Official Journal of the European Paediatric Neurology Society

Original article

General movements of preterm infants in relation to their motor competence between 5 and 6 years

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ARTICLE INFO

Article history:
Received 22 January 2012
Received in revised form
21 May 2012
Accepted 24 May 2012

Keywords:
Prematurity
General movements
Motor outcome
M-ABC

ABSTRACT

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.

1. Introduction

A high prevalence of developmental abnormalities presenting with motor deficits occurs in ex-preterm children at school age.[1,2] In addition to cerebral palsy (CP), these include milder motor deficits including poor coordination, poor physical fitness and deficits in postural stability. The motor difficulties of ex-preterm children do not resolve as the child matures.[3] Previously it was believed that in the absence of major complications these children would catch-up. Recent research suggests that preterm infants remain and often become increasingly disadvantaged in many measures of neuro-integrative functioning. The children experience difficulties in academic achievement or activities in daily living tasks in

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1090-3798/$ – see front matter
http://dx.doi.org/10.1016/j.ejpn.2012.05.008

self-care. They show difficulties in behavior regulation, social and emotional adaptation. Risk for learning and behavioral disorders, such as attention problems, is higher.[4] Different terms referring to milder motor deficits have been used since the problem was highlighted for the first time over 40 years ago[5]: clumsy child, minimal cerebral palsy, minimal cerebral dysfunction, developmental apraxia or dyspraxia, minimal brain dysfunction and sensory integrative dysfunction. Recently, a consensus of professionals from various fields suggested the term "developmental coordination disorder (DCD)", taken from the Diagnostic and Statistical Manual of Mental Disorders, 4th edition, Text Revision (DSM- IV-TR), to be used for this group of children.[6,7] DCD is defined as a neurodevelopmental condition that has an impact on child's ability to perform everyday tasks in self-care and academic areas. Children with DCD are a heterogeneous group who has a marked impairment in the performance of functional motor skills. The diagnosis of DCD should be made within a diagnostic setting and may require a multidisciplinary approach. To identify children that meet the motor impairment diagnostic criterion for DCD, the Movement Assessment Battery for Children (M-ABC) test and the Bruininks–Oseretsky Test of Motor Proficiency are the most popular tools used.

While the criteria for identification of children with high risk of cerebral palsy have already been documented by many authors, the early identification of children at highest risk of minor motor deficits remains less clear. In the last two decades, 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. General movements are part of the spontaneous movement repertoire observed in fetus from 9 weeks postmenstrual age onwards until the end of the first half year of life. If the nervous system is impaired, GMs lose their complex and variable character and become monotonous and poor.[8,9] A persistent abnormal pattern of cramped-synchronized GMs during the writhing period and the absence of GMs of fidgety character during the fidgety period reliably predict later cerebral palsy.[10] However, it is still uncertain whether the GMs assessment can be used to predict mild neurologic deficits.

In order to determine the predictive value of GMs to identify children with definite or borderline motor difficulties consistent with DCD, the present study aimed to analyze the correlations between GMs and motor competence as tested by M-ABC between 5 and 6 years of age.

2. Participants and methods

2.1. *Participants*

Forty-five infants (23 boys, 22 girls), were included in our study. All were referred after discharge from the maternity hospital for close follow up to the regional outpatient Developmental Centre because of known risk factors for impaired neurologic function. Apart from prematurity (gestational age of 36 weeks or less), the criteria for inclusion in the study were (i) the existence of one or more neonatal complications (Apgar score 7 or less at 5 min, mechanical ventilation for more than one week, documented sepsis or central nervous system infection, convulsions, exchange transfusion due to hyperbilirubinemia, documented central nervous system hemorrhage, surgical intervention) and, (ii) first examination at the corrected gestational age of 40 weeks (plus/minus 5 days). Children with dysmorphic syndromes and chromosomal abnormalities were excluded from the study.

All except 3 children were born at the Ljubljana Maternity Hospital. They were born preterm, with gestational ages from 23 to 36 weeks (mean 31.6 weeks, SD 3.3 weeks) and birth weights from 525–3240 gm (mean 1788 gm, SD 718 gm). 7 children had very low birth weights and in 15 children the birth weight was below 1500 gm. Six infants were small, 2 were large and the others were appropriate for gestational age. There were 8 pairs of twins. Twenty-six children experienced one additional neonatal complication, while 19 children experienced 2 or more. Characteristics of the studied population are presented in Table 1.

