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Neurodevelopmental Screening at Five Years of Children Who Were At Risk Neonatally

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Introduction

The extent to which neonatal risk factors are the cause of minor neurological disturbances later in life is not fully known. With the neurodevelopmental screening test developed by Bax and Whitmore (1973), it is possible to investigate five-year-old children for a broad range of neurodevelopmental skills in a relatively short time, about 15 to 20 minutes. The scores for abnormal test responses give a summary of neurodevelopmental status.

This study presents the results of a neurodevelopmental study of five-year-old Finnish children whom the authors have been following prospectively from birth and who had had certain high-risk factors in the newborn period.

Material

Between 1976 and 1979, 857 five-year-old children (4 years 10 months to 5 years 3 months) were given a neurodevelopmental examination at the Children's Hospital, University of Helsinki. All the children had been born at the Institute of Midwifery, Helsinki, between 1971 and 1974, and in the newborn period they had had one or more of the following risk factors:
birthweight $\leqslant$2000g;
Apgar scores $\leqslant$6 at five minutes or later;
hyperbilirubinaemia, at least two values $\geqslant$340mmol/l;
hypoglycaemia, at least two values $\leqslant$1·67mmol/l for fullterm and $\leqslant$1·21 mmol/l for preterm;
respiratory difficulties needing continuous positive airway pressure (CPAP) or respirator care;
neurological symptoms such as convulsions, marked hypotonia, rigidity or prolonged feeding difficulties;
septic infections;
mothers were diabetic.

The total number of live births in the Institute of Midwifery between 1971 and 1974 was 22,217, of which 1196 (5·38 per cent) belonged to the high-risk group. 857 of these high-risk children were examined at the age of five years. The others were not examined for the following reasons: 158 had died in the newborn period or later, 20 were severely handicapped, 67 could not be traced and in 94 cases the parents did not bring their children for examination, mainly because of travel difficulties.

The control group consisted of 70 children of corresponding ages, also born at the Institute of Midwifery, who had had

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no risk factors during pregnancy, delivery or the neonatal period.

Method

Some scores on the Bax and Whitmore neurodevelopmental screening test were changed slightly from those of Bax (1974): the points for undescended testes (4 or 8) were omitted, and the points for failing to stand with arms extended and eyes closed were summed (up to 14). Table I shows the points given for the various items in the examination.

The children were examined by four physicians: two were paediatricians, one was a paediatric neurologist and one a neurologist. The performance of the test and the scoring of the different items were demonstrated to all the examiners, and they also received a detailed written description, with directions on how to score each item.

The total number of points awarded for unsuccessful responses in the different items represented the neurodevelopmental status; *i.e.* the higher the score the poorer the status.

In addition to the neurodevelopmental screening test, several psychological tests and investigations by speech therapists were performed. The parents also completed a questionnaire concerning the development of the child and the social environment. These results, with a comparison of the various test results, will be reported later.

Results

Of the 857 children who arrived for the check-up, seven refused to co-operate in some of the tests. Another three children were omitted from the final results because they had Down's syndrome, in addition to the neonatal risk factor, and had scores of 64, 106 and 119 in the neurodevelopmental test. Two more children were omitted because they had severe cerebral palsy and mental retardation: their scores were 156 and 160. Thus, 845 children (462 boys, 383 girls) comprised the final series.

The mean neurodevelopmental score for the group was 19·7 (17·7 for girls, 21·3 for boys) (Table II). The mean score for the control group was 9·0 (7·5 for girls, 10·2 for boys). The difference between the scores of girls and boys was statistically

TABLE I
Scoring of test items in neurodevelopmental screening test

Test items	*Points*
Visual acuity	0–16
Squint, absent or present	0– 8
Gross motor performance:	
Gait, even pace	0–16
Hopping on one foot	0– 8
Fine motor performance:	
Patting hands	0–10
Pencil grip	0– 8
Co-ordination and balance:	
Heel-toe walking	0– 8
Finger-nose pointing	0–16
Diadochokinesis	0–16
Tongue tremor	0– 8
Involuntary movements when standing	0– 8
Upper motor neuron disturbances:	
Standing, asymmetry	0– 6
Facial asymmetry, function	0– 4
Reflexes; biceps, brachio-radialis, knee-jerk	0–18
Articulation:	
Consonant substitution	0– 6
Articulation of single words	0– 4
Articulation of sentences	0– 4
Language skills:	
Forms sentences on own initiative	0–16
Repeats sentences	0– 4
Speech comprehension	0– 8
Perception:	
Drawing of a circle, square and triangle	0–10
Imitation of gestures, Bergés-Lèzine 5–8	0–16
Reed hearing test	0– 8
Concentration:	
Attention span	0– 4
Tongue impersistence	0– 4
Behaviour:	
Overactivity	0– 4
Slowness	0– 4
Shyness	0– 4
Aggressiveness	0– 8
Guardedness	0– 2

