

## Predictive Value of Assessment of General Movements for Neurological Development of High-Risk Preterm Infants: Comparative Study

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**Aim.** To assess the predictive value of normal, abnormal, or absent general movements in high-risk preterm infants for the later neurological development.

**Methods.** The study involved 120 high-risk preterm infants (gestational age,  $\leq 37$  weeks) having at least three or more antenatal, perinatal, or neonatal risk factors for impaired neurological development, and 112 age-matched controls. The method of general movements of fidgety character assessment was compared with classical neurological examinations performed longitudinally until the corrected age of two years. The age-adequate neurological examinations based on the criteria by Amiel-Tison and Grenier and Illingworth were used. Specialists in clinical psychology also monitored the child's development. The results of specialists' examinations were taken into account.

**Results.** Out of 83 high-risk preterm infants with normal fidgety movements, 81 (97%) had a normal neurological outcome. Abnormal or absent fidgety movements were followed by abnormal neurological outcome in 30 (81%) out of 37 infants. Cerebral palsy was diagnosed in 13 children, mental retardation in one, whereas 16 children had both cerebral palsy and mental retardation. The validity of the general movement assessment was 92%, sensitivity 94%, specificity 92%, positive predictive value 81%, and negative predictive value 98%. These values were better than those of the classical neurologic examination (60%, 97%, 43%, 44%, and 97%, respectively).

**Conclusion.** The method of general movement assessment had significantly better validity, sensitivity, specificity, positive, and negative predictive value than classical neurological examination of high-risk preterm infants.

**Key words:** cerebral palsy; follow-up studies; infant, premature; mental retardation; neurologic examination; predictive value of tests; risk; Slovenia

In spite of highly developed medical technology, neurological diagnosis in newborns, infants, and children is still based mainly on their medical history data and clinical neurological examination. To perform neurological examination and assess the findings requires clinical knowledge and time, which are increasingly lacking in modern medicine. Ever greater number of children at risk of impaired development of the central nervous system is also a frequent excuse for not performing a thorough neurological examination of such children. However, it is very important that the children at risk of neurological impairment be examined at the earliest age, ie, while newborns and infants, for the assessment of their neurological status and early detection of the central nervous system impairment.

According to the World Health Organization, 6-7% of children have various developmental difficulties (1). This percentage is even higher among the children in developed countries of Western Europe and North America, amounting to around 10% (1),

because of better antenatal, perinatal, and neonatal intensive medical care and treatment of preterm infants. Therefore, it is important for the neurological examination technique to be as simple, quick, non-intrusive, and easy-to-repeat as possible. This realization encouraged Prechtl (2) to persist in his years-long research. With the help of numerous collaborators, he developed a method of assessment of general movements of preterm and full-term newborns and infants. The method is based on the observation of the spontaneous movements of a child with an unaided eye and by using video-technique, whereas the assessment of the general movements' quality is made on the basis of observer's visual Gestalt perception, ie, general impression of the quality of general movements (3,4). Visual Gestalt perception is a complex technique for a global judgment of the quality of general movements. It is very vulnerable to attention to detail but a powerful instrument in the analysis of complex phenomena (3,4).

The qualitative assessment of general movements is a method that takes the complexity of the nervous system fully into account and, at the same time, fulfils the requirement of not being time-consuming at all (2). The human fetus and young infant have a repertoire of distinct movement patterns that are spontaneous (5). One set of these movement patterns is known as general movements. These movements can be observed in fetuses as young as 10 weeks postmenstrual age (6). In infants at low-risk of neurological damage, general movements continue in a similar pattern until about the end of the second month post term. After birth, general movements are commonly referred to as writhing movements. Between 6 and 9 weeks post term, the form and character of general movements change from the writhing type into a fidgety pattern. General movements of fidgety character, or fidgety movements, are defined as an ongoing stream of small, circular, and elegant movements of the neck, trunk, and limbs. Fidgety movements of a healthy infant are a transient phenomenon; they emerge gradually at 6 weeks post term, come to full expression between 9 and 13 weeks post term, and taper off again between 14 and 20 weeks post term (7).

