Abstract booklet

Publications on Prechtl’s Method on the Qualitative Assessment of General Movements in Preterm, Term and Young Infants

Publications, updated to May 2nd, 2014
VIDEO:

Spontaneous Motor Activity as a Diagnostic Tool:  The Functional Assessment of the Young Nervous System: A Scientific Illustration of Prechtl's Methods

This easy to use demonstration video is aimed at physicians, physiotherapists and other professionals working in the field of infant neurology.
Using a host of recorded observations, this demonstration video sets a standard both for normal General Movements in the infant (from birth to 20 weeks postterm) and for the abnormal movements which indicate neurological deviations, often leading to cerebral palsy.

How to Order the Video
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MANUAL:

Prechtl's Method on the Qualitative Assessment of General Movements in Preterm, Term and Young Infants
(Clinics in Developmental Medicine)
Prechtl's Method on the Qualitative Assessment of General Movements in Preterm, Term and Young Infants
Publisher: Mac Keith Press

Prechtl's Method provides a quick, non-invasive and cost-effective means of making early assessments of infants to identify any neurological deviations which may lead to cerebral palsy and other developmental deficits later on. The method has high reliability and validity.
There is a pressing need for a reliable way of recognising those infants who require treatment. Equally important is the need to provide parents with a realistic prediction of their child's development.
Publications, updated to May 2nd, 2014

(Papers are listed in order of publication; abstracts are enclosed; reprints can be downloaded from journal websites or requested to the authors)


BACKGROUND: The placenta plays a crucial role during pregnancy and dysfunction causes long-term neurological problems. Identifying placenta-related risks for neurological problems shortly after birth may provide clues for early interventions aiming to improve neurological outcome.

OBJECTIVE: To determine the association between placental pathology and neurological morbidity in preterm infants during the first two weeks after birth.

STUDY DESIGN: Placentas of 52 singleton, preterm infants (GA: 25-31 weeks, BW: 560-2250 grammes) were examined for histopathology. The infants' neurological condition shortly after birth was determined by assessing the quality of their general movements (GMs): normal, abnormal, or hypokinetic, on days 5, 8, and 15. A motor optimality score (MOS) was also assigned.

RESULTS: Examination of the placentas revealed maternal vascular underperfusion (n=29), ascending intrauterine infection (AIUI) (n=19), villitis of unknown aetiology (n=6), chronic deciduitis (n=11), foetal thrombotic vasculopathy (FTV) (n=9), and elevated nucleated red blood cells (NRBCs) as a marker for foetal hypoxia (n=7). None of the placental lesions were significantly associated with the quality of GMs or MOS.

CONCLUSIONS: This study indicated that placental lesions were not associated with infants' neurological condition as measured by the quality of their general movements during the first two weeks after birth.


BACKGROUND: The assessment of General Movements (GMs), i.e. age-specific motor patterns during the first months of life, has repeatedly proven to be a valuable tool to predict neurodevelopmental outcomes. Abnormal spontaneous GMs were found to be among the most reliable markers for cerebral palsy. To add to the knowledge of the abnormal early motor repertoire we analysed prospectively collected video recordings of a boy clinically diagnosed with Cornelia de Lange syndrome. The observed atypical GMs are a further step to disentangle early motor peculiarities in the light of the genetic impact on the developing brain.


BACKGROUND: The quality of general movements (GMs) is a widely used criterion to assess neurological dysfunction in young infants. It is unknown, however, whether the birth process influences the motor repertoire of healthy full term infants during the first week after birth.

AIMS: To assess the quality of GMs and to determine the motor optimality score (OS) in healthy full term infants during the first week after birth and to evaluate the influence of the mode of delivery on GM quality.

STUDY DESIGN: Thirty-three healthy full term infants born either vaginally or after caesarean section (CS) under spinal anaesthesia were video recorded in the first week after birth in order to assess GM quality and to determine OS with Prechtl's method.

RESULTS: Abnormal GMs were observed mainly on the early recordings: 86% on the day of birth (day 0), 94% on day 1, and 68% on day 2. On days 5 to 7 (day 5-7) all GMs were normal (P<.001). The OSs increased significantly from median 12 on day 0 to 18 on day 5-7 (P<.001). Monotonously slow movements were frequently seen during the first days but not on day 5-7 (P<.001). GM quality and OS did not differ between infants born by vaginal delivery or after CS under spinal anaesthesia.

CONCLUSIONS: Healthy full term infants often showed abnormal GM quality and lower OSs during the first week after birth, irrespective of the mode of delivery. GM quality normalised during subsequent days and was normal on day 5-7.


OBJECTIVE: Spontaneous movements at 2 months of corrected age in preterm infants with intellectual disability (ID) were investigated by assessing individual motor elements separated from movements involving the entire body.

METHODS: Video recordings of 20 preterm infants with ID (16 males, 4 females; median gestational age 26 weeks;...
OBJECTIVE: Although ~50% of very preterm (VP) children have neurodevelopmental impairments, early prediction of infants who will experience problems later in life remains a challenge. This study evaluated the predictive value of general movements (GM; spontaneous and endogenous movements) at 1 and 3 months' corrected age for infants who will experience problems later in life remains a challenge. This study evaluated the predictive value of general movements (GM; spontaneous and endogenous movements) at 1 and 3 months' corrected age for neurodevelopment at 2 and 4 years of age in VP children.

METHODS: At 1 and 3 months' corrected age, infants born <30 weeks' gestation had GM assessed as normal or abnormal. Motor, cognitive, and language development at 2 years was assessed using the Bayley Scales of Infant and Toddler Development, Third Edition. At 4 years, cognitive and language outcomes were assessed by using the Differential Ability Scale-Second Edition and motor outcomes with the Movement Assessment Battery for Children-Second Edition; a diagnosis of cerebral palsy was documented.

RESULTS: A significant correlation was found between GMs and outcome both at writhing (rs 0.68; p < 0.001) and at fidgety age (rs 0.78; p < 0.001). The assessment at 1 month showed 100% sensitivity and 86% specificity of predicting the development of cerebral palsy (CP), that at 3 months was 100% sensitivity and 97% specificity.

CONCLUSIONS: During the fidgety age GMs predict CP with very high sensitivity and specificity. The qualitative assessment of GMs should be employed to help identify VP infants who require early intervention for neurological abnormalities.

STUDY DESIGN AND SUBJECTS: 574 LP infants were examined using the standard methodological principles of Prechtl's method for assessing GMs both during writhing and fidgety periods.

OUTCOME MEASURES: Infants were assessed at 2 years of age with neuromotor and developmental scales. CP status was reported at 2 years. Nine children developed CP of whom all recordings had absent FMs. The mean variability of the centroid of motion (CSD) from two recordings was more accurate than using only one recording, and identified all children who were diagnosed with CP at 2 years. Age at assessment did not influence the detection of FMs or prediction of CP. The accuracy of computer vision techniques in identifying FMs and predicting CP based on two video recordings should be confirmed in future studies.

RESULTS: Ninety-nine VP infants were recruited, with 97% and 88% of survivors followed up at age 2 and 4 years, respectively. Abnormal GM at 1 month were associated with worse motor outcomes at 2 and 4 years but not language or cognitive outcomes. Abnormal GM at 3 months were associated with worse motor, cognitive, and language outcomes at both 2 and 4 years. Overall, GM at 1 month demonstrated better sensitivity to impairments at 2 and 4 years, whereas GM at 3 months had better specificity and were more accurate overall at distinguishing between children with and without impairment.

CONCLUSIONS: Abnormal GM in VP infants, particularly at 3 months postterm, are predictive of worse neurodevelopment at ages 2 and 4 years.


BACKGROUND: The quality of general movements (GMs) and its predictive value have never been evaluated in late-preterm (LP) infants.

AIMS: To determine the characteristics of GMs and their predictive value for neurodevelopmental outcome in a cohort of infants born between 34 and 36 weeks' gestation.

METHODS: At 1 and 3 months' corrected age, startle response, lateral decumbent position, predominant shoulder rotation, and maintaining hip abduction, to-and-fro elbow flexion, isolated hip adduction, to-and-fro hip abduction, and leg lift were less frequently seen than in the normal preterm infants (Fisher's exact test, p<0.05). Conclusion: Abnormal spontaneous movements at 2 months of age in preterm infants with ID result from persistent immature movements and non-emergence of mature movements.


BACKGROUND: The general movement assessment has mainly been used to identify children with cerebral palsy (CP). A detailed assessment of quality of infant motor repertoire using parts of the "Assessment of Motor Repertoire - 3 to 5Months" which is based on Prechtl's general movement assessment can possibly identify later motor and cognitive problems in children without CP.

AIMS: This study aims to determine whether analysis of quality of infant motor repertoire has predictive value for motor and cognitive outcomes at age 10 in children at risk for later neurological impairment.

STUDY DESIGN: A longitudinal study design was used.

SUBJECTS: Video-recordings of 40 "neurologically high-risk" infants at 14weeks post-term age were analysed with respect to motor repertoire.

OUTCOME MEASURES: Fidgety movements were classified as present or absent. Quality of concurrent motor repertoire was classified as normal if smooth and fluent and abnormal if jerky, monotonous or stiff. Poor motor outcome was defined as a score ≤5th centile on the Movement-Assessment-Battery-2, while poor cognitive outcome as total IQ <85 on Wechsler Intelligence Scale-III.

RESULTS: Among the high-risk children with presence of fidgety movements, poor motor and/or cognitive outcome at 10years was identified by abnormal concurrent motor repertoire at 14weeks post-term age in 86% (95% CI: 0.60-0.96) of the children. On the other hand, 71% (95% CI: 0.47-0.87) of those with normal motor and cognitive outcomes were identified by presence of fidgety movements and normal motor repertoire.

CONCLUSIONS: Assessment of quality of infant motor repertoire may be a valuable early clinical marker for later impaired motor and cognitive outcomes in high-risk children who do not develop CP.

De Vries NK, Van der Veere CN, Reijneveld SA, Bos AF. Early Neurological Outcome of Young Infants Exposed to Selective Serotonin Reuptake Inhibitors during Pregnancy: Results from the Observational SMOK Study. PLoS One. 2013 May 28;8(5). Print 2013

BACKGROUND: Use of selective serotonin reuptake inhibitors (SSRI) during pregnancy is common while the effect on the infant's neurological outcome is unknown. Our objective was to determine the effects of prenatal SSRI-exposure on the infants' neurological functioning, adjusted for maternal mental health.

METHODS: A prospective observational study from May 2007 to April 2010. The study groups comprised 63 SSRI-exposed infants (SSRI group) and 44 non-exposed infants (non-SSRI group). Maternal depression and anxiety were measured using questionnaires. The main outcome measures during the first week after birth and at three to four months were the quality of the infants' general movements (GMs) according to Prechtl and a detailed motor optimality score. We calculated odds ratios (ORs) and 95% confidence intervals (CIs) for abnormal GM quality in the SSRI and non-SSRI groups, and adjusted for maternal depression, anxiety, and other confounders. The study was registered under 53506435 in the ISRCTN.

FINDINGS: All infants were born around term. During the first week, abnormal GMs occurred more frequently in the SSRI group than in the non-SSRI group (59% versus 33%) and the median MOS was lower (13 versus 18). The OR for abnormal GMs in the SSRI versus the non-SSRI group was 3·0 (95% CI, 1.3 to 6.9) and increased after adjustment for confounders. At three to four months, more SSRI-exposed infants had monotonous movements (48% versus 20%) with lower median MOSs (26 versus 28). The OR for monotonous movements was 3·5 (95% CI, 1.5 to 8.6) and increased after adjusting for confounders.

INTERPRETATION: Prenatal exposure to SSRI had an adverse effect on early neurological functioning as reflected by GM quality, irrespective of maternal depression and anxiety, and other confounders. Physicians should take this into account in consultation with parents.


OBJECTIVE: Cerebral palsy (CP) is a permanent disorder in the development of movement and posture in the developing infant brain and is one of the major disabilities that result from extremely preterm birth. Early identification of possible neurodevelopmental injury offers the opportunity to deliver intervention at a very early age and thus prevent severe disability. The assessment of general movements (GMs), has emerged as a reliable and valid predictor of severe neurologic deficits in infants. This method is based on a visual Gestalt perception of the quality of GMs in the preterm and term periods, and postterm up to 5 months. The quality of "fidgety movements" is the most valuable marker for predicting neurologic outcomes.

Einspieler C, Marschik PB, Bos AF, Ferrari F, Cioni G, Prechtl HFR
Early markers for cerebral palsy: insights from the assessment of general movements

Future Neurology November 2012, Vol. 7, No. 6, Pages 709-717

Overt clinical symptoms of cerebral palsy do not emerge before a child is at least half a year old. Among the most reliable early markers for cerebral palsy are abnormal ‘general movements’ (GMs). Two specific abnormal GM patterns predict cerebral palsy: cramped-synchronized GMs (during preterm and term age), which lack the usual smoothness and fluent character; and limb and trunk muscles contract almost simultaneously and relax almost simultaneously. In addition, the absence of so-called fidgety movements at 3–5 months post-term age. Fidgety movements are small movements of the neck, trunk and limbs in all directions and of variable acceleration. Beside a high sensitivity (>91%) and specificity (>81%), the assessment of GMs is quick, nonintrusive and easy to acquire.

Sustersic B, Sustar K, Paro-Panjan D.
General movements of preterm infants in relation to their motor competence between 5 and 6 years.

BACKGROUND: The criteria for identification of children with high risk of cerebral palsy are well documented, but the early identification of children at highest risk of minor motor deficits remains less clear.
AIM: To analyze the correlation between the quality of general movements (GMs) from term to twenty weeks postterm age and the motor competence between 5 and 6 years of age.
METHODS: In the group of 45 preterm infants, the quality of GMs was assessed using Prechtl's method. The Movement Assessment Battery for Children (M-ABC) was used to test motor competence between 5 and 6 years of age. The correlations between GMs and M-ABC results were analyzed.
RESULTS: During writhing period, the sensitivity of GMs to identify children with definite motor problem was 0.86 for total impairment, 0.67 for manual dexterity, 0.89 for ball skills and 0.92 for balance. During fidgety period, the sensitivity was higher than during the writhing period: 1.00 for total impairment, 1.00 for manual dexterity, 1.00 for ball skills and 0.83 for balance, respectively. The specificity was low at both ages (total scoring 0.24 at term and 0.21 at 3 months corrected age).
CONCLUSION: The sensitivity of GMs to identify children with definite motor problems is higher at the fidgety than at the writhing period. The specificity of GMs at the term and fidgety age to predict later motor abilities is low.

Sabel KG, Strandvik B, Petzold M, Lundqvist-Persson C.
Motor, mental and behavioral developments in infancy are associated with fatty acid pattern in breast milk and plasma of premature infants.

The objective of this study was to investigate any association between infants’ early development and PUFA concentrations in early breast milk and infants’ plasma phospholipids at 44 weeks gestational age. Fifty-one premature infants were included. The quality of general movement was assessed at 3 months, and motor, mental and behavioral development at 3, 6, 10 and 18 months corrected age using Bayley's Scales of Infant Development (BSID-II). Linoleic acid, the major n-6/n-3 FA ratios, Mead acid and the EFA deficiency index in early breast milk were negatively associated with development up to 18 months of age. DHA and AA, respectively, in infants' plasma phospholipids was positively, but the AA/DHA ratio negatively, associated with development from 6 to 18 months of age. Our data suggest that the commonly found high n-6 concentration in breast milk is associated with less favorable motor, mental and behavioral development up to 18 months of age.

Preterm birth and developmental problems in the preschool age. Part I: minor motor problems.

Nearly half of very preterm (VP) and extremely preterm (EP) infants suffers from minor disabilities. The paper overviews the literature dealing with motorproblems other than cerebral palsy (CP) during infancy and preschool age. The term “minor motor problems” indicates a wide spectrum of motor disorders otherthan CP; “minor” does not mean "minimal", as a relevant proportion of the preterminfants will develop academic and behavioural problems at school age. Early onset disorders consist of abnormal general movements (GMs), transient dystonia and postural instability; these conditions usually fade during the first months. Theywere underestimated in the past; recently, qualitative assessment of GMs using Prechtl's method has become a major item of the neurological examination. Lateonset disorders include developmental coordination disorder (DCD) and/or minorneurological dysfunction (MND); both terms cover partly overlapping problems. Simple MND (MND-1) and complex MND (MND-2) can be identified and MND-2 gives ahiger risk for learning and behavioural disorders. A relationship between thequality of GMs and MND in childhood has been recently described. The Touwen infant neurological examination (TINE) can reliably detect neurological signs of MND even in infancy. However, the prognostic value of these disorders requires further investigations.

