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Development of the quality of reaching in infants with cerebral palsy: a kinematic study

ANKE G BOXUM[1] | SACHA LA BASTIDE-VAN GEMERT[2] | LINZE-JAAP DIJKSTRA[1] | ELISA G HAMER[1,3] | TJITSKE HIELKEMA[1,4] | HELEEN A REINDERS-MESSELINK[4,5] | MIJNA HADDERS-ALGRA[1]

1 University of Groningen, University Medical Center Groningen, Department of Paediatrics – Developmental Neurology, Groningen; **2** Department of Epidemiology, University of Groningen, University Medical Center Groningen, Groningen; **3** Department of Neurology, Radboud University Medical Center, Nijmegen; **4** Department of Rehabilitation Medicine, Center for Rehabilitation, University of Groningen, University Medical Center Groningen, Groningen; **5** Rehabilitation Center 'Revalidatie Friesland', Beetsterzwaag, the Netherlands.

Correspondence to Mijna Hadders-Algra at University Medical Center Groningen, Developmental Neurology, Hanzeplein 1, 9713 GZ Groningen, the Netherlands.
E-mail: m.hadders-algra@umcg.nl

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ABBREVIATIONS

cPVL	Cystic periventricular leukomalacia
IMP	Infant Motor Profile
L2M 0-2	LEARN2MOVE 0-2 years
VHR-infants	Infants at very high risk

AIM To assess development of reaching and head stability in infants at very high risk (VHR-infants) of cerebral palsy (CP) who did and did not develop CP.
METHOD This explorative longitudinal study assessed the kinematics of reaching and head sway in sitting in 37 VHR-infants (18 CP) one to four times between 4.7 months and 22.6 months corrected age. Developmental trajectories were calculated using linear mixed effect models. Motor function was evaluated with the Infant Motor Profile (IMP) around 13 months corrected age.
RESULTS Throughout infancy, VHR-infants with CP had a worse reaching quality than infants without CP, reflected for example by more movement units (factor 1.52, 95% CI 1.16–1.99) and smaller transport movement units (factor 1.86, 95% CI 1.20–2.90). Total head sway of infants with and without CP was similar, but infants with CP used more head movement units to achieve stability. The rate of developmental change in infants with and without CP was similar. Around 13 months, head control and reaching quality were interrelated; both were associated with IMP-scores.
INTERPRETATION Infants with CP showed a worse kinematic reaching quality and head stability throughout infancy from early age onwards than VHR-infants without CP, implying that kinematically they do not grow into a deficit, but exhibit deficits from early infancy on.

INTRODUCTION

Cerebral palsy (CP) constitutes a group of disorders in which motor impairment is an important feature.[1] In children with CP, motor impairments may induce difficulties on a daily basis, for example during reaching and grasping.[2] Reaching is essential for daily routine and participation in social contexts, as it is used during actions such as eating, drinking, dressing, but also during interaction with the environment, for example during play activities.

Learning to reach is challenging because of biomechanical and neural complexity. Infants with typical development start to acquire goal-directed reaching movements and learn to successfully grasp objects between 3 months and 5 months of age.[3] An important factor in successful reaching and grasping in sitting position is head stability.[4] Around 2 months, head control still involves some oscillating head movements; proper stability is achieved around 4 months.[5]

When reaching emerges, the trajectories of reaching movements are varied. Adjustments in movement trajectories are called movement units and consist of one acceleration and deceleration in the velocity profile.[6] With increasing age reaching movements become more smooth, fluent, and straight: the number of movement units, reaching duration, and travelled distance decrease, and the relative size of the movement unit responsible for most of the transport of the hand increases.[6,7] A major part of the developmental improvements occurs before the age of 6 months, thereafter development progresses at a slower speed. Around 2 years, the velocity profile and transport movement unit are comparable with those of adults;[8,9] straightness[8] and number of movement units[9] continue to develop after this age.

Preschool- and school-age children with CP show worse kinematic characteristics of reaching than children with typical development.[10] Little is known on the kinematics of reaching in infants who are later diagnosed with CP. Current knowledge is restricted to research on reaching development in infants born preterm. At 4 months corrected age, low-risk infants born preterm show a slightly advanced reaching development compared with infants

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born at term;[11] at 6 months corrected age, both low-[12] and high-risk infants born preterm, that is infants with an Apgar score lower than 3 after 5 minutes or with respiratory problems, show less optimal reaching movements than infants born at term.[11]

The aim of this explorative study is to evaluate the kinematics of reaching and head stability throughout infancy in VHR-infants, in particular to evaluate whether developmental trajectories of infants who do develop CP differ from those not developing CP. Longitudinal data of VHR-infants were collected in the context of LEARN2MOVE 0-2 years (L2M 0-2), a study evaluating two types of early intervention.[13] We hypothesize that infants who are diagnosed with CP at 21 months corrected age grow into a deficit with increasing age, as generally the clinical signs of CP at early age are less clear than at later age. Additionally, we studied the effect of cystic periventricular leukomalacia (cPVL) and hypothesized that infants with cPVL exhibit a worse reaching quality from early age onwards compared with other VHR-infants, as cPVL is one of the most severe lesions of the developing brain. The systematic review by Hielkema and Hadders-Algra (2016) indicated that 86% of the infants with cPVL develop those forms of CP in which both upper and lower limb function are impaired.[14] Thus, our primary question was: Do kinematics of reaching and head stability of VHR-infants developing CP (hereafter called: infants with CP) differ from VHR-infants without CP from early age onwards? A secondary question was: Do reaching quality and head stability of infants with cPVL differ from all other VHR-infants from early age onwards? In addition, we explored associations between head stability and reaching quality and whether either were associated with motor function as measured using the Infant Motor Profile (IMP) around the age of 13 months.

