Does general movements quality in term infants predict cerebral palsy and milder forms of limited mobility at 6 years?

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ABBREVIATIONS

DBAT	Difficult birth at term
MABC	Movement Assessment Battery for Children
MACS	Manual Ability Classification System
MND	Minor neurological dysfunction

AIM To evaluate in term infants associations between quality of general movements and developmental outcome in term infants at 6 years with either cerebral palsy (CP) or limited mobility without CP.

METHOD Participants of this prospective study were 145 term infants (86 male, 59 female). Their general movements quality was assessed at 'writhing' and 'fidgety' general movements age (3wks and 13wks post term). The assessment at 6 years consisted of a neurological examination, including assessment of minor neurological dysfunction (MND), evaluation of mobility with the Movement Assessment Battery for Children, and of behaviour and learning problems with questionnaires.

RESULTS Definitely abnormal general movements at writhing age were not associated with CP, whereas definitely abnormal general movements at fidgety age were (sensitivity 60%; specificity 91%; positive predictive value 19%, negative predictive value 98%). In children without CP, general movements quality was not associated with limited mobility, but it was associated to a minor extent with MND.

INTERPRETATION In term infants, definitely abnormal general movements at fidgety age do predict CP, but with lower accuracy than in preterm infants. General movements quality does not predict limited mobility in children without CP. The study supports suggestions that predictive value of general movements assessment in term infants is lower than that in preterm infants.

Evidence suggests that infants at risk for neurodevelopmental disorders may benefit from early intervention.[1] Therefore it is important to detect these infants as early as possible. Assessment of the quality of general movements is a tool used to assist detection of infants at risk.[2,3] General movements are spontaneous movements of the whole body present up until 3 to 4 months post term. The quality of general movements is used to evaluate the integrity of the central nervous system. Two reviews concluded that general movements assessment has good sensitivity and specificity in predicting cerebral palsy (CP) in high-risk populations.[2,3] This holds particularly true for general movements assessment around 3 months corrected age. However, the reviews also noted that the large majority of subjects included in these studies were preterm infants. Only a few studies comprised predominantly term infants. The studies of Prechtl et al.[4] and Ferrari et al.[5] demonstrated that the predictive value of general movements in asphyxiated term infants was excellent. However, both study groups consisted of infants with moderate to severe forms of asphyxia who were at very high risk for major neurodevelopmental disorder, and therefore not representative of all term infants. A more recent study[6] showed that prediction of CP in the general population was substantially worse than that in high-risk populations. The quality of general movements predicted serious neurodevelopmental disorders including CP only to a limited extent.

Relatively little is known about the association between general movements quality during early infancy and other developmental problems, such as milder forms of limited mobility – that is, limitations in the skill to move around from one place to another in a flexible and adaptive way, and limitations in arm and hand use. The latter may include limitations in the manipulation of objects, such as eating utensils and buttons, and in throwing and catching a ball (see the activity chapters of the International Classification of Functioning, Disability and Health, Children and Youth Version).[7] The milder forms of limited mobility, which may result in developmental coordination disorder, and specific learning problems often first emerge at school age. Four studies that addressed relationships between general movements quality and minor developmental disorders used relatively small and heterogeneous groups of at-risk infants.[8–11] The studies suggested that an abnormal quality of general movements around 3 months corrected age is associated with minor neurological dysfunction (MND),

attention-deficit–hyperactivity disorder, and aggressive behaviour at school age, but not with measures of intelligence;[8–10] another small study of preterm infants indicated an association between abnormal general movements and motor performance at school age.[11] Bennema et al.[12] recently studied the predictive value of general movements in a relatively large group of low-risk infants and reported that definitely abnormal general movements at 2 weeks of age were associated with MND at 18 months and behavioural problems at 4 years. General movements quality at 3 months did not predict developmental outcome at preschool age.

