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Development of bladder and bowel control: significance of prematurity, perinatal risk factors, psychomotor development and gender

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Abstract Development of bladder and bowel control from 6 months to 6 years was investigated in 140 preterm children and a control group of 349 healthy term children. Structured parental interviews and neurodevelopmental assessments were carried out when the child was 1, 3, 6, 9, 12, 18 and 24 months, and at yearly intervals thereafter. Even though preterm children were put on the potty at significantly earlier ages and significantly more frequently than term children, they expressed their need for evacuation and attained day and night bladder and bowel control at the same corrected age as term children. Initiation and intensity of toilet-training were not significantly correlated with the development of bladder and bowel control. Gestational age, being too small for gestational age, adverse perinatal conditions and mild to moderate neurological impairment did not affect the occurrence of the child's initiative and the development of bladder and bowel control. Neither developmental and intelligence quotients at the age of 1 to 3 years nor the socioeconomic status of the families influenced the age at which the child became clean and dry. Girls were significantly more advanced in expressing their needs and gaining bladder and bowel control than boys in both the preterm and term groups.

Conclusion Development of bladder and bowel control is largely a maturational process which cannot be accelerated by an early onset or a high intensity of training. It is not affected by prematurity, adverse perinatal events or mild to moderate neurological impairment, nor is it related to psychomotor development or actual Swiss socioeconomic conditions.

Key words Bladder and bowel control · Toilet-training · Prematurity · Psychomotor development

Abbreviations *AGA* appropriate for gestational age · *SES* socioeconomic status · *SGA* small for gestational age

Introduction

Neuropsychological development has been studied extensively during the last 30 years in preterm children, the

largest high-risk group for developmental disturbances. Neuromotor and intellectual development have been evaluated in a large number of follow up studies [review articles see 18, 20, 21]. The impact of adverse pre-, peri- and neonatal events on growth and development in these

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children has been analysed in detail [14] and various strategies of intervention have been investigated [1,5]. Much less attention has been given to language development [11] and interactive behaviour [19]. Essential aspects of early child development such as social behaviour and autonomy have been studied only sporadically. One important area of autonomic development is that of bladder and bowel control. Even in healthy term children, parents may become anxious if there is a delay in achieving competence. Many parents invest considerable time and effort in getting their children clean and dry.

Only a few studies report on toilet-training and the development of bladder and bowel control in term children [13]. In preterm children, there has just been one study carried out about 40 years ago by Drillien [2]. Our article addresses the following questions regarding the development of bladder and bowel control in preterm and term children:

1. Are preterm children treated differently than term children by their parents with regard to toilet-training?
2. Do age at onset and intensity of toilet-training influence the development of bladder and bowel control?

3. What impact do prematurity, being too small for gestational age (SGA), adverse perinatal conditions and neurological impairment have on the development of bladder and bowel control?
4. Is there a relationship between psychomotor development, socioeconomic conditions, and the development of bladder and bowel control?
5. Are there sex differences in the occurrence of the child's initiative and the development of bladder and bowel control?

Subjects and methods

Subjects

In the Zurich Longitudinal Studies, 140 preterm children and a control group of 349 term children, all of Swiss origin, have been followed from birth to adulthood. The preterm infants were born between October 1974 and September 1978, and the term infants between October 1974 and September 1982. The term and preterm children formed a representative selection of the Swiss urban population, according to the socioeconomic status (SES) of their families (Table 1). During the first 7 years of life, four boys and four girls from the preterm group (6%) and one boy and six girls from the term group (2%) were lost from the study because

Table 1 Perinatal characteristics, neurodevelopmental outcome and socio-economic status (SES) of the study population. (*F* female, *M* male)

