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A comparison of the early motor repertoire of very preterm infants and term infants

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ABSTRACT

Objective: To obtain reference data on the early motor repertoire of very preterm infants compared with healthy term infants at three months' post-term age.
Study design: In this observational study, using Prechtl's method on the assessment of the early motor repertoire, we compared the quality of fidgety movements and the concurrent motor optimality score - revised of infants with a gestational age <30 weeks and/or a birth weight <1000 g with healthy infants with a gestational age of 37–42 weeks.
Results: One hundred eighty very preterm and 180 healthy term infants participated. The median motor optimality scores - revised of very preterm infants were significantly lower in comparison to those of term infants, with scores of 24 (25th-75th percentiles: 23–26) and 26 (25th-75th percentiles: 26–28), respectively. Fidgety movements were aberrant (abnormal or absent) more often in very preterm infants than in term infants. The odds ratio was 4.59 (95% CI, 1.51–13.92). Compared with term infants, very preterm infants had poorer scores on the subscales age-adequate movement repertoire, observed postural patterns, and movement character with odds ratios ≥2.97. We found no differences regarding observed movement patterns.
Conclusion: This study provides reference data on the early motor repertoire of very preterm and healthy term infants. It demonstrates that the early motor repertoire of very preterm infants is poorer than that of term infants, a finding consistent with existing knowledge that prematurity increases the risk of poor neurodevelopment.

1. Introduction

The assessment of the early motor repertoire according to Prechtl's method is a widely accepted means of predicting developmental outcome in various types of vulnerable infants [1]. Preterm-born infants are known to be at risk of moderate to severe developmental problems [2]. To date, several studies have been published on the association between the early motor repertoire and developmental outcomes of preterm infants. These have proven the assessment of the early motor repertoire to be a good predictor of motor, cognitive, behavioral, and language outcomes [3–11].

Prechtl's method of assessing infants' early motor repertoire is based on observations of spontaneous movements and postures and reflects their neurological status. At 10–20 weeks post-term age (PTA), fidgety movements (FMs) are part of infants' spontaneous motor repertoire. These FMs are small circular movements which are visible in all joints and can be judged as normal or aberrant (subtypes: abnormal and absent). Together with the evaluation of several subscales, i.e. other qualitative and quantitative movement and postural patterns, a motor optimality score -revised (MOS-R) can be calculated [1,3,12]. Although the quality of FMs is seen as an important predictor of neurodevelopment, the

Abbreviations: GIC, Groningen infant COMPARE (Comparison of Exposure-Effect Pathways to Improve the Assessment of Human Health Risks of Complex Environmental Mixtures of Organohalogens); FMs, fidgety movements; GA, gestational age; IVH, intraventricular hemorrhage; MOS-R, motor optimality score - revised; PVL, periventricular leukomalacia; PTA, post-term age; RENCO, Risk of Endocrine Contaminants on human health.

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more comprehensive MOS-R is being used increasingly for this purpose [7].

Even though the predictive value of the early motor repertoire for development is quite well established, studies on MOS-Rs in large numbers of infants are scarce. To the best of our knowledge only one study has thus far compared MOS-Rs of preterm-born infants to the scores of healthy controls [13]. That study reported that extremely preterm-born infants obtain lower scores on all but one subscale of the early motor repertoire, when compared to healthy term-born controls. Regarding the assessment of FMs, another study reported that in extremely preterm-born and infants with an extremely low birth weight, FMs are more likely to be abnormal or absent than in term-born controls [14]. These findings are in line with preterm infants' risk of developmental problems but should, nevertheless, be confirmed in a larger sample to obtain reference data. The availability of reference data shall enable the assessment of the early motor repertoire to be applied more reliably. The objective of this study is to obtain reference data on MOS-Rs of very preterm-born and healthy term-born infants.

2. Materials and methods

2.1. Participants

Very preterm infants, born between May 2015 and July 2020 and who participated in a longitudinal neurodevelopmental cohort study called NeoLifeS of University Medical Center Groningen in the Netherlands, were included. Criteria for inclusion were a gestational age (GA) of less than 30 weeks and/or a birth weight of less than 1000 g. Exclusion criteria were the presence of a chromosomal or congenital abnormality or an intrauterine infection. The remaining sample can be considered representative for a very preterm born population admitted to a Dutch tertiary neonatal intensive care unit (NICU) with regard to neonatal morbidity and mortality [15,16].