Nieuwenhuis T, da Costa SP, Bilderbeek E, Geven WB, van der Schans CP, Bos AF.
OBJECTIVE: To examine the association between sucking patterns and the quality of fidgety movements in preterm infants.  

STUDY DESIGN: We studied the sucking patterns and fidgety movements of 44 preterm infants (gestational age < 35 weeks) longitudinally from 34 weeks' postmenstrual age up to 14 weeks postterm. We used the Neonatal Oral-Motor Assessment Scale during feeding and scored the sucking patterns as normal or abnormal. Abnormal sucking patterns were categorized into arrhythmic sucking and uncoordinated sucking. At 14 weeks postterm, we scored the quality of fidgety movements from videotapes as normal, abnormal, or absent.  

RESULTS: The postmenstrual age at which sucking patterns became normal (median, 48 weeks; range, 34 to >50 weeks) was correlated with the quality of fidgety movements (Spearman ρ = 0.33; P = 0.038). The percentage per infant of normal and uncoordinated sucking patterns was also correlated with the quality of fidgety movements (ρ = 0.31; P = 0.048 and ρ = -0.33; P = 0.035, respectively). Infants with uncoordinated sucking patterns had a higher rate of abnormal fidgety movements (OR, 7.5; 95% CI, 1.4-40; P = .019).  

CONCLUSION: The development of sucking patterns in preterm infants was related to the quality of fidgety movements. Uncoordinated sucking patterns were associated with abnormal fidgety movements, indicating that uncoordinated sucking, swallowing, and breathing may represent neurologic dysfunction.

Einspieler C, Hirota H, Yuge M, Dejima S, Marschik PB.  
Early behavioural manifestation of Smith-Magenis syndrome (del 17p11.2) in a 4-month-old boy.  

OBJECTIVE: There is little systematic data on early neurodevelopmental functioning of infants with Smith-Magenis syndrome, since early diagnosis is rare.  

METHODS: A boy with cytogenetically confirmed Smith-Magenis syndrome was videotaped at 4 months and 1 week of age. His posture and spontaneous movements were analyzed without knowing the diagnosis.  

RESULTS: The motor repertoire appeared significantly reduced; fidgety general movements, which are typical of that age, were missing. Posture was abnormal and overall movements were jerky and monotonous. The findings indicate a severe motor impairment by no more than 4 months of age.  

CONCLUSION: It was concluded that an absence of fidgety movements that goes along with subtle dysmorphic features indicates an increased risk of maldevelopment and justifies the need to refer for genetic evaluation with the potential of facilitating earlier diagnosis.

Disselhorst-Klug C, Heinez F, Breitbach-Faller N, Schmitz-Rode T, Rau G.  

Coordination between perception and action is required to interact with the environment successfully. This is already trained by very young infants who perform spontaneous movements to learn how their body interacts with the environment. The strategies used by the infants for this purpose change with age. Therefore, very early progresses in action control made by the infants can be investigated by monitoring the development of spontaneous motor activity. In this paper, an objective method is introduced, which allows the quantitative evaluation of the development of spontaneous motor activity in newborns. The introduced methodology is based on the acquisition of spontaneous movement trajectories of the feet by 3D movement analysis and subsequent calculation of specific movement parameters from them. With these movement-based parameters, it was possible to provide an objective description of age-dependent developmental steps in healthy newborns younger than 6 months. Furthermore, it has been shown that pathologies like infantile cerebral palsy influence development of motor activity significantly. Since the introduced methodology is objective and quantitative, it is suitable to monitor how newborns train their cognitive processes, which will enable them to cope with their environment by motor interaction.

Hitzert MM, Benders MJ, Roescher AM, van Bel F, de Vries LS, Bos AF. Hydrocortisone vs. dexamethasone treatment for bronchopulmonary dysplasia and their effects on general movements in preterm infants.  

INTRODUCTION: Hydrocortisone (HC) and dexamethasone (DXM) are used to treat preterm infants at risk for bronchopulmonary dysplasia (BPD). This may, however, affect their long-term neurological development. We aimed to determine the effect of HC and DXM therapy in preterm infants on neurological functioning as assessed by the quality of general movements (GMs) until 3 months after term.  

RESULTS: We found no difference in the quality of GMs between HC and DXM infants until term age. At 3 months, HC infants had a higher median motor optimality score (MOS) than DXM infants (25 vs. 21, P = 0.015). In the DXM group, MOS on the first day of treatment was lower than before treatment (19 vs. 11, P = 0.030).  

DISCUSSION: MOS decreased in DXM infants on the first day following treatment and at 3 months after term. This was not the case in HC infants. Our study suggests that neurological functioning at 3 months after term is better in infants treated with HC than in infants treated with DXM.
METHODS: We performed a longitudinal, observational study including 56 preterminfants (n = 17 HC, n = 17 DXM, n = 22 controls). GM quality, videoed before and after treatment, was assessed. In addition, a MOS was assigned to details of the GMs.


AIM: The aim of this study was to systematically review the clinimetric properties of longitudinal neonatal neurobehavioural and neuromotor assessments for preterm infants.

METHOD: Twenty-seven assessment measures were identified. The following eight measures met the study inclusion criteria: Assessment of Preterm Infants’ Behaviour (APIB), Neonatal Intensive Care Unit Neurobehavioural Scale (NNNS), Test of Infant Motor Performance (TIMP), Prechtl’s Assessment of General Movements (GMs), Neurobehavioural Assessment of the Preterm Infant (NAPI), Dubowitz Neurological Assessment of the Preterm and Full-term Infant (Dubowitz), Neuromotor Behavioural Assessment (NMBA), and the Brazelton Neonatal Behavioural Assessment Scale (NBAS). The primary purposes included prediction (TIMP, GMs, Dubowitz), discrimination (all assessments), and evaluation of change (TIMP, NAPI). Measures of assessment were included in the study if they were (1) primarily neurobehavioural or neuromotor assessments that were suitable for use with preterm infants (<37 weeks gestation) up to 4 months corrected age and were discriminative, predictive, or evaluative; (2) standardized procedures designed for serial/longitudinal use; or (3) criterion or norm referenced. However, all assessment tools that were not published in English in a peer-reviewed journal or were primarily neurological assessments, one-time evaluations, screening tools, or not commercially available were not used.

RESULTS: All of the measures included in the review demonstrated adequate content and construct validity. Concurrent validity was reported for APIB, NNNS, Dubowitz, and GMs. Predictive validity was high for GMs with studies reporting up to 100% sensitivity for predicting cerebral palsy at the age of 12 to 24 months. Interrater reliability was strong for the TIMP (intraclass correlation = 0.95), GMs (K = 0.8), and moderate for the NAPI (r = 0.67-0.97). Clinical utility was variable for ease of scoring, interpretability, cost, and access.

INTERPRETATION: In the absence of a criterion standard for neonatal neuromotor assessments, the NNNS and APIB have strong psychometric qualities with better utility for research. Similarly, the GMs, TIMP, and NAPI have strong psychometric qualities but better utility for clinical settings. The GMs has best prediction of future outcome and the TIMP has best evaluative validity.


The challenge of identifying infants who are at risk for developmental delay and possible adverse neurodevelopmental outcome demands methods of evaluation that will lead to early intervention to minimize developmental disability and to maximize the infant’s potential. A qualitative assessment of spontaneous general movements (GMs) in the preterm, term, and young infant at risk is a valid and reliable tool for evaluation (Prechtl [1990] Early Hum. Dev. 23:151-158). The aim of this review is to describe the theoretical and clinical bases for the assessment of GMs and its relationship to developmental delay and brain dysfunction. Thirty-seven studies related to the predictive validity of GMs were included in this review. Results suggested that consistent cramped synchronized GMs are highly predictive of later development of cerebral palsy. The fidgety movement quality that appears at the age of 2 to 3 months was found to be a most sensitive predictor of neurodevelopmental outcome in different populations of infants.


AIM: The aim of this study was to assess the motor repertoire of extremely low-birthweight infants at term-equivalent age (TEA), in relation to their neurological outcome.

METHOD: Using Prechtl’s method, we assessed both the quality of general movements and a detailed motor optimality score in 13 extremely low-birthweight infants (four males; nine females; mean gestational age 27.9 weeks, SD 2.9 weeks; mean birthweight 798g, SD 129g) at TEA, and related them to general movements at the age of 3 months after term and neurological outcome at the age of 2 years 6 months.

RESULTS: At TEA, 10 of the 13 infants had abnormal general movements. All infants showed abnormal leg lifting with extended legs; nine showed stiff movements, three showed cramped movements, and two showed cramped...
synchronized general movements. At 3 months, three infants still had abnormal general movements. Concurrent movements were abnormal in nine infants owing to monotony and jerkiness. Abnormal posture was seen in seven infants. None developed cerebral palsy; one infant showed cognitive and motor delay. Neurological outcome was not related to general movement quality and optimality score at TEA.

INTERPRETATION: Abnormal general movements at TEA are common in extremely low-birthweight infants. General movements often appear stiff and cramped with extended legs. At the age of 3 months after term, general movements are mostly normal, but concurrent movements are not. Nevertheless, these abnormalities do not imply an impaired neurological outcome such as cerebral palsy.


AIM: To assess the development of preterm infants from 40 weeks gestational age to 18 months corrected age to identify early predictors of later development.

METHODS: Fifty-one infants were involved. Infant development was assessed at 40 and 44 weeks gestational age with the Brazelton neonatal behavioral assessment scale and a self-regulation scale and at 3, 6, 10, 18 months corrected age with the Bayley Scales of Infant Development. The quality of general movements was assessed at 1 and 3 months corrected age and maternal attachment style at infant's age of 6 months corrected age with the Relation Scale Questionnaire.

RESULTS: At term age and 1-month corrected age, preterm infants were less mature and had lower levels of self-regulation than full-term infants. At 3 months corrected age, a higher proportion of preterm infants (43%) had mildly abnormal motor quality compared to the general population (25%). At all follow-ups, preterm infants had delayed mental, motor, and behavioural development, which was associated with the level of self-regulation, motor quality and maternal attachment style. Maternal education level was the most predominant background factor related to infant development.

CONCLUSION: Preterm infants show early-in-life deviations in self-regulation, motor quality and development. These deviations are risk factors for lateroptimal functioning.

Bernhardt I, Marbacher M, Hilfliker R, Radlinger L. Inter- and intra-observer agreement of Prechtl's method on the qualitative assessment of general movements in preterm, term and young infants. Early Hum Dev. 2011 Sep;87(9):633-9

BACKGROUND: Prechtl's method on the qualitative assessment of general movements (GMs) has been shown to be a good predictor of neurological outcome. There is substantial evidence that this method has good inter- and intra-observer agreement. AIM: We wanted to find out whether this high agreement is reproducible in the clinical setting.

STUDY DESIGN: Reliability study (inter- and intra-observer agreement).

SUBJECTS: Twenty video-sequences of children at the age of preterm and writhing movements (31-41 weeks postmenstrual age) and 10 video-sequences of children at the fidgety movements age (49-54 weeks postmenstrual age) were rated by five physiotherapists.

OUTCOME MEASURES: Intra- and inter-observer agreements were analyzed with percentage agreement and with nominal kappa statistic with bootstrapped biascorrected 95% confidence intervals.

RESULTS: We found fair to substantial inter-observer reliability for the six response categories (time-point 1 (t1): median kappa 0.44, range 0.27 to 0.59, time-point 2 (t2): median kappa 0.55, range 0.41 to 0.77) and fair to almost perfect for the normal/abnormal ratings (t1: median kappa 0.53, range 0.29 to 0.61, t2: median kappa 0.63, range 0.29 to 0.85). There was statistically significant improvement from t1 to t2 for the six response categories. The intrasubjective agreement for the 9-week interval was moderate to almost perfect (median kappa 0.68, range 0.41 to 0.86).

CONCLUSIONS: We were not able to exactly reproduce the generally very good results. In our clinical setting, new videos are evaluated by at least two physiotherapists and the results are discussed, if necessary, to reach a consensus.


This study was performed to assess the neurological status of high-risk infants by "general movements" (GMs) method and to compare it with the findings of standard clinical neurological examination and neuroimaging findings during the early rehabilitation period. Neurodevelopmental examination was performed by aneunatologist at the corrected ages of 40 weeks, and 3, 6 and 12 months. Assessment of the physiotherapist included video recording of "Prechtl Analysis of GMs" from the first week of life to the corrected age of 5 months. All infants underwent an early physiotherapy program, and follow-up examinations continued until 12 months. A percentage of agreement of 0.86 was found between cranial ultrasound imaging results and GMs and of 0.78 between neurological examination and GMs. Prechtl analysis was found to be important for detecting neurological dysfunction and differentiating normal neurological development in high-risk infants during the early intervention period. This analysis can be used complementary to other diagnostic and imaging techniques in the follow-up of preterm infants.
Neurobehavior represents development of the central nervous system (CNS). Fetuses and newborns exhibit a large number of endogenously generated motor patterns, among which general movements are often investigated pre- and post-natally. Spontaneous activity is probably a more sensitive indicator of brain dysfunction than reactivity to sensory stimuli while testing reflexes. Nutritional stress at critical times during fetal development can have persistent and potentially irreversible effects particularly on brain growth and function. Unfavorable intrauterine environment can affect adversely brain growth. All endogenously generated movement patterns from un-stimulated CNS might be observed as early as from the seven to eight weeks' gestation, with a rich repertoire of movements within the next two or three weeks, continuing for five to six months postnata tally. It is still uncertain whether a new scoring system for prenatal neurological assessment will be adequate for the distinction between normal and abnormal fetuses in low-risk pregnancies. The continuity of behavioral patterns from prenatal to postnatal life might answer these intriguing questions.


STUDY AIM: To describe general movement in extremely premature infants and examine correlations with risk factors for antenatal, perinatal, and postnatal morbidity.

STUDY TYPE: Prospective, single-center study. Nineteen patients were followed up.

METHODOLOGY: The infants' general movement was analyzed using video recordings. Qualitative and quantitative assessments were performed during the writhing movement (WM) period and fidgety movement (FM) period. The quality of the general movements (GMs) and the scores achieved were then correlated with antenatal, perinatal, and postnatal factors.

RESULTS: Infants' motor activity fluctuated during the WM period, especially in extremely premature infants where poor repertoire is often observed. Nocorrelations were found between WMs and obstetric factors. Gestational age correlated with WMs' quality (p=0.034) and nosocomial infections (p=0.05). At 3 months corrected age, the spontaneous movement quality was correlated with neurological explorations such as US brain (p=0.032), MRI (p=0.039), EEG (p=0.036), and neurological follow-up assessments (p=0.015).

CONCLUSION: Prudence must be used when performing the analysis of general movement in extremely preterm infants. WMs may be influenced by perinatal morbidity, and possibly by the severe brain immaturity of these infants. WMs correlate with CLD and nosocomial infections. Analysis of general movement in infants of 3 months corrected age is a valuable means to detect neurodevelopmental disorders.


OBJECTIVE: To correlate the site and severity of brain lesions seen on magnetic resonance imaging (MRI) with the quality of general movements in term infants with hypoxic-ischemic encephalopathy (HIE) and compare the prognostic value of general movements and MRI for motor outcome.

STUDY DESIGN: Early brain MRI scans in 34 term infants with HIE not treated with hypothermia were reviewed and scored for site of injury and lesion pattern by an experienced neuroradiologist. General movement quality and trajectories at 1 and 3 postnatal months were evaluated. Motor outcome was assessed at 24 months.

RESULTS: MRI scores for the basal ganglia and thalami, posterior limb of the internal capsule, white matter, and cortex lesion patterns were correlated with 1-month and 3-month general movements and general movement trajectories; central gray matter scores were correlated most strongly with cramped-synchronized general movements and abnormal motor outcome. MRI scores were 100% sensitive and 72.2% specific for motor outcome, and cramped-synchronized general movements were 100% specific and 68.7% sensitive for motor outcome.

CONCLUSIONS: In term infants with HIE, the site and severity of brain lesions seen on early MRI are highly correlated with general movements. Central gray matter damage leads to cramped-synchronized general movements and poor motor outcome. Early MRI scans and general movements are complementary tools for predicting motor outcome.

Manacero SA, Marschik PB, Nunes ML, Einspieler C. Is it possible to predict the infant's neurodevelopmental outcome at 14 months of age by means of a single preterm assessment of General Movements? Early Hum Dev. 2011 Jul 18

BACKGROUND: It continues to be a challenge for clinicians to identify preterm infants likely to experience subsequent neurodevelopmental deficits. The Test of Infant Motor Performance (TIMP) and the assessment of spontaneous general
movements (GMs) are the only reliable diagnostic and predictive tools for the functionality of the developing nervous system, if applied before term.

AIM: To determine to what extent singular preterm assessments of motor performance can predict the neurodevelopmental outcome in 14-month olds.

