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Developmental Course of Very Preterm Children in Relation to School Outcome

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Objective: Developmental course of preterm and term children is studied within a prospective longitudinal design in relation to school outcome at 10 years of age. Methods: Differences between the term and preterm children were studied in somatic, neuro- motor, cognitive and socio-emotional development. In addition, comparisons were made concerning the developmental course of the subgroup of preterm children attending age appropriate school classes at 10 years of age, and the subgroup of preterms that showed school problems, reflecting a history of grade retention or attendance of special education school. Results: Term and preterm children differed in all developmental domains. The subgroup of preterms without school problems is characterized by less serious neonatal difficulties, better drinking capacities in the first month, faster early head growth and better early mental and motor development. Cognitive developmental course gradually diverged during the first two years between the preterm subgroups and seemed to stabilize thereafter.

KEY WORDS: prematurity; developmental course; school outcome.

Very preterm children are at risk for problems in somatic, neuro-motor, cognitive, and socio-emotional development (Wolke, 1998), especially those with extremely low birth weight (Taylor *et al.*, 2000) or very short term

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gestational ages at birth (Marlow *et al.*, 2005). However, not all preterms experience difficulties, and preterm children without disabling developmental problems are found in every study. In what way and how early such normal developing preterms can be identified and distinguished from the preterm children that experience enduring sequelae is unclear (McCormick, 1997). Perinatal risk factors are related to outcome, especially early brain abnormalities (Peterson *et al.*, 2000). However, even children with clear morphological brain damage as seen in abnormal neonatal ultrasound brain scans, have been found to show normal development (Van Baar *et al.*, 2005). The same study also showed that several preterm children without abnormal neonatal ultrasound brain scans were found to develop multiple disabilities. Many questions still remain concerning developmental patterns of preterm children and the factors or processes involved. One question concerns the extent to which the developmental course of preterm born children with outcomes within the normal variation resembles developmental patterns of term children. Are catch up processes involved, or does such a preterm subgroup never show any developmental delay at all? What indications can be found for important beneficial factors or adaptation and compensation processes in such preterm children that develop without severe problems? Prospective longitudinal and multidisciplinary studies comparing preterm and term children on frequent measurement points within several developmental domains can clarify the course of development as well as the factors that are associated with such favourable outcome within the preterm group.

We conducted a prospective longitudinal and multidisciplinary study of a group of preterm children and a term comparison group in somatic, neuromotor, cognitive and socio-emotional development, including several interaction observations, over their first $5^1/_2$ years and a follow up at 10 years. As a final outcome school level at 10 years of age was chosen. A school level appropriate for age at 10 years implies satisfactory cognitive functioning and in general also sufficient social, behavioral and motor capacities up until that age. In this paper the differences between the preterm and term group in the main developmental domains are described, as well as the developmental course and the characteristics of the subgroup of preterm children without school problems compared to that of the preterm subgroup that shows school problems at 10 years of age.

METHOD

Participants

The selection criteria for the preterm children consisted of a gestational age less than 32 weeks with an appropriate birth weight, from Dutch

Table I. Characteristics of the Groups and Subgroups

	Term group	Preterm group	School okay	School problems
Number of subjects	35	38	15	19
Mean gestation (*SD*), weeks,	39.7 (1.0)	28.6 (1.7)*	29.1 (1.6)	28.2 (2.0)
Range	38–42	25–31	25–31	26–31
Mean birth weight (*SD*),	3403 (414)	1291 (319)*	1432 (374)	1212 (264)*
grams, range	2550–4570	800–2090	820–2090	800–1710
Neonatal complications	–	9	7	10
(median), Range	–	3–15	3–14	4–15
Ventilation, n (%)	–	11 (29%)	2 (13%)	8 (42%)*
IVH < 3, n (%)[a]	–	6 (16%)	1 (7%)	5 (26%)
IVH > 2,n (%)[a]	–	3 (8%)	1 (7%)	2 (11%)
Number of boys	15 (43%)	21 (55%)	9 (60%)	11 (58%)
White children	30 (79%)	30 (79%)	10 (67%)	17 (90%)
SES (median)	7	8	8	8
Range	3–15	4–15	4–15	4–12
Mothers' educational level				
Primary level	2 (6%)	5 (9%)	1 (7%)	2 (11%)
Secondary level	27 (77%)	29 (76%)	11 (73%)	16 (84%)
Tertiary level	6 (17%)	4 (11%)	3 (20%)	1 (5%)

Note. Differences in mean scores and proportions between the 3 groups are analyzed using *t*-tests or Chi-square test.
[a] Papile, Munsick-Bruno and Schaefer, 1983.
*$p < .05$.
**$p < .01$.
***$p < .001$.

or Surinam/Antillean background living in Amsterdam or in the neighborhood. Multiplets and infants with congenital malformations were excluded. For the comparison group term children without perinatal problems from the same background as the preterm children were acquired through midwives, while multiplets and infants with congenital malformations were also excluded.

No significant differences existed between the preterm and term groups in gender, ethnic origin and SES or more specifically educational level of the mothers, see Table I. The groups obviously did differ in gestational age, birth weight and neonatal complications. The subjects were born between December 1982 and August 1985.

Informed consent of the parents for the longitudinal study was obtained before the first measurement and once again before the examinations at the age of ten years. This study was approved by the Committee of Medical Ethics of the Academic Medical Centre of Amsterdam.