Healthy term-born controls were derived from two cohort studies on environmental influences on the development of healthy term-born children: the Risk of Endocrine Contaminants on Human Health (RENCO) study and the Groningen Infant Comparison of Exposure-Effect Pathways to Improve the Assessment of Human Health Risks of Complex Environmental Mixtures of Organohalogens (COMPARE) study, the GIC study for short [17–19]. Both studies included mothers of the three northern provinces of the Netherlands and their healthy, singleton, term infants (GA, 37–42 weeks). Mothers were invited to participate by their midwifes. The data of the RENCO study were collected between September 1998 and December 2000. The GIC study data were collected between October 2001 and November 2002. Details of the early motor repertoire obtained in both studies have been previously reported [19,20].

All three studies were approved by our local Medical Ethical Committee and written consent was obtained from all parents.

2.2. Video recordings of the early motor repertoire

The infants were videotaped for approximately 10 min at three months PTA (median 12.9 weeks, 25th-75th percentiles: 12–14). During the recording the infants were in active wakefulness (between feedings), partly dressed, and in supine position.

Several certified scorers who were not familiar with the children's clinical and developmental history, assessed the video recordings according to Prechtl's method and classified the infant's fidgety movements (FMs) as normal or aberrant (either abnormal or absent) [1]. Additionally, the infant's MOS-R was determined. The MOS-R comprises five subscales: FMs, observed movement patterns, age-adequate movement repertoire, observed postural patterns, and movement character (Table 2). These subscales were scored according to the manual and given scores of 1, 2, or 4 points, in ascending order of normality. FMs are an exception and scores of 1 (absent), 4 (abnormal), and 12 (normal) are used. The sum results in the MOS-R, which can range from 5 to 28 points, reflecting low to high optimality [3,7,12,21]. We considered a score between 25 and 28 as optimal [10]. For all subscales except FMs, a score of 4 was considered as optimal and a score of $\leq$2 as atypical. In the case of FMs this was divided into normal (12 points) and aberrant (4 points or 1 point).

All recordings (of both very preterm and term infants) were assessed for the purpose of the current study. For all recordings consensus was achieved with the help of a singular assessor (GM trust tutor AFB). Previously, the inter-scorer agreement for the MOS was reported as good with Cohen's Kappa statistics varying from 0.75 to 0.91 [22].

2.3. Statistical analyses

For the statistical analyses we used SPSS Statistics for Windows, Version 23.0 (Armonk, NY: IBM Corp.). Participant characteristics were compared using the independent samples *t*, Mann-Whitney, and chi-square tests. Correlations between MOS-R subscales were determined using Spearman rank correlations. The MOS-R and subscale scores of very preterm and term infants were compared using the Mann-Whitney, chi-square, Fisher-Freeman-Halton, and Fisher's exact tests. The odds ratios for aberrant or atypical features of the MOS-R and its subscales and various demographic and perinatal characteristics were calculated using univariable logistic regression analyses. For a repeated calculation of odds ratios, infants with a severe IVH ($\geq$grade III), PVL ($\geq$grade III), or a cerebellar hemorrhage were excluded.

3. Results

3.1. Participants

A total of 311 infants with a GA of less than 30 weeks and/or a birth weight of less than 1000 g were born between May 2015 and July 2020 at University Medical Center Groningen. Of these infants, three were not eligible for participation in the NeolifeS study because of congenital anomalies and 43 infants died before reaching the age appropriate for a video recording. Thirty-three infants were not invited to participate on account of language barriers (n = 28), a complex social situation (n = 1), or logistics problems (n = 4). The parents of 50 infants withheld consent. The video recordings of two infants were excluded from analysis because the infant was not in the required behavioral state of wakefulness during the videotaping. Finally, we could include 180 infants.

The parents of 104 healthy term infants responded to the invitation to participate in the RENCO cohort and gave their informed consent. Two infants were not videotaped for logistic reasons. The recordings of two other infants were too short to be assessed. We were able to include 100 infants from this cohort for our study.

For the COMPARE cohort, the parents of 90 healthy term infants volunteered for participation and gave their consent. Of these infants, nine were excluded for logistic reasons. Another infant was excluded due to severe developmental delay. Finally, we included 80 infants from this cohort in our study. A total of 180 healthy term-born infants from the RENCO and COMPARE cohorts served as controls.

All clinical characteristics are presented in Table 1. The very preterm infants had lower Apgar scores than the term infants. No

Table 1
Participant characteristics.