In previous studies, normal quality of fidgety movements predicted the later normal neurological outcome, whereas abnormal quality or absence of fidgety movements seemed to have clinical significance for predicting the later neurological impairment (2,3,7). This has been true for low-risk full-term and low-risk preterm infants, as well as for high-risk full-term infants (8,9). The present study was conducted to clarify this issue in high-risk preterm infants, by using the same method of general movements of fidgety character assessment and neurological follow-up.

## Participants and Methods

### Participants

The study included 232 high-risk preterm infants of gestational age  $\leq 37$  weeks examined at the Center for the Children with Developmental Disabilities, Dispensary for Children, Maribor Public Health Center, Maribor, Slovenia, between October 1, 1994, and December 31, 2000 (Table 1). Random number table was used to select the study participants among 930 preterm infants referred to the Center for the Children with Developmental Disabilities for neurological examination and follow-up. Randomly selected infants were divided into two groups, a high-risk group ( $n=120$ ) and a control group ( $n=112$ ). During the ran-

domization I excluded (a) the infants who did not have three or more risk factors ( $n=350$ ), (b) those whose parents refused to include their child into the study ( $n=16$ ), and (c) infants with birth anomalies of the central nervous system and/or other organs or organ systems, infants with clinical signs of known syndromes that could be recognized in the newborn and infant (10), and infants at risk of inheriting neurological disorders ( $n=9$ ) (Fig. 1).

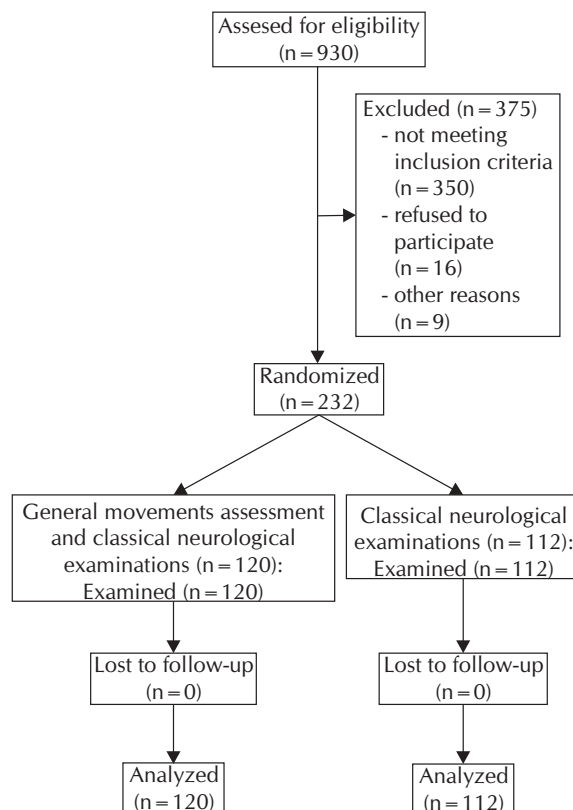


Figure 1. Flow of the participants through the study.

The infants were born either at the Department of Gynecology and Obstetrics, General Hospital Maribor, or at the Department of Gynecology and Obstetrics, Ljubljana University Hospital Center, Ljubljana (transport *in utero* from the Department of Gynecology and Obstetrics, General Hospital Maribor to the Department of Gynecology and Obstetrics, Ljubljana University Hospital Center, Ljubljana), between January 13, 1994, and December 30, 1998. Delivery date for children was calculated on the basis of the date of the mother's last menstrual period. Hospital pediatricians-neonatologists assessed the gestational age of infants according to Farr et al (11). It was agreed that pediatrician-neonatologists, general pediatricians, or general practitioners in Maribor refer all preterm infants to the Center for the Children with Developmental Disabilities.