	Preterm		Term		<i>P</i> both sexes
	M	F	M	F	
Gestational age (weeks)					
mean	33.9	33.2	39.8	39.7	< 0.001
range	28.7–36.8	27.1–36.8	37.6–42.6	37.1–41.9	
Weight for gestational age					
AGA (%)	84	85	93	93	
SGA (%)	16	15	7	7	
Parity					
mean	1.5	1.6	1.6	1.6	> 0.05
SD	0.7	0.8	0.8	0.7	
Perinatal optimality score (optimum = 90) mean	72	73.1	86.8	87.0	< 0.001
SD	7.1	6.6	3.3	3.2	
range	56–86	60–84	74–90	78–90	
Development quotient (Griffiths)					
12 months mean	98	99	114	116	< 0.001
SD	6.8	6.5	6.7	5.9	
range	80–117	86–119	82–150	89–142	
24 months mean	95	96	115	116	< 0.001
SD	5.4	5.5	6.7	5.9	
range	78–98	82–97	82–150	89–142	
Intelligence quotient (Stanford-Binet)					
4 years mean	106	108	112	114	< 0.05
SD	18.1	17.6	4.7	3.9	
range	58–150	62–142	83–100	86–100	
Cerebral palsy					
<i>n</i>	16	5	0	0	
SES					
(optimum = 12) mean	7.3	6.9	7.4	7.6	> 0.05
SD	2.7	2.0	2.3	2.4	
<i>n</i>	82	58	175	174	

of lack of interest (seven), migration (five), adoption (two) and death (one).

Perinatal characteristics and neurodevelopmental outcome of the study population are presented in Table 1. Gestational age (estimated within 48 h of birth by the Dubowitz method [3]) in the preterm infants varied between 27.1 and 36.8 weeks, and in the term children between 37.1 and 42.6 weeks. With respect to weight, length and head circumference at birth, both the preterm and term groups were comparable to the Swiss population according to the Swiss perinatal growth standards [10]. Some 15.3% of the preterm infants and 7% of the term infants had a birth weight below the 10th percentile of the Swiss intra-uterine growth chart (SGA). Birth order was comparable in both groups. With respect to perinatal complications such as fetal distress, infection or sepsis, metabolic problems and respiratory difficulties, the preterm infants have to be regarded as a high-risk group; at birth, 83% had respiratory distress and 28% required artificial ventilation. For the term infants, pregnancy and labour were free of complications; delivery was spontaneous and vaginal, with vertex presentation. There was a highly significant difference between the mean perinatal optimality scores of the preterm and term infants ($P < 0.001$) (for definition see methods).

Methods

The children were seen for a comprehensive neurodevelopmental assessment at the ages of 1, 3, 6, 9, 12, 18 and 24 months, and at yearly intervals thereafter (time limits: for the age of 3 to 18 months ± 1 week, for 2 years and above ± 2 weeks). Correction of preterm birth was made by calculating the ages of examination from term. Some 97% of the maximum number of possible examinations were carried out at the appropriate ages.

Structured interviews were performed investigating child rearing practices and the development of bladder and bowel control (for detailed information, see [4] where the complete questionnaires are published). The parents, mostly the mothers, were asked about the initiation of toilet-training, frequency of daily prompting and the child's behaviour expressing his/her need for evacuation by mimic expressions and gestures, going to the toilet, grabbing the potty or verbally. The stage of bowel and bladder control by day and at night observed during the month before each examination was recorded as follows: 0% = no control; 1% to 30% = partial control during approximately one-third of the time; 30% to 70% = control during one-third to two-thirds of the time; 70% to 99% = total control except for a few relapses; and 100% = total control.

Psychomotor development was assessed during the first 2 years by the Griffiths test [6] and at 3 years by the Stanford-Binet test (L-form) [22]. Neurological integrity was judged during the first 2 years by an extensive standardized examination (a modified version of the neurological examination of Prechtl and Beintema [16]).

Non-optimal perinatal conditions were rated by the perinatal optimality score (a modified version of the score by Prechtl [17]). The score included 90 optimal conditions noted during pregnancy, delivery and neonatal period (for details see [12]). SES was defined by means of a 6-point score of both paternal occupation and maternal education. The lowest possible SES score was 2 (lowest status of both paternal occupation and maternal education), and the highest was 12.