TABLE II
Neurodevelopmental scores for various disorder groups: children with one risk factor only

	All children		*Girls*		*Boys*	
Diagnosis	No.	Mean ±SD	No.	Mean ±SD	No.	Mean ±SD
Neurological disorders	55	23·0±16·8	21	25·6±22·1	34	21·4±12·6
Birthweight ⩽2000g	119	20·5±16·1	76	18·3±16·5	43	24·3±14·6
Child of diabetic mother	47	19·4±13·3	22	18·9±13·3	25	19·9±13·6
Respiratory disturbances	21	17·6±10·6	6	15·5± 8·6	15	18·4±11·5
Hypoglycaemia	38	17·2±15·5	12	9·4± 4·6	26	20·8±17·5
Apgar ⩽6 at 5 min. or later	138	17·2±11·7	66	14·9± 8·8	72	19·3±13·6
Hyperbilirubinaemia	257	17·1±12·2	105	16·2±13·9	152	17·6±10·8
Septic infections	7	15·1±14·8	6	13·5±15·5	1	25·0
Total with one diagnosis	682	18·3±13·6	314	16·9±14·2	368	19·5±12·8
Multiple diagnoses concomitantly	163	25·3±19·2	69	21·0±16·7	94	28·5±20·4
Total	845	19·7±15·1	383	17·7±14·8	462	21·3±15·1
Controls	70	9·0± 6·0	33	7·5± 5·3	37	10·2± 6·3

TABLE III
Neurodevelopmental scores for 163 children with multiple risk diagnoses concomitantly*

	All children		*Girls*		*Boys*	
Diagnosis	No.	Mean ±SD	No.	Mean ±SD	No.	Mean ±SD
Neurological symptoms + other diagnosis	46	30·3±23·0	14	32·4±24·4	32	29·4±22·8
Birthweight⩽2000g + other diagnosis	77	26·2±19·8	38	21·9±16·9	39	30·3±21·8
Respiratory disorder + other diagnosis	43	26·4±19·8	18	22·5±21·7	25	29·3±18·4
Apgar⩽6 at 5 min. + other diagnosis	76	26·1±21·1	33	24·7±19·7	43	27·2±22·3
Hyperbilirubinaemia + other diagnosis	48	25·8±19·1	15	22·4±17·5	33	27·3±19·8
Hypoglycaemia + other diagnosis	43	24·3±19·9	20	16·3±11·6	23	31·3±23·0
Septic infection + other diagnosis	10	20·9±11·9	3	15·3±13·1	7	23·3±11·6
Diabetic mother + other diagnosis	25	19·2±15·4	14	15·8±11·4	11	23·5±19·1
Total with multiple diagnoses concomitantly	163	25·3±19·2	69	21·0±16·7	94	28·5±20·4
Child with one risk diagnosis	682	18·3±13·6	314	16·9±14·2	368	19·5±12·8
Total	845	19·7±15·1	383	17·7±14·8	462	21·3±15·1
Controls	70	9·0± 6·0	33	7·5± 5·3	37	10·2± 6·3

*Some children are in several groups because of multiple risk factors.

significant in the study group ($p<0{\cdot}001$, t test, difference between means). In the control group the difference was not significant.

Table II shows the neurodevelopmental scores when the children were divided into groups according to their neonatal risk factors. The highest scores occurred for children who had had neurological symptoms, a birthweight of $\leqslant$2000g, or many risk factors simultaneously. In most groups the scores were higher for boys than for girls.

Table III shows the neurodevelopmental scores of the children who had had several risk factors concomitantly. In all diagnostic groups the scores were higher when the child had had many of the risk factors in the newborn period. For instance, if the child had had only neurological symptoms the mean score was 23·0 (Table II), but if there had also been other risk factors, *e.g.* low birthweight or hyperbilirubinaemia, the score increased to 30·3 (Table III).

Figure 1 presents the histograms of the scores of the high-risk children and the control series examined during 1979. These children were all examined by the same child neurologist. Fig. 2 shows the histograms of the scores for all the girls and boys in the study group.

Discussion

When we started the prospective study of newborn risk infants in 1970, our

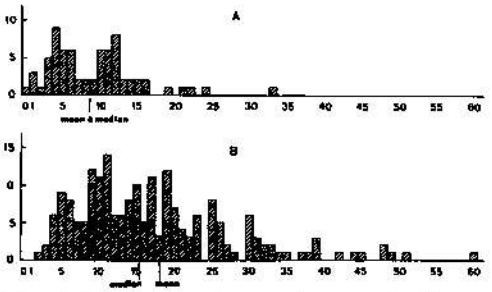

Fig. 1. Histogram of scores in controls (A) and risk children (B) examined in 1975.