Measures

A socio-economic status score (SES) was based upon scales for education of the mothers, professional level of the fathers and family income

that all were assessed in five categories. In total this SES score could range from 3 (low) to 15 (high). In addition, a neonatal complications score was made based on eight types of neonatal problems or specific treatments. In three categories (0–2) was summarized if a problem or treatment had been absent, present or serious, concerning respiratory problems, infections, metabolic disorders, convulsions, bilirubine, feeding, temperature and assistance needed for respiration.

Assessments in the domain of somatic development consisted of repeated measurements of growth parameters concerning weight, height and head circumference and health evaluations by a pediatrician. The children were seen at the (corrected) ages of 3, 6, 9, 12, 18, 24, 30 months, at $3^1/_2$, $4^1/_2$, $5^1/_2$ and at 10 years. A specific examination of vision was done at four years by an eye-specialist and at five years an audiogram was made.

Regarding neuro-motor development, neuro-physiological measures as well as neurological examinations and assessments of motor functioning were done. An electro-encephalogram was assessed at term age and at 12 months by an experienced clinical neurophysiologist. Neurological examinations were done by a child neurologist, who used at term age the Dubowitz examination, scoring obvious poor responses (Dubowitz and Dubowitz, 1981; Van Baar *et al.*, 1989). At 6 and 12 months the examination according to Touwen (1976) was used. Early motor functioning was assessed with the Dutch version of the Bayley motor scale by developmental psychologists at 6, 12, 18, 24 and 30 months (Van der Meulen and Smrkovsky, 1983). The Bruininks-Oseretsky tests was done by the neurologist when the children were five years of age (Bruininks, 1978). At ten years a pediatrician assessed minor neurological dysfunctions (MND) according to Touwen (1979).

Cognitive development was examined by developmental psychologists using age appropriate standardized tests. Mental functioning was examined with the Dutch version of the Bayley scale at 6, 12, 18, 24 and 30 months (Van der Meulen and Smrkovsky, 1983). At preschool age cognitive development was assessed using the Snijders-Oomen nonverbal intelligence test (SON) at $3^1/_2$ years (Snijders and Snijders-Oomen, 1975). At four years the Dutch version of the Reynell language comprehension and expression scales was done (Bomers and Mugge 1982; Reynell and Huntley 1985). At $4^1/_2$ and $5^1/_2$ years the short version of the revision of the Amsterdam intelligence test for children (RAKIT) was done (Bleichrodt *et al.*, 1987). Finally at 10 years the Dutch version of the revision of the Wechsler intelligence scale for children was done by a psychologist blind for perinatal characteristics (Van Haassen *et al.*, 1986).

Socio-emotional development was studied by developmental psychologists. At term age and four weeks later the neonatal behavioral

assessment scale (NBAS) was done, using a deviation from an optimum score (Brazelton, 1973; Van Baar *et al.*, 1989). Also several parent-infant interaction observations were done: at one month during a feeding, at nine months during play according to Riksen-Walraven (1979) and at 18 months during play and dinner according to Clarke-Stewart (1978). Attachment was assessed using the ABC scoring procedure for secure attachment, or insecure-avoidant and insecure-ambivalent attachment behavior (Ainsworth *et al.*, 1978). At 6 and 18 months the home observation and measurement of the environment (HOME) was done (Caldwell and Bradley, 1978). Furthermore, several age appropriate temperament questionnaires were used: at one month the neonatal perception inventory (NPI; Broussard and Hartner, 1971), at nine months the infant behavior questionnaire (IBQ; Rothbart, 1981), at 18, 24 and 30 the Werry-Weiss-Peters activity questionnaire (Werry *et al.*, 1966), and at four years the emotionality, activity, sociability, impulsivity (EASI) questionnaire (Buss and Plomin, 1975). Behavior problems were assessed using the Dutch version of the child behavior checklist (CBCL) at $4^1/_2$, $5^1/_2$ and 10 years (Verhulst *et al.*, 1996; Achenbach, 1991a) and the teacher report form (TRF) at 10 years (Verhulst *et al.*, 1997; Achenbach, 1991b). A personality assessment was made when the children were 5 years by both parents and the teachers using the California Child Q-sort procedure (CCQ; Block and Block, 1980; Van Lieshout *et al.*, 1986). At 10 years, a child psychiatrist interviewed parents and children assessing presence of DSM IV diagnoses (American Psychiatric Association, 1994).

As a final outcome measure school situation at 10 years was used. Normal functioning at an age appropriate level in mainstream education was distinguished from school problems, such as grade retention or the attendance of special education.

Examinations of the preterm children started at term age and were done at the ages corrected for the number of weeks prematurity, except at ten years. Appropriate training or inter rater reliability assessments for all neuro-motor and psychological measurements were done before the examinations started.

Statistical Analyses

The report of the analyses concerning differences between the term and preterm group is focused upon the most frequently repeated measures in the four domains. Growth parameters are reported in relation to somatic development, Bayley motor development scores concerning the neuro-motor domain, Bayley mental developmental quotients and

intelligence quotients of the SON, RAKIT and WISC regarding the cognitive domain and the CBCL behavior problem assessments by the parents reflecting the socio-emotional domain in development.

