The early motor repertoire is related to the level of self mobility in children with cerebral palsy at school age

Janneke LM Bruggink¹
Giovanni Cioni²
Christa Einspieler³
Carel GB Maathuis⁴
Rosa Pascale²
Arend F Bos¹

¹ Department of Pediatrics, Division of Neonatology, Beatrix Children’s Hospital, University Medical Center Groningen, University of Groningen, Groningen, the Netherlands
² Department of Developmental Neuroscience, Stella Maris Scientific Institute, University of Pisa - Medical School, Pisa, Italy
³ Institute of Physiology, Developmental Physiology and Developmental Neurology, Center for Physiological Medicine, Medical University, Graz, Austria
⁴ Department of Rehabilitation, University Medical Center Groningen, University of Groningen, Groningen, the Netherlands

Chapter 5

Abstract

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.

Methods: Video-recordings were made at 11-17 weeks post-term of 37 preterm infants (20 male/17 female) who later developed CP. The early motor repertoire was assessed by obtaining a motor optimality score. At 6-12 years, children were classified according to the Gross Motor Function Classification System (GMFCS).

Results: Of 37 children (gestational ages: 29.1 weeks [SD 1.9], birth-weights 1273g [SD 324]) nine had unilateral and 28 had bilateral spastic CP. Twelve children had GMFCS-level I, three level II, ten level III, four level IV and eight had level V. The absence of the age-adequate motor repertoire, a cramped motor repertoire, an abnormal kicking pattern, and a non-flat posture were associated with lower levels of self-mobility (Chi²-for-trend-test, \( p < 0.05 \)). Predictive for a low level of self-mobility was a cramped motor repertoire/ non-flat posture (PPV 100%, NPV 54%). Predictive for a high level of self-mobility was a non-cramped repertoire/ flat posture (PPV 80%, NPV 74%).

Interpretation: Several aspects of the motor repertoire at 11-17 weeks post-term predicted the degree of functional limitations in children with CP at school age.

Introduction

Neurological and developmental impairment is common in preterm born infants. Several studies showed that approximately 10% of infants born before 32 weeks' gestational age develop cerebral palsy (CP).\(^1\) There are several indicators for the early identification of infants at highest risk. Gestational age and birth weight are two rather rough early indicators. Neuro-imaging (brain ultrasound and MRI)\(^2,3\) and specific clinical risk scores\(^4\) are more accurate. The quality of spontaneous general movements (GMs), assessed in the individual infant using Prechtl's method, has emerged as a reliable and valid predictor of CP.\(^5-8\) This method is based on visual Gestalt perception of the quality of GMs in preterm infants and infants from term up to the age of 5 months post-term. Normal GMs are characterised by complexity, variability and fluency, whereas abnormal GMs are characterised by reduced complexity, variability and fluency. At 6 to 9 weeks' post-term age, the character of the GMs gradually changes into so-called fidgety movements (FMs). Particularly the presence of these FMs, that can be observed until 20 weeks post-term, is an accurate marker for neurological outcome: most infants (96%) with normal FMs have a normal neurological outcome, while most infants (95%) in whom FMs are absent during this particular period develop CP.\(^9\) However, the absence of FMs does not predict the level of self mobility in the children who develop CP.

The motor repertoire between 6 and 20 weeks post-term does not only consist of FMs but of other movement and postural patterns as well. Previous studies showed that several qualitative and quantitative aspects of these movement and postural patterns are predictive of the development of minor neurological dysfunction (MND) at school age.\(^10,11\) This raised the question whether these aspects of the early motor repertoire might also have predictive value for the severity of the functional limitations of CP at school age. The aim of the study was therefore to investigate the predictive value of the motor repertoire at 11 to 17 weeks post-term, in relation to clinical data, for the level of self
mobility in children with CP at 6 to 12 years of age.