METHOD

Participants

Forty-three VHR-infants were included in L2M 0-2 before 9 months corrected age, based on one of the following criteria: (1) cystic periventricular leukomalacia; (2) parenchymal lesion of the brain; (3) severe asphyxia with brain lesions on magnetic resonance imaging (MRI); or (4) neurological dysfunction suggestive for the development of CP. Exclusion criteria were: (1) infants with an additional severe congenital disease such as congenital heart disorder; (2) infants of parents or caregivers who did not master the Dutch language. The ethics committee of the University Medical Center Groningen (UMCG) approved the L2M 0-2 protocol (trial number NTR1428). Parents gave informed consent.[13]

Imaging data obtained as part of standard care were available. An experienced paediatric neurologist who was blinded to clinical data categorized the brain lesions (seven neonatal cranial ultrasounds and 33 MRIs) of infants who did not drop out of the study into: (1) lesion of the basal ganglia or thalamus; (2) cortical infarction; (3) (cystic) periventricular leukomalacia; (4) posthaemorrhagic porencephaly; or (5) non-specific or no significant lesions.[15]

What this paper adds

- Reaching quality improves throughout infancy in all infants at high risk (VHR-infants).
- Infants with cerebral palsy (CP) show a worse reaching quality than VHR-infants without CP.
- Infants with CP achieve head stability differently from infants without CP.
- Infants with CP exhibit kinematic reaching problems from early age onwards.

Kinematic assessment

We intended to assess the kinematics of reaching four times: at baseline (before 9mo corrected age), 6 months and 12 months after baseline, and at 21 months corrected age, resulting in an age range variation of about 9 months per assessment. The aim was to assess reaching in supine and supported sitting position, but we restricted our analyses to the supported sitting position as it furnished the best set of longitudinal data. In the standard condition of supported sitting, an infant chair was used that provided back support and support at the front from a horizontal bar at the level of the upper abdomen (Fig. S1, online supporting information). No foot support was provided. When infants refused to sit in the infant chair, the infant was seated on the lap of a parent who provided support mimicking that of the infant chair (in 5 sessions; see van Balen et al. 2012).[16]

During each session, the assessor presented a toy at arm-length distance to elicit a reaching movement, aiming to obtain at least 10 reaching movements with the right arm or – if the right arm was the non-preferred arm – the left (right arm n=28, left n=7 [at 21mo corrected age diagnosed with unilateral CP: n=3; bilateral CP n=2; complex minor neurological dysfunction n=2], changing during infancy n=2, both diagnosed at 21mo with bilateral CP). Continuous kinematic recordings were made using a dual camera system with a sampling rate of 50 Hz. The two cameras (Samsung HMX-H200, Samsung, Suwon, Korea) were placed about 1.5m from the infant, 55cm apart at an angle of 80°. This configuration resulted in a resolution of 2.5mm. Three reflective markers (diameter 10mm) were placed on the preferred side of the body: lateral to the eye, the mandibular angle, and dorsal side of the distal radioulnar joint.

Neurodevelopmental assessments

Before each kinematic assessment, the IMP was used to evaluate motor performance. The IMP is a video-based assessment in which the motor repertoire of infants and the ability to adapt strategies from the repertoire to the situation are tested. It has a good reliability and construct and concurrent validity.[17] At 21 months corrected age, the Touwen Infant Neurological Examination – with good reliability and validity[18] – was used to assess neurological outcome. CP was diagnosed when infants displayed a clear neurological syndrome with dysregulation of muscle tone, pathological reflexes, and postural and motility impairments. The neurodevelopmental assessments also revealed whether the infant had a clear hand preference.

Data analyses

PedEMG (Developmental Neurology, UMCG, the Netherlands[16]) was used to select the segments containing the reaching movements from the continuous recording by indicating start and end of those reaching movements in which the wrist-marker was visible, with the preferred arm, and when the infant was in a calm and alert behavioural state on video. To calculate the positions of the markers in space during the reaching movements, SIMI Motion System Analysis (SIMI Reality Motion Systems GmbH, Unterschleissheim, Germany) was used. Subsequently, the Kinematic module of PedEMG was used to calculate reaching parameters: (1) number of movement units of the wrist, in which one movement unit consists of one acceleration and deceleration; (2) transport movement unit, expressed as the proportional length of the first movement unit relative to the total length of the reaching movement; (3) curvature index, that is the ratio of the length of the straight line between starting and stopping position relative to the actual travelled distance of the wrist; (4) reaching duration; (5) total length of the reaching path; and (6) average speed of the wrist. To assess head stability, we first calculated the total angular change of the head vector between the markers lateral to the eye and the mandibular angle, between start and stop of the reaching movement. Second, the number of movement units was calculated for the marker lateral to the eye. Data were excluded from further analysis if less than three reaching movements were present that furnished data on a specific parameter (Fig. S2, online supporting information, shows examples of kinematic recordings). This resulted in different trial numbers for reaching and head stability data.

Statistical analyses

Power calculation of L2M 0-2 was based on the IMP. To detect a clinically relevant change of 7.5 in the total IMP-score with a power of 80% (α=0.05), two groups of 19 infants were needed. The present data were collected as additional observational data.