For the statistical analyses of the data on height, weight, and head circumference, the total scores of the intelligence tests and the behavior problems questionnaires, the BMDP 5 V program for the analyses of variance of repeated measurements was used, as it allows inclusion of cases with incomplete data (Schluchter, 1988). These analyses result in a Wald chi square concerning a main group effect and an interaction effect evaluating a group and time effect. The missing values in these analyses were substituted on a first order autoregressive model (AR1), which assumes that correlations between measurements decrease as the measurement times become farther apart.

Comparisons between the preterm subgroups according to age appropriate school functioning or not at 10 years were also done for all measurements separately, using multivariate and univariate analyses of variance, Student's *t*-test, the Mann Whitney *U* or chi-square tests when appropriate. The results of drop outs and of handicapped children were used in the analyses whenever the examinations had been done properly, according to the demands of the tests.

RESULTS

Participants

At the age of 10 years, parents of 34 preterm and 34 term children could still be contacted and they gave at least information on school situation. Three preterm children were lost and one preterm girl had died of cot death at the corrected age of three months. Five of the 34 preterm children (14,7%) had a severe handicap, varying from two with cerebral palsy, two with hearing difficulties and one generally retarded child.

Differences between Preterm and Term Children

Overall group differences between term and preterm born children, to the disadvantage of the latter, were found for repeated measures over their first 10 years in all four developmental domains; somatic, neuromotor, cognitive and socio-emotional development. Concerning growth parameters corrected for sexe and ethnic background and age since term date, differences were found in weight (main effect $\chi^2(1) = 8.74$, $p < 0.01$; interaction effect $\chi^2(10) = 12.10$, $p = 0.28$) and height (main effect

$\chi^2(1) = 6.23$, $p = 0.01$; interaction effect $\chi^2(10) = 13.3$, $p = 0.21$), but not in head circumference (main effect $\chi^2(1) = 1.71$, $p = 0.19$; interaction effect $\chi^2(10) = 13.9$, $p = 0.18$).

Early motor development assessed with the Bayley scales showed a group difference (main effect $\chi^2(1) = 6.41$, $p < 0.05$; interaction effect $\chi^2(4) = 8.15$, $p = 0.09$). Univariate analyses of these measurements with *T*-tests showed that the groups differed significantly at 12 months, T(66)3.45, $p < .01$ (preterm group: mean = 102, $SD = 20.2$, $n = 35$; term group mean = 119, $SD = 20.0$, $n = 33$) and at 18 months T (67)1.96, $p = .05$ (preterm group: mean = 102, $SD = 24.6$, $n = 36$; term group: mean = 113, $SD = 19.2$, $n = 33$).

In addition, a group difference was found in cognitive development that gradually became more clear over the first two years and stabilized later on (main effect $\chi^2(1) = 18.6$, $p < 0.001$; interaction effect $\chi^2(8) = 15.8$, $p < 0.05$). Univariate analyses of these measurements with *T*-tests showed that the groups differed significantly according to the Bayley mental scale at the corrected age of 12 months, T(66)3.45, $p < .01$ (preterm group: mean = 98, $SD = 21.7$, $n = 35$; term group mean = 115, $SD = 16.9$, $n = 33$), 24 months T (67)2.26, $p < .05$ (preterm group: mean = 88, $SD = 24.4$, $n = 35$; term group: mean = 99, $SD = 16.1$, $n = 34$) and 30 months T(62)2.41, $p < .05$ (preterm group: mean = 88, $SD = 23.5$, $n = 30$; term group: mean = 102, $SD = 20.4$, $n = 34$), as well as according to the SON nonverbal intelligence test at the corrected age of $3^1/_2$ years, T(58)3.44, $p < .01$ (preterm group: mean = 97, $SD = 17.6$, $n = 32$; term group: mean = 109, $SD = 11.1$, $n = 35$); at the RAKIT at $4^1/_2$ years of corrected age T(59)2.16, $p < .05$ (preterm group: mean = 94, $SD = 17.6$, $n = 30$; term group: mean = 103, $SD = 14.6$, $n = 31$); and at the WISC at 10 years of age, see Table II. The preterm children had most difficulties with tasks that evaluate performance capacities and logical reasoning. No group differences are found in tasks to assess memory capacities and factual knowledge.

Concerning behavior problems as measured with the CBCL at the children's age of $4^1/_2$, $5^1/_2$ and 10 years, a group difference was found in externalizing behavior (main effect $\chi^2(1) = 7.10$, $p < 0.01$; interaction effect $\chi^2(2) = 1.17$, $p = .56$), but not in internalizing behavior problems (main effect $\chi^2(1) = 0.08$, $df = 1$, $p = .77$; interaction effect $\chi^2(2) = 2.04$, $p = .36$), nor in the total behavior problem score (main effect $\chi^2(1) = 1.91$, $p = .17$; interaction effect $\chi^2(2) = 1.23$, $p = .54$). Analyzing the measurements for each age separately, *T*-tests showed significant group differences at $4^1/_2$ years of age: for the total behavior problem *t*-score T(63)2.16, $p < .05$ (preterm group: mean = 52, $SD = 8.4$, $n = 34$; term group mean = 49, $SD = 5.6$, $n = 31$); and externalizing behavior problems