Methods

Participants
After informed consent a total number of 347 children were prospectively included in studies investigating the relationship between the early motor repertoire and neurological and developmental data at follow-up. Inclusion criteria were born before 34 weeks’ gestational age, exclusion criteria were congenital malformations and chromosomal abnormalities. Previously, several studies have reported on parts of the study population.6,10,12 For this study, data analysis was performed in those children who developed CP, by the age of at least six years (n=37). Twenty infants were born and treated at the tertiary neonatal intensive care unit (NICU) of the University Medical Center Groningen (UMCG) between 1992 and 2000. Seventeen infants were treated at the Stella Maris Institute Pisa between 1988 and 2001. The ethical review boards of the UMCG and the Stella Maris Institute Pisa approved the study design. Patient characteristics are listed in Table 1.

Recording and evaluation of the spontaneous motor repertoire between 11 and 17 weeks’ post-term age
Video recordings, approximately 5 to 10 minutes long, were made of the infants between the age of 11 to 17 weeks post-term. The recordings were made either at the outpatient clinic or at home, during periods of active wakefulness between feeds, with the partially dressed infants lying in supine position. All recordings of those infants who developed CP, were later evaluated off-line by

Table 1. The clinical characteristics and risk factors of the study group according to neurological findings at 6 to 12 years of age. Data are expressed as median (P25-75), or N (%).

<table>
<thead>
<tr>
<th>GMFCS Level 1 - 2</th>
<th>Level 3 – 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>15</td>
</tr>
<tr>
<td>Age (y) at GMFCS</td>
<td>9 y (7 -11y)</td>
</tr>
<tr>
<td>Unilateral or bilateral</td>
<td>9/ 6</td>
</tr>
<tr>
<td>Gestational Ages</td>
<td>28.8 weeks (27.1 – 31.0 weeks)</td>
</tr>
<tr>
<td>Birth Weights (BW)</td>
<td>1225 g (870 – 1485 g)</td>
</tr>
<tr>
<td>Male/female infants</td>
<td>10/5</td>
</tr>
<tr>
<td>ICH1 gr1-2</td>
<td>2 (13)</td>
</tr>
<tr>
<td>ICH1 gr 3-4</td>
<td>8 (53)</td>
</tr>
<tr>
<td>PVL2 gr1</td>
<td>11(73)</td>
</tr>
<tr>
<td>PVL2 gr 2-3</td>
<td>1 (7)</td>
</tr>
</tbody>
</table>

1ICH is intracranial haemorrhage graded according to Papile et al.13
2PVL is periventricular leukomalacia graded according to De Vries et al.14 PVL grade 1 is also called prolonged flaring.

a p< 0.05, compared to children with a GMFCS level 1 – 2, (Chi2 test for trend)
Chapter 5

JLMB, AFB and partly by CE according to Einspieler et al. The observers were unaware of the infant’s clinical history and the degree of functional impairment.

The motor optimality score was used to judge the motor repertoire. It is the sum of five components:
1. the quality of the FMs, 2. the presence and normality of movement patterns, 3. the presence and normality of postural patterns, 4. the age-adequacy of the concurrent motor repertoire, 5. the quality of the concurrent motor repertoire. Together these components provide the basis for calculating a motor optimality score, with a minimum of 5 points, and a maximum (optimal) score of 28 points. Previous data on this method reported on the inter-observer reliability: a Cohen’s kappa of 0.87 was found for the quality of FMs, 0.91 for the quality of the concurrent motor repertoire, and 0.89 for the age-adequacy of the concurrent motor repertoire.

FMs are movements of small amplitude, moderate speed and variable acceleration of the neck, trunk and limbs in all directions. They are continually or intermittently present in the awake infant, except during periods of fussing or crying. FMs may be seen as early as 6 weeks post-term but usually appear around the 9th week and persist until 15 to 20 weeks post-term. We assessed the quality of FMs as normal, abnormal (amplitude, speed and jerkiness were exaggerated) or absence of FMs (FMs were not observed during the entire recording).