METHODS: Thirty-seven preterm infants born <34 weeks gestational age were recruited for the study at the NICU of the São Lucas University Hospital, Porto Alegre, RS, Brazil. At 34 weeks, their GMs were assessed; and the Test of Infant Motor Performance (TIMP) was applied. A prospective design was used to examine (A) the association between the GM assessment and the TIMP; and (B) the relation between GMs or the TIMP and the developmental status at 14 months, assessed by means of Alberta Infant Motor Scales (AIMS) and the Pediatric Evaluation of Disability Inventory (PEDI).

RESULTS: Nineteen infants (41%) had abnormal GMs; only one scored within the TIMP average range. Hence, GMs and TIMP were not related. Children with cramped-synchronized GMs at 34 weeks preterm had a lower AIMS centile rank than those with poor repertoire or normal GMs. There was a marginal association between cramped-synchronized GMs and a lower PEDI mobility score.

CONCLUSIONS: A single preterm GM assessment is only fairly to moderately associated with the 14-month motor development. The TIMP is not suitable as a complementary assessment tool at such a young age.

Burger M, Frieg A, Louw QA.
General movements as a predictive tool of the neurological outcome in very low and extremely low birth weight infants - a South African perspective.

BACKGROUND: At a time of increasing demands on South African limited healthcare resources, there is a need for an assessment method that can reliably predict neurological deficits in high-risk infants at an early age.

OBJECTIVE: The objective of the study is to determine whether the qualitative assessment of fidgety movements will predict the neurological outcome of very low birth weight and extremely low birth weight infants admitted to Tygerberg Children's Hospital (TCH), Cape Town, South Africa.

METHODOLOGY: A prospective descriptive study was conducted using Prechtl's method of qualitative assessment of fidgety movements at three months corrected age (CA). The study sample consisted of 115 infants, with a birth weight of ≤1250 g each. At 12 months CA, the infants' final motor outcome was classified as normal, abnormal or suspect according to assessments undertaken in line with those of Amiel-Tison and Gosselin, the Peabody Developmental Motor Scale and the Alberta Infant Motor Scale (AIMS).

RESULTS: A significant relationship was found (p<0.01) between fidgety movement outcome and the infants' final motor outcome at 12 months corrected age, with a sensitivity of ≥71%, a specificity of ≥89%, a positive predictive value of ≥80%, and a negative predictive value of ≥96%.

CONCLUSIONS: The results of the study indicated that Prechtl's qualitative method of fidgety movement assessment, as used in a clinical setting, is a highly sensitive and specific predictor of neurological outcome in preterm infants, which might effectively be used at TCH.

Zahed-Cheikh M, Brévaut-Malaty V, Busuttil M, Monnier AS, Roussel M, Gire C.
Comparative analysis of perinatal and postnatal factors, and general movement in extremely preterm infants.
Brain Dev. 2011 Sep;33(8):856-65

Study aim: To describe general movement in extremely premature infants and examine correlations with risk factors for antenatal, perinatal, and postnatal morbidity. Study type: Prospective, single-center study. Nineteen patients were followed up. Methodology: The infants' general movement was analyzed using video recordings. Qualitative and quantitative assessments were performed during the writhing movement (WM) period and fidgety movement (FM) period. The quality of the general movements (GMs) and the scores achieved were then correlated with antenatal, perinatal, and postnatal factors. Results: Infants' motor activity fluctuated during the WM period, especially in extremely premature infants where poor repertoire is often observed. No correlations were found between WMs and obstetric factors. Gestational age correlated with WMs' quality (ρ=0.023). WMs correlated with factors of postnatal morbidity such as chronic lung disease (CLD) (ρ=0.034) and nosocomial infections (ρ=0.05). At 3 months corrected age, the spontaneous movement quality are correlated with neurological explorations such as US brain (p=0.032), MRI (p=0.039), EEG (p=0.006), and neurological follow-up assessments (p=0.015). Conclusion: Prudence must be used when performing the analysis of general movement in extremely preterm infants. WMs may be influenced by perinatal morbidity, and possibly by the severe brain immaturity of these infants. WMs correlate with CLD and nosocomial infections. Analysis of general movement in infants of 3 months corrected age is a valuable means to detect neurological disorders.

Yuge M, Marschik PB, Nakajima Y, Yamori Y, Kanda T, Hirota H, Yoshida N, Einspieler C.
Movements and postures of infants aged 3 to 5 months: to what extent is their optimality related to perinatal events and to the neurological outcome?

BACKGROUND: The quality of spontaneous general movements (GMs), assessed in the individual infant, has emerged as one of the most reliable and valid predictors especially of severe neurological impairments.
AIMS: To implement a more detailed assessment of GMs and co-existing movements and postural patterns in a rehabilitation clinic, and to examine to what extend is the optimality of movements and postures of infants aged 3 to 5 months related to perinatal events and the neurological outcome.

STUDY DESIGN: Prospective study of 41 infants (15 boys and 26 girls; 11 infants born preterm) admitted to the Department of Paediatric Neurology and Rehabilitation of the St. Joseph's Hospital in Kyoto (Japan).

OUTCOME MEASURES: Clinical, neurological and psychological status at age 5.

RESULTS: Motor optimality at age 3 to 5 months correlated positively with neonatal optimality (r=0.48, p<0.01), especially regarding factors associated with hypoxic events. A non-optimal motor performance (lowest possible scores) predicted cerebral palsy with 100% accuracy. Other adverse outcomes such as developmental delays, developmental coordination disorders, pervasive developmental disorder or attention deficit hyperactivity disorder turned out not to be associated with early motor performance. In 13% of cases absence of fidgety movements proved to be false positives, but their normal appearance along with a smooth concurrent motor performance was solely found in infants with a normal neurological development.

Darsaklis V, Snider LM, Majnemer A, Mazer B.
Dev Med Child Neurol. 2011 Jun 17

The aim of this systematic review was to examine the evidence for the Aim predictive validity of Prechtl's Method on the Qualitative Assessment of General Movements (GMsA) with respect to neurodevelopmental outcomes. Method Six electronic databases (PsychINFO, Embase, Health and Psychosocial Instruments, PubMed, and AMED) were searched using the following keywords to identify all studies that examined the predictive validity of the GMsA: 'general movements', 'assessment', 'movement', 'child development', 'infant', and 'predictive value of test'. Only English- and French-language studies were included, whereas studies that focused on spontaneous mobility in preterm infants, but not necessarily the GMsA, or which did not report on the predictive value of the GMsA were excluded. A total of 39 studies were included in the final analysis. Studies were separated according to the age at follow-up: 12 to Results years. All used a longitudinal cohort months, 2 to 3, 4 to 11, and 12 to 18 23 study design; however, the outcome measures differed greatly amongst the studies. Values for sensitivity, specificity, positive predictive value, and negative predictive value varied amongst studies. The overall trend indicated that the presence of abnormalities in the quality of fidgety weeks adjusted age is more movements at 12 predictive of adverse outcomes than abnormal writhing. The GMsA demonstrates potential as a cost-effective, movements. Interpretation non-intrusive means of infant examination. However, current studies include important sources of bias. Future methodologically rigorous studies with functional outcomes are suggested.

Hamer EG, Bos AF, Hadders-Algra M.
Assessment of specific characteristics of abnormal general movements: does it enhance the prediction of cerebral palsy?

AIM: Abnormal general movements at around 3 months corrected age indicate a high risk of cerebral palsy (CP). We aimed to determine whether specific movement characteristics can improve the predictive power of definitely abnormal general movements.

METHOD: Video recordings of 46 infants with definitely abnormal general movements at 9 to 13 weeks corrected age (20 males; 26 females; median gestational age 30wks; median birthweight 1200g) were analysed for the following characteristics: presence of fidgety, cramped synchronized, stiff, or jerky movements and asymmetrical tonic neck reflex pattern. Neurological condition (presence or absence of CP), gross motor development (Alberta Infant Motor Scales), quality of motor behaviour (Infant Motor Profile), functional mobility (Pediatric Evaluation of Disability Inventory), and Mental Developmental Index (Bayley Scales) were assessed at 18 months corrected age. Infants were excluded from participating in the study if they had severe congenital anomalies or if their caregivers had an insufficient knowledge of the Dutch language.

RESULTS: Of the 46 assessed infants, 10 developed spastic CP (Gross Motor Function Classification System levels I to V; eight bilateral spastic CP, two unilateral spastic CP). The absence of fidgety movements and the presence of predominantly stiff movements were associated with CP (Fisher's exact test, p=0.018 and p=0.007 respectively) and lower Infant Motor Profile scores (Mann-Whitney U test, p=0.015 and p=0.022 respectively); stiff and predominantly stiff movements were associated with lower Alberta Infant Motor Scales scores (Mann-Whitney U test, p=0.01 and p=0.004 respectively). Cramped synchronized movements and the asymmetrical tonic neck reflex pattern were not related to outcome. None of the movement characteristics were associated with Pediatric Evaluation of Disability Inventory scores or the Mental Developmental Index.

INTERPRETATION: The assessment of fidgety movements and movement stiffness may improve the predictive power of definitely abnormal general movements for developmental outcome. However, the presence of fidgety movements does not preclude the development of CP.

Lundqvist-Persson C, Lau G, Nordin P, Strandvik B, Sabel KG.
Early behaviour and development in breast-fed premature infants are influenced byomega-6 and omega-3 fatty acid status.
Early Hum Dev. 2010 Jul;86(7):407-12
BACKGROUND: The requirement of essential fatty acids (EFA) for the development of the brain is well documented.

OBJECTIVE: To investigate the early neurological development at term and 44 weeks gestational age in preterm infants in relation to EFA concentrations in breastmilk and in infants' and mothers' plasma phospholipids.

METHOD: Fifty-one premature infants and their mothers were consecutively included in the study. The median gestational age was 34 weeks (range 24-36). The motor quality, motor and behavioural development were assessed by General Movements (GMs), the Brazelton Neonatal Behavioral Assessment Scale (BNBAS) and a SelfRegulation Scale.

RESULTS: Mother's education and gestational age correlated to several outcome variables. Multiple regression with correction for background factors showed negative associations between early breast milk concentrations of Mead acid and GMs and between AA and the BNBAS clusters Orientation and Range of States, respectively. Between 40 and 44 weeks gestational age, no expected increased scores were observed for Regulation of States, Range of States and SelfRegulation. During the corresponding time, increased concentration of linoleic acid in mothers' plasma was negatively associated with improvement in Orientation and increased concentration of EPA in the infants' plasma was positively associated with improvement in Autonomic Stability.

CONCLUSIONS: The major omega-6 fatty acids and Mead acid were negatively associated with early development and omega-3 fatty acids positively associated. Mother's education and the gestational age influenced the outcome more strongly than mother's and infant's morbidities. Further follow-up will elucidate the significance of these early findings.

Van Iersel PA, Bakker SC, Jonker AJ, Hadders-Algra M.
Does perinatal asphyxia contribute to neurological dysfunction in preterm infants?

Early Hum Dev. 2010 Jul;86(7):457-61

BACKGROUND: Children born preterm are known to be at risk for neurodevelopmental disorders. The role of perinatal asphyxia in this increased risk is still a matter of debate.

AIM: To analyze the contribution of perinatal asphyxia in a population of preterm infants admitted to a secondary pediatric setting to neurological dysfunction in the first months after birth and to the development of cerebral palsy.

METHODS: 17 preterm infants with perinatal asphyxia born before 35 weeks postmenstrual age (PMA) and 34 carefully matched preterm controls without asphyxia were studied. Neuromotor outcome was examined by means of three assessments of the quality of general movements (GM) at "preterm" (around 34 weeks PMA), "writhing" (around term age) and "fidgety" GM age (around 3 months postterm). Follow-up until at least 18 months corrected age focused on the presence of cerebral palsy (CP).

RESULTS: GM-quality of infants with asphyxia and of those without did not differ. Multivariate analysis revealed that abnormal GMs at "preterm" age were associated with respiratory problems, those at "writhing" age with none of the assessed riskfactors, and those at "fidgety" age with the severity of periventricularleukomalacia (PVL) on neonatal ultrasound scan. Perinatal asphyxia was not associated with the development of CP. CP was associated with PVL and the presence of abnormal GMs at "fidgety" age.

CONCLUSION: Perinatal asphyxia in preterm infants is not associated with an increased risk for neurodevelopmental problems including CP. Respiratory problems during the neonatal period are associated with PVL and adverse neurological outcome.

Bruggink JL, Van Braeckel KN, Bos AF
The early motor repertoire of children born preterm is associated with intelligence at school age.


OBJECTIVE: The goal was to determine whether the quality of general movements (GMs) for preterm children had predictive value for cognitive development at school age.

METHODS: In this prospective cohort study, 60 preterm infants (gestational age, median: 30.0 weeks [range: 25-33 weeks]; birth weight, median: 1130 g [range: 595-1800 g]) without cerebral palsy were studied. The quality of GMs was assessed prospectively as normal or abnormal, from video recordings that were made at regular intervals until 17 weeks after term. At 7 to 11 years, intelligence was tested by using the Wechsler Intelligence Scale for Children III, Dutch version. Total IQ (TIQ), verbal IQ (VIQ), and performance IQ (PIQ) scores were calculated.

RESULTS: The median TIQ was 93 (range: 67-113), VIQ 96 (range: 68-117), and PIQ 92 (range: 65-119). Fifteen children (25%) had low TIQ scores (<85). When the quality of GMs normalized before 8 weeks after term, TIQ, VIQ, and PIQ scores were in the normal range. Consistently abnormal GMs to 8 weeks after term were associated with lower TIQ, VIQ, and PIQ scores. With correction for male gender and the educational levels of the parents, the likelihood ratio of consistently abnormal GMs for a low TIQ was 4.9 (95% confidence interval: 1.3-17.6). The model explained 22.4% of the variance.

CONCLUSIONS: The quality of GMs during the early postterm period is a marker for intelligence at school age. Abnormal GMs during the early postterm period may reflect injury or developmental disruptions of brain areas involved in cognitive development.

Kodric J, Sustersic B, Paro-Panjan D.
Assessment of general movements and 2.5 year developmental outcomes: pilot results in a diverse preterm group.

BACKGROUND: While the predictive value of general movements for later cerebral palsy is well known, its value to predict minor neurological and developmental impairments is less clear.

AIM: To analyze the results of the assessment of general movements in relation to the developmental outcome measured by the Bayley scales of infant development in a group of preterm infants.

METHODS: Twenty-six preterm infants (gestational age from 23 weeks to 36 weeks) were included. The results of the assessment of general movements at term age and at 3 months corrected age were compared to the results of the mental and psychomotor developmental index of the Bayley scales assessed between two and three years of chronological age.

RESULTS: Infants with normal writhing general movements achieved the highest scores on the mental and psychomotor developmental index, and those with cramped-synchronized general movements had the lowest scores. Infants with normal general movements during the fidgety period achieved the highest scores on both scales; those with an absence of fidgety movements achieved the lowest scores. We found the sensitivity of general movements to predict cognitive impairments to be 1.00 during the writhing period and 0.83 during the fidgety period; and 0.85 and 0.54, respectively, to predict motor impairments. The differences in the mental developmental index score between the groups with different qualities of general movements were significant in the writhing period and approached significance in the fidgety period, while for the psychomotor developmental index the differences between the groups with different qualities of general movements were not significant.

CONCLUSION: The quality of general movements may be predictive of later development.

Hand movements at 3 months predict later hemiplegia in term infants with neonatal cerebral infarction.
Dev Med Child Neurol. 2010 Aug;52(8):767-72

AIM: The aim of this study was to explore the predictive value of quantitative assessment of hand movements in 3-month-old infants after neonatal stroke.

METHOD: Thirteen infants born at term (five females, eight males; mean gestational age 39.4wks, SD 1.19, range 37-41wks; mean birthweight 3240g, SD 203, range 2900-3570g) with neonatal arterial ischaemic cerebral infarction, and 13 healthy infants (mean gestational age 39.1wks, range 37-41wks, SD 1.26; mean birthweight 3190g, SD 259, range 2680-3480g) were enrolled in the study. The absolute frequency and the asymmetry of global hand opening and closing, wrist segmental movements, and independent digit movements were assessed from videotapes recorded at around 12 weeks. Neurological outcome was assessed when the infants were at least 18 months old using Touwen's neurological examination.

RESULTS: Five of the 13 infants with neonatal stroke had normal neurological development, and eight had hemiplegia. Asymmetry of wrist segmental movements and the absolute frequency of independent digit movements were significantly different between infants with and without hemiplegia (p=0.006 and p=0.008, respectively). No differences were found in global hand movements.

INTERPRETATION: We propose that the observed abnormalities of hand movements are the result of two different mechanisms: direct disruption of the corticospinal projection to the spinal cord, and altered modulation of the central pattern generators of general movements.