Table II. Results of the WISC-R at 10 Years

	Term: 30		Preterm: 28		School okay: 12		School problems: 16	
Group: number	Mean	*SD*	Mean	*SD*	Mean	*SD*	Mean	*SD*
Total IQ	104	12,6	94**	14,4	101	11,7	88*	13,6
Verbal IQ	102	12,0	94	15,2	104	12,9	89**	13,6
Performal IQ	106	13,6	93**	15,2	98	13,7	90	15,7
Information	10	2,3	9	3,6	11	3,9	9	3,1
Similarities	11	2,6	9**	2,8	10	2,5	9	2,9
Arithmetic	11	2,2	8**	2,7	10	2,6	7**	2,2
Vocabulary	10	2,3	10	3,2	11	2,9	9	3,2
Comprehension	10	2,2	10	2,8	12	2,2	9	2,6
Digit span	10	3,2	9	2,7	11	2,8	8**	1,8
Picture completion	11	2,4	9*	3,2	9	3,1	9	3,3
Picture arrangement	12	2,4	10**	2,4	10	1,6	9	2,8
Block design	10	2,4	8*	3,1	9	2,8	8	3,3
Object assembly	10	3,1	8**	2,6	8	2,6	7	2,6
Substitution	10	2,5	9	3,6	11	3,5	8**	3,1
Mazes	11	2,2	10*	2,2	10	2,1	10	2,4

NB Preterm group compared with term group; school okay (preterm subgroup) compared to school problems (preterm subgroup).
*$p < .05$, analyses of variance.
**$p < .01$, analyses of variance.

T (2.75), $p < .05$ (preterm group: mean = 54, $SD = 9.8$, $n = 34$; term group mean = 49, $SD = 5.5$, $n = 31$). At $5^1/_2$ years of age significant group differences were only found for externalizing behavior problems T (57)2.48, $p < .05$ (preterm group: mean = 52, $SD = 9.8$, $n = 32$; term group mean = 47, $SD = 7.4$, $n = 31$), whereas at 10 years of age no significant differences were seen any more. The child psychiatrist diagnosed at 10 years Attention Deficit Hyperactivity Disorder (ADHD) in 9 (32%) of 28 preterm and in 2 of 27 (7%) term children, $\chi^2(1) = 5.83$, $p = .016$. No group differences were found in other psychiatric diagnoses.

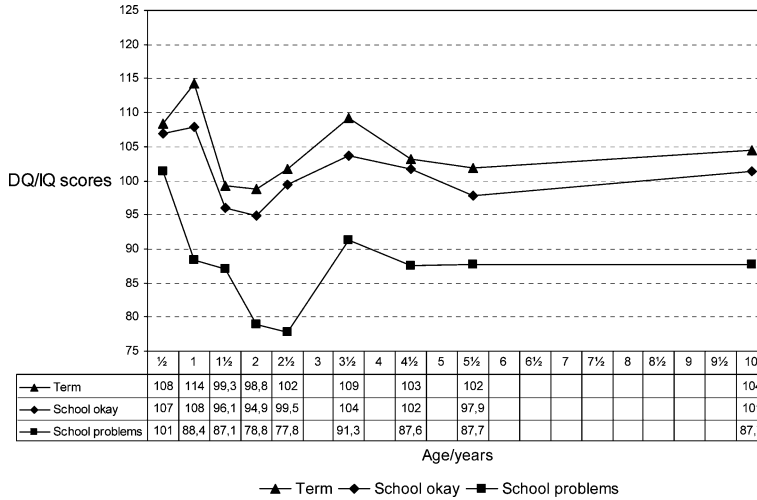
School Outcome at 10 Years of Age

A clear group difference was seen in school functioning as reported on 34 term and 34 preterm children by the parents. In the term group three children (9%) had repeated a grade and one child (3%) needed special education, whereas more than half of the preterm group was found to have difficulties at school: 11 (32%) needed special education and 8 (24%) had repeated a grade. Some children, who had no school problems, were found to have other difficulties. Within the term group one of the two children that were diagnosed with ADHD was in an age appropriate class and two term children at the age appropriate school level were found to have a WISC IQ of 84. Within the preterm subgroup without school problems, three children were diagnosed with ADHD and one other had a WISC IQ of 78, i.e. more than one standard deviation under the mean. All children with severe disabilities had school problems, according to our operationalization.

Comparison of Preterm Subgroups with or Without School Problems at 10 Years of Age

The preterm subgroup without school problems consisted of 15 (44%) children that were at regular elementary schools in grades expected for their age. Within this subgroup 12 children could be examined with the WISC, which showed a mean IQ of 101 (*SD* 11.7), whereas the 16 examined children with school problems, had mean IQ of 88 (*SD* 13.6), $T(28)2.80$, $p = .01$. These subgroups differed to the disadvantage of the subgroup with school problems on the WISC verbal IQ as in the subtests arithmetic, digit span and substitution, see Table II.