Statistical methods

Proportions were calculated for all parameters at the given ages. In two-sample questions, e.g., comparisons between term and preterm group or between sexes, Student *t* tests, Fisher exact tests and non-parametric Mann-Whitney tests were used. Logistic regression with binomial dependent variable and binary or continuous regressors was applied for a more refined global assessment of the significance of group and sex differences and of the effect of certain covariates (for details see [14]). Associations between pairs of variables, e.g.,

SES and daily prompting, were obtained by calculating Spearman correlation coefficients.

Results

The observed proportions for all parameters at any given age are provided in Table 2, for preterm and term children and for both sexes separately. The developmental course of toilet-training, daily prompting, child's initiative, bladder and bowel control is presented in Fig. 1.

The main findings were as follows: the developmental course in preterm children differed significantly from that in term children with respect to onset of toilet-training and intensity of daily prompting. Preterm children were placed on the potty at an earlier age and more frequently than the term children. However, there were no significant differences between preterm and term children regarding the occurrence of the child's initiative and the development of bowel and bladder control by day and at night. Sex differences in favour of the girls were noted in both groups for all parameters, being less pronounced in preterm than in term children.

The individual parameters are subsequently presented in more detail for the neurologically unimpaired appropriate for gestational age (AGA) preterm and term children. Percentile values for the age of onset of the child's initiative, day and night bladder and bowel control are given in Table 3. The significance of the perinatal and postnatal variables and of neurodevelopmental outcome will be discussed separately.

Toilet-training

Onset of potty-training

Toilet-training was initiated at the earliest between 6 and 9 months in both the preterm and term group (Fig. 1). A higher proportion of preterm children than term children were being placed on the potty between 9 and 36 months. Toilet-training at 9 months was started in 22% of the girls and 34% of the boys of the preterm group, but only in 7% of the term infants. At 18 and 24 months, 22% to 27% more preterm than term children were placed on the potty. Toilet-training was initiated in 91% to 100% of the children in both groups by 36 months of age. Significant differences of the onset of toilet-training between preterm and term children were noted at the age of 9, 12, 18 and 24 months (Fisher exact test $P < 0.01$ at all ages, except 24 months for girls, $P < 0.06$). The median age of the initiation of toilet-training in the preterm group was 13 months for girls and 15 months for boys; the corresponding values in the term children were 19 and 22 months, respectively (Mann-Whitney test $P = 0.001$ for girls and 0.002 for boys, respectively).

Table 2 Course of toilet-training, child's initiative and of bowel and bladder control in term and preterm children. Values (except "actual numbers") are percentages of the total number of subjects for whom the condition applies at each age. (CP cerebral palsy)