SPSS (version 23) was used for descriptive statistics and the Spearman correlation. The latter was used to explore associations among reaching quality, head stability, and total IMP-score in the middle of the age period studied. To take into account repeated measurements over time per infant, a linear mixed effects model of median values per infant per assessment for the continuous variables was fitted using R version 3.3.1.[19] The model also included the corrected ages of the infants at each assessment. Clustering of observations was accounted for by incorporating random subject effects. Fixed effects were included for age, group (CP/non-CP, cPVL/non-cPVL), and interaction between the two. (Log-)Transformation was used to meet the model assumptions when needed.

Generalized linear mixed effects models with the Poisson loglinear link function were used to calculate time profiles for the count variable number of movement units. The data are displayed in Figures 1a, b. The plots indicate that the implied assumption of (here decreasing) means and related variances over time are not violated. No overdispersion was found. The models resulted in developmental trajectories reflecting the average of the outcome parameter over time per group. The growth factors of the developmental trajectories have a parameter specific interpretation. The interaction term between group and age indicates whether two subgroups differ significantly in the rate of change (the slope) of the developmental trajectories. As the interaction terms of group by age were not significant, we interpreted and presented the models without interaction term.

RESULTS

Thirty-seven of the 43 VHR-infants from the L2M 0-2 study underwent one to four proper kinematic assessments, resulting in a total of 91 measurements between 4.7 and 22.6 months corrected age (Fig. S3, supporting information, displays the age distribution). Reasons for missing series of data in the other six infants were: infants were not able to sit in a chair (n=3); drop-out from the study after the baseline assessment with only data in supine position (n=2); intolerance for the reflective markers (n=1). Baseline characteristics, brain lesions, and neurological outcome of the 37 infants are presented in Table I. Preliminary analyses indicated that the type of intervention did not affect the kinematics.

Reaching quality

The mixed model analyses indicated that diagnosis of CP and the presence of cPVL affected development. However, the rate of change in the developmental trajectories (the interaction term) of all parameters of infants with and without CP and of those with and without cPVL was not statistically significantly different (data not shown). In the results below on the models without interaction term, first the effect of age on reaching parameters is discussed while correcting for CP. Next, the effects of CP throughout infancy are presented. Mostly the models for cPVL yielded similar effects as those for CP. In case of similarity only the model for CP is presented, whereas if the models differed both are reported. The results are summarized in Table II. Figure 2 shows the developmental trajectories of the different parameters for infants with and without CP.

Corrected for CP, the number of movement units decreased significantly with increasing age (factor 0.92, 95% CI 0.90–0.95) per month. Throughout infancy, that is corrected for age, infants with CP used more movements units than infants without CP (factor 1.52, 95% CI 1.16–1.99). The transport movement unit increased in all infants with increasing age (factor 0.90, 95% CI 0.86–0.94; note the different transformation with factor <1 implying increase, see Table II). Throughout infancy, infants with