The above overview indicates that knowledge is lacking on the predictive value of general movements quality for functioning at school age in the major population visiting paediatric clinics – that is, term infants with low to moderate risk for developmental disorders. Therefore, the primary aim of this study is to evaluate to what extent the quality of general movements in the first postnatal months in children born at term with low to moderate risk for developmental disorders predicts serious neurological disorder such as CP, and, in children without CP, milder forms of limited mobility at the age of 6 years. To this end, we used the data available from a prospective cohort study on neuromotor outcome at 6 years in children with a difficult birth at term (DBAT), which included children with and without DBAT.[13,14] The presence of limited mobility was determined with the Movement Assessment Battery for Children (MABC).[14,15] In addition, we evaluated associations between general movements quality in the first postnatal months and the presence of learning and behaviour problems and of MND in children at school age without CP. This evaluation was made to gain insight into the neurological substrate of the associations between general movements quality and functioning in daily life at school age.

What this paper adds

- Definitely abnormal general movements at fidgety general movements age predict cerebral palsy (CP) in term infants with lower accuracy than in preterm infants.
- General movements quality of term infants does not predict limited mobility in children without CP.
- Predictive value of general movements assessment is lower in term infants than in preterm infants.

METHOD

Participants

Participants took part in a prospective study on the effect of DBAT on developmental outcome at 6 years. Included in the study were 64 term infants admitted because of DBAT to the neonatal ward of the regional general hospital, Gelre Hospital in Apeldoorn, the Netherlands, between January 1999 and July 2005 (for details see van Iersel et al.[13]), and 84 healthy term infants without DBAT who were recruited at the obstetric ward of the same hospital (n=25) or from nearby midwife practices (n=59). DBAT was defined as fulfilling at least two of the following criteria: (1) abnormal cardiotocogram; (2) Apgar score at 5 minutes <7; (3) umbilical pH lower than 7.20; and (4) umbilical base excess lower than –10mmol/l. Infants with visible congenital anomalies were excluded.

All infants were assessed twice during the first 3 months. At the age of 6 years, five children could not be reassessed: two children of the study group had died and families of three comparison children declined participation. The two children who died had been diagnosed with severe CP (Gross Motor Function Classification System [GMFCS] level V).[16] They died at the ages of 2.5 and 4 years. The data of these two children are included in the evaluation of the predictive value of general movements quality for CP. The perinatal, social, and anthropometric characteristics of the studied population are presented in Table I.[13,14] The parents of the children gave signed informed consent and the procedures were approved by the medical ethical committee of University Medical Centre in Utrecht.

Assessment of general movements quality

General movements quality in supine position was assessed twice during the first postnatal months – that is, at 'writhing' general movements age (38–47wks postmenstrual age; median age 3wks corrected age), and at 'fidgety' general movements age (48–58wks postmenstrual age; median age 13wks corrected age). To this end, spontaneous motility in supine position was video-recorded for at least 5 minutes in an awake, active, non-crying state. The general movements were assessed by the first author, who was aware of the perinatal clinical condition of the infant, and by the last author, who was blinded to the infant's perinatal clinical condition. Interobserver agreement between the two assessors was good.[13] Both assessors were unaware of the infant's developmental outcome.

Movement quality was classified as normal optimal, normal suboptimal, mildly abnormal, or definitely abnormal, according to Hadders-Algra et al.[17] Normal optimal movements are very variable and complex and fluent. Normal suboptimal movements have a sufficient amount of movement variation and complexity, but are not fluent. Mildly abnormal movements are characterized by a limited amount of variation and complexity; definitely abnormal movements by a virtual or total absence of movement variation and complexity. Clinical data based on hospital and midwifery records were collected on standardized forms. Data on social class were collected by means of a parental questionnaire.