	Very preterm infants n = 180	Term infants n = 180
Boys, n (%)	104 (50.7)	102 (49.5)
Gemelli, n (%)	51 (28.3)	0 (0)
Gestational age (weeks), mean ± SD	**27.9 ± 1.5**	**40.1 ± 1.2*****
Birth weight (g), mean ± SD	**1079 ± 278**	**3641 ± 510*****
<10th percentile, n (%)	19 (10.6)	0 (0)
Apgar 5 min, median (25th-75th percentiles)	**8 (7–8)**	**10 (10–10)*****
Antenatal steroids, n (%)	117 (65)	0 (0)
Periventricular leukomalacia, n (%)[a]		
Grade I	109 (60.6)	0 (0)
Grade II	1 (0.6)	0 (0)
Grade III	1 (0.6)	0 (0)
Grade IV	0 (0)	0 (0)
Intraventricular hemorrhage, n (%)[b]		
Grade I	47 (26.1)	0 (0)
Grade II	12 (6.7)	0 (0)
Grade III	4 (2.2)	0 (0)
Grade IV	5 (2.8)	0 (0)
Cerebellar hemorrhage, n (%)	1 (0.6)	0 (0)
Ventilatory support (days), median (25th-75th percentiles)	2.5 (0–10)	0 (0)
Bronchopulmonary dysplasia, n (%)[c]	57 (31.7)	0 (0)
Postnatal steroids, n (%)	21 (11.7)	0 (0)
Treated patent ductus arteriosus, n (%)[d]	67 (37.3)	0 (0)
Necrotizing enterocolitis ≥ Bell stage 2A, n (%)	15 (8.4)	0 (0)
Single intestinal perforation, n (%)	6 (3.3)	0 (0)
Sepsis, n (%)[e]	59 (32.8)	0 (0)
Retinopathy of prematurity ≥ grade III, n (%)	4 (2.2)	0 (0)
Age at recording (weeks), mean ± SD	**12.4 ± 0.9**	**13.6 ± 1.7*****

The statistical tests used were independent samples *t*, Mann-Whitney, and chi-square tests.
[a] is according to the classification of De Vries et al. [28].
[b] is according to the classification of Papile et al. [29].
[c] is mild or moderate.
[d] is ibuprofen or surgical clip.
[e] is confirmed with positive blood culture. The *** signifies $P \leq .001$.

Table 2
Motor Optimality Scores and subscales in very preterm and term infants.

	Very preterm infants n = 180	Term infants n = 180	*P* values
Motor Optimality Score, median (25th-75th percentiles)	**24 (23–26)**	**26 (26–28)**	<.001***
Fidgety movements, n (%)			
Normal (12)	**163 (90.6)**	**176 (97.8)**	.006**
Abnormal (4)	9 (5)	3 (1.7)	.14
Absent (1)	**8 (4.4)**	**1 (0.6)**	.037*
Observed movement patterns, n (%)			
Normal > Abnormal (4)	174 (96.7)	176 (97.8)	.75
Normal = Abnormal (2)	2 (1.1)	3 (1.7)	.10
Normal < Abnormal (1)	4 (2.2)	1 (0.6)	.37
Age-adequate movement repertoire, n (%)			
Present (4)	**84 (46.7)**	**130 (72.2)**	<.001***
Reduced (2)	**73 (40.6)**	**36 (20.0)**	<.001***
Absent (1)	23 (12.8)	14 (7.8)	.12
Observed postural patterns, n (%)			
Normal > Abnormal (4)	**119 (66.1)**	**161 (89.4)**	<.001***
Normal = Abnormal (2)	23 (12.8)	14 (7.8)	.12
Normal < Abnormal (1)	**38 (21.1)**	**5 (2.8)**	<.001***
Movement character, n (%)			
Smooth and fluent (4)	**28 (15.6)**	**94 (52.2)**	<.001***
Abnormal, not cramped-synchronized (2)	**152 (84.4)**	**86 (47.8)**	<.001***
Cramped-synchronized (1)	0 (0)	0 (0)	

Scores for all subscale levels are presented (…). The statistical tests used were Mann-Whitney, chi-square, Fisher-Freeman Halton, and Fisher exact tests. The * signifies $P \leq .05$, ** signifies $P \leq .01$, and *** signifies $P \leq .001$.

clinical conditions such as sepsis were present in the term-born control group. The very preterm infants were 1.2 weeks younger at the time of videotaping than the term-born controls.

3.2. Motor repertoire in infancy

The scores on the MOS-R and its subscales at the PTA of three months for both very preterm and term infants are presented in Table 2. Most subscales correlated significantly with each other (Table 3). The very preterm infants had significantly lower MOS-Rs than the term infants (Fig. 1 and Table 2) and obtained significantly poorer scores on the following subscales: fidgety movements, age-adequate movement repertoire, observed postural patterns, and movement character, but not for observed movement patterns. The odds ratio of having aberrant FMs was 4.59 (95% CI, 1.51–13.92, *P* .007) for very preterm infants in comparison to term infants. More

Table 3
Correlation coefficients between the subscales of the early motor repertoire of very preterm infants and term infants.

n = 360	Observed movement patterns	Age-adequate movement repertoire	Observed postural patterns	Movement character
Fidgety movements	.25***	.26***	.21***	.18***
Observed movement patterns	–	.29***	.044	.12*
Age-adequate movement repertoire	–	–	.21***	.32***
Observed postural patterns	–	–	–	.25***

Correlations were calculated using Spearman rank correlation. The # signifies $P \leq .1$, ** signifies $P \leq .01$, and *** signifies $P \leq .001$.