Looking backwards at the mental and cognitive assessments, we found that these subgroups related to school functioning at 10 years of age, clearly differed in their developmental course; (main effect $\chi^2(1) = 14.7$, $p < 0.001$; interaction effect $\chi^2(8) = 16.1$, $p = 0.04$). These preterm subgroups differed



	½	1	1½	2	2½	3	3½	4	4½	5	5½	6	6½	7	7½	8	8½	9	9½	10
Term	108	114	99,3	98,8	102		109		103		102									104
School okay	107	108	96,1	94,9	99,5		104		102		97,9									101
School problems	101	88,4	87,1	78,8	77,8		91,3		87,6		87,7									87,7

Fig. 1. Cognitive development: BSID, SON, RAKIT, WISC.

already by 12 months of age and diverged mainly during the first two years, see Figure 1. Univariate analyses showed significant differences at 12, 24, and 30 months corrected age and at $3^1/_2$ and $4^1/_2$ years of age as well: (12 months: $T(31)2.83$, $p < .01$ (school okay group: mean = 108, $SD = 19.5$, $n = 15$; school problems group mean = 88, $SD = 20.0$, $n = 18$); 24 months T (31)2.13, $p < .05$ (school okay group: mean = 95, $SD = 22.5$, $n = 14$; school problems group: mean = 79, $SD = 20.6$, $n = 18$); 30 months $T(27)2.78$, $p < .05$ (school okay group: mean = 99, $SD = 14.8$, $n = 13$; school problems group mean = 78, $SD = 24.9$, $n = 16$); $3^1/_2$ years ($T(31)2.19$, $p < .05$ (school okay group: mean = 104, $SD = 14.0$, $n = 15$; school problems group mean = 91, $SD = 15.0$, $n = 18$); $4^1/_2$ years $T(26)2.38$, $p < .05$ (school okay group: mean = 102, $SD = 16.9$, $n = 14$; school problems group mean = 88, $SD = 14.6$, $n = 14$).

Developmental course could also be compared on early motor development. The subgroups were also found to differ in early motor development as assessed with the Bayley scales (main effect $\chi^2(1) = 14.7$, $p < 0.001$; interaction effect $\chi^2(8) = 16.1$, $p < 0.05$, see Figure 2). A slower motor development was seen from six months onwards in the children with school problems with significant group differences at 12, 24 and 30 months of corrected age (12 months: $T(31)2.22$, $p < .05$ (school okay group: mean = 110, $SD = 13.6$, $n = 15$; school problems group mean = 94, $SD = 23.5$, $n = 18$); 24 months T (29)2.96, $p < .01$ (school okay group: mean = 109, $SD = 13.2$, $n = 14$; school problems group: mean = 90, $SD = 23.8$, $n = 19$); 30 months

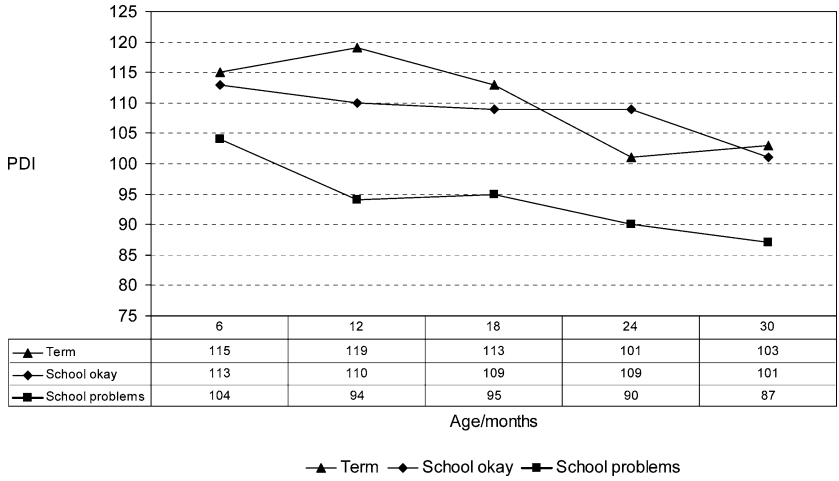
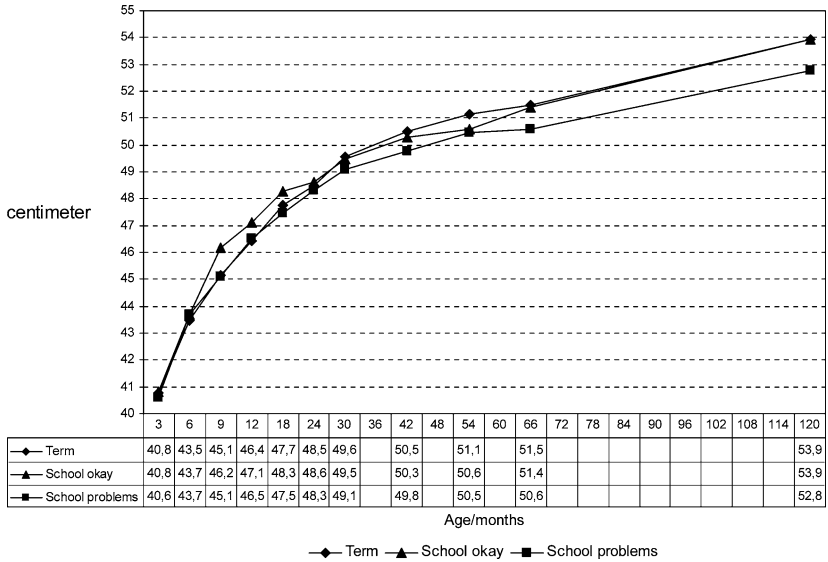


Fig. 2. Motor development according to BSID.

$T(26)2.33$, $p < .05$ (school okay group: mean = 101, $SD = 14.0$, $n = 12$; school problems group mean = 87, $SD = 17.0$, $n = 16$).