Neurodevelopmental assessments at 6 years

The assessment at 6 years consisted of a neurological examination, an assessment of mobility, and an evaluation of academic achievement and behaviour by means of parental and teachers' questionnaires.[14]

Neurological condition was assessed with the neurological examination of the child with MND.[18] This assessment not only allows diagnosis of neurological disorders such as CP, but it also permits a standardized assessment of

Table I: Perinatal characteristics, general movements quality, and neurodevelopmental outcome at 6y of the total population, the DBAT, and non-DBAT groups

Perinatal characteristics	Total study group, *n*=145	DBAT group, *n*=62	Non-DBAT group, *n*=81
Male sex, *n* (%)	86 (59)	37 (58)	49 (61)
Gestational age at birth in wks, median (range)	40 (36–43)	40 (36–43)	40 (37–43)
Birthweight, g; mean (SD)	3454 (601)	3387 (630)	3510 (568)
Sarnat score (%)			
2	14 (10)	14 (22)	–
1	18 (12)	18 (28)	–
0	113 (78)	32 (50)	–
General movements: normal optimal/normal suboptimal/mildly abnormal/definitely abnormal (%)			
Writhing	5 (4)/46 (32)/59 (40)/35 (24)	1 (2)/15 (23)/26 (41)/22 (34)	4 (5)/31 (38)/33 (41)/13 (16)
Fidgety	9 (6)/60 (41)/60 (41)/16 (12)	4 (6)/27 (42)/24 (38)/9 (14)	5 (6)/33 (41)/36 (44)/7 (9)
Diagnosed CP at 2y (%)	5 (3)	5 (8)	0 (0)
General characteristics at 6y (in children without CP)	*n*=140	*n*=59	*n*=81
Age at follow-up in mo, median (range)	77.5 (75–83)	77 (75–83)	77.5 (74–81)
Maternal high education, *n* (%)[a]	51 (36)	16 (27)	35 (43)
Outcome at 6y (%)			
Total MABC ≤P15	25 (18)	16 (27)	8 (10)
Manual abilities ≤P5	3 (2)	3 (5)	0 (0)
Balance skills ≤P5	16 (11)	10 (17)	6 (7)
Ball skills ≤P5	10 (7)	5 (9)	5 (6)
Learning problems[b]	36 (26)	24 (41)	12 (15)
Behavioural problems (%)			
CBCL total score ≥P95	16 (11)	8 (14)	8 (10)
CBCL internalizing behaviour ≥P95	22 (16)	12 (20)	10 (12)
CBCL externalizing behaviour ≥P95	17 (12)	9 (15)	8 (10)
TRF total score ≥P95	20 (14)	10 (17)	10 (12)
TRF internalizing behaviour ≥P95	27 (19)	13 (22)	14 (17)
TRF externalizing behaviour ≥P95	17 (12)	9 (15)	8 (10)
Neurological classification: normal/sMND/cMND	65 (46)/46 (33)/29 (21)	22 (37)/20 (34) /17 (29)	43 (53)/26 (32)/12 (15)
Dysfunctional posture and muscle tone	22 (16)	14 (23)	8 (10)
Dysfunctional reflexes	79 (56)	37 (33)	42 (52)
Involuntary movements	6 (4)	3 (5)	3 (4)
Coordination problems	60 (43)	30 (51)	30 (37)
Fine manipulative disability	33 (24)	17 (29)	16 (20)
Excess of associated movements	1 (1)	1 (2)	0 (0)
Sensory deficits	0 (0)	0 (0)	0 (0)
Impaired cranial nerve function	0 (0)	0 (0)	0 (0)

[a]Social class according to maternal education: high=university education/vocational colleges. [b]Any learning problem=need of special assistance or special education, or being in an inappropriate grade for age. DBAT, difficult birth at term; CP, cerebral palsy; MABC, Movement Assessment Battery for Children; CBCL, Child Behavior CheckList; TRF, Teacher Report Form; sMND, simple minor neurological dysfunction; cMND, complex minor neurological dysfunction.

