follow up. Indian Pediatr 1996; 33: 645-653.
6. Chaudhari S, Bhalerao MR, Chitale A, Pandit A, Nene U. Pune Low Birth Weight Study - A six year follow up. Indian Pediatr 1999; 36: 669-676.
7. Bhatt M C, Patel C N. Weschler's Intelligence Scale for Children (WISC). Adaptation. Jayashree Mudranalaya, Ahmedabad, 1973.
8. Koppitz E M. Bender Gestalt Test for young children. Grune and Stratton, New York, 1963.
9. Jastak S, Wilkinson GS. Wide Range Achievement Test (WRAT) Jastak Associates Inc, Cincinati, 1984.
10. Naglieri J A, Timothy J, McNeish L, Bardos AN. Draw A Person. Screening procedure for emotional disturbance PRO-ED Inc. Austin, 1991.
11. Henderson S E. Sugden DA. Movement Assessment Battery for Children The Psychological Corporation-Harcourt Brace & Co., London. 1992.
12. Drillen C M. The incidence of mental and physical handicap in school age children of very low birth weight. Pediatrics 1961; 27: 452-464.
13. Horwood U, Morgridge N, Darlow BA. Cognitive, educational, and behavioral outcomes at 7 to 8 years in a national very low birthweight cohort. Arch Dis Child Fetal neonatal Ed 1998;79: FI2-F20.
14. Hack M, Flammery D J, Schluchter M, Cartar L, Boraswki E, Klein N. Outcomes in young adulthood for very low birth weight infants. N Engl J Med 2002; 346: 149-157.
15. Hunt J, Cooper BAB, Tooley W. Very low birth weight infant at 8 and 11 years of age: Role of neonatal illness and family status. Pediatrics 1988; 82: 596-603.
16. The Scottish low birth weight study group. The Scottish low birth weight study. I. Survival growth, neuromotor and sensory impairment. Arch Dis Child 1992; 67: 675-681.
17. Saigal S, Szatrnan P, Rosenbaum P, Campbell D, King S. Cognitive abilities and school performance of extremely low birth weight children and matched term control children at age 8 years: A regional study. J Pediatr 1991; 118 : 751-760.
18. Hunt N, Tooley WH, Harvin D. Learning disabilities in children with birth weight <1500 g. Semin Perinatol 1982; 6: 280-287.
19. Low J A, Handley-Derry M H, Berke S O, Peters D, Pater E A, R N Killen HL, et al. Association of intrauterine fetal growth retardation and learning deficits at age 9 and 11 years. Am J Obstet Gynecol 1992; 167: 1499-1505.
20. Powls A, Botting N, Richard WI, Cooke, Marlow N. Motor impairment in children 12 to 13 years old with a birthweight of less than 1250g. Arch Dis Child 1995; 73: F62-F66.
21. Saigal S. Follow up of very low birth weight babies to adolescence. Semin Neonatol 2000; 5: 107-118.
22. Strauss RS, Dietz William. Growth and development of term children born with low birth weight: Effects of genetic and environmental factors. J Pediatr 1998; 133: 67-72.