	Age (years)																	
	0.6		0.75		1		1.5		2		3		4		5		6	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
Initiation of toilet-training (%)																		
Term	1	2	7	7	16	20	33	48	61	75	91	99	100	100	100	100	100	100
Preterm AGA	2	2	22	34	38	47	60	70	87	87	100	98	100	100	100	100	100	100
SGA			7		23	25	33	29	69	86	100	100	100	100	100	100	100	100
CP			8	40	25	40	50	80	66	80	83	100	100	100	100	100	100	100
Frequency of daily prompting (%)																		
Term																		
0	100	99	94	93	87	83	72	61	51	37	32	38	41	54	43	56	46	68
<1			1	1	3	1	1	4	2	4	5	8	7	11	7	11	12	7
1-2			1	4	4	6	8	17	18	18	21	29	39	36	30	43	30	40
3-5			1	2	3	8	10	17	29	35	32	14	15	5	7	5	2	2
>5					1					3	2	1	1					
Preterm AGR																		
0	100	100	80	66	68	52	46	38	26	24	10	21	17	39	38	42	26	30
<1			4	2	2	2		7	4	9		5	24	6	20	12	16	12
1-2			14	16	13	23	19	21	26	24	43	51	55	39	36	39	52	49
3-5			2	16	17	18	35	34	40	41	45	21	4	16	6	7	6	7
>5						5			4	2	2	2						2
Child's initiative (%)																		
Term					1	2	17	31	41	60	76	92						
Preterm AGA					6	2	21	32	34	60	80	95						
SGA								29	49	71	92	87						
CP							34	17	50	40	75	75						
Bladder control, day (%)																		
Term																		
0%	100	100	98	96	95	92	92	83	66	50	17	5	1					
1-30%			1	3	3	6	4	11	19	17	8	2						
30-70%			1	1	2	2	4	5	11	20	8	2	1		3			
70-99%								1	1	6	14	5	10	2	9	3	4	4
100%									2	7	53	84	88	98	88	97	96	94
Preterm AGA																		
0%	100	100	94	93	85	82	70	68	49	44	2	7		2				
1-30%			2	2	2	11	15	14	28	28	6	5						
30-70%			4	5	11	7	15	14	13	13	6	2						
70-99%								2	6	4	22	14	6	5	8	2	6	5
100%									4	11	64	72	94	93	92	98	94	95
SGA 100%									15		55	51	100	87	100	83	100	80
CP 100%											67	60	83	80	92	100	92	100
Bladder control, night(%)																		
Term																		
0%	100	100	100	100	100	100	99	98	97	89	47	33	15	11	7	1	1	2
1-30%								1	1	5	12	13	5	3	3	1	2	1
30-70%							1	1	1	3	9	8	5	3	3	1	3	1
70-99%									1	1	8	3	8	3	11	6	8	3
100%										2	23	42	67	80	76	91	86	93
Preterm AGA																		
0%	100	100	100	100	100	100	98	98	92	80	47	42	8	9	4	2	2	
1-3-0%							2		4	9	2	5	8	2			2	
30-70%								2		7	4	7	2	5	4			
70-99%									4		8	11	16	9	2	7	2	5
100%										4	39	33	66	75	90	91	96	95
SGA 100%											15	37	61	37	100	67	92	80
CP 100%											25	40	42	100	75	100	92	100
Bowel Control (%)																		
Term																		
0%	100	100	96	94	92	88	85	74	67	50	25	8	2	1	3	1	3	3
1-30%			2	1	3	5	4	12	14	17	5	2						
30-70%			1	3	1	4	5	7	8	11	8	2						
70-99%				1	3	1	2	5	4	4	5	2	4		2		1	
100%					1	1	1	1	3	10	54	82	92	99	93	99	96	97
Preterm AGA																		
0%	100	100	86	73	72	63	60	54	36	44	2	7		5	4			2
1-30%			8	11	15	11	19	18	28	15	10	14						

Table 2 (continued)

	Age (years)																	
	0.6		0.75		1		1.5		2		3		4		5		6	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
30–70%			4	11	9	11	17	9	11	13	8							
70–99%							4	16	16	15	14	5	8	2				
100%			2	5	4	13		5	8	13	64	74	92	93	96	96	100	98
SGA 100%									15		54	74	92	50	100	83	92	100
CP 100%									8	20	75	50	92	80	92	100	100	100
Actual numbers																		
Term	154	144	153	146	152	145	146	145	150	138	138	120	131	119	116	115	104	101
Preterm AGA	62	48	63	49	62	49	63	49	62	49	62	49	61	48	63	47	63	47
SGA	13	9	13	9	13	9	13	9	13	8	13	9	13	8	13	7	13	8
CP	16	5	16	5	16	5	16	5	16	5	16	5	16	5	16	5	16	5

Table 3 Percentiles (10th, 50th and 90th of child's initiative, bladder and bowel control in term children (age in months)

	Percentile					
	10th		50th		90th	
	M	F	M	F	M	F
Child's initiative	15	14	27	22	43	35
Bladder control by day	26	24	35	31	63	41
Bladder control at night	29	26	43	38	75	58
Bowel control	26	24	35	30	47	42

Incidence of daily prompting

The mean developmental course of daily prompting in both groups is illustrated in Fig. 1. At 12 and 18 months, the preterm children were prompted significantly more often than the term children, boys also at the age of 24 and 36 months ($P < 0.01$ to 0.001). In the preterm and term groups, the peak of average daily prompting was observed at 24 months in girls, but not before 36 months in boys.