The movement repertoire during this age consists of a large variety of movement patterns. The number and variety of these movements increase with age. A score for the presence and normality of movement patterns was derived from the relative frequency of their occurrence; normality being defined by the preponderance of normal patterns during the observation period and abnormality by the preponderance of abnormal patterns. The presence and normality of several postural patterns were also scored. Normality was again defined by the preponderance of normal postural patterns during the observation period and abnormality by the preponderance of abnormal patterns.

The occurrence of all specific movement and postural patterns provided the basis for scoring the age-adequacy of the concurrent motor repertoire (all movement and postural patterns besides FMs) as age-adequate, reduced or absent. The age-adequacy of the concurrent motor repertoire was scored absent when less than five normal movement and postural patterns were observed, reduced in case five or six observed movement and postural patterns were observed and age-adequate in case seven or more movement and postural patterns were observed.

The last item to be judged was the quality of the concurrent motor repertoire. The quality of the concurrent motor repertoire was considered normal if it was smooth, variable, fluent and complex. Reduced complexity (monotony), jerkiness and/or a cramped character were considered to be signs of abnormality, and were scored separately. Differences in the degree of monotony, jerkiness and cramped character were not scored.

Functional assessment of the neurological and motor findings at 6 to 12 years of age

The diagnosis of CP was based on a recently proposed definition. Between 6 and 12 years of age a functional assessment was obtained in all children who had developed CP. They were scored and
classified by a physiatrist, according to the Gross Motor Function Classification System (GMFCS). The GMFCS provides a standardised method of classifying the gross motor function of children with CP.\textsuperscript{20} The GMFCS is based on a 5-level classification system, the higher the level, the more severe the CP. The distinction between the levels of motor function is based on functional limitations and the need for assistive technology including mobility devices and wheeled mobility.\textsuperscript{20,21}

**Statistical analysis**

Statistical analysis was performed using the SPSS package for Windows, version 14.0. The Chi\textsuperscript{2} test for trend was applied to evaluate the association between the GMFCS and the motor optimality score and its various components. Univariate analysis was performed to evaluate the association of several components of the motor optimality score with the degree of functional limitations in children with CP. Next, multiple logistic regression analysis was performed to evaluate the independent predictors of the degree of functional limitations in children with CP. In case of logistic regression analysis (whether univariate or multiple) the analysis was performed in two groups of GMFCS; those infants who did not need a wheelchair to mobilise (GMFCS levels I and II, high level of self mobility) versus those infants who did need a wheelchair to mobilise (GMFCS levels III to V, low level of self mobility). The predictive value of several components of the early motor repertoire for a low level of self mobility was assessed by calculating sensitivity, specificity, positive predictive values (PPV) and negative predictive values (NPV), including 95% confidence intervals (CI). Throughout the analyses \( p < 0.05 \) (two-tailed) was considered to be statistically significant.

**Results**

Of the thirty-seven children who developed CP, nine showed spastic type with unilateral involvement, whereas twenty-eight showed bilateral involvement. Twelve children (32%) had GMFCS level I, three children (8%) GMFCS level II, ten children (27%) GMFCS level III, four children (11%) GMFCS level IV, and eight children (22%) had GMFCS level V.

**The relationship between the motor repertoire at the age of 11 to 17 weeks post-term and neurological findings at 6 to 12 years of age**

The higher the motor optimality score of the infants, the better the GMFCS level (Chi\textsuperscript{2} test for trend = 4.9; \( p = 0.027 \)). The motor optimality score was median 9 (range 7 to 15) in the group with a low level of self mobility (GMFCS III to V), and median 12 (range 9-22) in the group with a high level of self mobility (GMFCS I and II). The optimal cut-off point of the motor optimality score for distinguishing between these two groups, determined by the receiver operating characteristics curve, was 9. Using this cut-off point, the PPV for limited self mobility was 70% (95% CI: 53-87), and the NPV was 70% (95% CI: 42-98) (Table 2a). The associations between each of the components of the motor optimality score and the neurological
Table 2a. Sensitivity, specificity, positive predictive value and negative predictive value of the motor optimality score, a non-flat posture, a cramped movement character and combinations of posture and movement character, for a low level of self mobility (GMFCS levels III to V) at school age.