Comparison of these preterm subgroups on growth parameters corrected for sexe, ethnic background and age since term date showed main effects in head circumference (main effect $\chi^2(1) = 6.7$, $p < 0.01$; interaction effect $\chi^2(10) = 18.9$, $p = 0.041$; see Figure 3 for a presentation of the mean scores as measured at all ages). No subgroup differences emerged in weight (main effect $\chi^2(1) = 0.89$, $p = .35$; interaction effect $\chi^2(10) = 9.19$, $p = 0.51$) or height (main effect $\chi^2(1) = 1.23$, $p = 0.27$; interaction effect $\chi^2(10) = 33.9$, $p < 0.001$).

In the domain of socio-emotional development, developmental course was followed with three repeated assessments with the CBCL, which showed no subgroup differences in the total amount of behavior problems (main effect $\chi^2(1) = 2.21$, $p = 0.14$; interaction effect $\chi^2(2) = 1.97$, $p = 0.37$), internalizing (main effect $\chi^2(1) = 0.76$, $p = 0.39$; interaction effect $\chi^2 = 2.8$, $df = 2$, $p = 0.24$) or externalizing difficulties (main effect $\chi^2(1) = 0.89$, $p = 0.35$; interaction effect $\chi^2(2) = 1.35$, $p = 0.51$). Further analyses in this domain showed that at five years the teachers ascribed better problem solving capacities with the CCQ to the subgroup without school problems ($F(1,27) = 12.6$, $p < .01$); no differences were found with the CCQ regarding emotional control nor in assessments of the mothers or fathers. The temperament questionnaires answered at younger ages, showed no subgroup differences. The only one of the interaction observations that showed a significant subgroup difference was the observation during a



	3	6	9	12	18	24	30	36	42	48	54	60	66	72	78	84	90	96	102	108	114	120
Term	40,8	43,5	45,1	46,4	47,7	48,5	49,6		50,5		51,1		51,5									53,9
School okay	40,8	43,7	46,2	47,1	48,3	48,6	49,5		50,3		50,6		51,4									53,9
School problems	40,6	43,7	45,1	46,5	47,5	48,3	49,1		49,8		50,5		50,6									52,8

Fig. 3. Head circumference.

feeding at one month ($F(1,32) = 4.35$, $p < .01$); the children in the subgroup without school problems showed less motility and their mothers responded less frequently to them. They also had a shorter duration of their feeding, ($T(32)3.25$, $p < .01$), see Table III. See appendix for all measurements and comparisons done.

Finally, regarding background characteristics was found that the preterm subgroup with school problems had had more perinatal difficulties than the subgroup without school problems, with a significantly lower birth weight and more children needing ventilation see Table I. No other subgroup differences were found in perinatal characteristics.

DISCUSSION

This study clearly shows differences between very preterm and term children in the domains of somatic, neuro-motor, cognitive and socio-emotional development during their first 10 years of life. A small number of preterm children show a severe disability. Concerning physical development, the preterm children are somewhat lighter and shorter than the term children are. The preterm group shows delay in early motor development compared to the term group. In cognitive development, the preterm group

Table III. Behavior During a Feeding at one Month Corrected Age

Mothers	Term $N=34$ Mean (*SD*)	Preterm $N=38$ Mean (*SD*)	School okay $N=15$ Mean (*SD*)	School problems $N=19$ Mean (*SD*)
Touching	1.64 (2.64)	2.55 (2.73)	2.81 (3.46)	2.19 (2.09)
Talking	3.25 (2.75)	5.30 (3.43)**	5.99 (3.61)	4.75 (3.50)
Touching and talking	.28 (.38)	.62 (1.72	.61 (1.71)	.59 (1.21)
Change of baby's posture	.39 (.30)	.56 (.47)	.68 (.59)	.46 (.37)
Nipple out of mouth	.37 (.37)	.54 (.55)	.68 (.65)	.38 (.40)
Nipple in mouth	.46 (.48)	.62 (.80)	.88 (1.16)	.41 (.36)
Stimulation with nipple	.74 (1.21)	.70 (1.05)	.50 (.56)	.69 (1.16)
Responsivity[c]	9.85 (4.14)	11.31 (3.53)	9.93 (3.53)	12.53 (3.25)*
Infants				
Movements	1.43 (1.90)	.96 (1.05)	.33 (.54)	1.56 (1.09)**
Vocalisation	3.12 (2.86)	7.20 (7.07)**	7.31 (7.41)	7.00 (6.97)
Pause drinking	5.56 (1.85)	4.58 (2.31)	4.48 (2.58)	4.76 (2.34)
Duration of feeding (sec)	926 (343)	854 (331)	693 (234)	1011 (317)**

[a] Multivariate analysis of variance $F(1,32)=2.08$, $p=.035$.
[b] $F(1,32)=4.35$, $p=.002$.
[c] Responsivity: mother's behavior following the baby's within 5 s. Inter-observer agreement between two raters who indicated precoded behavior categories for every 5 s, was above .70 for all variables, as measured by the end of a training period.
*$p<.05$.
**$p<.01$ univariate analysis of variance.

gradually diverges from the term group during the first three years and this difference seems to stabilize later on. More externalizing behaviors were seen in the preterm children than in the term children, reflecting a difference in socio-emotional development.