Development of bladder and bowel control

Bladder control by day and bowel control displayed comparable developmental course in the preterm and term children (Fig. 1). Less than 10% of girls and boys in both groups reached complete bladder control by day and/or bowel control before 24 months (Table 2). Most preterm and term children became dry and clean between 24 and 48 months. Between 93% and 99% of the girls and 88% and 94% of the boys attained complete bowel and bladder control by day at 48 months.

None of the preterm or term boys and only 4% of the preterm girls and 2% of the term girls reached complete bladder control at night before 24 months. In comparison with bowel and bladder control by day, bladder

control at night developed significantly more slowly (Mann-Whitney $P < 0.01$). In the preterm group, 75% of the girls and 66% of the boys, and 80% of the girls and 67% of the boys in the term group reached complete control by 48 months. The corresponding figures at 60 months were 95% and 96% for the preterm children and 93% and 86% for the term children, respectively.

In the development of bladder control by day and at night as well as of bowel control, term girls tended to be slightly more advanced than preterm girls, while the opposite finding was noted in boys. However, none of these differences was significant.

The child's initiative

Incidence of asking for the potty

The children expressed their need for evacuation by mimic expressions and gestures, going to the toilet, grabbing the potty or less often verbally. At the earliest the children displayed such behaviours between 12 and 18 months. Most preterm and term children became active between 24 and 36 months. By 36 months, 95% of the girls and 80% of the boys in the preterm group and 92% of the girls and 76% of the boys in the term group asked for the potty.

Significance of toilet-training, perinatal variables, neurodevelopmental outcome, and gender

Toilet-training

In both the preterm and term groups, no significant correlational relationships were found between age at initiation of potty-training, frequency of daily prompting on the one hand and occurrence of the child's initiative, onset of bladder and bowel control on the other (Spearman correlations, $P > 0.05$). Thus, an early onset