This group of preterm infants was first assessed at the corrected term age.[11] Their developmental and neurological condition was periodically assessed with psychodiagnostic and neurologic follow up.[12,13] They were regularly followed later on with the intention to study the developmental and neurologic outcome at school age. In this paper the relation between GMs and motor competence measured by M-ABC is presented.

2.2. *Methods*

2.2.1. *Observation of spontaneous movements*

The quality of spontaneous movements was blindly assessed by a developmental pediatrician experienced in this technique (B. Š.) according to the standard Prechtl method, from term to 20 weeks postterm age. Serial videotape recordings, each lasting about 15 min, were made and collected on a separate tape for each infant, documenting the developmental course of GMs from term to 20 weeks postterm. Two assessments were performed (1) a global judgment of the

Table 1 – Summary of characteristics in the studied group.

Number of patients	45	
Male/female	23/22	
Gestational age		
23–27 weeks	8	18%
28–32 weeks	15	33%
33–36 weeks	22	49%
Birth weight		
<1000 g	7	16%
1000–1500 g	10	22%
>1500 g	28	62%
Apgar score <7 at 5 min	12	27%
Mechanical ventilation >1 week	28	62%
Sepsis	18	40%
CNS infection	3	7%
Convulsions	6	13%
Hyperbilirubinemia-exchange transfusion	4	9%
Surgical intervention	2	4%
CNS hemorrhage	6	13%

quality of GMs based on gestalt perception for both writhing and fidgety age, and (2) during the fidgety age an assessment of the presence and quality of concurrent motor repertoire, in which all age adequate specific movement and postural patterns were taken into account. Findings were classified according to different patterns of general movements and other concurrent repertoire: during the writhing period as normal (N), poor repertoire (PR), or cramped synchronized (CS); and during the fidgety period, as normal – fidgety present with normal other concurrent repertoire (F + NOR) or as abnormal – fidgety present with abnormal other concurrent repertoire (F + AOR), absence of fidgety (F-) or abnormal fidgety (AF).[8]

2.2.2. *Outcome measures*

2.2.2.1. *Cerebral palsy*. Follow up consisted of regular neurologic examination based on Prechtl's standardized techniques with age-specific adaptations of the Touwen criteria.[14] CP was diagnosed according to Hagberg's criteria and proposed definition and classification of CP.[15–17] Children with CP were scored and classified according to the Gross Motor Function Classification System (GMFCS), which provides a standardized 5-level classification system for motor functioning.[18]

2.2.2.2. *Motor competence between 5 and 6 years*. Motor competence between 5 and 6 years was tested using the M-ABC test.[19] The M-ABC test is a task set designed to screen for motor impairment and is the most commonly reported norm-ranked assessment used to determine the presence of DCD. The M-ABC test can be used to identify children who are significantly behind their peers in motor development, assist in planning an intervention program in either school or clinical setting, measure change as a result of intervention, or serve as a measurement instrument in research involving motor development. The M-ABC test is designed for use with children aged 4–12 years. The test contains a total of 32 items organized into 4 sets of 8 tasks, each designed for use with children of a different age band. We used the first set of items, labeled Age Band 1, which is designed for use with 4–6-year old children. The performance test was administered to a child, in the presence of a parent, in an occupational therapy room by OT (K.Š.) who has extensive experience in the administration of this instrument. The child was required to perform eight tasks measuring manual dexterity, ball skills, and static and dynamic balance. To obtain the parents' views on the child's difficulties the checklist was completed by their father or mother. A total impairment score was calculated by summing the scores for all the tasks; a higher impairment score indicates poorer motor performance. Results were grouped as described in the M-ABC manual: as normal or acceptable competency if above 15th percentile; as abnormal – indicative of problem that is considered borderline if between 15th and 5th percentiles, or indicative of definite motor problem if less than 5th percentile.