De Vries NK, Bos AF
The quality of general movements in the first ten days of life in preterm infants.
Early Hum Dev. 2010 Apr;86(4):225-9

BACKGROUND: The assessment of the quality of general movements (GMs) in preterm infants early in life has been used mainly to determine temporary or permanent neurological dysfunction and not to predict outcome.

AIM: Assessing the quality and evolution of GMs during the first ten days of life in preterm infants, and relating them to clinical factors and neurological outcome at 24months' post-term.

METHODS: Using Prechtl's method, the GM quality was assessed in 45 preterm infants on days 2, 4, 6 and 10. They were related to clinical factors and outcome. After GM assessment, an extra item was scored: chaotic features (ChF). ChF was defined as chaotic GMs or poor repertoire GMs+chaotic movements.

RESULTS: Abnormal GMs were seen mostly in early recordings. A better GM trajectory correlated with a higher birth weight, a higher gestational age and a lower Nursery Neurobiologic Risk Score (NBRS). Predictive value for normal outcome of at least one normal GM was 94%. Predictive value for abnormal outcome of only abnormal GMs was 21%. ChF were seen mostly in early recordings. Occurrence of ChF on day 2 correlated with lower serum calcium.

CONCLUSIONS: Preterm infants often showed abnormal GMs during the first few days. This was related mostly to a higher NBRS. Normalization of GMs during the first ten days was associated with a lower NBRS and was a reliable predictor for neurological outcome. ChFs could be a GM quality that is associated to lower calcium, indicating hyperexcitability of the nervous system.

Bouwstra H, Dijk-Stigter GR, Grooten HM, Janssen-Plas FE, Koopmans AJ, Mulder CD, van Belle A, Hadders-Algra M.
Predictive value of definitely abnormal general movements in the general population.
AIM: Definitely abnormal general movements in populations of high-risk infants predict serious neurodevelopmental impairment. This study aimed to assess predictive values of definitely abnormal general movements at 3 months for serious neurodevelopmental impairment in a representative sample of the general population.

METHOD: A prospective cohort study of 455 3-month-old infants was performed (241 females, 214 males; mean birthweight 3452g, SD 604g; mean gestational age 39.4wks, SD 1.96; n=32 born preterm). At enrolment, general movement quality was assessed by means of video recording. At 4 years, all participants were reassessed by well-baby health clinicians; if serious neurodevelopmental impairment was identified, clinical records were reviewed. Predictive values of definitely abnormal general movement quality for major neurodevelopmental impairment were calculated.

RESULTS: Five children were diagnosed as having a major neurodevelopmental disorder with serious implications for daily life, including three children with cerebral palsy (CP). Three out of the five had shown definitely abnormal general movements; they had lesions involving the periventricular white matter. Two children did not show definitely abnormal general movements; one had unilateral spastic CP due to a cortical lesion and the other had ataxia due to cerebellar atrophy. The positive predictive value of definitely abnormal general movements for major neurodevelopmental impairment was 18/100, and for CP it was 12/100. Negative predictive values approached 100%.

INTERPRETATION: The good predictive value of general movement assessment in high-risk populations cannot be generalized to the general population.

Elise Roze, Lisethe Meijer, Koenraad N. J. A. Van Braeckel, Selma A. J. Ruiter, Janneke L. M. Bruggink and Arend F. Bos
Developmental Trajectories From Birth to School Age in Healthy Term-Born Children
PEDIATRICS Volume 126, 5, Nov 2010 e1134-1142

OBJECTIVE: To determine the stability of the scores obtained on tests of motor development from birth until school age in healthy, term singletons and to determine if early motor scores are associated with more complex cognitive functions at school age, such as attention and memory.

PATIENTS AND METHODS: This longitudinal, prospective cohort study included 77 infants. The motor development of these infants was assessed during the neonatal period with Prechtl’s neurologic examination; in early infancy with Touwen’s neurologic examination and general movement assessment; at toddler age with Hempel’s neurologic examination and the Psychomotor Developmental Index from the Bayley Scales of Infant Development; and at school age with the Movement Assessment Battery for Children. Cognition was determined at toddler age with the Mental Developmental Index from the Bayley Scales of Infant Development; and at school age with an intelligence test and attention and memory tests.

RESULTS: The mean absolute difference in standardized motor scores for all time points was 1.01 SD (95% confidence interval: 0.91–1.11). Only the explained proportions of variance of maternal socioeconomic status and verbal intelligence were significant for sustained attention and verbal memory (r^2 = 0.104, P < 0.030 and r^2 = 0.074, P < 0.027), respectively. The children’s scores on early motor tests added little value for their motor and cognitive development at school age.

CONCLUSIONS: In healthy children the stability of motor development from birth until school age is low. Maternal socioeconomic status and verbal intelligence rather than the infants’ scores on early motor tests signified added value for complex cognitive functions at school age.

Butcher PR, van Braeckel K, Bouma A, Einspieler C, Stremmelaar EF, Bos AF.
The quality of preterm infants’ spontaneous movements: an early indicator of intelligence and behaviour at school age

BACKGROUND: The quality of very preterm infants’ spontaneous movements at 11 to 16 weeks post-term age is a powerful predictor of their later neurological status. This study investigated whether early spontaneous movements also have predictive value for the intellectual and behavioural problems that children born very preterm often experience.

METHODS: Spontaneous movement quality was assessed, using Prechtl’s method, at 11 to 16 weeks post-term in 65 infants born at or= 33 weeks of gestation in a single centre. Intelligence and behaviour were assessed with standardised tests at 7 to 11 years of age. Neurological status was assessed with Touwen’s test. Multiple regression was used to determine the predictive value of movement quality for intelligence and behavioural problems. The Sobel test was used to determine if neurological status mediated associations found between early movement quality and outcome.

RESULTS: Spontaneous movement quality at 11 to 16 weeks post-term was significantly, positively associated with later intelligence. The number of normal postural patterns displayed contributed most strongly to the association, which was not mediated by neurological status. Fidgety movements, strong predictors of later neurological dysfunction, were not associated with intelligence. Spontaneous movement quality was not associated with internalising or externalising problems but showed a trend to an association with attention problems. CONCLUSION: These findings suggest that, in children born preterm, early spontaneous movement quality has clear prognostic value for neurological and intellectual outcome, and to a lesser extent, for attentional outcome. However, cognitive outcome was associated with the presence of specific, age-appropriate postural patterns, while neurological outcome has been associated with the presence of global movement abnormalities. The presence of specific, age-appropriate postural patterns may reflect the integrity of areas of the brain involved in cognitive processing and the regulation of attention later in childhood. Alternately, it may facilitate cognitive and attentional development.

Bouwstra H, Dijk-Stigter GR, Grooten HM, Janssen-Plas FE, Koopmans AJ, Mulder CD, van Belle A, Hadders-Algra M.
Prevalence of abnormal general movements in three-month-old-infants.

BACKGROUND: The quality of general movements (GMs) is a sensitive tool to measure neurodevelopmental condition in early infancy. No information is available on prevalence rates of abnormal GMs in the general population. OBJECTIVE: To assess the prevalence of abnormal GMs in the general population of three-month-old infants and to evaluate the association of abnormal GM quality with medical and social risk factors. METHOD: We recruited 535 infants in six well baby clinics in The Netherlands. GMs were video-taped at the corrected age of 2 to 4 months. GM-quality was assessed by two persons unaware of the infant's history. GM-quality was classified as normal optimal (NO), normal suboptimal (SO), mildly abnormal (MA) and definitely abnormal (DA). Only the last category implies clinically relevant dysfunction. Social, perinatal and postnatal characteristics were collected and their association with DA and abnormal (DA+MA) GMs were evaluated by means of univariate and logistic regression analyses. RESULTS: GM-quality could be assessed reliably in 455 infants (85%). Seventeen infants (3.7%) showed DA GMs and 113 (25%) MA GMs. DA GMs were associated with preterm birth and smoking during pregnancy; abnormal (DA+MA) GMs with preterm birth, a relatively low level of maternal profession and urban living conditions. These factors explained between 3% and 7% of variance. CONCLUSION: The study indicates that the prevalence of definitely abnormal GMs in the general population is 3.7% and that of mildly abnormal GMs 25%. The clinically relevant definitely abnormal GMs were associated with preterm birth and smoking during pregnancy.

Bruggink JL, Cioni G, Einspieler C, Maathuis CG, Pascale R, Bos AF.
Early motor repertoire is related to level of self-mobility in children with cerebral palsy at school age.
Dev Med Child Neurol 2009 Mar 20. [Epub ahead of print]

Aim To determine the predictive value of the early motor repertoire for the level of self-mobility in children with cerebral palsy (CP) at school age. Method Video recordings were made at 11 to 17 weeks post-term of 37 preterm infants (20 males, 17 females) who later developed CP. The early motor repertoire was assessed by obtaining a motor optimality score. At 6 to 12 years, children were classified according to the Gross Motor Function Classification System (GMFCS). Results Of 37 children (mean gestational age 29.1wks, SD 1.9; mean birthweight 1273g, SD 324), nine had unilateral and 28 had bilateral spastic CP. Twelve children were in GMFCS level I, three level II, 10 level III, four level IV, and eight level V. The absence of the age-adequate motor repertoire, a cramped motor repertoire, an abnormal kicking pattern, and a non-flat supine posture were associated with lower levels of self-mobility (chi(2) for trend test, p<0.05). Predictive for a low level of self-mobility was a cramped motor repertoire/non-flat supine posture (positive predictive values [PPV] 100%, negative predictive values [NPV] 54%). Predictive for a high level of self-mobility was a non-cramped repertoire/flat supine posture (PPV 80%, NPV 74%). Interpretation Several aspects of the motor repertoire at 11 to 17 weeks post-term predicted the degree of functional limitations in children with CP at school age.

Bruggink JL, Einspieler C, Butcher PR, Stremmelaar EF, Prechtl HF, Bos AF.
Quantitative aspects of the early motor repertoire in preterm infants: do they predict minor neurodevelopmental dysfunction at school age?

BACKGROUND: Qualitative aspects of the motor repertoire, at 11-16 weeks post-term are predictive for minor neurodevelopmental dysfunction (MND) at 7 to 11 years of age. Predictive value of quantitative aspects is unknown so far. AIM: To investigate whether quantitative aspects of the motor repertoire between 6 and 24 weeks post-term also have predictive value for neurological outcome at 7 to 11 years of age. STUDY DESIGN: Prospective cohort study. SUBJECTS: Preterm infants from whom several quantitative aspects of the motor repertoire were assessed between 6 and 24 weeks post-term. OUTCOME MEASURES: Neurological outcome at 7-11 years of age was assessed according to Touwens' neurological examination. Children were classified as neurologically normal, or as having complex MND or cerebral palsy (CP). RESULTS: Eighty-two children were included. At 7 to 11 years of age 15 children (18%) had developed CP, 49 (60%) were neurologically normal, and 18 (22%) had MND. Multiple logistic regression analysis showed that, when the qualitative aspects of the motor repertoire known to predict neurological outcome were taken into account, only the asymmetric tonic neck (ATN) posture provided additional predictive value. In case of normal fidgety movements (FMs) accompanied by an abnormal concurrent motor repertoire, the presence of an obligatory ATN increased the risk for developing complex MND to 75%; absence of an obligatory ATN reduced the risk to 15% (p<0.05). CONCLUSIONS: Quantitative aspects of the motor repertoire at 11-16 weeks post-term, in particular the presence of an obligatory ATN posture, contribute to the prediction of neurological outcome at 7 to 11 years of age.

Hadders-Algra M.
Reduced variability in motor behaviour: an indicator of impaired cerebral connectivity?

Evidence is accumulating that abundance in cerebral connectivity is the neural basis of human behavioural variability, i.e., the ability to select adaptive solutions from a large repertoire of behavioural options. Recently it was demonstrated that variability in motor behaviour—the hallmark of typical development—emerges coincident with the onset of synaptic activity in the embryonic cortex. This inspired the hypothesis that variability results from cortical activity and that its expression depends on integrity of corticospinal connectivity. Recent findings in preterm infants with cerebral white matter injury and in children with autism spectrum disorder (ASD) allow the elaboration of this hypothesis: diffuse damage of the cerebral white matter is associated with an overall reduction in variability, i.e., in a reduction of movement complexity and...
General movements (GMs) are a distinct movement pattern carried out spontaneously without external stimulation and seen in fetuses of 9 weeks gestational age till 21 weeks postterm. GMs are helpful in the early diagnosis of an impaired central nervous system and the specific prediction of later neurological deficits. Autism spectrum disorder (ASD) is a neurodevelopmental disorder involving a life-long deficit in several aspects of the social and communicative behavior. Recently there appeared studies proving that children with ASD demonstrate disorders of motor development. The aim was: to detect whether abnormalities in spontaneous motor activity can be observed already in the first months of life in infants with ASD. A retrospective study was performed by analyzing the family videos provided by parents of 20 children (male 17, female 3) later diagnosed as ASD. Home videos provided by parents of a control group of healthy children (n=20; male 10, female 10) matched for age with the ASD subjects and recorded in similar conditions were also analysed. In total 70 sequences were studied. Two independent observers, blind of the infants' outcome (ASD or normal), assessed the cases applying a global and a more detailed assessment of GMs. Hence, the age-specific GM pattern (normal or abnormal) as well as the motor optimality scores were determined for each video sequence. Cohen kappa was 0.614. During the writhing movement period 70.0% sequences of infants with ASD showed poor repertoire GMs. In the control group, poor repertoire GMs were only seen in 12.5% of the sequences. In the fidgety movement period 20.8% of sequences were assessed as absent fidgety movements, 29.2% as abnormal fidgety movements. The large majority of the videos for the control cases were scored as normal (88.9%), 11.1% had no fidgety movements. According to the Mann-Whitney U test there were significant differences between the ASD and the control groups' optimality scores. The optimality scores were lower in the ASD group. The reduced optimality scores were mainly due to a lack of variable sequences, amplitude and speed of writhing GMs and an altered quality of fidgety and other spontaneous movements in the ASD group. Infants with ASD had more often poor repertoire writhing GMs as well as abnormal or absent fidgety movements than control infants. These data encourage further studies involving a larger number of family videos.
OBJECTIVE. Preterm infants are at an increased risk for abnormalities of general movements, which predict subsequent poor neurodevelopmental outcome. The cerebral lesion that predisposes the preterm infant to abnormal general movements remains unknown. The objective of this study was to determine the association between MRI-defined cerebral abnormalities and general movements at 1 and 3 months’ corrected age in infants who were born very preterm. METHODS. Eighty-six preterm infants (≤30 weeks’ gestation) were prospectively recruited and underwent brain MRI at term-equivalent age to investigate the relationship between qualitative white and gray matter pathology and abnormality of general movements. Standardized videotaped recordings of general movements were obtained at 1 and 3 months postterm (+/-1 week) and scored without knowledge of the MRI findings. At 1 month corrected age, general movements of a writhing character were classified as normal or abnormal (poor repertoire, cramped synchronized, or chaotic). At 3 months’ corrected age, fidgety general movements were classified as present or absent. RESULTS. At 1 month, 53 (62%) infants had abnormal general movements, 46 of whom had poor repertoire general movements and 7 of whom had cramped synchronized general movements. At 3 months, 23 (25%) infants had absent fidgety movements. At both 1 and 3 months of age, consistently abnormal general movement classifications were related to increasing white matter abnormality on MRI. In contrast, there were no significant relationships between general movement classifications and gray matter abnormalities, either individually or in total. CONCLUSION. The significant relationships between general movements at 1 and 3 months and cerebral white matter abnormalities on MRI in the very preterm infant support the concept that abnormal general movements reflect white matter injury.


BACKGROUND: The qualitative assessment of general movements (GMs) proved to be a highly sensitive and specific diagnostic tool for the assessment of the integrity of the young nervous system. It is essential that the quality of GMs remains consistent in an individual during a given recording at a certain date. OBJECTIVES: The aim of the study was to investigate the intra-individual consistency of the quality of GMs during one recording. METHODS: 39 preterm infants were recorded at least twice; some were recorded three times. In all, 88 recordings were available but three recordings were excluded due to frequent crying, seizures or hypokinesia. Three scorers assessed 2-3 sequences of these 85 GM recordings. RESULTS: The inter-scorer agreement was high (kappa 0.85-0.94). Intra-individual consistency revealed a kappa of 0.90 with a 95% CI (0.51, 1.00) for preterm GMs, 0.96 with a 95% CI (0.57, 1.00) for writhing GMs, and 0.92 with a 95% CI (0.53, 1.00) for fidgety GMs. CONCLUSIONS: The individual quality of GMs remains consistent for a neonate or young infant at a certain date.