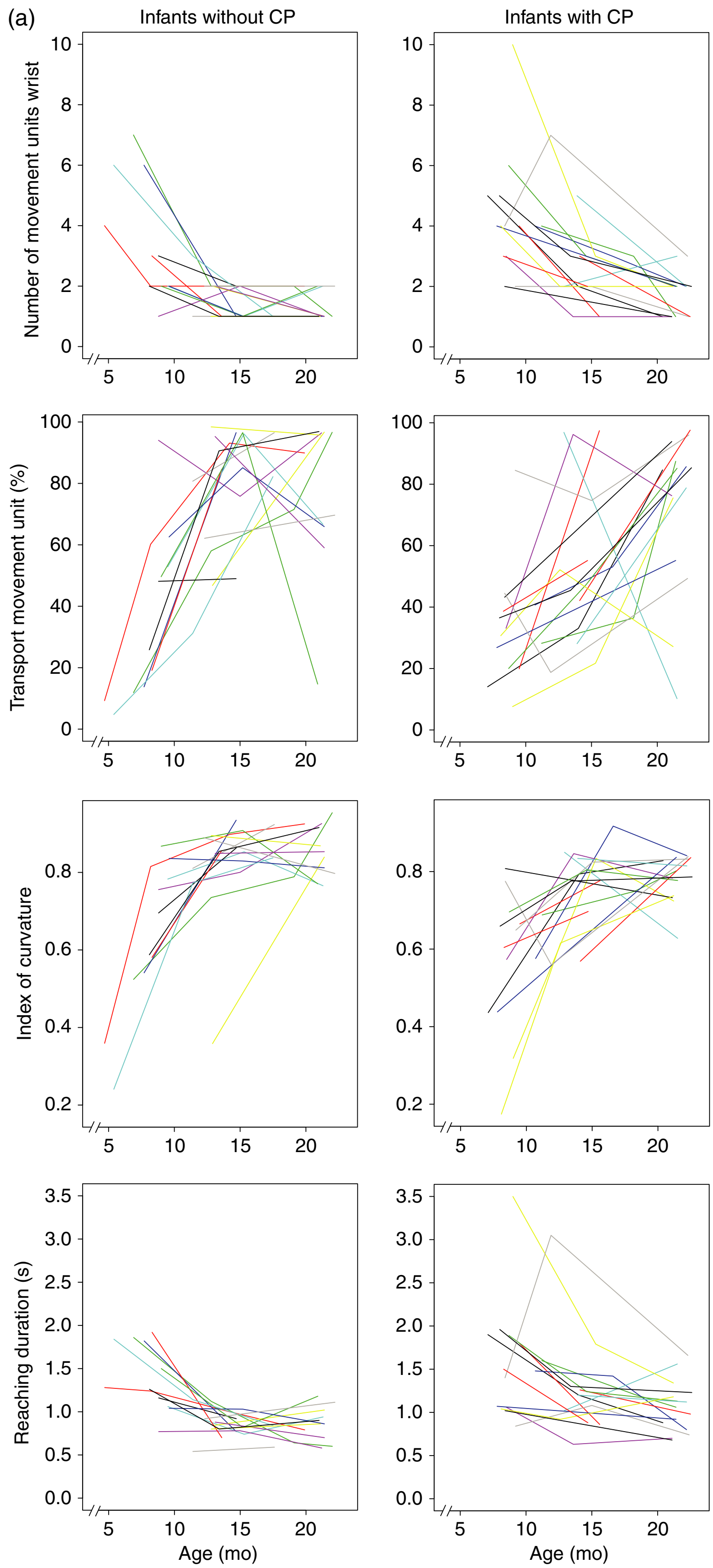

Figure 1: (a and b) Individual trajectories of infants with and without cerebral palsy (CP). The lines represent individual trajectories of the median values per infant per assessment of the kinematic parameters throughout infancy. The left panels display trajectories of infants who were not diagnosed with CP at 21 months corrected age, on the right infants with CP are presented. [Colour figure can be viewed at wileyonlinelibrary.com].

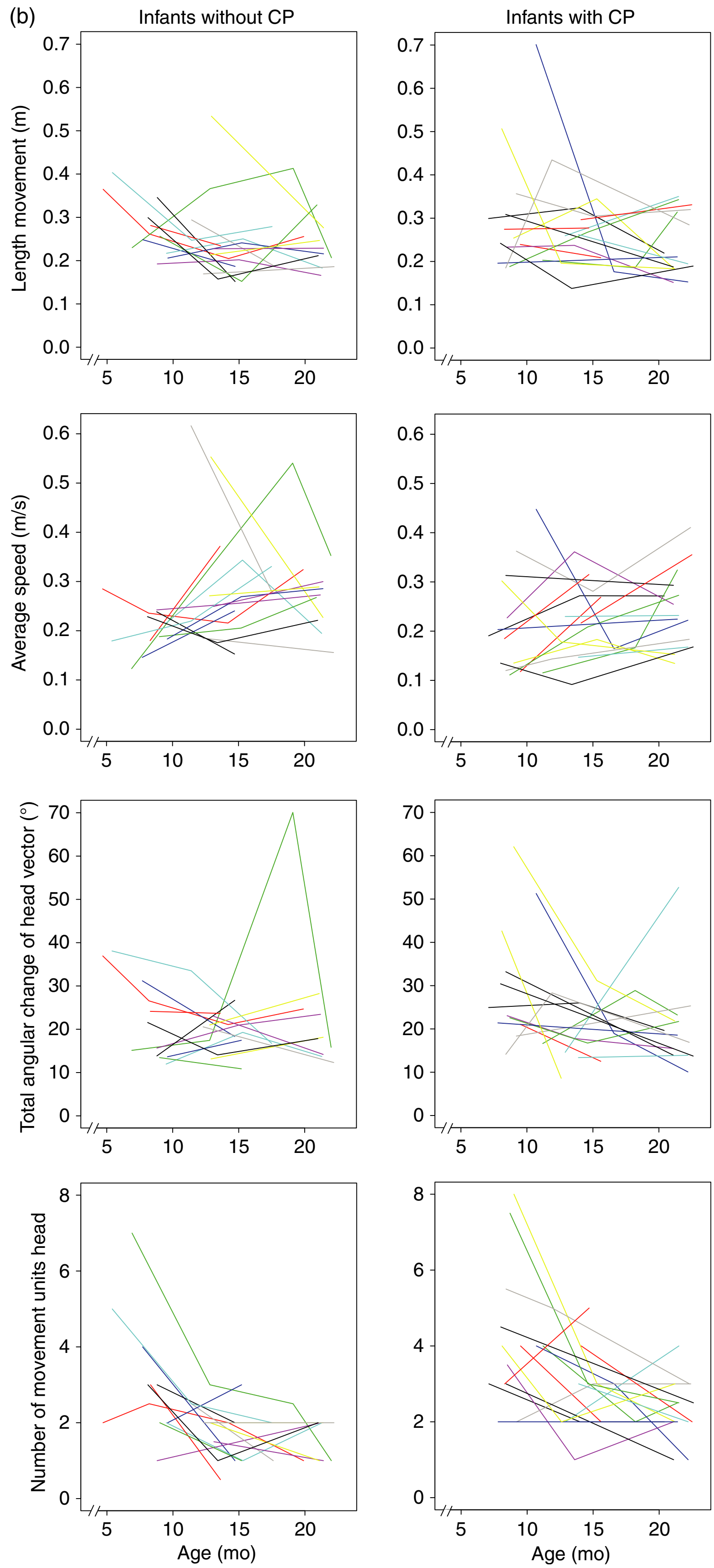

Figure 1: Continued.