Infants with three or more risk factors were classified as at high risk of developing neurological deficits, ie, neurologically high-risk infants. Antenatal, perinatal, and neonatal risk factors were as follows: pathologic pregnancy (vaginal bleeding in the first, second, or third trimester of pregnancy; insufficiency of the cervix uteri; infection in pregnancy caused by viruses, bacteria, fungi, and parasites; use of drugs during pregnancy, EPH gestosis; gestational diabetes; and pregnancy after *in vitro* fertilization); multigestational pregnancy (twins or triplets); pathological delivery (premature birth, Cesarean, breech delivery, and use of vacuum extractor and/or forceps delivery); mild or severe asphyxia at the time of birth (12); intrauterine growth retardation (12); hypoglycemia (blood glucose concentration below 1.1 mmol/L in a preterm newborn in the first week of life, ie, since the day of birth until the end of the seventh day of life; ref. 13); hyperbilirubinemia (serum bilirubin concentration above 204  $\mu\text{mol/L}$  in a

Table 1. Characteristics of high-risk preterm infants and their controls neurologically examined at the Center for the Children with Developmental Disabilities, Dispensary for Children, Maribor Public Health Center, Slovenia, between October 1, 1994, and December 31, 2000

Characteristic	Group of infants	
	high-risk (n = 120)	control (n = 112)
No. of infants:		
from single pregnancy	63	74
from twin pregnancy	54	35
from triplets pregnancy	3	3
Boys/girls	56/64	55/57
Gestational age (weeks):		
median (range)	33 (26-37)	34 (24-37)
Birth weight (g):		
median (range)	1.975 (660-3.820)	1.930 (600-3.680)

preterm newborn in the first week of life; ref. 14); hemolytic disease of the newborn (14); apneic attacks (15); respiratory distress syndrome – hyaline membrane disease (15); bacterial, fungal, parasitic, or viral infections in the newborn period, ie, since the day of birth until the end of the 28th day of life; severe diseases of the newborn: anemia (hemoglobin in blood in g/L below normal values, associated with the infants' birth weight and early age, ie, since the day of birth until the end of the seventh day of life (16); acute renal insufficiency due to prerenal causes and sepsis in the newborn; neonatal convulsions (17); pathological neurological signs (generalized muscular hypertonia, muscular hypertonia of upper limbs only, muscular hypertonia of lower limbs only, generalized muscular hypotonia); and mother's age >35 years at the time of conception.

A detailed medical history was obtained for all infants. All medical records from the Hospital maternity wards were reviewed and for neurological development risk factors noted. Medical history was completed as needed during the follow-up visits. At the control neurological examinations, parents of each child were asked about the possible delayed onset of convulsions (18). All children had undergone all examinations planned for the study. In children in the high-risk group, general movement assessment and classical neurological examinations were performed. Children in the control group underwent only classical neurological examinations. Psychomotoric development was assessed in the children at 24 months of corrected age. Clinical psychologists used Brunet-Lezin test and Vineland scale of social maturity for the assessment. The study conformed to the Slovenian Code of Medical Deontology and principles of the Helsinki Declaration on Biomedical Research on Humans (Hong Kong, 1989) (18). Written informed consent was obtained from parents whose children were included into the study. The consent form was reviewed, evaluated, and approved by the Commission for Medical Ethics, Ministry of Health of the Republic of Slovenia. The Commission for Medical Ethics of the Slovenian Ministry of Health also appraised the study.