MND. MND is assessed in eight domains such as posture and muscle tone, dyskinesia, coordination, and fine manipulative ability.[18] The children are classified as (1) neurologically normal if they do not show dysfunction in any of the domains or isolated dysfunction in the domain 'reflexes'; (2) simple MND if they show dysfunction in one or two domains; (3) complex MND if dysfunction is present in at least three domains; and (4) neurologically abnormal in case of a clear neurological disorder, such as CP. Simple MND implies the presence of typical but non-optimal brain function; it has a relatively high prevalence. Complex MND is regarded as the clinically relevant form of MND; it is known to have strong correlation with pre- and perinatal adversities.[18] The neurological examination of the child with MND has a good reliability and construct and concurrent validity. Predictive validity of the presence of complex MND is satisfactory, as it is associated with clinically relevant forms of MND and learning and behavioural problems at later age.[18] In children with CP, Gross Motor Function Classification System (GMFCS) and Manual Ability Classification System (MACS) levels were determined.[16,19]

Mobility was assessed with the MABC, which is a test specifically developed to identify and evaluate children aged 4 to 12 years with mild to moderate forms of limited mobility.[15] It evaluates eight age-appropriate functional motor tasks representing manual dexterity, ball skills, and balance skills. Outcome is summarized in three subscores and a total score. In the present study we dichotomized outcomes of the total score using the 15th centile (P15) of the total score as a cut-off into 'typical (>P15) and atypical' (≤P15), and the three domain scores manual dexterity, ball skills, and balance skills, using the P5 as a cut-off, into 'typical' (>P5) and 'atypical' (≤P5). The MABC has been standardized for Dutch

children. It has a good test–retest and interrater reliability and a good construct validity, but a moderate concurrent validity lacking a suitable criterion standard.[15]

Behavioural and emotional competences were measured using the Child Behavioral Checklist and the Teachers' Report Form.[20] We used the Child Behavioral Checklist and Teachers' Report Form versions for children from 6 to 18 years. The behavioural scores of both lists may be summarized with a total score and scores of internalizing and externalizing behaviour. The reliability and the validity of the Child Behavioral Checklist and Teachers' Report Form are well confirmed. We dichotomized these three scores into 'typical', implying a score up to the 95th centile (P95), and 'behavioural problems', indicating a score greater than or equal to P95. The latter includes borderline scores (P95–P98) and clinical scores (>P98). The Teachers' Report Form also furnished information on academic achievement. The presence of learning problems was defined as the need for special education or special educational assistance, or being in an inappropriate grade for age.

Statistical analysis

Statistics were performed with the software package of SPSS, version 20 (IBM Corp., Armonk, NY, USA). The analyses were performed for the total study group of children with and without DBAT, and for the two subgroups separately. At first univariable analyses were applied to evaluate differences in outcome at 6 years between children with abnormal and normal general movements with the Mann–Whitney *U*, χ^2, and Fisher's exact tests where appropriate. Next, multivariable logistic regression analysis was applied. The multivariate logistic regression was adjusted for potential confounders including the presence of DBAT (total study group only), sex, and maternal education. Differences with *p*-levels lower than 0.05 were considered statistically significant (two-tailed).

RESULTS

General movements quality and diagnosis of CP

At writhing general movements age, 35 out of 145 infants (24%) had definitely abnormal general movements; 94 infants (65%) had abnormal (mildly abnormal or definitely abnormal) general movements. At fidgety general movements age, 16 infants (12%) had definitely abnormal general movements; 76 infants (52%) showed abnormal general movements (for the distributions in the two subgroups, see Table I).

Five children had been diagnosed with CP; they belonged to the DBAT group. Three had bilateral spastic CP, two with GMFCS level V (they died at preschool age), and one with GMFCS level IV. The other two children had unilateral CP, one with a relatively severe form (MACS level IV, GMFCS level II), the other with a mild form (MACS and GMFCS level I).

The presence of definitely abnormal general movements at writhing age was not associated with the diagnosis of CP. Yet definitely abnormal general movements at fidgety age showed a statistically significant association with CP (Table II). This was true for the total study group and the DBAT subgroup only. The sensitivity of definitely abnormal general movements at fidgety age to predict CP was 60%; their specificity was 91%. The positive predictive value was 19% and the negative predictive value was 98% (for the values in the DBAT group only, see Table III). Two children with CP had not shown definitely abnormal general movements at fidgety age. One child presented with a mild unilateral CP; he had shown normal suboptimal general movements, a normal neonatal electroencephalogram, and a normal ultrasound scan of the brain. The other child had a severe bilateral CP (GMFCS level IV); she had definitely abnormal general movements at writhing age and mildly abnormal general movements at fidgety age. At neonatal age she presented with seizures and the ultrasound scan of her brain showed widespread cortical lesions.