Within the preterm group, however, important subgroups were found. At the age of 10 years slightly less than half of the preterm group, born more than two months too soon, are still in a regular elementary school class appropriate for age. This subgroup shows several differences in development from the subgroup of preterm children with school problems that need special education or repeated a grade by that age. Concerning developmental course an important finding is that the subgroup without school problems shows a cognitive developmental pattern that is comparable to that of the term group, although consistently, but non-significant, slightly lower mean DQ and IQ scores are found. Specifically for the subgroup with school problems, a gradual increase in cognitive delay is found in the first three years. During the preschool and later years, this delay seems to stabilize. Teachers of the subgroup of preterm children without school problems at 10 years of age gave, when they were five years of age, better assessments for their problem solving capacities. No other subgroup differences were found concerning behavior problems or temperament questionnaires. Early motor development in the first three years of the subgroup without school problems was also better than that of children with school problems. In growth parameters, one important subgroup difference was seen. Early head growth of the preterm subgroup without school problems showed a catch up process during the first 18 months, whereas the other subgroup with school problems had means comparable to those of the term children during the first 18 months. A divergence showing slower head growth in the subgroup with school problems appears around $3^1/_2$ years. The parent-infant interaction observations at 18, 13, and 9 months showed no subgroup differences, however the observation of a feeding situation at the corrected age of one month, did. Surprisingly perhaps, the mothers in the subgroup without school problems responded less frequently to their preterm children. This interaction pattern may indicate a situation in the subgroup without school problems, where mother and infant concentrate on the feeding and drinking process, and social contact may be secondary, in that the mothers may be careful not to intrude upon their infants drinking efforts. The children in this subgroup without school problems also showed better drinking skills and less motility during feeding that may also indicate better coordination capacities. However, similar differences did not appear in the results of the NBAS, also done at that age. The subgroup without school problems did not differ systematically from the preterm subgroup that had school problems, in assessments reflecting stimulation at home or in charac-

teristics reflecting parent educational levels or SES. These preterm children had experienced less perinatal difficulties than the subgroup identified by school problems at 10 years of age. This concerns number of children that needed ventilation, indicating more lung problems and the associated oxygenation difficulties for the brain. Another difference was found in birth weight, indicating that these preterm children were already experiencing more difficulties during their gestation.

The most important weakness of our study is the small sample and the resulting limitations in power to detect group differences, in that only large effects can appear. For reasons of comparability, it is important that several outcome results of our small group of very preterm children are similar to those of studies on larger samples of mainly very low birth weight (VLBW) children. The number of children who developed a handicap is comparable to the percentages found in other studies, also to the 10% found at ten years in the Dutch Prematurity and Small for gestational age Study (POPS) (Walther *et al.*, 2000). At the age of 9 years, 19% of the POPS children were in special education and of the children in mainstream education, 32% were in a grade below the appropriate level for age and 38% had special assistance (Hille *et al.*, 1994). Concerning growth parameters, other authors also found that very low birth weight children had persisting growth problems in weight, height and head circumference compared to term children (Powls *et al.*, 1996; Hack *et al.*, 2003). In addition, neuro-motor difficulties and cognitive delay have been found frequently (Powls *et al.*, 1995; Buttha *et al.*, 2002). Parent-infant interaction difficulties as well as behavior problems reflecting more activity of the children have been reported in other studies too (Singer *et al.*, 2003; Klebanov *et al.*, 1994). Increased prevalence of ADHD was also reported by other authors, who found that 28% of VLBW children at 12 years versus 9% of control children showed a psychiatric disorder of some type (Botting *et al.*, 1997).

Individual characteristics of the preterm children and their early history of perinatal problems may be more important than the kind of stimulation at home during infancy and toddler age. Although the power of our study using small groups is too little to show more subtle effects, the severe perinatal circumstances of our sample may have overruled other environmental or genetic factors (Koeppen-Schomerus *et al.*, 2000). The importance of socio-economic background factors has been found in low risk preterm children, especially for low birth weight infants with less perinatal problems, who also could benefit from intervention programs (Koeppen-Schomerus *et al.*, 2000; Brooks-Gunn *et al.*, 1994).

Systematic prospective data collection with frequent and multidisciplinary measurements of development in different domains are found to provide a lot of information. It generates a picture of a group of very

preterm children that consists of a substantial number of children that recover from their difficult start in life and are able to function within normal limits. A greater number of preterm children experiences developmental delay and difficulties in functioning often in more than one domain, as has been found in other studies (Van Baar *et al.*, 2005). Prediction on an individual level remains very difficult for the preterm children, whereas the divergence of important subgroups appears already in the second year of life. Intervention efforts therefore need to start at a very young age of the children. Next to the medical intensive care, it should focus at support for recovery of the infants and improvement of basic functional capacities and brain development. The neonatal individualized developmental care and assessment program (NIDCAP) and the infant behavioral assessment intervention program (IBA-IP) based upon the synactive theory of development of Als (1986) are promising examples of such efforts (Als *et al.*, 2004; Koldewijn *et al.*, 2005). Identification of slow or adequate drinking patterns in the first months after term age and slow or increased head growth during the first year and may be important indications of developmental delay or not. For identification of clear difficulties or delay the children and their parents need specific attention. Repeated early standardized developmental tests can identify many of the preterm children that will experience difficulties in functioning or actual disabilities. Further prospective and longitudinal research on large groups of preterm children regarding the evaluation of combined intervention studies is needed.

Knowledge based on group outcomes of children at risk provides guidelines for professionals working with individual cases. For very preterm children developmental problems specifically in the neuro-motor and cognitive domain are to be expected. Identifying for which individual children this actually holds and knowing that not all of these children at risk and their parents have to deal with such outcomes, should inspire the professionals.