CP had a smaller transport movement unit than infants without CP (factor 1.86, 95% CI 1.20–2.90). The curvature index increased with increasing age (factor 0.94, 95% CI 0.92–0.96; note the different transformation with factor <1 implying increase, see Table II). Throughout infancy, infants with CP showed lower curvature indices than infants without CP (factor 1.50, 95% CI 1.23–1.84).

Table I: Infant characteristics

Baseline characteristics	n=37
Sex, n, male/female	24/13
Gestational age, wks, median (range)	32.3 (25.9–41.4)
Birthweight, g, median (range)	1800 (720–5400)
Age range of measurements throughout infancy, mo	4.7-22.6
Diagnosis CP, n	18[a]
Unilateral CP	5
Bilateral CP	13
Type of brain lesion, n (n: diagnosis of CP at 21mo corrected age[a])	
Cortical infarction	3 (3)
Cystic periventricular leukomalacia	8 (8)
Periventricular leukomalacia[b]	3 (0)
Basal ganglia and/or thalamic lesion	6 (2)
Posthaemorrhagic porencephaly[a]	11 (5)
Non-specific or no significant lesions	6 (0)

[a]Of two infants with posthaemorrhagic porencephaly, no information on diagnosis of CP is available because of drop-out. [b]Without cysts. CP, cerebral palsy.

The duration of the reaching movement decreased with increasing age (factor 0.97, 95% CI 0.96–0.98). Throughout infancy, infants with CP had longer lasting reaching movements than infants without CP (factor 1.31, 95% CI 1.11–1.54). The total length of the movement decreased when the diagnosis CP was taken into account (factor 0.99, 95% CI 0.98–1.00), it did not change with age when correcting for cPVL (factor 0.99, 95% CI 0.98–1.00). The length of the reaching movement was not affected by CP or cPVL. The average speed increased during infancy (factor 1.02, 95% CI 1.01–1.03). Infants with and without CP demonstrated a similar average speed (factor 0.84, 95% CI 0.69–1.01), while infants with cPVL showed lower reaching speed than infants without cPVL (factor 0.79, 95% CI 0.65–0.96).

In summary, the effect of CP and cPVL on the development of most of the reaching parameters was similar; average reaching speed and total length were exceptions. Figure 1 shows the graphs of the individual developmental trajectories of infants with CP or without CP. It illustrates the interindividual variability.

Head stability

The total angular change of the head vector remained similar throughout infancy when the effect of diagnosis CP was taken into account (factor 0.98, 95% CI 0.97–1.00). However, it decreased with increasing age when corrected

Table II: Associations of kinematic parameters with CP and cPVL

	Variables in model	Fixed effect (β) CP	Exp (β) (95% CI) CP	p	Fixed effect (β) cPVL	Exp (β) (95% CI) cPVL	p
Reaching							
Number of movement units wrist	Intercept	1.77	5.90 (4.02–8.56)	<0.001	1.88	6.53 (4.58–9.22)	<0.001
	Age	−0.08	0.92 (0.90–0.95)	<0.001	−0.08	0.92 (0.90–0.95)	<0.001
	CP/cPVL	0.42	1.52 (1.16–1.99)	0.002	0.48	1.61 (1.22–2.11)	<0.001
Transport movement unit	Intercept	4.45	85.65 (44.47–164.94)	<0.001	4.65	104.28 (56.59–192.18)	<0.001
	Age	−0.11	0.90 (0.86–0.94)	<0.001	−0.11	0.90 (0.86–0.93)	<0.001
	CP/cPVL	0.62	1.86 (1.20–2.90)	0.007	0.70	2.02 (1.23–3.31)	0.006
Index of curvature	Intercept	−0.80	0.45 (0.33–0.61)	<0.001	−0.68	0.50 (0.38–0.67)	<0.001
	Age	−0.06	0.94 (0.92–0.96)	<0.001	−0.06	0.94 (0.92–0.96)	<0.001
	CP/cPVL	0.41	1.50 (1.23–1.84)	<0.001	0.38	1.46 (1.15–1.83)	0.002
Reaching duration	Intercept	0.42	1.52 (1.26–1.84)	<0.001	0.46	1.58 (1.33–1.87)	<0.001
	Age	−0.03	0.97 (0.96–0.98)	<0.001	−0.03	0.97 (0.96–0.98)	<0.001
	CP/cPVL	0.27	1.31 (1.11–1.54)	0.002	0.33	1.40 (1.17–1.66)	<0.001
Total length of reaching movement	Intercept	−1.26	0.28 (0.23–0.34)	<0.001	−1.28	0.28 (0.23–0.34)	<0.001
	Age	−0.01	0.99 (0.98–1.00)	0.046	−0.01	0.99 (0.98–1.00)	0.055
	CP/cPVL	0.07	1.07 (0.94–1.22)	0.317	0.12	1.13 (0.97–1.30)	0.109
Average speed	Intercept	−1.70	0.18 (0.14–0.23)	<0.001	−1.75	0.17 (0.14–0.22)	<0.001
	Age	0.02	1.02 (1.01–1.03)	0.006	0.02	1.02 (1.01–1.04)	0.003
	CP/cPVL	−0.18	0.84 (0.69–1.01)	0.057	−0.24	0.79 (0.65–0.96)	0.018
Head stability							
Total angular change of head vector	Intercept	3.20	24.44 (18.52–32.24)	<0.001	3.24	25.44 (19.60–33.01)	<0.001
	Age	−0.02	0.98 (0.97–1.00)	0.059	−0.02	0.98 (0.97–1.00)	0.049
	CP/cPVL	0.13	1.14 (0.95–1.38)	0.155	0.15	1.16 (0.94–1.44)	0.162
Number of movement units lateral to the eye	Intercept	1.51	4.53 (3.11–6.52)	<0.001	1.63	5.10 (3.59–7.16)	<0.001
	Age	−0.05	0.95 (0.93–0.97)	<0.001	−0.05	0.95 (0.92–0.97)	<0.001
	CP/cPVL	0.42	1.52 (1.17–1.97)	0.002	0.46	1.59 (1.21–2.06)	<0.001