OBJECTIVE: To evaluate the possible additional benefit in terms of prognostic accuracy of an integrated application of a traditional scorably method of neurologic examination and the Prechtl's method of qualitative assessment of general movements (GMs) in a large population of 903 consecutive preterm infants. STUDY DESIGN: Infants were enrolled from the Intensive Care Unit of the University of Catania. Inclusion criteria were a gestational age below 37 weeks and the absence of genetic disorders. All infants underwent serial ultrasound and at 3 months performed both the GMs assessment and the Hammersmith Infant Neurologic Examination (HINE). Outcome was assessed at 2 years by the Touwen neurologic examination and the Clinical Adaptive Test/Clinical, Linguistic and Auditory Milestone Scale. RESULTS: The integration of the two methods was shown to be more effective than the single assessments in predicting neurologic outcome. The additional benefit of combining the two approaches was particularly clear for the discrimination between unilateral and bilateral cerebral palsy. CONCLUSIONS: The integrated use of a scorably neurological examination and Prechtl's assessment of GMs can improve early prediction of neurodevelopmental outcome in preterm infants and should complement other clinical and instrumental exams in follow-up programs.


BACKGROUND: Assessment of the quality of general movements (GMs) is an early clinical marker for prediction of cerebral palsy. AIM: To explore how the General Movements Assessment (GMsA) relates to traditional newborn and infant measures currently in use. STUDY DESIGN: A prospective cohort design was used to examine concurrent validity of the GMsA in Neonatal Intensive Care (NICU) survivors (n=100) at three age points: preterm (34 weeks gestational age GA), term (38-40 weeks GA), and post term (12 weeks adjusted age [AA]) with traditional assessments (see below).
Correlation analysis was used to determine the strength of the associations between tests at each age point. 

SubjecTs: Preterm infants born at \(\leq 32\) weeks gestational age and birth weight \(< 1500\) g \((n=108)\) were recruited sequentially from the NICU of a large teaching hospital and referral centre. Infants with diagnoses of metabolic disorders, cardiac, chromosomal, or congenital abnormalities were excluded. Outcome Measures: Test of Infant Motor Performance (TIMP), Einstein Neonatal Neurobehavioral Assessment Scale (ENNAS), Alberta Infant Motor Scales (AIMS). Results: A low-strength relationship \((r=0.25)\) was found between the GMsA and the traditional tests which increased across age points \((r=0.25-0.50)\). Relationships between the traditional tests over time was characterized by stronger associations \((r=0.50-0.75)\). Conclusions: Evidence of concurrent validity of the GMsA with traditional assessments was not found. These early findings support Prechtl's suggestion that GMs reflect a unique neurologic construct, different from traditional tests and reinforce the complementary perspective which the GMsA brings to neonatal assessment.

Seme-Ciglenecki P.
Predictive values of cranial ultrasound and assessment of general movements for neurological development of preterm infants in the Maribor region of Slovenia.

Objective: The aim of the study was to assess the predictive values of cranial ultrasound (US) scans and assessment of general movements of fidgety character (GMs) for the later neurological development of preterm infants in the Maribor region of Slovenia. Methods: Results of cranial US scans done longitudinally from the day of birth until the end of three months of chronologic age and results of GMs at three months of corrected age were compared with traditional neurological examination and evaluation of psychomotor development of the same children at the corrected age of six years. Results: A total of 112 preterm infants (gestational age 37 weeks and below) were included in the study. The infants were classified as low-risk or high-risk for neurological impairment on the basis of cranial US scans. The scans classified as low-risk were followed by a normal neurological outcome in 74 (89%) of 83 infants; those classified as high-risk for neurological impairment were followed by abnormal neurological outcome in 21 (72%) of 29 infants. Of 77 infants with normal fidgety movements, 73 (95%) had a normal neurological outcome and 4 (5%) had an abnormal neurological outcome; of 35 infants with abnormal or absent fidgety movements, 26 (74%) had an abnormal neurological outcome and 9 (26%) had a normal neurological outcome. Of 30 children with abnormal outcome, cerebral palsy was diagnosed in 16, mental retardation in one, nine children had both of these, and four had complex minor neurological dysfunction. The validity of the scans was 85%, sensitivity 70%, specificity 90%, positive predictive value 72% and negative predictive value 89%; the validity of the GMs was 88%, sensitivity 87%, specificity 89%, positive predictive value 74% and negative predictive value 95%. Conclusions: The sensitivity of the cranial US scans was clearly lower than that of assessment of general movements of a fidgety character. The specificities of the two methods were almost the same.

Predictive value of neurodevelopmental assessment versus evaluation of general movements for motor outcome in preterm infants with birth weights <1500 g.

Purpose: The aim of this study was to make a comparison of predictive values of neurodevelopmental assessment and evaluation of videotaped spontaneous movements of premature infants for motor outcome. Methods: We performed a prospective longitudinal study of 103 VLBW infants, 96 (455-1490 g, 24-35 weeks gestational age) including (a) a neurodevelopmental assessment based on criteria by Amiel-Tison/Grenier at 40 weeks postconceptional age, 3 and 20 months corrected age; (b) an evaluation of general movements with fidgety character, based on criteria by Prechtl, at 3 months; and (c) a standardized testing using the Griffiths Developmental Motor Scale at 20 months. We calculated sensitivity, specificity and predictive values for each method. Results: For predicting motor outcome, the assessment of general movements (GM) had a positive predictive value of 89% and negative predictive value of 84%; neurodevelopmental assessment (NA) at 40 weeks had a positive predictive value of 33% and negative predictive value of 88%, respectively, with similar results for neurodevelopmental assessment at age 3 months. Conclusions: Normal motor outcome of VLBW infants may be accurately predicted by clinical neurodevelopmental assessment, but for adverse outcomes, evaluation of general movements (fidgety movements) is superior. GM assessment has a high predictive value, especially for CP, but it needs to be complemented by NA for non-CP outcomes. It is a simple, repeatable and non-intrusive technique, and may be a valuable method for the early detection of central nervous system impairment in VLBW infants in routine follow-up.

Hadders-Algra M.
Putative neural substrate of normal and abnormal general movements.

During the last decade it has become clear that the assessment of the quality of general movements (GMs) in foetus and young infant is a sensitive tool to evaluate the integrity of the young nervous system. GMs are movements in which all parts of the body participate. The hallmark of typical GMs is movement complexity and variation; in abnormal GMs movement complexity and variation is reduced or absent. Abnormal GMs may predict developmental outcome. Prediction on the basis of longitudinal series of GM assessments is best. Second best is prediction on the basis of an assessment at ‘fidgety’ GM age, i.e. at 2-4 months post-term. Definitely abnormal GMs at ‘fidgety’ age are related to

**OBJECTIVE:** To assess the clinical value of a modified version, not employing video recording, of Prechtl’s method on the qualitative assessment of general movements (GMs) in preterm, term and young infants at neurological risk.

**MATERIALS AND METHODS:** One-hundred and fifteen infants consecutively enrolled in our follow-up program were selected for the study (103 preterm and 12 term infants). While being video recorded, each infant’s spontaneous motor activity was directly observed and documented using a written proforma. An evaluation of the video was later performed by a different assessor blind to the infant’s clinical history. **RESULTS:** The correlation between the two techniques was significant both at writhing age (birth to 6 weeks post-term age) and at fidgety age (9-15 weeks post-term age). Both methods showed a very high sensitivity for the prediction of cerebral palsy, as no false negatives were observed. The direct assessment showed a lower specificity, particularly during the writhing period. **CONCLUSIONS:** These results support the use of the direct assessment of GMs when the full application of the standard video observation cannot be routinely applied, restraining the use of video recordings to the abnormal or doubtful cases. This may facilitate the wished integration of the assessment of spontaneous motility into more general protocols of neurological examination and into clinical follow-up programs.


**OBJECTIVE:** To evaluate whether lying in a nest affects the posture and spontaneous movements of healthy preterm infants. **METHOD:** 10 healthy preterm infants underwent serial video recording in the supine position, when lying in a nest and outside it, at three ages: 30-33 weeks postmenstrual age (PMA) (early preterm), 34-36 weeks PMA (late preterm) and 37-40 weeks PMA (term). The nest was shell-shaped, made by putting two rolled blankets in a form of an oval. Posture was assessed both before and after general movements by scoring the predominant postural pattern. Movements towards and across the midline, elegant wrist movements, abrupt hand and/or limb movements, rolling to side, and frozen postures of the arms and legs were assessed during four general movements. All data relating to motor and postural items were normalised into frequencies of events per minute because the general movements varied in duration. **RESULTS:** When lying in the nest, the infants more often displayed a flexed posture with shoulder adduction and elbow, and hip and knee flexion, and the head was frequently in the midline. The nest was also associated with an increase in elegant wrist movements and movements towards and across the midline and a reduction in abrupt movements and frozen postures of the limbs. The nest did not affect the occurrence of asymmetrical tonic neck posture. **CONCLUSIONS:** A nest promotes a flexed posture of the limbs with adduction of shoulders, facilitates elegant wrist movements and movements towards and across the midline and reduces abrupt movements and frozen postures of the arms and legs.


**OBJECTIVE:** To study the relative efficacy of three early predictors of cerebral palsy. **METHOD:** One Hundred and thirty infants with birth weight <1500 g were recruited. Video recordings of spontaneous general movements were made at 36 and 52 weeks postconceptional age. Magnetic resonance imaging and the neurobehavioral assessment of the preterm infant were done at 36 weeks postconceptional age. Follow-up neurological examination and Bayley assessments were made at 18 months corrected age to make early identification of cerebral palsy. **RESULTS:** Magnetic resonance imaging gave the best specificity and accuracy of 91 and 84% respectively. General movements at 52 weeks showed an improved specificity and accuracy over performance at 36 weeks postconceptional age. The negative predictive value for all methods tested was between 90 and 97%. Combining the results of magnetic resonance imaging and the neurobehavioral assessment improved the sensitivity of prediction to 80%, suggesting that a holistic approach to early detection of cerebral lesions is preferable to a single test. **CONCLUSIONS:** The majority of infants who appeared to behave within normal limits and exhibit normal brain structure in the newborn period were classified as neurologically intact at follow-up.


Cerebral palsy, mildly abnormal GMs to minor neurological dysfunction at school age. In the present paper the hypothesis is advanced that GM complexity and variation are brought about by the transiently present cortical subplate and that abnormal GMs are the result of damage or dysfunction of the subplate and its efferent motor connections in the periventricular white matter.
BACKGROUND: Prechtl's method on the qualitative assessment of general movements (GMs) is a powerful tool for early and specific prediction of cerebral palsy. However, it is uncertain whether the GM assessment can be used to predict mild neurological impairment. AIMS: To determine whether the quality of GMs from the age of 3 to 5 months, i.e. fidgety movements, is related to the presence of complex minor neurological dysfunctions (MND) 13 to 15 years later. STUDY DESIGN: Prospectively collected data on the quality of GMs during infancy were retrospectively analysed on the basis of MND at puberty. SUBJECTS: Twenty-eight participants (14 girls and 14 boys) with a median gestational age of 40 weeks (range: 35 to 42 weeks) and an appropriate birth weight (median 3390 g; range 1900 to 4200 g). OUTCOME MEASURES: Touwen's neurological examination. RESULTS AND CONCLUSIONS: Abnormal fidgety movements were not related to later complex MND, but to fine manipulative disabilities (p<0.05). Normal fidgety movements, which are continually present in the whole body, might be required for optimal calibration of the proprioceptive system.

PMID: 17129688 [PubMed - indexed for MEDLINE]


OBJECTIVE: The general movement assessment (GMA) method is used to predict cerebral palsy (CP) in infants with high risk of developing neurological dysfunctions. Most of the work on GMA has been performed from the same group of researchers. The aim of this study was to demonstrate to what extent GMA predicted CP in our hands. METHOD: A prospective study was performed using the Prechtl classification system for GMs in the fidgety period to predict later cerebral palsy. The study population consisted of 74 term and preterm infants at low and high risk of developing neurological dysfunction. The absence or presence of CP was reported at 23 months median-corrected age by the child's physician and the parents. RESULTS: The GMA identified all 10 infants that later were classified as having CP. GMA also identified all the infants that did not develop CP except for one infant with abnormal GMA and no CP. Three infants had uncertain CP status at follow-up. The sensitivity of GMA with regard to later CP was 100% with 95% CI (0.73, 1.00) and the specificity was 98% with 95% CI (0.91, 0.99) when the three uncertain cases were excluded. CONCLUSION: Our study indicates that the GMA used in a clinical setting strongly predicts the development of CP. The work supports the results of previous studies and contributes to the validation of GMA. The qualitative nature of this method may be a problem for inexperienced observers. Larger clinical studies are needed.


Prenatal essential fatty acid (EFA) status might be an important factor in the development of the central nervous system (CNS). The aim of the present study was to evaluate the relationship between the fatty acid compositions of the umbilical blood vessels at birth, used as a proxy of prenatal EFA status, and quality of general movements (GMs) at 3 mo. Umbilical artery and vein fatty acid compositions were investigated in a mixed group of breastfed infants and infants fed with formula with or without long-chain polyunsaturated fatty acid (LOPUFA) supplementation. At the age of 3 mo, video assessment of the quality of GMs was performed to evaluate neurologic condition. The quality of GMs was scored by assessing the degree of variation, complexity, and fluency. Outcomes were classified as normal-optimal, normal suboptimal, mildly abnormal, and definitely abnormal movements. Information on potential confounders, including the type of postnatal feeding, was collected prospectively. Associations between fatty acid status at birth and quality of GMs were investigated, and multinomial logistic regression analyses were carried out. None of the infants showed definitely abnormal movements. Infants with mildly abnormal GMs had a lower EFA index, lower arachidonic acid (AA) content, higher total n-9 fatty acid, and higher total monounsaturated fatty acid (MUFA) content in the umbilical artery compared with infants with normal GMs. Multivariate analyses confirmed these findings. We conclude that mildly abnormal GMs are associated with a less favorable EFA status in the umbilical artery.


The introduction of the general movement assessment into pediatric practice as a prognostic method (HFR Prechtl, et al., 1997) has prompted the necessity of further, more extended study of spontaneous motor activity. Possible correlations of this method with the well-established diagnostic and prognostic methods in the neonatal and early post-neonatal period need also more extensive study. Fidgety movements seem to be considered the most convenient to study and of the greatest prognostic value. OBJECTIVE: To study prospectively the spontaneous motor activity in the period of fidgety movements and compare it with the results of the clinical and ultrasound methods of investigation. MATERIAL AND METHODS: Thirty five infants aged 0 to 3 months (7 preterm infants) referred to the Pediatric Neurology Service at Plovdiv University Clinic of Pediatrics and Medical Genetics for consultation or hospitalisation were prospectively followed up to one year of age. Fidgety movements were examined from six to 20 weeks corrected age; neurologic examination and transfontanel ultrasonography were conducted on the day of an infant's inclusion into the study, during the period of fidgety movements and between 12 to 18 months of age. The clinical and ultrasonographic findings from the neonatal period were analysed. RESULTS: Normal fidgety movements were observed in 31 infants;
four infants were with absent fidgety movements. The rate of agreement of the results was high (more than 91%, p<0.05) when presence of normal fidgety movements was correlated with absent or mild neonatal and postneonatal neurologic and ultrasonographic abnormalities, and absent fidgety movements with severe clinical and ultrasonographic abnormalities. CONCLUSION: Abnormal fidgety movements are statistically significantly correlated with the grade of neonatal neurologic and ultrasonographic abnormalities and with the clinical and imaging findings during their investigations.


INTRODUCTION: In neonates with spina bifida aperta (SBA), leg movements by myotomes caudal to the meningo(myelo)cele (MMC) are transiently observed. It is unclear whether these leg movements relate to functional neural conduction through the MMC. For optimal therapeutical intervention, pathophysiological insight in these transient leg movements seems relevant. If leg movements by myotomes caudal to the MMC concur with the execution of general movements (GMs), functional neural conduction through the MMC is implicated. OBJECTIVE: In neonates with SBA, we aimed to determine whether the transiently present leg movements caudal to the MMC indicate functional neural conduction through the MMC. METHODS: During the perinatal period, fetuses and neonates with SBA (n = 7 and n = 13, respectively) were longitudinally analysed for concurrence between leg movements caudal to the MMC and GMs. To address the integrity of the reflex arc in spinal segments (at, or) caudal to the MMC, tendon leg reflexes were assessed during the first postnatal week. RESULTS: At postnatal day 1, leg movements caudal to the MMC concurred with GMs in 12 of 13 infants. Isolated leg movements were observed in only 3 of these 12 infants (isolated vs. concurrent; p < 0.005). Leg movements concurring with GMs lasted longer than isolated leg movements (median duration = 11 s vs. 2 s; p < 0.05). Between days 1 and 7, tendon leg reflexes (at, or) caudal to the MMC had disappeared in all but 1 neonate. However, leg movements caudal to the MMC remained concurrently present with GMs in all five neonates available for follow-up after day 7. Comparing these leg movements between days 1 and 7 indicated a decreased duration (-44%, p < 0.05). CONCLUSIONS: In neonates with SBA, leg movements caudal to the MMC concur with GMs, indicative of functional neural conduction through the MMC. The disappearance of these leg movements is caused by lower motor neuron dysfunction at the reflex arc, whereas neural conduction through the MMC is still functional.