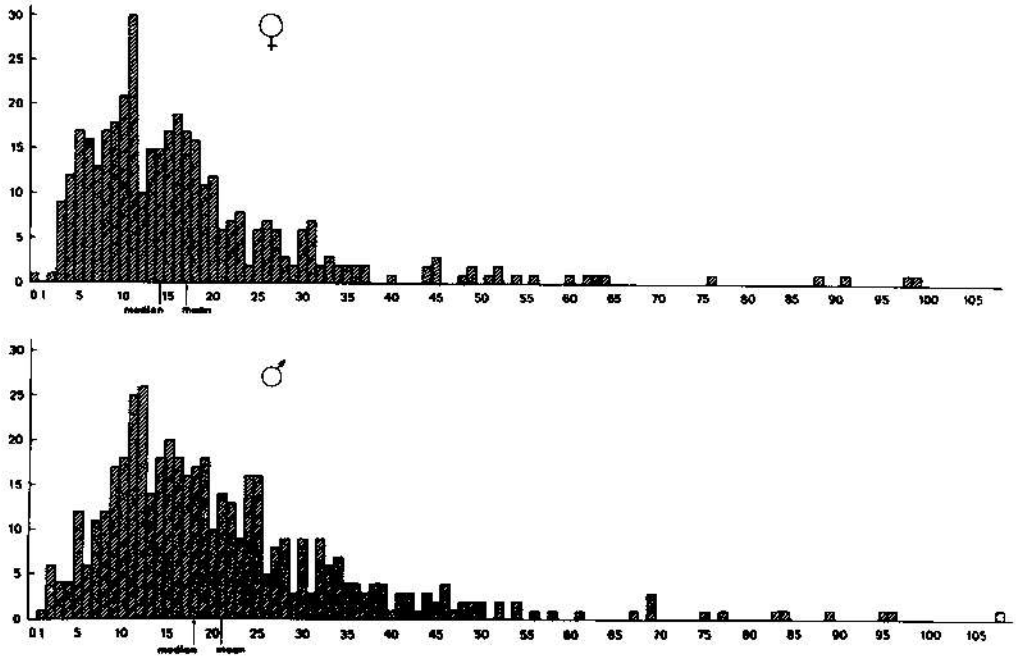

Fig. 2. Histograms of scores for 383 girls and 462 boys in study group.

particular aim was to trace those children who showed signs of minimal brain dysfunction, a term which covers deviations in motor development, behaviour, perception, and learning and language disorders (Hagberg 1975). We assumed, because of age-related development of children, that these abilities would be sufficiently developed to investigate by the age of five years. Children at this age usually are able to co-operate in an examination comprising many different tasks. This was so in our study, as only seven of the 857 children refused to co-operate.

In selecting the method of investigation, we decided on a neurodevelopmental examination which would be short enough to use as a screening method, and yet still enable us to select those children who needed further neurological, psychological and logopedic examinations. To the best of our knowledge, the method by Bax and Whitmore was the only available test battery by which various aspects of neurological dysfunction in gross and fine motor skills, co-ordination, balance, involuntary movements, upper motor neuron disturbances, perception, articulation, speech and behaviour could be assessed in 15 to 20 minutes. Additionally, the test gave each child a score for neurodevelopmental status; *i.e.* the points accumulated for items which the child failed.

The mean score for the Isle of Wight children studied by Bax and Whitmore (1973) was 14. In a series of 246 unselected five-year-old kindergarten children in Helsinki, the mean score was 12·9 (Saarnivaara *et al.* 1976). If the 10 per cent cut-off point in the scores of the Isle of Wight children (above 27) is applied to the Helsinki series, the limit is 22 points. The explanation for the better scoring of the Helsinki series compared with the Isle of Wight children could be that all the children in Helsinki had attended kindergarten for several years and thus had had training in some of the abilities needed for the neurodevelopmental test. The differences in the scores could also partly be due to the omission of the scores for undescended testes in Helsinki: the points added for failing to stand with arms extended did not influence the total scoring very much, as most children passed this test.

The mean score of 19·7 for the risk group of children, compared with 9·0 for the controls, indicates that the children who were at risk in the newborn period had significantly more divergent neurodevelopmental behaviour than the control children. The results also showed differences according to the dominant risk factor, and especially high scores occurred when the children had had several risk factors simultaneously. It is evident, therefore, that slight neurodevelopmental deviations at the age of five years can derive from disorders in the newborn period.

When examining their series at the age of nine years, Bax and Whitmore (1973) found that over half of those with a neurodevelopmental score above 27 had troubles in school, compared with less than 5 per cent of those with a score in the lowest 10 per cent. Among our control children, 10 per cent had a score of 16 or higher and 5 per cent had a score of 22 or higher. In the risk group, as many as 52 per cent had scores of 16 or more, and 31 per cent had scores of 22 or more. This indicates that the proportion of children with school problems will be greater among those who have been at risk in the newborn period. Thus, to a greater degree than has been suspected, neonatal risk factors can be the cause of failure in school because of clumsiness, perceptual disturbances, learning difficulties and behavioural disorders.