<table>
<thead>
<tr>
<th></th>
<th>Motor optimality score ≤ 9</th>
<th>Cramped movement character</th>
<th>Non-flat posture</th>
<th>Combined: cramped non-flat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity (95% CI)*</td>
<td>86 (72-100)</td>
<td>64 (44-84)</td>
<td>68 (49-87)</td>
<td>41 (20-62)</td>
</tr>
<tr>
<td>Specificity (95% CI)</td>
<td>47 (22-72)</td>
<td>80 (60-100)</td>
<td>73 (51-95)</td>
<td>100 (94-100)</td>
</tr>
<tr>
<td>Positive predictive value (95% CI)</td>
<td>70 (53-87)</td>
<td>82 (64-100)</td>
<td>79 (61-97)</td>
<td>100 (90-100)</td>
</tr>
<tr>
<td>Negative predictive value (95% CI)</td>
<td>70 (42-98)</td>
<td>60 (39-81)</td>
<td>61 (38-84)</td>
<td>54 (36-72)</td>
</tr>
</tbody>
</table>

CI is confidence interval

Figure 1. The association between several aspects of the early motor repertoire at the age of 11 to 17 weeks post-term and GMFCS level at school age. Each dot represents an individual child. These associations were significant. A: the age-adequacy of the motor repertoire (Chi² test for trend = 5.3; p = 0.021). B: the quality of the kicking pattern (quadratic model, Chi² test for trend = 6.2; p = 0.012). C: the presence or absence of a flat posture (Chi² test for trend = 6.1; p = 0.017). D: the presence or absence of a cramped movement character (Chi² test for trend = 8.0; p = 0.005).

findings at school age were further analysed to identify which of these components differentiated between children on a lower versus higher GMFCS level.

Concerning FMs, thirty-three infants (89%) showed an absence of FMs at the age of 11 to 17 weeks post-term, one infant (3%) had abnormal FMs and three infants (8%) had FMs of a normal quality. The infants with normal FMs had GMFCS level I (n=2) or II (n=1), the one infant with abnormal FMs had GMFCS level III. No association existed between the quality of FMs and GMFCS levels.
Analysis of the age-adequacy of the motor repertoire showed an association with the age-adequacy and GMFCS levels at school age (Figure 1a). The concurrent motor repertoire was age-adequate in only two children (5%). Infants in whom the age-adequate repertoire was absent were more often on a higher GMFCS level when compared to those with a normal or reduced age-adequacy ($\chi^2$ test for trend = 5.3; $p=0.021$). Univariate analysis by logistic regression (high versus low level of self mobility), revealed a likelihood ratio (LR) of 10.5 (95% CI: 1.1-102; $p=0.043$).

The analysis of the presence and normality of movement patterns showed that no association existed between the number of normal and abnormal movement patterns and the GMFCS level. More detailed analysis of particular movement patterns revealed that monotonous, repetitive kicking was common in our study group. The quality of the kicking pattern showed a trend towards being more often observed in children with higher GMFCS levels, but this was not significant for the association including all GMFCS levels separately. The raw data revealed that abnormal kicking was frequently observed in GMFCS levels II to IV, but less frequently in GMFCS levels I and V. (figure 1b).

We therefore applied a quadratic transformation. For that purpose, we replaced the number of -2 for GMFCS level I, -1 for GMFCS level II, 0 for GMFCS level III, 1 for GMFCS level IV and 2 for GMFCS level V. Next, we squared these numbers, and analysed the relationship between the result and the quality of the kicking pattern with the $\chi^2$ test for trend. It showed a significant relationship ($\chi^2$ test for trend = 6.2; $p=0.012$).