Information provided by the neonatal neurologic assessment is important for identifying infants with neurologic abnormalities at a very early age. The aim of this study was to compare two distinct approaches to the neurologic assessment of newborns: the Amiel-Tison neurologic assessment, and Prechtl's qualitative assessment of general movements. The results of both assessments were studied in a group of 45 preterm infants with different risk factors for brain damage that were compared at term age and at a corrected age of 3 months. The predictive power of the two methods regarding the neurologic and developmental outcome at a corrected age of 12-15 months was analyzed. The agreement of the two methods was excellent at term (kappa = 0.87) and good at 3 months (kappa = 0.54). The sensitivity of both methods for detecting children with neurologic abnormalities was high both at term and at 3 months (0.92, 1.0 for the Amiel-Tison assessment and 0.96, 1.0 for general movements). The specificity of both techniques was low at both ages (0.45, 0.75 for the Amiel-Tison assessment and 0.40, 0.35 for general movements). The agreement of the neurologic and developmental outcome was better with the Amiel-Tison assessment (kappa = 0.39, 0.77) than with the observation of general movements (kappa = 0.38, 0.37).

Groen SE, de Blécourt AC, Postema K, Hadders-Algra M. General movements in early infancy predict neuromotor development at 9 to 12 years of age. Dev Med Child Neurol 2005, 47: 731-738

Assessment of the quality of general movements (GMs) in early infancy is a powerful instrument to predict cerebral palsy (CP). The aim of the present study is to explore the value of GM assessment in predicting minor neurological dysfunction (MND) at 9 to 12 years of age. Two groups of infants were studied prospectively: 28 low-risk full-term infants (11 females, 17 males) and 24 high-risk infants, mostly born preterm (<37 weeks; 11 females, 13 males). In each group the quality of GMs (normal or abnormal) was assessed during two developmental periods: the age at which 'wriggling' GMs occur (46 weeks' postmenstrual age to 7 weeks' postterm) and the age at which 'fidgety' GMs occur (8 to 17 weeks' postterm). Eight of 24 high-risk infants were diagnosed as having CP at 4 to 9 years of age. The remaining 44 children were followed-up at 9 to 12 years. In children without CP, quality of GMs at 'fidgety age' was related to neurological condition (normal, simple MND, complex MND) at follow-up (rho=0.46, p<0.01). Abnormal GMs at 'fidgety-GM age' showed a specific relationship to the development of coordination problems (chisq=6.1, p=0.01) and fine manipulative disability (Fisher, p<0.05) at 9 to 12 years. This finding supports the notion that the quality of GMs may provide information on the integrity of complex supraspinal circuitries.

Einspieler C, Kerr AM, Prechtl HFR.
Abnormal general movements in girls with Rett disorder: The first four months of life.

Brain Dev 2005, 27: Suppl 1 S8-S13

An apparently normal early development was one of the initial criteria for classical Rett syndrome. However, several investigators considered Rett syndrome to be a developmental disorder manifesting very soon after birth. Videos of 14 infants with Rett disorder were carefully assessed for their spontaneous movements, in particular general movements (GMs), during the first 4 months of life. A detailed analysis clearly demonstrated that none of the infants had normal GMs. However, a specific abnormal GM pattern could not be detected for Rett disorder. The abnormal GMs described here, and their individual developmental trajectories are different from the abnormal GMs described in infants with acquired brain lesion. Our study is the first to apply specific standardised measures of early spontaneous movements to infants with Rett syndrome, proving conclusively that the disorder is manifest within the first weeks of life.

Nakayima Y, Einspieler C, Marschik PB, Bos AF, Prechtl HFR.
Does a detailed assessment of poor repertoire general movements help to identify those infants who will develop normally?


BACKGROUND: The assessment of the quality of general movements (GMs) in young infants is a reliable and valid diagnostic tool for detecting brain dysfunction early in life. Poor repertoire GMs are the most frequently observed abnormal GMs during the preterm, term and early postterm period. However, their predictive value for the neurological outcome is low. AIM: To find out whether a detailed scoring of poor repertoire GMs might lead to a better prediction of the neurological outcome. SUBJECTS: We studied 18 preterm infants who were repeatedly videoed from birth to 22 weeks postterm age, including several recordings assessed as poor repertoire GMs. At 8 to 10 years, six children were neuromotorically normal, six had mild neurological abnormalities, and the remaining six were classified as cerebral palsy.

STUDY DESIGN: Each GM globally assessed as poor repertoire was scored in details according to several aspects of neck and trunk, arm and leg movements applying Prechtl's optimality concept. RESULTS: By and large, the detailed score of poor repertoire GMs was not related to the neurological outcome. CONCLUSION: For the clinical application of the GM assessment, it remains important to assess the fidgety movements of those infants with poor repertoire GM trajectories in order to predict their outcome.

Valentin T, Uhl K, Einspieler C.
The effectiveness of training in Prechtl's method on the qualitative assessment of general movements.


BACKGROUND: Prechtl's method on the qualitative assessment of general movements (GMs) is a highly sensitive and specific diagnostic tool for the assessment of the integrity of the young nervous system. AIM: To find out whether the ability to assess GMs correctly could be gained after receiving a few days' standardised training. STUDY DESIGN: We evaluated 700 scoring sheets (containing a total of 8019 assessments) from the final tests of 18 training courses held between 1997 and 2002. RESULTS: Eighty-three per cent of the assessments were correct after completing a 4- to 5-day training course. The correct discrimination between normal and abnormal GMs was 92%. It proved more difficult to assess infants correctly if they had been recorded around term age. CONCLUSION: Standardised training courses enable professionals in the field of infant and child neurology to apply Prechtl's method of GM assessment accurately.

Einspieler C, Prechtl HFR.
Prechtl's assessment of general movements: a diagnostic tool for the functional assessment of the young nervous system.


General movements (GMs) are part of the spontaneous movement repertoire and are present from early fetal life onwards until the end of the first half a year of life. GMs are complex, occur frequently, and last long enough to be observed properly. They involve the whole body in a variable sequence of arm, leg, neck, and trunk movements. They wax and wane in intensity, force and speed, and they have a gradual beginning and end. Rotations along the axis of the limbs and slight changes in the direction of movements make them fluent and elegant and create the impression of complexity and variability. If the nervous system is impaired, GMs loose their complex and variable character and become monotonous and poor. Two specific abnormal GM patterns reliably predict later cerebral palsy: 1) a persistent pattern of cramped-synchronized GMs. The movements appear rigid and lack the normal smooth and fluent character. Limb and trunk muscles contract and relax almost simultaneously. 2) The absence of GMs of fidgety character. So-called fidgety movements are small movements of moderate speed with variable acceleration of neck, trunk, and limbs in all directions. Normally, they are the predominant movement pattern in an awake infant at 3 to 5 months. Beside a sensitivity and specificity of 95% each, the assessment of GMs is quick, noninvasive, even nonintrusive, and cost-effective compared with other techniques, e.g., magnetic resonance imaging, brain ultrasound, and traditional neurological examination.

Einspieler C, Prechtl HFR, Bos AF, Ferrari F, Cioni G.
OBJECTIVE: Aim of our study was to describe the character of General Movements (GMs) in children with Down Syndrome (DS). MATERIAL AND METHODS: GMs of 23 children with DS and of 30 healthy full-term infants were assessed from birth to 6th month corrected age. A qualitative and a semi-quantitative evaluation of GMs were achieved for each child. Data were graphically displayed to obtain growth curves of motor optimality scores. RESULTS: GMs in children with DS are characterised by low-low/moderate speed, large-large/moderate amplitude, partially creating impression of fluency, smoothness and complexity, abrupt beginning and end, few other concurrent gross movements. During the 6 months, all children showed an improvement of qualitative and semi-quantitative evaluation, but it was possible to observe great heterogeneity among children in the evolutionary course. GMs evaluation of children with no known motor problems was normal, showing only slight and transient abnormalities at first months. CONCLUSION: GMs character of children with DS could be related to central nervous system and peripheral abnormalities characterizing this syndrome. The evaluation of GMs in children with DS could be an early marker of motor impairment and help in early management decisions making.

Garcia JM, Gherpelli JL, Leone CR.
The role of spontaneous general movement assessment in the neurological outcome of cerebral lesions in preterm infants..

OBJECTIVE: To study the relationship among the quality, type, and trajectory of general movements in preterm infants and neonatal cranial ultrasonography findings and neurological outcome. METHOD: Forty preterm newborn infants, with gestational ages under 35 weeks, had their general movements recorded through video-tape during the preterm, term (37th - 42nd postconceptional weeks of age) and post-term (49th - 56th postconceptional weeks of age) periods, and were prospectively followed up to one-year conceptional age. RESULTS: Our results showed that the quality of general movements, particularly in the post-term period (p = 0.009), were related with the presence of severe cerebral lesions in the neonatal cranial ultrasonography and the neurological outcome. While the presence of severe ultrasonography lesions was associated with an adverse neurological outcome (p = 0.01), the finding of normal general movements patterns was associated with a normal neurological outcome, with negative predictive values of 100%, for the preterm, and 80%, for both term and post-term periods. CONCLUSIONS: When concurrently used, these evaluation methods may increase the specificity and sensitivity in detecting the group of preterm infants at high risk for neurological disturbances in long-term follow-up.

Palmer FB.
Strategies for the early diagnosis of cerebral palsy.

Strategies for the early detection and diagnosis of cerebral palsy include multiple measures of the underlying brain abnormalities and their neurodevelopmental consequences. These measures can be grouped into the categories of pathogenesis, impairment, and functional limitation. Neuroimaging techniques are the most predictive measures of pathogenesis of cerebral palsy in both the preterm and term infant. Measures of neurological impairment focusing on muscle tone, reflexes, and other features of the neurological examination are poorly predictive in the first months of life. Detection of functional limitations manifested by motor developmental delay is sensitive and specific for later cerebral palsy, but not until well into the second 6 months of life. Abnormal spontaneous general movements in the infant 16 to 20 weeks postterm and earlier reflect functional limitations in the first months of life and have been shown to predict later cerebral palsy. Recognition of abnormal spontaneous general movements may improve early detection and diagnosis of cerebral palsy if these techniques can be successfully incorporated into organized follow-up programs and developmental surveillance. Copyright 2004 Elsevier Inc.

Hadders-Algra M.
General movements: A window for early identification of children at high risk for developmental disorders.

Detection of children with a developmental disorder, such as cerebral palsy, at an early age is notoriously difficult. Recently, a new form of neuromotor assessment of young infants was developed, based on the assessment of the quality of general movements (GMs). GMs are movements of the fetus and young infant in which all parts of the body participate. The technique of GM assessment is presented and the features of normal, mildly abnormal, and definitely
abnormal GMs discussed. Essential to GM assessment is the Gestalt evaluation of movement complexity and variation. The quality of GMs at 2 to 4 months postterm (so-called fidgety GM age) has been found to have the highest predictive value. The presence of definitely abnormal GMs at this age—that is, GMs devoid of complexity and variation—puts a child at very high risk for cerebral palsy. This implies that definitely abnormal GMs at fidgety age are an indication for early physiotherapeutic intervention. Copyright 2004 Elsevier Inc.

Zuk L, Harel S, Leitner Y, Fattal-Valevski A.
Neonatal general movements: an early predictor for neurodevelopmental outcome in infants with intrauterine growth retardation.

Intrauterine growth retardation plays a significant role in neurodevelopmental outcome. The assessment of general movements during the first 20 weeks is a new method for early detection of brain dysfunction. General movements in 31 infants with asymmetric intrauterine growth retardation and their appropriate for gestational age-matched controls were examined. General movements were scored as normal or abnormal by sequential videotape recordings in the writhing (term to 2 weeks), early fidgety (9-11 weeks), and late fidgety (14-16 weeks) periods. Scores were compared between the groups and correlated with neurodevelopmental outcome at 2 years. The incidence of normal general movements was lower in the intrauterine growth retarded infants than in the controls (P < .001). Significant correlations were found between general movement quality and neurodevelopmental scores in the intrauterine growth retarded group. The fidgety movements were the most sensitive and specific for prediction of neurologic outcome. The general movement assessment can, therefore, serve as an additional tool for examining the neurologic status of the preterm and term intrauterine growth retarded infant.

Sival DA, Brouwer OF, Meiners LC, Sauer PJJ, Prechtl HFR, Bos AF.
The influence of cerebral malformations on the quality of general movements in spina bifida aperta.

Takaya R, Yukuo K, Bos AF, Einspieler C.
Preterm to early postterm changes in the development of hand-mouth contact and other motor patterns.

Hand-mouth contacts (HMCs) and other spontaneous movements of five low-risk preterm infants were studied longitudinally after their birth until 60 weeks postmenstrual age. For all infants, HMCs that emerged in the preterm period could not be observed transiently after 45 weeks, however, they re-emerged after 50 weeks postmenstrual age. In actograms of the infants' behaviors, the frequency of other spontaneous movements, such as head rotation, showed the same re-emerging pattern. Movements such as cloni, which were also observed in the preterm period, decreased after the term period, with no subsequent increase. Only general movements were continuously present throughout the entire observation period; these changed from writhing to fidgety in nature around the third month. These findings clarify which spontaneous movements of preterm infants are important for later behavioral development.

Dibiase J, Einspieler C.
Load perturbation does not influence spontaneous movements in 3-month-old infants.

BACKGROUND: The assessment of the quality of general movements (GMs) in young infants is a reliable and valid diagnostic tool for detecting brain dysfunction early in life. Of special interest is a type of GMs called fidgety movements (FMs) characteristic for 3- to 5-month-old infants. GMs are part of an infant's spontaneous motor repertoire and as such endogenously generated by the nervous system. Visual, acoustic and social stimuli hardly had any influence on FMs. AIM: Our main purpose was to find out whether FMs are sensitive to load perturbation. STUDY DESIGN: Spontaneous motility in supine position, with and without weighting was recorded on video and the data were semiquantitatively analysed. Weights were attached to the ankles and wrists of all four limbs; on one side of the body only; or without visual feedback of the weighted arm. SUBJECTS: We studied 29 healthy infants with normal FMs at the age of 12 weeks. RESULTS: Spontaneous motility remained symmetrical during all the experimental trails. Weighting had no influence on the quality or temporal organisation of FMs. CONCLUSION: This study demonstrated that the mechanisms responsible for FMs in 3-month-old infants are all but impervious to weight perturbation, at least not with the loads studied. FMs is the stable and predominant motor pattern of this age.

General movements detect early signs of hemiplegia in term infants with neonatal cerebral infarction.

Background. Studies have reported that infants with hemiplegia of congenital origin may have a period between birth and up to 12 months when clinical signs of hemiplegia are not evident. The aim of this study was to establish whether the assessment of general movements (GMs) may help in the earlier detection of signs of hemiplegia. Subjects and Methods. Eleven infants with cerebral infarction on brain MRI, and eleven normal controls were enrolled in the study.
Quality of GMs was assessed from videotapes between 3 and 6 weeks and between 9 and 16 weeks. Neurological outcome was evaluated at least at two years. Results. Seven of the 11 infants had an assessment performed between 3 and 6 weeks: abnormal GMs were observed in all the infants who developed hemiplegia, but one child had abnormal GMs and a normal outcome. All 11 infants had a scorably assessment between 9 and 16 weeks. In all a specific type of GMs, fidgety movements (FMs), were predictive of neurological outcome. The presence of early asymmetries at both 3 - 6 and 9 - 16 weeks was also significantly associated with later signs of hemiplegia. Conclusions. The assessment of GMs after the neonatal period appears to be very useful in the early identification of hemiplegia in infants with cerebral infarction. Whilst the prediction of hemiplegia should be possible from early neonatal MRI brain scans, this facility is not always available. Observation of GMs is a bedside clinical approach that allows confirmation of early prediction from MRI, early rehabilitation if needed and reassurance that neurological outcome will be good where that is appropriate.