#### *Assessment of General Movements of Fidgety Character*

Assessment of general movements of fidgety character in all children of the high-risk group was carried out according to the recommendations described elsewhere (3,7). Each child was examined at the age of 12 weeks after calculated the delivery date, ie, at the corrected age of three months (corrected age is the age calculated from the day of calculated delivery date, whereas chronological age is the age of child since the day of birth), when general movements of fidgety character are easiest to observe. Neurological examinations by using the method of assessment of general movements were performed according to a protocol prepared for the study. Reliability and validity of the method was assured by use of videotape recordings of the spontaneous movements in children. The recordings were made on BASF videotape (BASF, Archive master PHG Hi Fi 45 Premium High Grade VHS C Pal Secam EC-45/65m, BASF, Ludwigshafen, Germany) by use of video camera (METZ mecavision, HQ VHS PAL Movie 9636 S VHS C 625; New York, NY, USA), and reviewed on PANASONIC video-recorder (NV-J45 HQ; San Diego, CA, USA). During the examination, the children were lying completely undressed on their backs in supine position on an Airex mat (200 cm × 125 cm × 2.5 cm; Airex, Way Anaheim, CA, USA) on the floor. Temperature of the room was between 24 °C and 26 °C. The assessment of the general movement quality was performed while children were actively awake, ie, in the active wakefulness, state 4 according to Prechtl (19). Children were not videotaped during prolonged episodes of fussing and crying, during drowsiness and episodes of hiccupping. It was not possible to judge the quality of general movements properly if the infant was sucking on a dummy, either. During the videotaping, there were no items or other persons in the child's vicinity, which could distract or disturb the child. The distance between the video camera and the child was about 1.5-2.0 m. Children were videotaped from aside, sometimes from above. Video camera was usually held by the investigator and rarely mounted on a tripod. Each video-session lasted 30 minutes or longer, and was performed at least 1.5 h after the last meal the child had. Videotapes were reviewed the same day on the video-recorder. The observation period did not last longer than the recommended 45 minutes (3). Between assessments of the two video-recordings, the investigator always re-

viewed the gold standard videotape recording that shows normal general movements in a child of a given age. The original videotape "Spontaneous Motor Activity as a Diagnostic Tool, Functional Assessment of the Young Nervous System, a Scientific Illustration of Prechtl's Method" from the GM Trust Medical Guide, the GM Trust, c/o the Secretary, Department of Physiology, Karl Franzens University, Graz, Austria was also used. Videotapes were at first reviewed at a faster speed because thus it was easier to determine the beginning and the end of the general movements. The representative sample of fidgety movements that lasted several minutes was chosen. After that, the tapes were reviewed at the normal speed to note the details. The global assessment of the general movement quality was made, based on the observer's visual Gestalt perception. General movements of fidgety character were classified based on their quality as normal, abnormal, or absent. The normal fidgety movements were defined as restless but smoothly rounded movements involving the whole body. These were circular movements of small amplitude, moderate speed, and variable acceleration of the neck, trunk, and limbs in all directions. They were continual in the awake infant, except during focused attention, fussing, and crying. The general movements might be concurrent with other movements. Fidgety movements were assessed as abnormal in nature, when they looked like normal fidgety movements but their amplitude, speed, and jerkiness were moderately or greatly exaggerated, or absent if they were never observed. Data were recorded in the protocol sheet. On the basis of general movement assessment, the expected neurological development of the child was determined. Normal neurological development was expected if a child had normal general movements of fidgety character. When general movements of fidgety character were abnormal or absent, the later development of neurological deficits was expected. Such a child was referred to early neurodevelopmental treatment according to Bobaths' method (20).

#### *Neurologic Examination According to Amiel-Tison and Grenier*

Neurological examination according to Amiel-Tison and Grenier (21) was performed in all children of the control group at 3 months of corrected age. Only basic method from the protocol for neurological assessment of newborns and infants according to Amiel-Tison and Grenier (21) was used; the additional neuromotoric examination, so-called early confirmation of normality (21), was not performed to spare the child from too many examinations. Neurological development of the child was assessed as normal, abnormal, or disharmonious (under risk). Amiel-Tison and Grenier also advised such a synthesis of findings after neurological examination and thorough analysis of the results of individual elements observed at the examination (21). Neurological development of the child with normal movement patterns was evaluated as normal. Neurological development of the child in whom abnormal movement patterns were dominant and continuously present was evaluated as abnormal, whereas neurological development of a child who had normal movement patterns intertwined with abnormal ones was evaluated as disharmonious (under risk). The child with abnormal or disharmonious neurological development was referred to early neurodevelopmental treatment according to Bobaths' method (20).