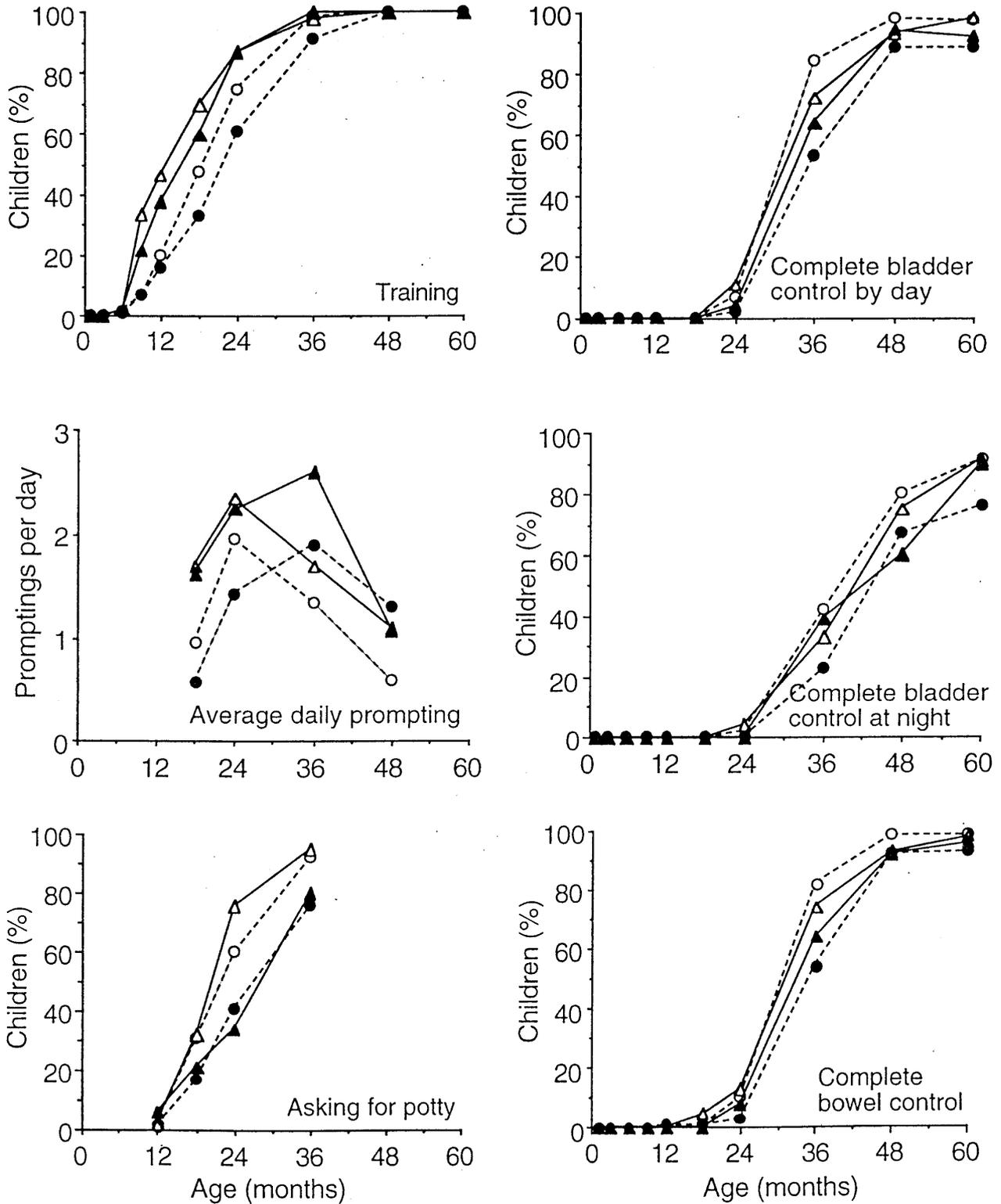


Fig. 1 Course of toilet-training, child's initiative and development of bladder and bowel control in preterm (Δ = girls, \blacktriangle = boys) and term children (\circ = girls, \bullet = boys)

and high intensity of the toilet-training did not promote the child's initiative or the development of bladder and bowel control.

Perinatal variables

Gestational age, parity and perinatal optimality score consisting of 90 optimal conditions of pregnancy, birth and neonatal period were not significantly correlated with onset of toilet-training, frequency of daily prompting, age at onset of the child's initiative, and development

of bladder and bowel control. AGA preterm children of both sexes and AGA term girls tended to be slightly more advanced in most parameters of bladder and bowel control than the SGA children. However, no significant differences could be established between AGA and SGA children in the preterm and term groups.

Neurodevelopmental outcome

In comparison with the term group, preterm children achieved significantly lower developmental quotients at 12 and 24 months ($P < 0.001$) and lower intelligence quotients at 3 years ($P < 0.05$) (Table 1). Neither in the preterm nor in the term group did developmental and intelligence quotients significantly correlated with onset and intensity of toilet training, occurrence of child's initiative or development of bladder and bowel control.

From among the preterm group, 16 boys and five girls in the preterm group (16%), but none of the term infants, were diagnosed as having cerebral palsy. Signs of a mild spastic diplegia were observed in ten boys and four girls, four boys and one girl had moderate spastic diplegia, one boy was moderately ataxic and hypotonic, and another had a severe spastic tetraplegia. There were no significant differences in bladder and bowel control observed in disfavour of the children with cerebral palsy in comparison with the unimpaired children.

Socio-economic status

The preterm children came from families of slightly lower, but not significantly different SES (Table 1). No significant correlations were noted between SES, age at onset and duration of toilet-training, frequency of daily prompting, age at occurrence of child's initiative, and development of bowel and bladder control day and night.