Exp (β) represents the growth factor of the developmental trajectory, for age it reflects the growth factor per month. Reaching duration, total length of the reaching movement, average speed, and the total path of the head vector were modelled using a log transformation. Transport movement unit was modelled using the natural logarithm of 100 - transport movement unit and the index of curvature using the logarithm of 1 – index of curvature. Both numbers of movement units were modelled using the Poisson loglinear link function. cPVL, cystic periventricular leukomalacia.

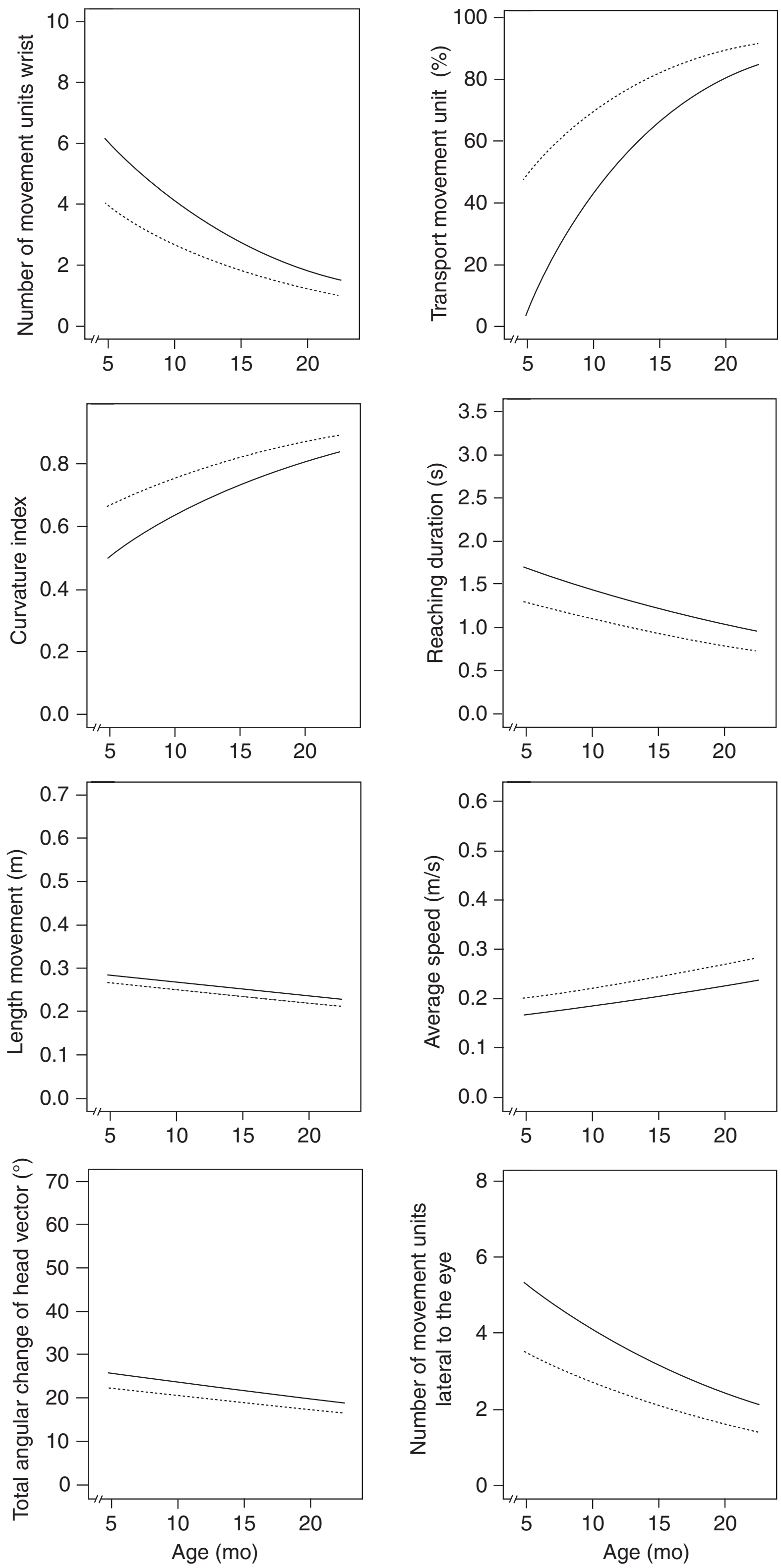

Figure 2: Developmental trajectories of reaching and head stability of infants with and without CP. The graphs represent the average developmental trajectories of the reaching and head stability parameters throughout infancy (between 4.7mo and 22.6mo corrected age). Median values of the parameters per infant per assessment were used. The continuous lines display the average trajectories of infants at very high risk (VHR-infants) who were diagnosed with cerebral palsy (CP) at 21 months corrected age; the dotted lines represent VHR-infants who did not develop CP.