#### *Neurological Examination According to Illingworth*

For neurological follow-up of all the children of the high-risk and the control group at the corrected age of 12, 15, 18, 21, and 24 months (two years), neurological examination according to Illingworth was performed (22,23). The protocol for neurological examination according to Illingworth was prepared according to the recommendations in the literature (22,23). Neurological development of a child at the corrected age of 24 months was finally evaluated by using Illingworth's method. For assessment of neurological development at the corrected age of 24 months, results of the psychomotoric examination at the corrected age of 24 months performed by clinical psychologists were also taken into account. Neurological development of a child with normal movement patterns and normal mental development was evaluated as normal. Neurological development was evaluated as abnormal if a child had cerebral palsy of any kind or degree and/or delayed mental development, including mental development slightly below normal. The assessment of neurological development at the corrected age of 24 months obtained by the Illing-

worth's method was used as a gold standard in comparison with the assessment of general movements of fidgety character and standard neurological examination according to Amiel-Tison and Grenier (21).

#### *Assessment of Psychomotor Development*

The evaluation of psychomotor development of the children at the corrected age of 24 months was performed by clinical psychologists at the Clinic for Pedopsychiatry, Maribor Health Center, Maribor. The psychologists used Brunet-Lezin test and Vineland scale of social maturity of the child, standardized for Slovenian children population (24). From global development quotient (DQ) used for evaluation of the psychomotor development of children of up to three years of age, partial quotient of motoric abilities was excluded if it was below 80 in all children with neuromotoric development deviating from normal. If DQ was under 80 (with excluded partial quotient of motoric abilities under 80), the child was assessed as mentally retarded.

#### *Cerebral Palsy Diagnosis*

Cerebral palsy diagnosis was made in children at the age of 24 months exclusively on the basis of the clinical picture (25). Early developmental period was limited to the age of one year, with the correction for preterm children taken into account. According to the clinically most pronounced neurological signs, cerebral palsy was divided into spastic, ataxic, dyskinetic, and hypotonic type. Spastic type was included spastic hemiparesis, spastic diplegia, and spastic quadriplegia (25). Children with cerebral palsy were divided into five groups according to the classification of the children with cerebral palsy, with respect to gross motoric function according to Palisano et al (26): minimal cerebral palsy (movement difficulties present but without significant functional impairment); mild cerebral palsy (movement difficulties causing milder functional impairment); moderate cerebral palsy (movement difficulties causing more severe functional impairment) moderately severe cerebral palsy (functions achieved by use of aids and/or by surgical corrections); and severe cerebral palsy (few useful intentional movements, although some functions could be achieved).

#### *Statistical Analysis*

Data were statistically analyzed by using Microsoft Excel 97 program (Windows 2000, Microsoft Corporation, Redmond, WA, USA). T-test, with the level of significance set at  $>0.1$ , was used to assess statistically significant differences in quantitative variables between the high-risk and the control group of children (27). Probability of difference between the two median values was determined by p-value for gestational age at birth (weeks), the infants' birth weight (g), number of risk factors for neurologic development in each individual child presented (absolute number), and age of the mother at the time of conception (years). Since there were no statistically significant differences between the high-risk and the control group of children, which could significantly influence the results, the comparison of study results was possible. Qualitatively changeable variables, such as assessment of neurological development of children based on the assessment of general movements, Amiel-Tison and Grenier's neurological examination method, Illingworth's method, assessment of psychomotor development, and cerebral palsy diagnosis as well as cerebral palsy degree, were expressed as frequencies and percentages. The validity, sensitivity, specificity, positive and negative predictive value of the method of general movements of fidgety character assessment were obtained from the comparison of results of general movements assessment at the corrected age of three months with the results of Illingworth's method at the corrected age of 24 months in the high-risk group. By comparing the results of Amiel-Tison and Grenier's neurological examination method at the corrected age of three months with results of Illingworth's method at the corrected age at 24 months in the control group, validity, sensitivity, specificity, positive and negative predictive values were calculated for the standard neurological examination according to Amiel-Tison and Grenier. The calculation was as follows:

validity (%) = [(true positive + true negative) / number of children in the group]  $\times$  100;

sensitivity (%) = [true positive / (true positive + false negative)]  $\times$  100;

specificity (%) = [true negative / (false positive + true negative)]  $\times$  100;

positive predictive value (%) = [true positive / (true positive + false positive)]  $\times$  100; and

negative predictive value (%) = [true negative / (true negative + false negative)]  $\times$  100.

The advantage of general movement assessment is that it allows repeated playback of the video recordings, even at different speeds, and storing them for documentation and future reference. In our study test-retest repeatability was checked: the analysis of all general movement video recordings was repeated by the same observer and by the same method after a time interval of three months (intrascorer agreement). With regard to intrascorer agreement, repeatability of neurological examination of high-risk preterm infants according to the method of general movements of fidgety character assessment was calculated. The calculation was as follows:

repeatability (%) = (number of same scores / number of all scores)  $\times$  100.

Unfortunately, there was no such possibility in classical neurological examination according to Amiel-Tison and Grenier.

## **Results**

The continuous follow-up of neurological development of the children included in the study required a multidisciplinary approach. All 232 children underwent all the examinations planned for the study. There were 68 (57%) children in the high-risk group with more than five risk factors for neurological development (median, 6; range, 3-13). In the control group, 82 (73%) children had more than five risk factors for neurological development (median, 7; range, 3-13).

#### *Quality of General Movements of Fidgety Character at the Corrected Age of Three Months*

Normal general movements of fidgety character were present in 83 (69%) children in the high-risk group. In 37 (31%) children of the high-risk group, the general movements of fidgety character diverged from normal. Out of all general movements of fidgety character varying from normal, in 20 children abnormal general movements of fidgety character were present, whereas in 17 children no general movements of fidgety character were found.

#### *Neurological Examination According to Amiel-Tison and Grenier at the Corrected Age of Three Months*

Neurological examination according to Amiel-Tison and Grenier at the corrected age of three months showed normal neurological development in 34 (30%) children of the control group, abnormal in 69 (62%), and disharmonious in 9 (8%) children of the control group.

#### *Neurological Examination According to Illingworth's Method at the Corrected Age of 24 Months*

In the high-risk group, neurological development according to Illingworth's method at the corrected age of 24 months was evaluated as normal in 88 (73%) and as abnormal in 32 (27%) children. Out of 32 children with abnormal neurological development, 13 had cerebral palsy and normal mental development, 18 had cerebral palsy and mental retardation, and one child was only mentally retarded. In the

**Table 2.** Assessment of general movements of fidgety character and the classical neurological examination according to Amiel-Tison and Grenier at the corrected age of three months, and the neurological outcome according to Illingworth's method at the corrected age of 24 months

Type of neurological examination at the corrected age of three months (No. of children)	Neurological outcome at the corrected age of 24 months according to Illingworth's method (No., %)			
	normal	cerebral palsy and mental retardation	cerebral palsy	mental retardation
Assessment of general movements of fidgety character:				
normal (n = 83)	81 (98.0)	2 (2.0)	0	0
abnormal (n = 20)	7 (35.0)	2 (10.0)	10 (50.0)	1 (5.0)
absent (n = 17)	0	14 (82.0)	3 (18.0)	0
Classical neurological examination according to Amiel-Tison and Grenier:				
normal (n = 34)	33 (97.0)	1 (3.0)	0	0
disharmonious (n = 9)	8 (89.0)	1 (11.0)	0	0
abnormal (n = 69)	36 (52.0)	20 (29.0)	11 (16.0)	2 (3.0)