Table 4
Relation between aberrant or atypical features of the total MOS-R and its subdomains and various demographic and perinatal characteristics, presented as odds ratios, including 95% confidence intervals.

	Fidgety movements *Aberrant vs normal*	Observed movement patterns *Atypical vs optimal*	Age-adequate movement repertoire *Atypical vs optimal*	Observed postural patterns *Atypical vs optimal*	Movement character *Atypical vs optimal*	MOS-R *<24 vs 25-28*
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Preterm vs term group	**4.59 (1.51–13.92)****	1.52 (0.42–5.47)	**2.97 (1.92–4.61)*****	**4.34 (2.46–7.66)*****	**5.93 (3.61–9.76)*****	**5.64 (3.57–8.91)*****
Preterm vs term group, adjusted for recording age	**4.29 (1.30–14.15)***	1.06 (0.29–3.91)	**4.42 (2.62–7.45)*****	**3.18 (1.76–5.74)*****	**4.73 (2.78–8.05)*****	**5.43 (3.30–8.95)*****
Preterm vs term group, no severe IVH[a]/PVL[a]/ cerebellar hemorrhage	**3.69 (1.18–11.55)***	1.35 (0.36–5.11)	**2.86 (1.83–4.46)*****	**3.91 (2.20–6.95)*****	**5.71 (3.45–9.46)*****	**5.31 (3.34–8.44)*****
Male sex	1.23 (0.50–3.04)	1.77 (0.45–6.96)	1.23 (0.81–1.89)	1.16 (0.70–1.92)	1.28 (0.82–1.98)	1.30 (0.85–1.98)
Socio-economic status (low vs high)	0.98 (0.28–3.49)	4.03 (0.44–36.6)	1.14 (0.66–1.98)	1.46 (0.71–2.99)	0.93 (0.56–1.55)	1.24 (0.71–2.14)
For preterm infants only						
Gestational age (per week lower)	1.12 (0.81–1.54)	0.98 (0.57–1.66)	0.97 (0.80–1.17)	0.97 (0.79–1.18)	0.98 (0.75–1.27)	0.98 (0.81–1.20)
Apgar score (per point lower)	1.34 (0.98–1.83)	0.88 (0.47–1.65)	1.02 (0.83–1.26)	1.03 (0.83–1.29)	0.90 (0.68–1.18)	0.99 (0.80–1.23)
SGA (birth weight 10th percentile)	1.15 (0.24–5.44)	4.62 (0.79–27.1)	1.23 (0.47–3.22)	0.67 (0.23–1.96)	1.64 (0.36–7.52)	0.97 (0.36–2.59)
Gemelli	0.51 (0.14–1.87)	0.50 (0.06–4.35)	1.36 (0.71–2.63)	0.97 (0.49–1.92)	0.99 (0.40–2.41)	0.93 (0.48–1.83)
No antenatal steroids	1.34 (0.48–3.70)	**10.0 (1.14–87.6)***	**1.89 (1.01–3.55)***	1.07 (0.56–2.05)	**3.81 (1.26–11.5)***	1.88 (0.97–3.67)
Days on ventilator (per day)	1.02 (0.99–1.05)	1.03 (0.99–1.07)	0.88 (0.98–1.02)	0.99 (0.97–1.02)	1.00 (0.97–1.03)	0.99 (0.96–1.01)
Postnatal steroids	2.64 (0.77–9.02)	NA	0.62 (0.25–1.56)	0.42 (0.14–1.31)	0.54 (0.18–1.62)	**0.38 (0.15–0.95)***
Bronchopulmonary dysplasia	2.70 (0.98–7.40)	1.08 (0.19–6.09)	1.06 (0.57–2.00)	0.76 (0.39–1.50)	1.19 (0.49–2.89)	0.69 (0.36–1.31)
PDA requiring treatment	0.91 (0.32–2.59)	0.33 (0.04–2.86)	0.70 (0.38–1.28)	0.93 (0.49–1.76)	1.30 (0.55–3.07)	0.75 (0.40–1.40)
Severe IVH or PVL[a] or cerebellar hemorrhage	**5.96 (1.58–22.47)****	2.96 (0.32–27.6)	1.82 (0.53–6.27)	**4.34 (1.25–15.0)***	2.11 (0.26–17.0)	3.00 (0.64–14.1)
NEC (Bell's stage ≥ 2A) or SIP	1.01 (0.21–4.77)	NA	0.62 (0.25–1.56)	1.54 (0.61–3.89)	4.09 (0.53–31.8)	0.91 (0.36–1.53)
NEC requiring surgery	2.28 (0.45–11.45)	NA	0.48 (0.14–1.70)	0.72 (0.18–2.81)	NA	0.45 (0.13–1.53)
Sepsis (blood culture proven)	0.84 (0.28–2.51)	0.40 (0.05–3.50)	1.43 (0.76–2.69)	1.12 (0.58–2.15)	1.96 (0.75–5.14)	1.16 (0.60–2.22)