Table III: Associations among reaching parameters, head stability, and total IMP-score at 11 to 16 months of age

	Total angular change of head vector		Number of movement units head		IMP total score	
	rho	*p*	*rho*	*p*	*rho*	*p*
Number of movement units wrist	0.373	**0.043**	**0.770**	**<0.001**	−0.509	**0.003**
Transport movement unit	−0.354	0.055	−**0.637**	**<0.001**	0.403	**0.022**
Curvature index	−0.129	0.498	−**0.668**	**<0.001**	**0.520**	**0.002**
Reaching duration	0.399	**0.029**	**0.848**	**<0.001**	−0.390	**0.027**
Total length of reaching movement	0.368	**0.045**	0.530	**0.003**	−0.497	**0.004**
Average speed	−0.111	0.559	−0.317	0.088	0.113	0.537
Total angular change of head vector			0.288	0.123	−0.225	0.231
Number of movement units head	0.288	0.123			−**0.580**	**0.001**

rho, Spearman's rank correlation coefficient. $p<0.05$ in bold. IMP, Infant Motor Profile.

for the presence of cPVL (factor 0.98, 95% CI 0.97–1.00). Infants with and without CP and those with and without cPVL had comparable values of angular change (CP factor 1.14, 95% CI 0.95–1.38; cPVL factor 1.16, 95% CI 0.94–1.44).

The number of movement units of the head decreased with increasing age (factor 0.95, 95% CI 0.93–0.97). Throughout infancy, infants with CP used more movement units than infants without CP (factor 1.52, 95% CI 1.17–1.97).

Associations among reaching, head stability, and the IMP

Spearman's *rho* and accessory *p* values for the associations among reaching parameters, head stability, and total IMP--score around 13 months (range 11-16) are presented in Table III. A more stable head was associated with better reaching. A higher IMP-score was associated with better reaching and a more stable head.

DISCUSSION

The present explorative study suggests that VHR-infants who later were diagnosed with CP showed worse kinematic quality of reaching and head stability from early age onwards than VHR-infants without CP. Developmental change in both groups was similar, implying a similar improvement of reaching quality. Possibly, a major part of the differences between infants with and without CP could be attributed to the presence of cPVL. In addition, our exploratory results suggested that around 13 months a more stable head was associated with better reaching quality and both reaching and head stability were associated with better motor function as measured with the IMP.

The results suggest that the difficulties in reaching experienced by preschool- and school-age children with CP[2,10] begin in early infancy. This contradicts our hypothesis that infants with CP 'grow into their deficit'. Van Balen et al. (2015) suggested that electromyographic measures of postural control of high-risk infants were similar to those of infants with typical development at 4 months and 6 months, but showed a significant delay at 18 months.[20] This 'growing into a deficit phenomenon' is also known from follow-up at school age, when increasingly complex motor and cognitive functions are demanded, and children at risk for developmental problems grow into their, for example, fine motor[21] or cognitive impairments.[22] However, other phenomena such as the pupillary light response,[15] pull-to-sit manoeuvre, or vertical suspension test[23] are impaired from early age onwards. Conceivably, effects of emerging CP are expressed from early age onwards in subtle measures of those functions that rely on extensive neural circuitries, such as kinematic reaching quality or modulation of the pupillary light response.

The current results complement those of Fallang et al. (2003), who reported that high-risk infants born preterm have a worse kinematic reaching quality at 4 months and 6 months than infants with typical development.[11]

Possibly, part of the differences in reaching quality between infants with and without CP may be attributed to the presence of cPVL. The similarity in effect of cPVL and CP on reaching suggests that infants with CP with and without cPVL have comparable difficulties with reaching. Interestingly, the effect of CP and cPVL on length, average speed, and on the total angular change of the head vector were not identical. This could imply that in infants with CP the presence of cPVL has a differentiating effect on these parameters, which should be addressed in future studies as our material was too limited to test this hypothesis.

We assessed head stability using two different measures. The total angular change of the head vector, describing the net result of head sway, did not change throughout infancy. Apparently, all VHR-infants who are able to reach achieve a rather stable head during reaching in sitting position, underscoring the importance of head stability in space.[4] Our data indicate that the way in which head stability is accomplished does change with age, as the number of movement units of the head – reflecting control of head movements[5] – decreased with increasing age. Infants with CP performed worse on this movement control parameter from early age onwards than infants without CP. The higher number of head movement units needed to achieve head stability is possibly an early indicator of the impaired head stability exhibited by older children with CP in other testing conditions.[24]

Around 13 months, better reaching quality was associated with better head stability. This is in line with data of preschool- and school-age children with CP.[25] Most of the detailed parameters of reaching quality and head stability were associated with general motor function, measured with the IMP, supporting the idea that the IMP is a sensitive measure of infant motor impairment. As infants with CP already encounter problems with reaching and head stability in early infancy, our findings suggest that both reaching and head balance of VHR-infants deserve attention in early intervention long before the diagnosis of CP is established.