Concerning the presence and normality of postural patterns, no differences were observed between the number of normal and abnormal postural patterns in relation to the GMFCS levels. However, more detailed analysis of the postural patterns showed that a predominantly flat posture differentiated between infants classified on lower and higher GMFCS levels ($\chi^2$ for trend = 6.1; $p=0.013$) (Figure 1c). A predominantly flat posture was scored when the infant, lying in supine, had all four limbs mainly lying on the surface. Antigravity movements and flexion in hips and knees were rare. Arms and legs hardly came above the level of the trunk. A normal, predominantly non-flat posture was scored when the infant, lying in supine, had antigravity movements, with arms or legs moving above the level of the trunk. Flexion of hips and knees was frequently observed. Infants with a predominantly flat posture more often had a high level of self mobility when compared to those without a predominantly flat posture (LR 5.9; 95% CI 1.4-25.2; $p=0.017$), with PPV of 79% (95% CI: 61-97) and NPV of 61% (95% CI: 38-84) (Table 2a).

At 11 to 17 weeks post-term, none of the infants had a normal quality of the concurrent motor repertoire. The abnormal quality noted in all cases was monotony, seventeen children were also jerky and seventeen were also cramped. Six infants showed cramped synchronised movements. Jerkiness of the concurrent motor repertoire did not differentiate between children classified on lower and higher GMFCS levels. A cramped character of the concurrent motor repertoire, however, was associated with a higher GMFCS level ($\chi^2$ test for trend = 8.0; $p=0.005$) (Figure 1d). Fourteen infants with a cramped movement character had a GMFCS level of III and more (LR 7.0; 95% CI: 1.5-32.5, $p=0.013$), with PPV of 82% (95% CI: 64-100) and NPV of 60% (95% CI: 39-81) (Table 2a).
The prognostic value of combining several qualitative characteristics of the motor repertoire for the level of self mobility in CP

At 11 to 17 weeks post-term, five aspects of the motor repertoire had a particularly high prognostic value for the degree of functional limitations in infants with CP. These were the motor optimality score, the age-adequacy of the concurrent motor repertoire, the quality of the kicking pattern, the presence of a flat posture, and the presence of a cramped movement character. The different qualitative aspects of the motor repertoire are likely to be interdependent. Therefore we performed a multiple logistic regression analysis to investigate which aspects contributed independently to the degree of functional limitations in infants with CP. When entering these aspects as predictors in a multiple logistic regression model we found that the presence of a non-flat posture (LR 15.1 (95% CI: 1.9-119; \( p \)=0.010), and a cramped movement repertoire (LR 18.2 (95% CI: 2.1-155; \( p \)=0.008) remained in the model as predictors of more severe functional limitations. The presence of an abnormal kicking pattern showed a trend towards more severe functional limitations (LR 7.0; 95% CI: 1.0-51; \( p \)=0.056).

Combining these aspects further differentiated between the degrees of functional limitations in infants with CP (Figure 2). Infants with a non-flat posture combined with a cramped movement character more often had a low level of self mobility, with PPV of 100% (95% CI: 90-100) and NPV of 54% (95% CI: 36-72) (Table 2a). In contrast, infants with a flat posture combined with a non-cramped movement character more often had a high level of self mobility, with PPV of 80% (95% CI: 55-100) and NPV of 74% (95% CI: 57-91) (Table 2b).

The relationship between clinical data at birth and neurological findings at school age

The associations between the clinical data and the neurological findings at 6 to 12 years of age are shown in Table 1. Hardly any difference in clinical data existed between children with a lower GMFCS level when compared to those with a higher GMFCS level. Only the presence of an intraventricular haemorrhage and periventricular leukomalacia differed between the groups.