To prevent these difficulties arising in school, early diagnosis is necessary, not only for treatment and habilitation, but also to avoid secondary behavioural disturbances; because of their organic handicap, these children tend to function worst in a group of children of the same age.

The neurodevelopmental screening test is not intended to be used for those who have severe handicaps, but rather to detect slight deviations which are not made manifest by the usual neurological investigations. Two children in our series had severe cerebral palsy which we did not know about when we invited them for examination. These children scored 156 and 160 points in the examination and were excluded from the final results. However, the test is very good for diagnosing minor cerebral-palsy syndromes and we found several children with slight degrees of hemiplegia which had not been detected previously.

The neurodevelopmental screening test fulfilled our expectations of being reliable and applicable to a large group of children, and also it tested a broad scale of neurodevelopmental abilities. The children co-operated willingly in the test. It is essential that investigators, before they start on the test, have a very detailed description of how to score the different items and what a five-year-old child can be expected to do, and that they bear in mind that some differences exist between the abilities of boys and girls.

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AUTHORS' APPOINTMENTS

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SUMMARY

A neurodevelopmental screening test with cumulative scoring for abnormal test responses was performed on 845 five-year-old Finnish children who, in the newborn period, had had disorders which placed them in a high-risk group, and on 70 controls. The results showed a significant difference between the neurodevelopmental scores of the risk-group children and those of the controls. The scores were higher if the child had had many of the risk factors simultaneously. Boys had significantly higher scores than girls. The mean scores also varied between different risk factors. It is evident that slight neurodevelopmental deviations at the age of five years can derive from disorders in the newborn period.

RÉSUMÉ

Appréciation neuro-développementale à cinq ans chez des enfants à risque au moment de la naissance

Un examen d'appréciation neurodévelopmentale avec score cumulatif pour les réponses anormales du test a été réalisé chez 845 enfants de cinq ans qui avaient présenté au moment de la naissance des troubles les ayant fait classer dans un groupe à haut risque; un groupe contrôle de 70 enfants a été également examiné. Les résultats ont montré une différence significative dans les scores neurodévelopmentaux des enfants du groupe à risque et de ceux du groupe contrôle. Les scores étaient plus élevés pour les enfants ayant présenté simultanément plusieurs facteurs de risque. Les garçons avaient des scores significativement plus élevés que les filles. Les scores moyens variaient selon les différents

facteurs de risque. Il est donc évident que de légères déviations neurodévelopmentales à l'âge de cinq ans peuvent venir de désordres durant la période néo-natale.

ZUSAMMENFASSUNG

Beurteilung der neurologischen Entwicklung im Alter von fünf Jahren bei Kindern, die in der Neonatalperiode als Risikokinder eingestuft waren

Bei 845 fünfjährigen Kindern, die in der Neugeborenenperiode Erkrankungen hatten, durch die sie in die Gruppe der Risikokinder eingestuft waren, und bei 70 Kontrollkindern wurden Screening Tests zur neurologischen Entwicklung durchgeführt, wobei die abnormen Testergebnisse kumulativ gezählt wurden. Die Ergebnisse zeigten einen signifikanten Unterschied zwischen den neurologischen Entwicklungsscores der Risikokinder und der der Kontrollkinder. Hatte ein Kind mehrere Risikofaktoren gleichzeitig, so waren die Scores höher. Jungen hatten signifikant höhere Scores als Mädchen. Die mittleren Scores schwankten zwischen verschiedenen Risikofaktoren. Es wird deutlich, daß leichte Normabweichungen in der neurologischen Entwicklung im Alter von fünf Jahren durch Erkrankungen in der Neugeborenenperiode bedingt sein können.

RESUMEN

Despistage del desarrollo neurológico a los cinco años de edad en niños que habían sufrido un riesgo neonatal

Se realizó un test de despistage de desarrollo neurológico con puntajes cumulativos para respuestas anormales a test en 845 niños de cinco años de edad, que en el período neonatal, habían tenido alteraciones que los colocaban en un grupo con alto nivel de riesgo, y en 70 controles. Estos resultados mostraron una diferencia significativa entre los puntajes del desarrollo neurológico de los niños del grupos con riesgo con respecto a los controles. Los puntajes eran más altos si el niño había tenido simultáneamente muchos de los factores de riesgo. Los muchachos tenían los puntajes significativamente más altos que las chicas. Los puntajes medios también variaban entre los distintos factores de riesgo. Es evidente que pequeñas desviaciones en al desarrollo neurológico a la edad de cinco años pueden derivar de alteraciones en el periodo neonatal.

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