**Table 3.** Reproducibility of the method of general movements of fidgety character assessment in the group of 120 high-risk preterm infants, with respect to intrascorer variations

Findings	No. of high-risk preterm infants	
	first evaluation of general movements	repeated evaluation of the same videotape recordings of general movements after three months by the same observer
Normal	83	86
Abnormal	17	14
Absent	20	20

control group, neurological examination according to Illingworth's method at the corrected age of 24 months revealed that 77 (69%) children had normal and 35 (31%) abnormal neurological development. Out of these 35 children, 11 had cerebral palsy and normal mental development, 22 had cerebral palsy and mental retardation, and two were only mentally retarded.

#### Comparison of the Methods

The assessment of general movements of fidgety character at the corrected age of three months and the neurological examination according to Illingworth's method at the corrected age of 24 months were compared with the neurological examination according to Amiel-Tison and Grenier at the corrected age of three months and the neurological examination according to Illingworth's method at the corrected age of 24 months (Table 2). The assessment of general movements of fidgety character gave two false negative and seven false positive results. Neurological examination by the method of Amiel-Tison and Grenier gave one false negative and 44 false positive results. The validity of the method of general movements assessment was 92%, sensitivity 94%, specificity 92%, positive predictive value 81%, and negative predictive value 98%. The validity of the classical neurological examination according to Amiel-Tison and Grenier was 60%, sensitivity 97%, specificity 43%, positive predictive value 44%, and negative predictive value 97%.

#### Intrascorer Agreement

With regard to intrascorer agreement, the repeatability of general movements assessment, calculated as a ratio between the same scores vs all scores, was 97% (Table 3).

#### Discussion

The present study showed that the method of general movements of fidgety character assessment also allowed a valid prediction to be made about later neurological outcome in neurologically high-risk preterm infants long before the first signs of spasticity appear. The technique is non-invasive and non-intrusive. It allowed the prognosis of further neurological development of these children as early as the corrected age of three months, ie, significantly earlier than the onset of the first signs of spasticity. Not only that the absent or abnormal general movements of fidgety character predicted neurological development varying from normal, but even normal general movements were excellent predictor of the further normal neurological development. In our study general movements of fidgety character in children with moderate or severe form of cerebral palsy were never observed, whereas in 98% of children with normal general movements of fidgety character, the further neurological development was normal.

The same was found in other studies done in neurologically low-risk preterm infants and neurologically low-risk and high-risk full-term infants. Constant presence of abnormal general movements of fidgety character and their absence was reported to predict the development of the clinical picture of cerebral palsy and/or mental retardation with the reliability of 93-96% (3,8,29,30). General movements of fidgety character have never been described in children with severe form of cerebral palsy, whereas in children with normal general movements of fidgety character, neurological development has almost always been normal (3,8,29,30).

The results of our study showed that the method of quality assessment of general movements of fidgety character had high reliability, validity, sensitivity, specificity, positive and negative predictive value also in neurologically high-risk preterm infants.

Other studies have shown high reliability of the method in neurologically low-risk preterm infants and in neurologically low-risk and high-risk full-term infants with regard to variations in interscorer agreement (median, 90%; range 75-100%) (3,8,29,30). The single study published on intrascorer variability reported the reliability of 82%, ranging between 69% and 100%, irrespective of the child's age (3). In the present study, the reliability of the method of assess-

ment of general movements of fidgety character was 97% at repeated evaluation of the same videotape recordings (intrascorer agreement) three months after the first evaluation. The reliability of the method of general movements of fidgety character assessment with regard to different scorers (interscorer variability) in the Republic of Slovenia could not be determined, because other specialists do not use this method in their everyday practice. Therefore, the comparison of results of our study and the results of other investigators was not possible. This is also the main limitation of this study, because the notorious subjectivity of the qualitative video-recordings interpretation could not be controlled with interscorer agreement.