2.2.2.3. *Developmental coordination disorder*. According to the recommendations of European Academy for Childhood Disabilities (EACD), we used the M-ABC test and the 15th percentile for the total score as the cut-off for identifying children with motor difficulties consistent with DCD. The definition of DCD comes from DSM- IV-TR, which defined DCD as a disturbance in motor coordination that (a) is substantially below expected levels given the child's chronological age, (b) significantly interferes with activities of daily living or academic achievement (e.g., self-care and self-maintenance; academic/school productivity, pre-vocational and vocational activities, and leisure and play), (c) is not due to a general medical or specific neurological disorder (e.g., cerebral palsy, hemiplegia, or muscular dystrophy), and (d) if mental retardation is present, the motor difficulties are in excess of those usually associated with it.

Informed consent was obtained from the parents, and the study was approved by the National Medical Ethics Committee (No 145/05/01).

2.3. *Data analysis*

Statistical analysis was performed using SPSS for Windows (version 10.1). Contingency tables were produced to analyze the relations between general movements at term age and at 3 months and the results of the M-ABC between 5 and 6 years. Predictive values: sensitivity, specificity, positive predictive value, and negative predictive value were calculated.

3. Results

3.1. *Motor competence between 5 and 6 years*

At the age between 5 and 6 years cerebral palsy was diagnosed in 4 children: they all had bilateral spastic form of CP. One child was in GMFCS level IV, one level I and two level II. They were excluded from the M-ABC test.

Among the remaining 41 children, 7 children were identified as having definite or borderline motor difficulties consistent with DCD; 3 children showed definite motor problem and scored below 5th percentile, and 4 had borderline motor difficulties and scored between 5th and 15th percentile. The majority (34) of children achieved normal or acceptable results above 15th percentile.

In the three subtests of the M-ABC, the majority of children had normal or acceptable results and none of them had a definite motor problem. Normal results were present in 32 children at testing ball skills, in 38 at testing manual dexterity and in 29 at testing balance. Borderline motor difficulties with scoring between 5th and 15th percentile were present in 9 children at testing ball skills, in three at testing manual dexterity and in 12 at testing balance.

3.2. *General movements in relation to motor competence between 5 and 6 years*

At term age, 9 children had normal GMs while PR was present in 23 and CS in 9. At fidgety age, 24 children had F+; in 7 of them NOR and in 17 AOR was present. AF was diagnosed in 10 children and F- in 7.

All the children with cerebral palsy had abnormal GMs at the term (2 PR, 2 CS) and fidgety age (F-). Motor competence was tested in the remaining 41 children. Normal or acceptable results above 15th percentile on the M-ABC were present in 8

out of 9 children with normal GMs at the term age and in all the children with normal GMs at the fidgety age (Fig. 1). Only one child with total scoring beetwen 5th and 15th percentile had normal GMs at the term age, while all the children with total scoring below 15th percentile had abnormal GMs at the fidgety age (F+AOR was present in 3 children, AF in another 3 and F- in one child). Three children with definite motor difficulties had abnormal GMs at the term age (PR was present in 2 and CS in one) and at the fidgety age (AF was present in 2 and F− in one). The majority of those with borderline motor difficulties also had abnormal GMs at the term age; only one child whose GMs were normal at the term age achieved the total score between 5th and 15th percentile (Fig. 1). All the children with F+NOR and 14 out of 17 children with F+AOR achieved scores in the normal range.

The distribution of the M-ABC results regarding the results of GMs at the term and fidgety age are presented in the Fig. 1 and Table 2.

The sensitivity of GMs to identify children with definite motor difficulties (scoring at or below 5th percentile) and borderline motor difficulties (scoring between 5thand15th percentile on the M-ABC) was higher at the fidgety than at the writhing age. The specificity was low at both ages. The statistical results are presented in the Table 3.