While the role of antiepileptic drug (AED) therapy in teratogenesis has widely been investigated, there are few prospective studies on later postnatal development in offspring of epileptic women in utero exposed. The aim of this study was a prospective investigation of the psychomotor development in a selected population of infant born to women with epilepsy on AED therapy during pregnancy. PATIENTS AND METHODS: Children were assessed at various times until 30 months of age by general movement (GMs) observation (at 7 days and 4 and 13 weeks), traditional neurologic examination (at 7 days and 4 and 13 weeks). From birth to the fifth month post-term, all infants were examined (at 7 days and 4 and 13 weeks, 6, 9 and 12 months) and Brunet-Lezine (B-L) administration (at 30 months). We present the preliminary results of our study conducted on 11 children. RESULTS: Psychomotor delay in children was confirmed by traditional neurological examinations scores at 7 days, 4 weeks, 13 weeks and 6 months and by B-L score at 30 months. Between 9 and 12 months of age, traditional neurologic examination became "silent". GM assessment was found to be a better predictor of psychomotor development. In fact, GM analysis, particularly at 4 weeks, was strongly correlated with the Brunet-Lezine score at 30 months. In conclusion, on the basis of these data we suggest a psychomotor delay in the offspring of epileptic women and that GMs and neurologic evaluation provide complementary information concerning psychomotor development and future outcome of these children.


Mortality rates do not decline markedly after postnatal corticosteroid therapy and concern has been raised about its neurological sequelae. We studied 37 preterm infants with Prechtl's method for the qualitative assessment of general movements before, during and after dexamethasone therapy and found that the quality of general movements was impaired in 9 of 13 initially normal infants (p = 0.004, McNemar test). The quality of fidgety movements at 3 months was abnormal in the majority of the infants and correlated strongly with neurological abnormalities at 2 years (Spearman r = 0.785, p < 0.001). Prechtl's method may prove useful for the early neurological evaluation of alternative corticosteroid treatment strategies for the treatment of chronic lung disease.


Qualitative abnormalities of spontaneous motor activity in newborns and young infants are early predictive markers for later spastic cerebral palsy. Aim of this research was to identify which motor patterns may be specific for later dyskinetic cerebral palsy. In a large, prospectively performed longitudinal study involving four European hospitals we identified twelve cases with the relatively rare condition of dyskinetic cerebral palsy and compared their early motor development with twelve spastic cerebral palsy cases and twelve controls. From birth to the fifth month post-term, all infants were repeatedly videoed and their spontaneous motor patterns, including general movements, were assessed. Until the second month post-term, the infants that later became dyskinetic displayed a poor repertoire of general movements, "arm movements in circles" and finger spreading. Abnormal arm and finger movements remained until at least five months and were then concurrent with a lack of arm and leg movements towards the midline. Later dyskinetic infants share with later spastic infants the absence of fidgety movements, a spontaneous movement pattern that is normally present from three to five months. Qualitative assessment of spontaneous motor patterns enabled us to identify infants at high risk for dyskinetic cerebral palsy early in life. Additionally, we were able to discriminate them from those infants at high risk for later spastic cerebral palsy. This is a matter of significant clinical relevance because the two types of cerebral palsy ask for different management and early intervention.


OBJECTIVE: To ascertain whether specific abnormalities (ie, cramped synchronized general movements [GMs]) can predict cerebral palsy and the severity of later motor impairment in preterm infants affected by brain lesions. DESIGN:
Traditional neurological examination was performed, and GMs were serially videotaped and blindly observed for 84 preterm infants with ultrasound abnormalities from birth until 56 to 60 weeks' postmenstrual age. The developmental course of GM abnormalities was compared with brain ultrasound findings alone and with findings from neurological examination, in relation to the patient's outcome at age 2 to 3 years. RESULTS: Infants with consistent or predominant (33 cases) cramped synchronized GMs developed cerebral palsy. The earlier cramped synchronized GMs were observed, the worse was the neurological outcome. Transient cramped synchronized character GMs (8 cases) were followed by mild cerebral palsy (fidgety movements were absent) or normal development (fidgety movements were present). Consistently normal GMs (13 cases) and poor repertoire GMs (30 cases) either lead to normal outcomes (84%) or cerebral palsy with mild motor impairment (16%). Observation of GMs was 100% sensitive, and the specificity of the cramped synchronized GMs was 92.5% to 100% throughout the age range, which is much higher than the specificity of neurological examination. CONCLUSIONS: Consistent and predominant cramped synchronized GMs specifically predict cerebral palsy. The earlier this characteristic appears, the worse is the later impairment.

Dibiasi J, Einspieler C.

Background: The assessment of the quality of general movements (GMs) in infants proves to be a reliable and valid diagnostic tool for detecting brain dysfunction early in life. Of special interest, particularly for the prediction of cerebral palsy, is the fidgety kind of GMs, the so-called fidgety movements (FMs) observable in 3- to 5-month-old infants. GMs are part of an infant's spontaneous motor repertoire and as such endogenously generated by the nervous system itself. Aim: The question was raised as to what extent the temporal organisation of FMs can be modulated by visual and acoustic stimulation. Study design: Spontaneous motility in supine position with and without stimulation was recorded on video and the data were semiquantitatively analysed. We studied the effect of visual stimulation (red ring, red puppet), unanimated acoustic stimulation (68, 77, 88 dB) and of the mother, approaching her infant in a talkative manner after an absence of a quarter of an hour. Subjects: Twenty-nine healthy infants at the age of 12 weeks who all showed normal FMs. Results: Visual stimulation demonstrated that only the presentation of a red puppet elicited a significant level of focussed attention and led to a decrease of FMs. A red ring, unanimated acoustic stimulation as well as the interaction with the mother had no influence on the temporal organisation of FMs. Conclusion: This study demonstrated that in 3-month-old infants, FMs is a predominant motor pattern and that it is possible to assess FMs during (playful) social interaction.

Prechtl HF, Cioni G, Einspieler C, Bos AF, Ferrari F.

For a better understanding of the contribution vision makes to the development of other sensory systems and to movement and posture, we studied effects of early blindness by examining video recordings of 14 totally blind infants. Infants were born at term or preterm and showed no evidence of brain damage. During preterm and term periods no noticeable changes in motor activity were observed. Around 2 months postterm all infants showed clear delay in head control and abnormal, exaggerated type of 'fidgety movements'. Later, postural control was characterized by a prolonged period of ataxic features. Results indicate a lack of normal calibration exerted by vision on proprioceptive and vestibular systems. Early visuomotor coordination such as coordinated eye-head scanning and head orientating were present but disappeared after several weeks.

Prechtl HFR.

Bos AF, Einspieler C, Prechtl HFR.

Bos AF, Venema IMJ, Bergervoet M, Zweens MJ, Pratt B, van Eykern LA.

Objective: To determine in preterm infants with a patent ductus arteriosus (PDA) the effect of indomethacin treatment on spontaneous motor activity. Study Design: Motor activity was assessed from repeated videotape recordings in 32 preterm infants (less than or equal to 33 weeks gestation). Sixteen infants required indomethacin therapy for treatment of PDA, 16 were control infants, matched for gestational age. Indomethacin (0.2 mg/kg i.v. in 5 min) was given thrice, with an interval of 12 h. One-hour recordings were made immediately before and immediately after the first dose of indomethacin and 24 h later before and after the third dose. The same recording schedule was used for the control
infants. The effects of indomethacin on quantity and quality of spontaneous motor activity were examined. Results: A significant reduction in the quantity of several spontaneous movement patterns and an increase in the occurrence of rest periods were found following the first indomethacin administration (p < 0.01). Concerning the quality of general movements, a reduction in the speed was found (p < 0.05). Both effects were not found after the third indomethacin administration. Conclusion: In preterm infants with a PDA, treatment with indomethacin leads to a transient reduction in the quantity of spontaneous movement patterns and to a decrease in the speed of general movements. We recommend a cautious use of bolus indomethacin for the treatment of PDA.


The aim of the study was to document the early developmental course of neurological signs in a group of preterm infants at risk for hemiplegia, due to unilateral intraparenchymal echodensity (UIPE). Sixteen preterm infants with UIPE and sixteen controls were given serial neurological examinations, according to the protocols currently adopted in the different NICUs of the project. Moreover, the quality assessment of their general movements (GMs) was assessed subsequently from videotapes, from birth until around four months postterm. At two years, 12 of the UIPE infants showed hemiplegia and one suffered from asymmetrical diplegia. The findings of the traditional neurological examination were abnormal for the large majority of the UIPE group, although normal findings were also recorded, especially during the preterm period. Asymmetries were found after term age in nine UIPE and in two control infants. From the first observation onwards, all infants with UIPE showed bilaterally abnormal GMs and in those with unfavourable outcome fidgety movements (FMs) were absent. At the FMs period (9-16 weeks postterm), all infants with subsequent hemiplegia showed asymmetry of distal segmental movements which were reduced or absent on the side contralateral to the lesion. Conclusion: Unilateral brain lesions induce clear neurological signs and abnormal GMs in particular, although these abnormalities are not initially asymmetrical. A reduction of segmental movements on one side of the body during the third month postterm is highly predictive of hemiplegia.


Objective: To determine in preterm infants with a patent ductus arteriosus (PDA) the effect of indomethacin treatment on spontaneous motor activity. Study Design: Motor activity was assessed from repeated videotape recordings in 32 preterm infants (less than or equal to 33 weeks gestation). Sixteen infants required indomethacin therapy for treatment of PDA, 16 were control infants, matched for gestational age. Indomethacin (0.2 mg/kg i.v. in 5 min) was given thrice, with an interval of 12 h. One-hour recordings were made immediately before and immediately after the first dose of indomethacin and 24 h later before and after the third dose. The same recording schedule was used for the control infants. The effects of indomethacin on quantity and quality of spontaneous motor activity were examined. Results: A significant reduction in the quantity of several spontaneous movement patterns and an increase in the occurrence of rest periods were found following the first indomethacin administration (p < 0.01). Concerning the quality of general movements, a reduction in the speed was found (p < 0.05). Both effects were not found after the third indomethacin administration. Conclusion: In preterm infants with a PDA, treatment with indomethacin leads to a transient reduction in the quantity of spontaneous movement patterns and to a decrease in the speed of general movements. We recommend a cautious use of bolus indomethacin for the treatment of PDA.


OBJECTIVE: The objective of this study was to determine in preterm infants at risk for severe chronic lung disease (1) the quality of general movements (GMs) and (2) the effect of dexamethasone treatment on spontaneous motor activity. STUDY DESIGN: In 15 very low birth weight infants the quality of GMs was assessed from repeated videotape recordings. Recordings were made at weekly intervals during the preterm period until term age and thereafter three times until the twentieth postterm week. All infants required dexamethasone therapy, and additional recordings were made a few hours before and 24 hours, 48 hours, and 7 days after dexamethasone was started. The relationship among movement quality, brain ultrasonographic abnormalities, and long-term outcome was explored. Acute effects of dexamethasone on motor activity were examined. RESULTS: After dexamethasone therapy was started, a significant transient reduction of the quantity of most spontaneous movements (p < 0.05) and a reduction of speed and amplitude of GMs was found (p < 0.05). A significant relationship was found between the severity of brain ultrasonographic
abnormalities and the extent to which developmental trajectories of GMs were abnormal (p < 0.001). The development of cerebral palsy was related to the presence of cramped-synchronized movements near term (p < 0.02) and to the absence of fidgety movements at the age of 3 months after term (p < 0.05). CONCLUSION: In preterm infants with severe chronic lung disease and brain lesions, dexamethasone treatment leads to an acute reduction in motility and changes in the speed and amplitude of GMs. Until more is known about long-term neurologic sequelae, a cautious use of systemic dexamethasone therapy in preterm infants is recommended.

Bos AF, Martijn A, Okken A, Prechtl HFR.
Quality of general movements in preterm infants with transient periventricular echodensities.

By means of sequential videotape recordings, the relevance of the quality of general movements for neurological outcome was determined in a group of 21 appropriate-for-gestational-age preterm infants with transient periventricular echodensities of variable localization and duration and in 6 infants without echodensities. Echodensities, especially in the parieto-occipital area, affected the quality of general movements. Echodensities persisting beyond 14d were associated with abnormal general movements; infants with echodensities up to 14 d had either normal or abnormal general movements. The developmental course of movement quality was correlated to neurological outcome (p < 0.005): normal outcomes were found in 11/12 infants with normal general movements throughout and in 9/11 infants with transient abnormal general movements; all 4 infants with persistent abnormal general movements had impaired outcomes. In infants with transient echodensities, longitudinal assessment of the quality of general movements helps to determine if there is brain dysfunction, either transient or persistent, and identifies infants at risk for impaired neurological outcomes.

Bos AF, van Asperen R M, de Leeuw DM, Prechtl HFR.
The influence of septicaemia on spontaneous motility in preterm infants.

The qualitative assessment of general movements (GMs) in preterm infants is a sensitive method to investigate the integrity of the central nervous system. The question arises whether systemic infections affect the quality of GMs in a similar fashion to brain lesions. We were able to provide an answer to this problem in six infants (gestational age 24.4-32.4 weeks, birth weight 600-1660 grams), who had initially normal GMs as analyzed from sequential video-recordings. All infants sustained a proven septicaemia (Candida albicans in two, Staphylococcus aureus in three, a coagulase-negative staphylococcus in one infant). Unintentionally, recordings were also made during the acute phase. The complexity and variability of the GMs remained largely intact in five of the six infants; only one infant had transiently abnormal GMs. Compared with 1 week before the acute phase, the speed and amplitude of the GMs were diminished, giving the GMs a sluggish appearance. One to two weeks after the acute phase of septicaemia, the quality of GMs, i.e. speed and amplitude, had normalized in all infants. This study demonstrates that it is possible to discriminate between abnormal GMs due to cerebral lesions and sluggish GMs due to severe systemic infections, when the complexity of the GMs is considered as the main characteristic for judgement of normality of GM-quality.

Bos AF, van Loon A J, Hadders-Algra M, Martijn A, Okken A, Prechtl HFR.
Spontaneous motility in preterm, small for gestational age infants. II. Qualitative aspects.

In order to document in detail the developmental course of qualitative aspects of early spontaneous motility in intrauterine growth-retarded infants, sequential videotape recordings were made in 19 preterm infants with a birth weight below the 5th percentile. The quality of general movements (GMs) was studied longitudinally during the preterm and postterm period until approximately 20 weeks corrected age, using Prechtl's method of quality assessment. An abnormal quality of GMs was present in 15 out of 19 infants. Compared to a low-risk group, consisting of appropriate-for-gestational age preterm infants, the proportion of infants with normal findings on brain scans who had an abnormal quality of GMs was high. The presence of 'abrupt chaotic' GMs was related to late fetal heart-rate decelerations and ischaemic alterations of the placenta. The quality of GMs normalized before or during the third month postterm in most infants with abnormal GMs. In four infants, the GMs did not normalize during the study period. The quality of fidgety movements was, in particular, a marker for neurological outcome at 24 months. This study demonstrates that intrauterine growth retardation may cause prolonged, but in most cases transient brain dysfunction; the qualitative assessment of GMs may help to identify infants at increased risk for neurodevelopmental abnormalities.

Cioni G, Ferrari F, Einspieler C, Paolicelli PB, Barbani MT, Prechtl HFR.
Comparison between observation of spontaneous movements and neurological examination in preterm infants.
J Ped 1997; 130: 704-711.

OBJECTIVE: The Prechtl method of qualitative assessment of general movements (GMs) has been shown to be a good predictor of neurologic outcome in fetuses, preterm infants, and term infants. The aim of this study was to compare the results of this new technique with those of traditional neurologic examination and of cranial ultrasonography in preterm infants. METHODS: Serial videotape recordings (with off-line assessment of GMs), ultrasound examination of the brain, and neurologic examinations were performed from birth until about 6 months of corrected age, on a group of 66 preterm infants whose gestational age ranged from 26 to 36 weeks (mean 30.7 weeks). The agreement between the two
periods and higher thereafter). At all ages the results of GM observation correlated highly with neurologic outcome; they showed higher sensitivity and specificity than the neurologic examination. This held true in particular before term age, when poor neurologic responses might be related to transient complications, and at term age, mainly because of infants with normal neurologic examination results but unfavorable outcome. During the preterm period the ultrasound results showed a better specificity and a lower sensitivity to outcome than GM findings. CONCLUSIONS: The results of this study indicate that quality assessment of GMs should be added to traditional neurologic assessment, neuroimaging, and other tests of preterm infants for diagnostic and prognostic purposes.


The qualitative assessment of general movements (GMs) has been shown to be a better predictor of neurological outcome than the traditional neurological examination in brain-damaged preterm infants. The aim of this study was to compare the results of the two techniques in term infants. Off-line assessment of GMs from videorecordings and neurological examinations were carried out, from birth till about 6 months of postterm age, in a group of 58 term infants, the majority of which were affected by mild to severe hypoxic-ischaemic encephalopathy. The agreement between the two techniques and their predictive power, with respect to the neurological outcome at 2 years, were evaluated for four age groups. The range of agreement between neurological and GM findings was between 78 and 83%. At all ages the results of GM observation correlated highly with the neurological outcome; their sensitivity and specificity with respect to outcome were consistently slightly superior to those of neurological examination. In infants normalize after an initial period of transient abnormalities, GMs normalize earlier than the neurological results.