Sex differences

Sex differences in favour of the girls were noted for all parameters in both the preterm and term groups. They were consistently larger in the term children except the child's initiative. Significant differences in the onset and intensity of toilet-training and in the development of bowel and bladder control by day and at night were noted in the term, but only for the child's initiative in the preterm children (Fisher exact test $P < 0.01$ for bladder and bowel control at age 36 months and for child's initiative at 24 months, respectively).

Discussion

In her comprehensive Scottish study on the growth and development of prematurely born infants, Drillien [2]

reported on child rearing practices and the development of bladder control. Toilet-training and the age at which children became reliably dry by day and night was related to prematurity, impairment, socioeconomic conditions and sex. Small, prematurely born children, in particular those with neurodevelopmental impairment, acquired sphincter control later than healthy children with a birth weight of more than 4.5 lb. Mothers of low social class gave birth to preterm infants more frequently than mothers of middle or upper working-classes. The former instituted toilet-training later and their children also achieved bladder control later than did those of higher social classes. Girls were more advanced in gaining bladder control than boys.

Our results in preterm children born in the late 1970s and early 1980s differ considerably from those of the Scottish study [2] carried out one generation earlier, in the late 1950s. The only significant and clinically relevant difference noted between preterm and term children concerned toilet-training. Preterm children were put on the potty at earlier ages and more frequently than term children. Neither the time of onset nor the intensity of toilet-training was significantly correlated with SES. These findings indicate that parents of all social classes were more anxious about development and functional competence of their preterm children than parents of term children. Perhaps these parents felt a compulsion to help their children along their development.

The significantly earlier initiation of toilet-training and the marked increase in daily prompting in the preterm children did not lead to a corresponding advancement in the onset of their bladder and bowel control. The preterm children expressed their need for evacuation and attained bowel control and bladder control by day and at night at the same ages as the term children (age corrected for preterm birth). There were also no correlational relationships expressing a significant impact of the initiation and intensity of toilet-training on bladder and bowel control in either the preterm and term groups. These findings support earlier reports indicating that the development of bladder and bowel control is largely a maturational process which cannot be accelerated by an early onset or high intensity of training [7, 9, 13].

Prematurity, SGA, and frequency of adverse pre-, peri- and neonatal conditions did not significantly affect the child's initiative or the development of bladder and bowel control. Cerebral palsy of a mild to moderate degree also had no significant impact on these developmental parameters. Drillien [2] observed significant delays in preterm children with moderate to severe cerebral palsy. Severe neurological impairment may be associated with slow development of bladder and bowel control.

In normal, healthy children, the relationship between bladder and bowel control and early psychomotor development has never been a subject of investigation. Von Wendt and his coworkers [23] reported on the development of bowel and bladder control in mentally retarded children. When comparing mildly mentally retarded

children with the general population, they observed no significant difference in night wetting and soiling at 7 years of age. However, in moderately to profoundly retarded children, a marked delay in becoming clean and dry was found. In our term and preterm populations, there were no significant correlational relationships noted between developmental and intellectual quotients during the first 3 years, the child's initiative or the development of bladder and bowel control. Thus, children who were slow in reaching motor, language and cognitive abilities did not reach bladder and bowel control at later ages than those children performing at higher functional levels. It should be noted, however, that the number of developmentally delayed preterm children was small and their delay was only of a minor degree.

Sex differences were noted in all developmental areas in both the preterm and term groups. The largest difference was observed in the child's initiative. Girls expressed their need for evacuation significantly earlier than boys. Consequently, the parents also started toilet-training earlier in girls than in boys. The development of bladder and bowel control in preterm girls was moderately, but significantly more advanced than in preterm boys. Comparable results have been obtained in previous investigations on term children [7, 8, 13, 15, 24]. This gender difference is most likely due to a difference in the maturity rates favouring the girls.

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