4. Discussion

The qualitative assessment of GMs is a sensitive and specific diagnostic tool for the assessment of the integrity of the young nervous system.[20,8] The predictive value of GMs for later CP is well known[20,21] and was also confirmed in our study.[12,13] However, the predictive value of GMs for minor neurological deficits is less clear. Some recent studies investigated the predictive value of the quality of spontaneous movements at fidgety age (FMs) for identifying infants with minor neurologic dysfunction (MND). The biological function of FMs is not clear; it has been speculated that they have an ontogenetic, adaptive function in calibrating the proprioceptive system.[20] Bruggink et al.[22] found the presence of abnormal FMs indicative for complex MND, and normal FMs in conjunction with normal concurrent motor repertoire at 11–16 weeks predictive of normal findings at school age. Groen et al.[23] explored the value of GMs assessment at the fidgety age in predicting MND at 9–12 years of age; motor competence was assessed by Touwen neurological examination. Abnormal FMs showed a specific relationship to the development of coordination problems and fine manipulative disability. The quality of FMs, in particular their complexity and variation, was related to the severity and type of neurologic outcome at 9–12 years of age. In another study, Bruggink et al.[24] evaluated the predictive value of the quality of the early motor repertoire for the development of MND at school age. Motor competence was assessed by Touwen neurological examination and M-ABC; good correlations between the methods were reported. The quality of FMs and the quality of the concurrent motor repertoire had independent prognostic value for MND at school age. On the contrary, in the study of Einspieler et al.,[25] abnormal FMs were not related to later complex MND, but only to fine manipulative disabilities at puberty age.

Our results support the findings that abnormal FMs (F + AOR, AF, or F-) may precede clinically relevant abnormalities of motor abilities. Analysis of the quality of FMs and the quality of the concurrent motor repertoire (NOR and AOR) in our study showed that all of the children with F + NOR had normal motor competence, whereas 3 out of 17 children with F + AOR had significant motor impairment. We established high predictive value of normal concurrent repertoire for

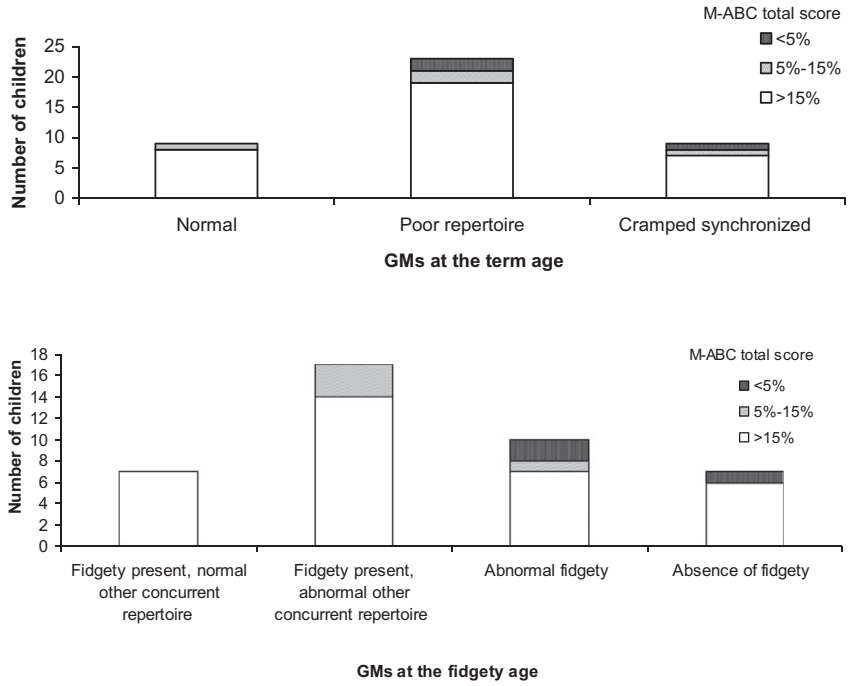

Fig. 1 – Results of total score at the M-ABC regarding general movements (GMs) at the term and at the fidgety age.

Table 2 – The distribution of the M-ABC results regarding the results of general movements.

		Term age			Fidgety age			
		N	PR	CS	F+NOR	F+AOR	AF	F–
Total	>15%	8	19	7	7	14	7	6
	5%–15%	1	2	1		3	1	
	<5%		2	1			2	1
Manual dexterity	>15%	8	21	9	7	15	9	7
	5%–15%	1	2			2	1	
Ball skills	>15%	8	18	6	7	13	6	6
	5%–15%	1	5	3		4	4	1
Balance	>15%	8	16	5	5	15	5	4
	5%–15%	1	7	4	2	2	5	3

normal or accessible motor development with scoring above 15th percentile on the M-ABC; this fact has already been underlined in the study of Bruggink et al.[22]