We describe the state of the art of Prechtl's method for the qualitative assessment of general movements as a diagnostic tool for early detection of brain dysfunction. After discussing the optimal technique for video recording general movements in preterm, term and young infants, attention is focused on the proper analysis of this spontaneous motor pattern. Recently, a group of active researchers in the field reached consensus on the various qualities of normal and abnormal general movements. These definitions are reported here in full. Since it is a newly introduced method careful investigation into its reliability is required. Various groups of investigators have obtained data which demonstrate the robust character of the method (interscorer agreement: 78-98%). Finally, we discuss the validity of this early assessment method on the basis of the reports published so far. While the method's sensitivity is similar in all age groups studied (preterm, term, first month, second month, and third month age epochs), and averages 94.5%, the specificity of the method is age-dependent. It is low during the early ages, increases gradually and reaches 82 to 100% at 3 months post-term. This phenomenon is explained by spontaneous recovery of early dysfunction. In contrast, consistent abnormalities of general movements are linked to neurological deficits found at the 2 year follow-up.


Posture, quality of spontaneous movement patterns, quality of general movements (GMs), and behavioural state organisation were studied in nine infants affected by documented brain malformations. A single 1 h video recording of five infants and two or more serial video recordings of another four infants were performed after birth. The graphic representation of single movement patterns (actogram) and of behavioural states of one video recording was performed in eight out of nine infants. The quality of GMs was assessed according to Prechtl's method in all video recordings. All nine infants showed a less variable posture than normal newborn infants and an unusual resting posture was detected in seven infants. Poor behavioural state organisation without sleep cycles was common to the nine infants and excessive wakefulness was observed in six infants. As for the quantity of single movement patterns, six infants lacked one or two movement patterns normally present in healthy newborn infants. An abnormal quality of GMs was noted in all nine infants and distinct motor abnormalities were observed in single infants. A monotonous and sometimes stereotyped sequence of different body parts involved in the movement (i.e. poor repertoire GMs) was common to all infants. In the four infants of whom two or more video recordings were available, initial poor repertoire GMs were followed by a further deterioration in movement quality. No relationship was found between the quantity of defective brain tissue, lack of a specific part of the brain, type and severity of GM and posture abnormalities.

The effect of type-I diabetes on the quality of general movements (GMs) was studied longitudinally in 12 human fetuses. GMs were analysed at two-weekly intervals from 16 weeks until delivery. A pregnancy optimality-score and a diabetes optimality-score were used to cover the course of the pregnancy and delivery and the severity of diabetes. GMs of infants were analysed 1, 4-6, and 12-18 weeks after birth and the Bayley developmental test was performed at 10 months. All fetuses showed normal GMs at 16 weeks. From 20 weeks onwards until delivery five fetuses developed abnormal GMs. The diabetes optimality-score was significantly lower in the group with abnormal GMs (P = 0.018) whereas the pregnancy optimality-score did not differ between fetuses with normal and abnormal GMs. Our results indicate that type-I diabetes can have a negative impact on prenatally observed GMs. Consistently normal GMs indicate normal neurodevelopmental outcome at 10 months whereas in the group with abnormal GMs reduced Bayley-scores may occur.

Prechtl H.F.R. (ed). 
Spontaneous Motor Activity as a Diagnostic Tool. Functional Assessment of the Young Nervous System. 

Prechtl H.F.R.
State of the art of a new functional assessment of the young nervous system. An early predictor of cerebral palsy. 

The paper provides a survey of the state of the art of a new neurological diagnostic procedure in fetuses, preterm and term infant as well as in young infants. This method consists of a judgement of the movement quality of a particular type of spontaneous movements, the so-called general movements. At a very early age normal and abnormal general movement quality predicts the neurological outcome over 2 years, in particular cerebral palsy. The reliability of this method turned out to be very robust. Recent animal experiments on isolated parts of the central nervous system provide convincing evidence of endogenously generated neural activity. Similar neural mechanisms must provide the basis for spontaneous movements seen in the human at early ages. Those neural defects leading to qualitative changes of general movements are described in detail.

Prechtl HFR, Einspieler C.
Is neurological assessment of the fetus possible? 

The possibility to assess the functional condition of the fetal nervous system is of great importance to the obstetrician, since a considerable part of early brain damage is of prenatal origin. Several attempts to develop such a technique are reviewed. In addition, a new method, the qualitative assessment of fetal general movements, is described as a successful tool to obtain reliable data on the fetal brain dysfunction. This new method is robust, non-intrusive and cost-effective. There is also the advantage that the same criteria for the diagnostic assessment can be used for the fetus as well as for the young infant.

Prechtl HFR, Einspieler C, Cioni G, Bos AF, Ferrari F, Sontheimer D.
An early marker for neurological deficits after perinatal brain lesions. 
Lancet 1997; 349: 1361-1363

BACKGROUND: In normal awake infants, fidgety movements are seen from the age of 6 weeks to 20 weeks. The aim of the study was to test the predictive value of absent or abnormal spontaneous movements in young infants for the later development of neurological deficits. METHODS: In a collaborative study involving five hospitals we collected data on the normal and abnormal quality of fidgety movements of 130 infants and compared it with assessments of neurological development done longitudinally until the age of 2 years. On the basis of ultrasound scans infants were classified as at low-risk or at high-risk of neurological deficits. Infants were videoed for 1 h every week from birth to discharge and then for 15 min every 3 to 4 weeks; quality of general movements was assessed. Repeated neurological assessments were also done until 24 months of corrected age. FINDINGS: 67 (96%) of 70 infants with normal fidgety movements had a normal neurological outcome. Abnormal quality or total absence of fidgety movements was followed by neurological abnormalities in 57 (95%) of the 60 infants (49 had cerebral palsy and eight had developmental retardation or minor neurological signs). Specificity and sensitivity of fidgety movement assessment were higher (96% and 95%, respectively) than of ultrasound imaging of the infants’ brain (83% and 80%, respectively). INTERPRETATION: Our technique of assessing spontaneous motor activity can identify and distinguish between those infants who require early intervention for neurological abnormalities and those who do not. Our technique is simple, non-intrusive, reliable, quick, and can be done on very young infants.

Albers S, Jorch G.
Prognostic significance of spontaneous motility in very immature preterm infant under intensive care treatment. 
Qualitative analysis of spontaneous motility was performed in 22 preterm infants (gestational age 25-31 weeks) on the intensive care unit. The infants were videorecorded once a week in the late afternoon during 1 h until 36 weeks of gestation. Quality of movement was analyzed by 8 observers using visual ‘Gestalt perception’ and compared with the neurological outcome 1 year after term. A normal quality of movement consistently predicted a normal neurological outcome with a probability of 90-100%. An abnormal quality of movement predicted an abnormal outcome with a probability of only 56% in the first, but with a probability of 82% in the third postnatal week. The average interobserver agreement was 78%. The analysis of spontaneous motility for the early diagnosis of neurological dysfunctions can reliably be applied on very immature preterms under intensive care conditions from the 3rd postnatal week on.

Einspieler C. Abnormal spontaneous movements in infants with repeated sleep apnoea.


Infants with repeated apnoea during sleep have received great attention for the assumed reason of being at-risk for sudden infant death. The present paper reports findings which indicate a different risk, namely for neurological impairment during infancy due to repeated hypoxia. A very strong correlation exists between the respiratory measurements based on a polygraphic all-night recording (PtCO2 drops and apnoea incidence and duration) and the impairment of the spontaneous movement repertoire in 114 infants, aged between 3 and 26 weeks. All infants have been video recorded at the same day as the registration of the sonogram. As there was a gradient of respiratory abnormalities from absent to severe, a similar gradient was present in the degree of motor deviations in these infants. A variety of qualitative changes in the spontaneous movement patterns was found which was similar to those previously described in cases with documented brain damage. These abnormalities could not be attributed to pre- and perinatal complications. It is concluded that infants with repeated sleep apnoea need special attention for prevention of neurological impairment irrespective of the supposed risk for sudden infant death.

Einspieler C, Prechtl HFR, van Eykern L, de Roos B.
Observation of movements during sleep in ALTE and apnoeic infants.


Fourteen infants of 2 months or 6 months of age were video-recorded during polysomnography. Four were normal infants, five had a history of ALTE (apparent life-threatening event) and five had repeated and prolonged apnoea during sleep. Two ALTE infants have been recorded at 2 months as well as at 6 months of age. Movements during sleep could be classified into general movements, isolated movements of the upper extremity, startles, head rotations, and trunk rotations. In the ALTE cases at 2 months of age, the motility was quantitatively not different from the control infants but was markedly reduced at 6 months of age. (All cases had their event before 8 weeks of age.) In contrast to these findings, infants with repeated apnoea did not show a clear change in the quantity of their movements. With the exception of one ALTE case at 2 months, all observed cases of ALTE and apnoeic infants showed an abnormal quality of their spontaneous movements during sleep. As reported in a previous study, all these cases had also been found moving abnormally during wakefulness. It is suggested that the abnormal motility is a sequelae of the event (ALTE or repeated apnoeas) with as a consequence, an impairment of neural functions.

Prechtl HFR.

Prechtl HFR, Ferrari F, Cioni G.
Predictive value of general movements in asphyxiated fullterm infants.

Early Hum Dev 1993; 35: 91 - 120.

The developmental course of spontaneous motility was investigated in a group of 26 fullterm infants, affected by mild to severe hypoxic-ischaemic encephalopathy. Serial 1-h videorecordings were carried out from birth to 15-22 weeks and a quality assessment of general movements (GMs) was made from a replay of the videos. Neurological follow-up of the infants were continued until at least 18 months of age; neonatal EEG and neuro-imaging techniques (US-scan, CT or MRI) were also carried out in all cases. The results indicate that perinatal asphyxia has important effects on the spontaneous motility of fullterm infants. Hypokinesia occurred very frequently during the first days of life, followed by a transient or prolonged (lasting longer than 15-22 weeks) abnormal quality of GMs. In the first 2 weeks the results of GM assessment did not correlate with the simultaneous findings of neurological examination, neuro-imaging and EEG, whereas they did when the results at 15-22 weeks were considered. The changes in spontaneous motility and especially GM developmental trajectories were good predictors of the neurological outcome. The predictive value of GM assessment was found to be similar to that of EEG and neuro-imaging, and better than neurological examination.

Hadders-Algra M, Prechtl HFR.
Developmental course of general movements in early infancy. I. Descriptive analysis of change in form.
In order to describe the developmental changes of general movements (GM) in early infancy and to relate them to changes in other aspects of the neurological repertoire, the spontaneous motility in supine position was recorded on video tape at 4-week intervals in a group of twenty-two full-term healthy infants aged 2-18 weeks. Each follow-up session included a neurological examination. In newborn infants GM have a 'writhing' quality. The movements are characterized by a tight appearance, a relatively slow speed and a limited amplitude. The 'writhing' character of the GM is gradually broken down into a so-called 'fidgety' quality. These GM are typified by an ongoing flow of small movements occurring irregularly all over the body. The transformation of GM from a 'writhing' character into a 'fidgety' character was related more closely to postmenstrual than to postnatal age. 'Fidgety' GM were almost constantly present at the age of 8-12 weeks. In the third month very rapid arm movements ('swipes' and 'swats') occurred. The developmental changes in the form of the GM and those of the neurological repertoire showed no significant correlation. This demonstrates that within the normal CNS the various functional modules develop autonomously.


In order to study developmental changes in muscle co-ordination during the first postnatal months, simultaneous polymyographic recordings and video-recordings were made during spontaneous movements of 22 healthy infants, who were followed from birth onwards. During the first 2 months general movements (GM) change from movements with a so-called 'writhing' character, which have a tight appearance, a relatively slow speed and a limited amplitude, into GM with a 'fidgety' character, which consist of an ongoing flow of small, elegant movements. We hypothesized that this transformation would coincide with a change from a pattern of co-contraction of antagonistic muscle groups into a pattern of reciprocal activation. This was not the case, a pattern of co-activation of antagonistic muscle groups remained the prevailing pattern. With increasing age, we found shorter burst durations of phasic activity, an attenuation of burst amplitude and a decrease of tonic background activity. These changes were attributed to a reduction of the sensitivity of the motor units due to spinal and supraspinal reorganization. It is hypothesized that the so-called 'bistable' properties of motoneurones play a central role in the observed phenomena: in neonates motor units are apt at displaying sustained activity, at 2 months of age the threshold for reaching this maintained activity increases, resulting in a low level of excitation of motor units during spontaneous movements. In the third month rapid arm movements ('swipes' and 'swats') develop. The 'swats' are characterized by a consistent pattern of reciprocal activity of antagonistic (shoulder) muscles.


The aims of the study were (1) to replicate previous quantitative studies of motor activity in low-risk and high-risk preterm infants and (2) to apply a new method of systematic analysis of the qualitative characteristics of general movements in these two groups of infants. Sequential one-hour videorecordings of the unstimulated infants in the incubator were made during the preterm period and then continued during the postterm period until about 20 weeks. The high-risk group consisted only of infants with signs of haemorrhage and/or leucoma. The neurological follow-up continued up to a minimum of one and a maximum of three years of corrected age. The
quantification of the various motor patterns in 12 matched pairs of low-risk and high-risk preterm infants revealed a slight but significant (P = 0.05) excess of isolated arm movements in the low-risk cases during the activity phase. No other movement pattern differed significantly. The qualitative assessment of general movements during the preterm period resulted in all but one of the 14 low-risk cases having a normal quality of general movements. In the lesion-group (N = 29) all the infants had an abnormal quality during the preterm period. Eight cases later became neurologically normal although 1 of them had strabism. In addition, one infant was blind (ROP) and retarded and one other had mental retardation. Nineteen infants later developed cerebral palsy (two monoplegia of a leg, three hemiplegia, 5 diplegia and 9 quadriplegia). Strabism was present in 48.3% of the whole group of 29 cases. A semi-quantitative estimation of various aspects of the abnormal general movements made a typology of abnormal patterns possible. A graphic display of developmental trajectories of individual cases, depicting the course of abnormal aspects along the time axis, helps document the evolution of abnormal signs. Their course is a better predictor of the neurological outcome than the nature and localization of the lesion, detected by imaging techniques. The qualitative assessment of general movements from videorecordings is a reliable, quick, cheap and totally non-intrusive method in neonatology for the early detection of functional impairment of the nervous system.

Prechtl HFR. Qualitative changes of spontaneous movements in fetus and preterm infants are a marker of neurological dysfunction. Early Hum Dev 1990; 23: 151-159.


Posture and spontaneous motor patterns during the first days of life were studied in ten healthy fullterm infants by direct observation and videorecording. The aim of the study was to provide a description of motor and postural characteristics of normal newborns. The infants were recorded for 1 h on their first and fourth day of life, when unstimulated in an incubator. Incidence and duration of the different body postures and motor patterns were scored during the replay of the videorecordings. The preference for the fully flexed posture of arms and legs described in the literature could not be confirmed. There was a large intra- and inter-individual variability in the postural repertoire. No particular posture, characteristic for each behavioural state, existed. Similar postures rarely occurred in the same infant on the first and fourth day. Extended postures more often occurred on the fourth day. Spontaneous motility consisted of several distinct movement patterns, the occurrence of which in states 1 and 2 was computed for day 1 and day 4. Motor patterns were differently related to the states. No differences were noted in the motor activity between the first and fourth days. Large inter-individual differences, but an intra-individual consistency, were found in the rates of specific motor patterns: infants who showed a low or high rate of particular movements on day 1 maintained the same characteristic on day 4. There was no overall low or high motor activity.


A new hypothesis is presented concerning the maturation of the human nervous system and the duration of pregnancy. It has been found that many neural functions characteristic of the fetus continue after birth until a major transformation takes place at the end of the second postnatal month. From a comparative perspective the duration of pregnancy in man is relatively short among primates. An explanation may be found in metabolic constraint. The special energy demands of a large fetal nervous system and the build-up of a subcutaneous fat deposit may have prevented a proportional prolongation of pregnancy during evolution of hominids.


One component of the major transformation of neural functions at the end of the second postnatal month is concerned with a change in the appearance of general movements. These endogenously generated complex movements lose their writhing character and are replaced by a transient form, termed 'fidgety' movements. There are individual differences in the age of onset and duration as revealed by longitudinal observations. It is speculated that 'fidgety' movements may be related to a postnatal calibration of the proprioceptive system.


Hopkins B, Prechtl HFR A qualitative approach to the development of movements during early infancy.