A major strength of the study is the longitudinal data collection, providing insight into developmental trajectories of VHR-infants. The statistical models allowed us to use all available data, taking exact ages of the infants, repeated measures, and missing data into account. The relatively small sample size and heterogeneity in causes and appearances of CP limit generalized conclusions. The small sample size and all infants with cPVL developing bilateral CP also precluded subanalyses on differences between infants with unilateral and bilateral CP. Nevertheless, we think our conclusion that kinematics of reaching of infants with CP differs from that of infants without CP is valid. It corresponds to the findings of van der Heide et al. (2005), that the reaching kinematics of the dominant arm of school-aged children with unilateral and bilateral CP differed from that of peers with typical development.[10] Additionally, it should be realized that some of the most severely affected infants could not be assessed in an infant chair. It might also be considered a limitation that the data were collected within an randomized controlled trial assessing two different paediatric physiotherapy programmes. However, both early intervention programmes had similar effects on neurological and motor outcome of the infants at 21 months corrected age (Hielkema T, personal communication 2016). Also, information on the extent of the brain lesions could not be further explored because of the study design in which infants were recruited in 12 different hospitals in the Netherlands. Imaging data could only be classified into the predominant pattern of lesion as the hospitals all used their own imaging techniques and protocols. Finally, absence of a control group with typical development precluded comparison of reaching in VHR-infants with typical development.

In conclusion, this study demonstrated that infants with CP showed worse kinematic quality of reaching and head stability than VHR-infants without CP from early age onwards, implying that kinematically they do not grow into a deficit, but exhibit the deficit from early infancy onwards. With regard to early intervention, the data may imply that both head balance and reaching deserve attention early in infancy.

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SUPPORTING INFORMATION

The following additional material may be found online:

Figure S1: Schematic drawing of the infant chair used during the assessment of reaching.

Figure S2: Examples of kinematic recordings.

Figure S3: Age distribution of the 91 kinematic measurements.

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RESUMEN

DESARROLLO DE LA CALIDAD DEL CONTROL CEFÁLICO EN LACTANTES CON PARÁLISIS CEREBRAL: UN ESTUDIO CINEMÁTICO

OBJETIVO Evaluar el desarrollo de la estabilidad de la cabeza en lactantes con riesgo muy alto de desarrolar parálisis cerebral (RA-PC) que subsecuentemente desarrollaron y no desarrollaron PC.
MÉTODO Este estudio exploratorio longitudinal evaluó la cinemática del control cefálico y el balanceo de la cabeza al sentarse en 37 lactantes con RA-CP (18 PC confirmados) de una a cuatro veces entre 4.7 y 22.6 meses de edad corregida. Las trayectorias de desarrollo se calcularon utilizando modelos lineales de efectos mixtos. La función motora se evaluó con el Perfil del Motor Infantil (IMP) alrededor de 13 meses de edad corregida.
RESULTADOS A lo largo de la infancia, los recién nacidos RA-PC que desarrollaron PC tuvieron una peor calidad de control cefalico que los infantes sin PC, reflejados por ejemplo por más unidades de movimiento (MU, factor 1.52, IC del 95%: 1.16-1.99) y MUs de transporte más pequeñas (factor 1.86; -2.90). La oscilación total de la cabeza de los lactantes con y sin PC fue similar, pero los niños con PC usaron más unidades de movimiento de la cabeza para lograr la estabilidad. La tasa de cambio en el desarrollo en los lactantes con y sin PC fue similar. Alrededor de 13 meses, el control de la cabeza y la calidad alcanzada estaban interrelacionados, ambos se asociaron con puntuaciones IMP.
INTERPRETACION Los lactantes con PC mostraron una cinemática disminuida, alcanzando el control y la estabilidad de la cabeza a lo largo de la infancia, en comparación con los niños con RA-PC que no desarrollaron PC, lo que implica que cinemáticamente presentan un déficit desde una edad temprana. Demostrando que, a nivel cinemática no desarrollaron un déficit sino que nacen con este.

RESUMO

DESENVOLVIMENTO DA QUALIDADE DO ALCANCE EM LACTENTES COM PARALISIA CEREBRAL: UM ESTUDO CINEMÁTICO

OBJETIVO Avaliar o desenvolvimento do alcance e estabilidade da cabeça em lactentes de muito alto risco (lactentes MAR) para paralisia cerebral (PC) que desenvolveram e que não desenvolveram PC.
MÉTODO Este estudo exploratório longitudinal avaliou a cinemática do alcance e oscilação da cabeça na postura sentada em 37 lactentes MAR (18 com PC) uma a quatro vezes entre 4.7 e 22.6 meses de idade corrigida. As trajetórias desenvolvimentais foram calculadas usando modelos lineares de efeitos mistos. A função motora foi avaliada com o Perfil Motor Infantil (PMI) por volta de 13 meses de idade corrigida.
RESULTADOS Ao longo da infância, lactentes MAR com PC tiveram pior qualidade do alcance, refletida por exemplo por maior número de unidades de movimento (UM; fator 1.52, IC 95% 1.16-1.99) e menores UMs na fase de transporte (fator 1.86, IC 95% 1.20-2.90). A oscilação total da cabeça de lactentes com e sem PC foi similar, mas os lactentes com PC usaram mais UMs da cabeça para obter estabilidade. A taxa de mudança desenvolvimental em lactentes com e sem PC foi similar. Por volta de 13 meses, o controle de cabeça e a qualidade do alcance foram interrelacionados; ambos se associaram com os escores PMI.
INTERPRETAÇÃO Lactentes com PC mostraram pior qualidade cinemática no alcance e estabilidade da cabeça ao longo da infância, de idades precoces em diante, em comparação com lactentes MAR sem PC. Este resutado implica que cinematicamente, eles não passam a apresentar um déficit, mas exibem déficits desde o início da infância.