The validity of the method of assessment of general movements of fidgety character, with presentation of false negative and false positive results, has been reported only by Prechtl et al (8). Their research included a large, mixed sample of low-risk and high-risk preterm and full-term infants. In the group of 130 children examined by the assessment of general movements of fidgety character, false negative result was obtained in only three (2%) children, and false positive also in three (2%). When their results are compared with the results of the present study, it shows that there was the same number of false negative results, but different number of false positive results. The possible reason for this difference could be that the normal general movements of fidgety character were more often evaluated as abnormal in the present study.

The sensitivity (median, 94.5%, range, 60-100%) and specificity (median, 85%; range 82-100%) of the method of assessment of general movements of fidgety character is high in neurologically low-risk preterm infants and in low-risk and high-risk full-term infants (3,8,9). In the present study, both sensitivity (94%) and specificity (92%) of the method in neurologically high-risk preterm infants were similarly high.

Cioni et al (30) proved higher predictive value of the method of general movement assessment than that of classic neurological examination according to Amiel-Tison and Grenier (21) and Touwen (31) at the age of three months. They showed equally high sensitivity of both methods, but different specificity. Specificity of the method of assessment of general movements of fidgety character was high (92%), whereas the specificity of classical neurological examination (21) at the corrected age of three months was low (43%). In all studies, including ours, classical neurological examination gave higher number of false positive results, which was the reason why specificity was so much lower. It seems that the classical neurological examination method is more sensitive to milder abnormalities of transitory neurological functions, which causes higher number of false positive results.

Prechtl et al (2,3,8) pointed out the drawbacks of the method of general movements assessment. Intensive care procedures used in the treatment of newborns and infants limit the possibilities of that method. Mechanically ventilated patients or patients on intravenous therapy cannot move freely. In such patients, it is not possible to perform a valid examina-

tion. The method of general movements of fidgety character assessment does not include the sight and hearing examinations, as classical neurological examinations do. Therefore, special care is needed to perform these examinations along with neurological examination of general movement assessment (32). The method, despite the use of technical equipment during examination, preserves the personal contact between the scorer and the child.

The children in the high-risk group in the present study were early referred to neurodevelopmental treatment according to Bobaths' method (20) if they showed abnormalities or absence of general movements of fidgety character. Neurodevelopmental treatment of the children with early brain damage started at the age of four months or earlier achieves the greatest success in habilitation of the children and prevention of invalidity (33). Abnormal or disharmonious development of the children, diagnosed by neurological examination according to Amiel-Tison and Grenier at the corrected age of three months, was the criterion for early neurodevelopmental treatment in the control group of children. The introduction of the general movements of fidgety character assessment method decreased the number of children referred to early neurodevelopmental treatment by 39%. Another limitation of this study is that there has been no similar research so far, so the comparison of the results with other studies is not possible.

The reduction in the number of neurologically high-risk preterm infants referred to early neurodevelopmental treatment is one of the major contributions of our study, because the neurodevelopmental treatment has its drawbacks in addition to its advantages. It is a burden for the child and parents; it is expensive and long-lasting. Indication for the beginning of the neurodevelopmental treatment should always be clear. It is unacceptable to introduce the treatment "to be safe", because, although it would not harm a healthy child in the functional sense, it definitely would increase the worry and fear of the parents. It is unacceptable to transfer the responsibility to parents and their child without them even being aware of that, because of one's own insecurity. Thus, the assessment and predictive methods regarding the neurological development of a child should be carefully chosen, research should be performed, and results always compared with those of other investigators. On the basis of our study, the method of general movement assessment can be highly recommendable as a valid predictor of later neurological outcome in neurologically high-risk preterm infants as well. The method proved reliable and valid. It was efficient and well accepted by the infants included in the study and their parents. The technique is non-invasive, non-intrusive, and is an excellent method to distinguish between infants in need of close surveillance and early intervention and those with no need for such an approach.

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