APPENDIX

MEASUREMENT PROTOCOL, NUMBER OF INFANTS AND (SUB-)GROUP DIFFERENCES

A = Preterm: School okay
B = Preterm: School problems
C = Preterm: total group
D = Term: total group

Age[a]	Examination	A	B	C	D
Term age	Dubowitz: Neonatal neurological examination (Dubowitz and Dubowitz, 1981)	14	19	37	34*
,,	EEG: Electro-Encephalo-Gram	14	17	35	33*
,,	NBAS: Neonatal Behavioral Assessment Scale (Brazelton, 1973)	15	19	38	35*
,,	Activity: Motility assessed during bath	15	19	38	35*
1 month	NBAS	14	19	37	35*
,,	Activity	14	18	36	35
,,	Interaction: observed during feeding	15	19”	37	34*
,,	Broussard: Questionnaire on perceptions of child (Broussard and Hartner, 1971)	15	18	37	35
,,	Interview on socio-economic background	15	19	38	35
3 months	Activity	14	19	36	34*
,,	Pediatric examination: health and growth	14	19	38	34*
6 months	Touwen: Neurological examination (Touwen, 1976)	15	18	34	35
,,	HOME: Home Observation and Measurement of the Environment (Caldwell and Bradley, 1978)	15	19	37	35
,,	Bayley: The Bayley Scales of Infant Development (Van der Meulen and Smrkovsky, 1983; Bayley, 1969)	15	19	36	35
,,	Activity	15	19	36	35
,,	Pediatric examination	15	19	36	35*
9 months	Temperament: Infant Behavior Questionnaire (Rothbart, 1981)	15	16	31	33
,,	Interaction: observed during play	12	17	32	31*
,,	Pediatric examination	13	17	31	28*
12 months	Touwen	15	18	34	33*
,,	EEG	14	18	34	33
,,	Bayley	15	18”	35	33*
,,	Pediatric examination	15	19	35	35*
,,	SSP: Strange Situation Procedure (Ainsworth *et al.*, 1978)	13	16	31	33
18 months	Bayley	15	19	36	34
,,	HOME	13	19	33	31*
,,	Activity questionnaire: according to the Werry-Weiss-Peters Activity Scale (Werry *et al.*, 1966)	14	17	33	32*
,,	Interaction observation during play and dinner	13	19	32	33*
,,	Pediatric examination	14	17	33	33*
24 months	Bayley	14	19”	35	34*
,,	Activity questionnaire	13	14	27	30
,,	Pediatric examination	14	19	35	34*
30 months	Bayley	13	16”	30	34*
,,	Activity questionnaire	14	14	29	30*
,,	Pediatric examination	12	16	29	33*

Appendix Continued.

Age[a]	Examination	A	B	C	D
$3^1/_2$ years	SON $2^1/_2$-7: Snijders-Oomen Non-verbal intelligence-scale (Snijders and Snijders-Oomen, 1975)	15	18”	35	32*
,,	Pediatric examination	14	17	32	32*
4 years	Reynell: Reynell Developmental Language Scales (Bomers and Mugge, 1982; Reynell and Huntley, 1985)	15	17”	34	32*
,,	EASI: Emotionality, Activity, Sociability, Impulsivity scale; (Buss and Plomin, 1975)	15	16	33	32*
,,	Examination of vision: Method Fooks, Landolt-C, Fly-test	15	17	34	31
$4^1/_2$ years	RAKIT: Revision of Amsterdamse Kinder-Intelligen-tie Test, short form (Bleichrodt *et al.*, 1984)	14	14”	30	31*
,,	CBCL: Child Behavior Check List, (Verhulst, 1985; Achenbach, 1991a)	14	18”	34	31*
,,	Pediatric examination	14	15	33	31*
5 years	Bruininks-Oseretsky: Bruininks-Oseretsky test of Motor Proficiency (Bruininks, 1978)	14	14	29	32
,,	Examination of hearing: audiogram, tympanogram	14	14	29	32
,,	NCKS: Nijmegen-California Kinder-Sorteertechniek (Q-sort, by parents); (CCQ; Block and Block, 1976; Van Lieshout *et al.*, 1988)	15	15	31	32*
,,	NCKS: Nijmegen-California Kinder-Sorteertechniek (Q-sort, by teachers); (CCQ; Block and Block, 1976; Van Lieshout *et al.*, 1988)	15	15”	30	31
$5^1/_2$ years	RAKIT	15	15”	31	31*
,,	CBCL	15	16	32	31*
,,	Pediatric examination	15	14	31	32*
10 years	Wechsler intelligence scale for children (WISC; Van Haassen *et al.*, 1986)	12	16”	28	30*
,,	CBCL	14	17”	31	31
,,	Teacher Report Form (TRF; Achenbach, 1991b)	12	15	27	32*
,,	Psychiatric interview	11	17	28	29*
,,	Minor neurological dysfunction (MND; Touwen, 1979)	12	16	28	27*
,,	Pediatric examination	12	17	29	29

[a] Age corrected for prematurity, except at 10 years; Weeks refers to gestational age, months to (corrected) chronological age.
*Significant group differences between preterm and term children, $p < .05$, two-tailed; “Significant group difference between preterm subgroups, $p < .05$, one-tailed.

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