Further analysis of trajectories revealed that children with CP had had abnormal GMs at the term and at the fidgety age, in accordance with previous studies done by Prechtl et al.[26] In the children with borderline motor difficulties, only one child had normal GMs at the term and all showed abnormal movement patterns at the fidgety age. All the children with definite motor difficulties had abnormal GMs at the term and also at 3 months corrected age. In the particular period of the fidgety age these children as well did not have normal age adequate other concurrent repertoire, which in the studies of Bruggnik et al. predicted the development of MND at school age.[22,24]

However, it is difficult to compare our results to other studies as none of them describes the results of motor skill testing by the M-ABC test at preschool age. In our country children start attending school at the age of 6 years and we decided to test their motor abilities before entrance to school as we think that standardized testing of motor function at preschool age of at risk ex-preterm population is important to identify children who are in need of support.[27] As we intend to follow the children from the group until puberty age we aimed to find out whether the ABC test is sufficient for identifying children at risk for motor disabilities on one side and to analyze their motor repertoire from term age on the other. We screened the motor abilities between 5 and 6 years but could not yet monitor other abilities (educational progress or self-concept). The motor domain was investigated only from 2 perspectives: by the M-ABC test and from the parents' descriptions. Due to the children's age it was also not possible to have teacher-based assessment of academic achievement.

Our results showed that the sensitivity of GMs to identify children with abnormal total scoring (below 15th percentile) at the M-ABC test was higher at the fidgety than at the writhing age. On the other side, our results show low specificity of GMs at the term and fidgety age to predict later motor abilities. One possible explanation for this fact could be that all children with abnormal GMs were enrolled into an early neuro-developmental intervention program before the corrected age of 3 months. This program stimulates infants' motor development and may gradually shift abnormal motor patterns toward more normal ones, resulting in normal motor competence. However, we are aware of the fact that M-ABC test may be too rough to identify children with milder motor disabilities. According to Rodger et al. the M-ABC may under identify children with motor problems.[28] Pless et al. reported that children scoring between 5th and 15th percentile at 5–6 years of age were likely to change group when retested at 7–8 years, while the children with total score below 5th percentile with definite motor difficulties remained in their category at follow up.[29] The M-ABC test may be less discriminating for 4–8 year old children due to the issues such as the high variability of performance in this group in comparison with higher age groups. We hope that further results of follow up in our group will clarify the predictive value of early motor repertoire on one side and M-ABC test at preschool age on the other for identifying children with motor problems.

One of the limitations of our study is the fact that our study group of children is very heterogeneous regarding gestational age and additional perinatal risk factors. However, the prevalence of children with significant motor difficulties in the present study (17%) agrees with the prevalence reported by Roberts and Williams with coauthors, who studied more homogeneous group of extremely low birth weight infants. In the study of Roberts et al.[30] the prevalence of DCD was examined in a cohort of extremely preterm or extremely low birth weight children and was found to be 16%; the children studied also experienced more academic difficulties than term born children. Similar results with increased risk of motor impairment, with prevalence three to four times greater in children born preterm than in the general population, were found in the review study done by Williams et al.[31] This fact highlights the need for improved surveillance and intervention strategies in preterm group of children.

Table 3 – Predictive indexes of the general movements at the term and fidgety age with respect to the M-ABC results.

	Term age				Fidgety age			
	Total impairment	Manual dexterity	Ball skills	Balance	Total impairment	Manual dexterity	Ball skills	Balance
Sensitivity	0.86	0.67	0.89	0.92	1.00	1.00	1.00	0.83
Specificity	0.24	0.21	0.25	0.28	0.21	0.18	0.22	0.17
Positive Predictive Value (PPV)	0.19	0.06	0.25	0.34	0.21	0.09	0.26	0.29
Negative Predictive Value (NPV)	0.89	0.89	0.89	0.89	1.00	1.00	1.00	0.71

To conclude, our results supplement the results of previous studies in which the predictive value of the quality of general movements was studied. Though we found high sensitivity of GMs at the fidgety age to identify children seriously at risk for DCD between 5 and 6 years, using GMs as a predictive tool results in many infants being falsely identified as being at risk for poor motor outcome.

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