Quality of writhing general movements and developmental outcome at 6 in children without CP

Details on neurodevelopmental outcome at 6 years are presented in Table I. Twenty-five children (18%) had limited mobility (MABC ≤P15) and 29 children (21%) had complex MND.

Table II: General movements and cerebral palsy in total study group and in subgroup of children with DBAT

	Total study group, *n*=143				DBAT group, *n*=62			
General movements quality	No CP (%)	CP (%)	Total	*p*-value	No CP (%)	CP (%)	Total	*p*-value
Writhing age								
Non-definitely abnormal general movements	108 (98)	2 (2)	110	0.091[a]	40 (95)	2 (5)	42	0.329[a]
Definitely abnormal general movements	32 (91)	3 (9)	35		19 (86)	3 (14)	22	
Total	140	5	145		59	4	64	
Fidgety age								
Non-definitely abnormal general movements	127 (98)	2 (2)[b]	129	0.010[a]	53 (96)	2 (4)	55	0.017[a]
Definitely abnormal general movements	13 (81)	3 (19)[c]	16		6 (75)	3 (25)	9	
Total	140	5	145		59	5	64	

[a]Tested with Fisher's exact test. [b]One bilateral CP (GMFCS, level V) with mildly abnormal general movements at fidgety age, one unilateral CP (GMFCS level I, MACS level I) with normal suboptimal general movements at fidgety age. The general movements quality of these two children has been confirmed by multiple masked colleagues. [c]Two bilateral CP (GMFCS, level V), one unilateral CP (GMFCS level II, MACS level IV). DBAT, difficult birth at term; CP, cerebral palsy; GMFCS, Gross Motor Function Classification System; MACS, Manual Ability Classification System.

Table III: Prediction of definitely abnormal general movements at fidgety age for CP in total study group and in DBAT group

	Total study group, *n*=145 (%)	DBAT group, *n*=62 (%)
Prevalence	3	8
Sensitivity	60	81
Specificity	91	60
Positive predictive value	19	33
Negative predictive value	98	96

CP, cerebral palsy; DBAT, difficult birth at term.

Definitely abnormal general movements at writhing age were not associated with neurodevelopmental outcome in children without CP. Also, abnormal (mildly abnormal and definitely abnormal) general movements at writhing age were not associated with limited mobility and behavioural problems (Table IV). However, infants with abnormal writhing general movements more often had learning problems at 6 years than infants with normal general movements (34% vs 12%; adjusted odds ratio [OR] 3.07; 95% confidence interval [CI] 1.12–8.41). Abnormal writhing general movements were also associated with a higher risk of a non-normal neurological condition (simple MND or complex MND; 62% vs 39%; adjusted OR 2.38; 95% CI 1.14–4.97). The associations between abnormal writhing general movements and learning problems and MND were also present in the DBAT group, but not in the non-DBAT group (Table SI, online supporting information).

Quality of fidgety general movements and developmental outcome at 6 years in children without CP

General movements quality at fidgety age was associated only to a limited extent to developmental outcome at 6 years. Only the presence of definitely abnormal general movements was weakly related to outcome (Table IV). Definitely abnormal general movements were not associated with limited mobility, learning, and behavioural problems. A minor association was found between definitely abnormal general movements and dysfunctional posture and muscle tone regulation (adjusted OR 4.98; 95% CI 1.31–18.98, Table IV). The latter association was present in the non-DBAT group, but not in the DBAT group (Table SII, online supporting information).