In order to investigate which aspects contributed independently to the development of more severe functional limitations again a multiple logistic regression analysis was performed, now also including

---

Table 2b. Sensitivity, specificity, positive predictive value and negative predictive value of the combination of a non-cramped movement character and flat posture, for a high level of self mobility (GMFCS levels I to II) at school age.

<table>
<thead>
<tr>
<th>Combined: non-cramped flat</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity (95% CI)*</td>
<td>53 (28-78)</td>
</tr>
<tr>
<td>Specificity (95% CI)</td>
<td>91 (79-100)</td>
</tr>
<tr>
<td>Positive predictive value (95% CI)</td>
<td>80 (55-100)</td>
</tr>
<tr>
<td>Negative predictive value (95% CI)</td>
<td>74 (57-91)</td>
</tr>
</tbody>
</table>

* CI is confidence interval

---

The prognostic value of combining several qualitative characteristics of the motor repertoire for the level of self mobility in CP
Early motor repertoire and level of self mobility in children with CP

Clinical data. Possible predictors were: the presence and grading of intraventricular haemorrhages, the presence of cystic periventricular leukomalacia, the quality of the kicking pattern, the presence of a non-flat posture, and the presence of a cramped movement character. Only the presence of an intraventricular haemorrhage grade 3/4 (associated with a lower GMFCS level, LR: 0.32; 95% CI 0.12–0.84, \( p = 0.020 \)), the presence of a non-flat posture (LR 9.7; 95% CI 1.18–80, \( p = 0.034 \)), and the presence of a cramped movement character (LR 19.7; 95% CI 1.7–225, \( p = 0.016 \)) remained in the model. Combining the various aspects of the motor repertoire (presence of cramped character and non-flat posture) as a single measure, LR for a low level of self mobility was 13.2 (95% CI 2.2–79, \( p = 0.005 \)).

Discussion

The present study demonstrates that in children with CP the motor repertoire between the age of 11 and 17 weeks post-term is associated with the level of self mobility at school age. A lower motor optimality score that is representative of the early motor repertoire is indicative of a lower level of self mobility. Previous studies already showed that the absence of FMs is predictive of the development of CP\(^{4,5} \) but this feature cannot predict the degree of later functional limitations. To the best of our knowledge, this is the first report on the predictive value of the qualitative and quantitative aspects of the motor repertoire at the age of the fidgety movements, condensed into

**Figure 2.** The association between the combination of the presence or absence of a flat posture and the presence or absence of a cramped movement character at the age of 11 to 17 weeks post-term and GMFCS level at school age. Each dot represents an individual child. These associations were significant (LR: 10.4; 95% CI: 2.2–49; \( p = 0.003 \)).
the motor optimality score, for the level of self mobility in children with CP. Several components of the motor optimality score were associated with functional limitations at 6 to 12 years of age. Firstly, the quality of the concurrent motor repertoire, if scored as cramped at 11 to 17 weeks post-term, was associated with more severe functional limitations when compared to a non-cramped motor repertoire. Previously, the predominant presence of cramped-synchronised movements (an abnormal type of GM) during the preterm to early post-term period, was also found to be predictive of the development and severity of CP. The earlier the onset of these cramped-synchronised movements, the more severe the CP. In the present study only six infants had cramped-synchronised movements at 11 to 17 weeks of age. An association was now also found with the cramped (and non-synchronised) character of the concurrent motor repertoire and the degree of functional limitation in children with CP. Apparently, a cramped character of the concurrent motor repertoire in combination with the absence of FMs has some predictive value for children developing CP. This association is not seen in infants with normal or abnormal FMs who do not develop CP.

Secondly, the age-adequacy of the motor repertoire, if scored as absent at 11 to 17 weeks post-term, was associated with more severe functional limitations when compared to a reduced or normal age-adequacy. This finding underscores the importance of the presence and normality of movement and postural patterns as predictors of the level of self mobility in children with CP. Of all the observed movement and postural patterns, only a monotonous kicking pattern at 11 to 17 weeks post-term was associated with more severe functional limitations at school age, whereas a predominantly flat posture was associated with less severe functional limitations.

Thirdly, a flat posture was associated with less severe functional limitations in children with CP, especially in case of a non-cramped movement character. In general, a flat posture can be considered as an abnormal sign. Apparently, in children without FMs, at risk for developing CP, a flat posture is a favorable sign for later functional limitations. Previously, Touwen et al. stated that shoulder retraction, hyperextension of neck and trunk in the first months of life (mimicking a flat posture) were not predictive of later neurological impairment. We now add that a predominant flat posture accompanied by a non-cramped movement character is an independent predictor of less severe functional limitations in infants with CP.

The spontaneous kicking pattern in young infants has also been investigated previously, but these studies only reported on the differences between low risk and high risk infants. They showed no difference when looking at either the quantity of the kicking patterns or the presence of a monotonous and repetitive kicking pattern at the age of 6 and 12 weeks post-term between low risk and neurologically impaired infants. However, at 3 to 5 months post-term, abnormal kicking patterns were more often observed in neurologically impaired infants. The findings of the present study indicated that in the group of children who developed CP the persistence of monotonous and repetitive kicking at the age of 11 to 17 weeks post-term was associated with more severe functional limitations. The persistence of a monotonous, repetitive kicking pattern could be due to delayed
maturation in those infants, or it could be the result of more severe neurological impairment at this particular age. Our study also showed that the absence of a kicking pattern combined with a cramped movement character was associated with more severe functional limitations of children with CP. This is probably caused by the incapacity of cramped infants to make kicking movements because their movements are too cramped.

Previous studies showed that infants with higher grade intracranial haemorrhage or periventricular leukomalacia are prone to develop adverse neurological outcome.\(^2\) In the present study, children with higher graded leukomalacia were mostly represented in the group with higher GMFCS levels whereas children with higher graded haemorrhages were represented more in the group with lower GMFCS levels. We cannot fully explain these findings. It might be due to selection. Unilateral grade 3/4 haemorrhages result more often in unilateral spastic CP in comparison with grade 2/3 periventricular leukomalacia.\(^2\) Unilateral CP is in general associated with a higher level of self mobility in comparison to bilateral spastic CP. However, these findings might also be just by chance, as the numbers of children in both categories of ultrasound abnormalities are very small.

There are some limitations to our study. One was the distribution of the children with CP over the different GMFCS levels. Firstly, this was due to our inclusion criteria, of only those infants born before 34 weeks’ gestational age. Therefore, the distribution of our study group may not be representative for the general CP population.\(^{27-29}\) Secondly, the consequence of combining two different follow-up groups: a NICU follow-up program (Groningen) and a rehabilitation follow-up program (Pisa), in which possibly more infants with severe functional limitations were included, could have caused bias. It should further be noted that the confidence intervals around LRs, sensitivity, specificity, PPV and NPV are very wide, because of the relatively small sample size. Estimates for the individual child may be imprecise. Although it is very tempting, one should also keep in mind that 11 to 17 weeks’ post-term age is very early to predict and talk to parents about severity of CP at the age of 6 years and older. When talking to the individual family, one should realise that variation in development is very wide. It therefore seems prudent to counsel parents thoughtfully, and observe children carefully without labelling them too soon.

**Conclusion**

Our study demonstrates that the motor repertoire of infants at the age of 11 to 17 weeks post-term was, to a considerable extent, associated with the level of self mobility in children with CP. Most predictive for the development of CP with a low level of self mobility was a non-flat posture combined with the presence of a cramped movement character, with PPV 100 % (95% CI: 90-100) and NPV 54% (95% CI: 36-72). Most predictive for the development of CP with a high level of self mobility was a flat posture combined with a non-cramped movement character, with PPV 80% (95% CI: 55-100) and NPV 74% (95% CI: 57-91).
Chapter 5

References