DISCUSSION

The present study demonstrated that abnormal general movements at writhing age did not predict CP or milder forms of limited mobility, but they were associated with an increased risk of learning problems and MND. These associations were found in the total study group and in the subgroup of DBAT infants, but not in the subgroup of non-DBAT infants. Definitely abnormal general movements at fidgety age did predict CP, especially in the children with a DBAT history, but they showed virtually no association with milder neurodevelopmental impairments.

Table IV: Association between abnormal (mildly abnormal and definitely abnormal) writhing general movements and definitely abnormal fidgety general movements and outcome at 6y in children without CP

	Abnormal (mildly and definitely) writhing general movements, *n*=140		Definitely abnormal fidgety general movements, *n*=140	
Outcome at 6y	Unadjusted OR (95% CI)	Adjusted OR (95% CI)[a]	Unadjusted OR (95% CI)	Adjusted OR (95% CI)[a]
MABC				
Total score: <P15	2.04 (0.76–5.49)	1.89 (0.67–5.32)	0.36 (0.04–2.87)	0.32 (0.04–2.67)
Manual abilities <P5	2.73 (0.74–10.11)	1.92 (0.49–7.50)	0.19 (0.02–2.28)	0.00
Ball skills <P5	0.00	0.00	0.37 (0.07–1.97)	0.37 (0.07–7.01)
Balance skills <P5	0.37 (0.10–1.35)	0.43 (0.11–1.63)	1.61 (0.20–13.26)	2.07 (0.23–18.75)
Learning problems	**3.81 (1.46–9.95)**	**3.07 (1.12–8.41)**	1.94 (0.59–6.35)	2.02 (0.57–7.09)
Behavioural problems				
CBCL total score ≥P95	0.70 (0.25–2.03)	0.59 (0.20–1.78)	0.62 (0.08–5.13)	0.57 (0.06–4.81)
Internalizing behaviour ≥P95	1.27 (0.48–3.38)	1.12 (0.41–3.06)	0.97 (0.20–4.73)	0.94 (0.19–4.61)
Externalizing behaviour ≥P95	0.80 (0.28–2.24)	0.62 (0.20–1.86)	1.35 (0.27–6.73)	1.13 (0.20–8.32)
TRF total score ≥P95	1.05 (0.39–2.83)	1.15 (0.40–3.31)	1.92 (0.48–7.71)	1.86 (0.43–7.99)
Internalizing behaviour ≥P95	1.15 (0.48–2.81)	1.10 (0.44–2.76)	0.74 (0.15–3.53)	0.68 (0.14–3.36)
Externalizing behaviour ≥P95	0.59 (0.21–0.64)	0.51 (0.17–1.49)	0.57 (0.07–4.71)	0.50 (0.06–4.30)
Neurological condition				
Normal[b]	0.40 (0.20–0.81)	0.42 (0.20–0.88)	0.70 (0.22–2.25)	1.28 (0.64–2.55)
Simple MND[c]	1.48 (0.70–3.15)	1.49 (0.69–3.24)	1.86 (0.59–5.91)	1.84 (0.58–5,86)
Complex MND[d]	2.61 (0.99–6.93)	2.38 (0.87–6.50)	0.67 (0.14–3.22)	0.62 (0.13–3.07)
Simple+complex MND[e]	**2.64 (1.31–5.34)**	**2.38 (1.14–4.97)**	1.57 (0.50–4.93)	1.50 (0.47–4.82)
Neurological domains				
Dysfunctional posture and tone	**4.34 (1.22–15.49)**	**3.88 (1.02–14.18)**	**4.04 (1.18–13.82)**	**4.98 (1.31–18.98)**
Coordination problems	**2.14 (1.04–4.41)**	2.01 (0.94–4.28)	0.56 (0.17–1.93)	0.51 (0.14–1.82)
Fine manipulative disability	1.72 (0.73–4.07)	1.52 (0.63–3.69)	0.56 (0.12–2.68)	0.52 (0.11–2.55)

[a]Adjusted for sex, social economic status, and presence of difficult birth at term. [b]Odds ratio (OR): normal vs non-normal (i.e. simple MND, complex MND and CP). [c]OR: simple MND vs normal neurological condition. [d]OR: complex MND vs normal neurological condition and simple MND. [e]OR: non-normal vs normal. Bold values indicate statistically significant difference. CP, cerebral palsy; CBCL, Child Behavior CheckList; TRF, Teacher Report Form; MABC, Movement Assessment Battery for Children; MND, minor neurological dysfunction.

The high specificity and negative predictive value of definitely abnormal general movements at fidgety age to predict CP match the values of the review of Bosanquet et al.,[2] but the low sensitivity and positive predictive value contrasts with the values of the studies mainly based on preterm infants.[2,11,21] Conceivably, our different results may be attributed to the different composition of our study group consisting of term infants only. It is well known that the nature of brain lesions in preterm infants differs from that of term infants.[21] Preterm infants have a specific vulnerability of the periventricular white matter, whereas in term infants the cortical areas and the basal ganglia and thalamus are predilection sites for injury.[5,22] Recent evidence suggests that an abnormal quality of general movements especially is associated with pathology of the periventricular white matter.[21,23,24] This suggests that the quality of general movements may reflect especially the integrity of subcortical grey and white matter structures. The absence of neuroimaging in the majority of our children – related to the non-academic setting of our study[14] – precluded testing of the hypothesis that our different results on prediction are caused by the different neuropathology occurring in term and preterm infants. Nevertheless, the findings of the two children with CP who did not present with definitely abnormal fidgety general movements seem in line with this hypothesis: one child had severe CP because of widespread cortical pathology; the other had a mild unilateral CP which may have been caused by a small cortical lesion. Our results on the predictive value of fidgety general movements in term infants correspond with those of Bouwstra et al.[6] in the general population.

In children without CP, general movements quality predicted developmental outcome to a minor extent only: general movements quality was not related to limited mobility or behavioural problems. The latter contrasts with the study of Bennema et al.[12] who found an association between general movements quality – at writhing age – and behaviour at 4 years. In the present study, abnormal movements at writhing age were associated with learning problems and MND. The latter association was unspecific, which differs from the findings of Groen et al.[9] in high-risk, mainly preterm infants that abnormal general movements were associated with fine manipulative dysfunction and coordination problems.

The major strength of the study is that it addresses for the first time the associations between general movements quality and developmental outcome at school age in terms of CP and minor developmental problems in a substantial group of infants born at term. An additional strength is the minimal attrition during follow-up. A limitation of the study is that half of the study infants had DBAT. Hence we studied a selective population implying that the findings cannot be extrapolated to the general population. Nevertheless, our mixed group of term infants with low to moderate risk for developmental problems may resemble a major proportion of infants attending paediatric clinics. In addition, it should be realized that some of our relatively weak associations between general movements quality and developmental outcome in children without CP may have been chance findings, as we calculated a relatively high number of associations.

In conclusion, in our group of term infants, general movements quality at writhing age did not predict CP nor limited mobility. Abnormal (mildly abnormal and definitely abnormal) writhing general movements were only associated with a mildly increased risk for learning problems and MND. However, definitely abnormal general movements at fidgety age did predict CP, especially in children with DBAT, but with considerably lower sensitivity and positive predictive value than in populations of preterm infants. General movements quality at fidgety age was not associated with limited mobility; it was only associated to a minor extent with MND. In other words, our study confirms previous suggestions that the predictive value of general movements assessment in term infants is less than that in preterm infants.[6,12] Thus, our study does not support the widespread use of general movements assessment in term children without an apparent risk for CP. Therefore we stress the need for further development of non-invasive and easily applicable tools for the evaluation of developmental outcome in infants born at term.

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SUPPORTING INFORMATION

The following additional material may be found online:

Table SI: Association between abnormal (mildly abnormal and definitely abnormal) writhing general movements and outcome at 6 years in children without CP.

Table SII: Association between definitely abnormal fidgety general movements and outcome at 6 years in children without CP.

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