*$P < .05$; **$P < .01$; ***$P \leq .001$.
Abbreviations: OR, odds ratio; CI, confidence interval; vs, versus; IVH, Intraventricular hemorrhage; PVL, periventricular leukomalacia; SGA, small-for-gestational age; MOS-R, motor optimality score, revised; PDA, persistent ductus arteriosus; NEC, Necrotizing enterocolitis; SIP, single intestinal perforation; NA, not applicable, 0 in one of the cells. [a], ≥ grade III.

specifically, the odds ratio of having absent FMs was 8.33 (95% CI, 1.03–67.27, *P* .047) for very preterm infants in comparison to term infants. The aforementioned odds ratios and those for atypical features of the total MOS-R and other subscales, based on various demographic and perinatal characteristics, are presented in Table 4. These odds ratios remained significant after correction for the age at video recording. In addition, odds ratios for the MOS-R and subscales for preterm-born infants only, based on several perinatal characteristics, are presented in Table 4. The quality of FMs for infants with cerebral pathology identified through repeated cerebral ultrasound and magnetic resonance imaging was studied in detail. Of two infants with periventricular leukomalacia (PVL) grade II or III (1.1% of all 180 very preterm infants), one had normal FMs and in one FMs were absent. None of the infants were diagnosed with PVL grade IV. Nine infants were diagnosed with an intraventricular hemorrhage (IVH) grade III or IV (5.0% of very preterm infants), which was bilateral in three infants. The FMs of infants with a bilateral IVH were normal. Of the six infants with a unilateral IVH, two had normal FMs, one had abnormal FMs, and in three infants FMs were absent. Asymmetrical segmental movements of fingers and wrists were not seen in any of these nine infants. One infant had a cerebellar hemorrhage (0.6% of very preterm infants) and had

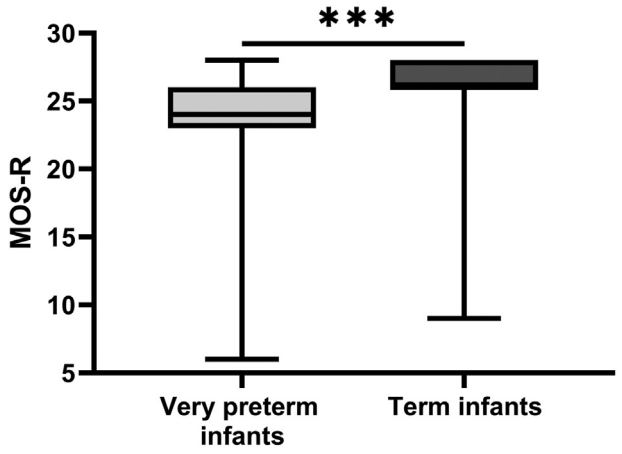

Fig. 1. Motor optimality scores - revised of very preterm infants and term infants. Box and whisker plots depicting the motor optimality scores - revised of very preterm and term infants at the age of three months' post-term. MOS-R, motor optimality score – revised. The *** signifies $P \leq .001$.

normal FMs. When comparing the early motor repertoires of very preterm and term infants, odds ratios for aberrant or atypical features of the MOS-R remained significant after exclusion of infants with severe IVH, PVL, or cerebellar hemorrhage.

4. Discussion

In this study we examined the scores on detailed aspects of the early motor repertoire in a relatively large sample of very preterm and healthy term-born infants. The main finding was that the MOS-R of very preterm infants was significantly lower compared with term infants. Furthermore, FMs were more often aberrant in very preterm infants. With the exception of observed movement patterns, the scores on all other subscales were poorer in very preterm infants.

Most importantly, the MOS-Rs of our very preterm infants were considerably lower compared with the MOS-Rs of term controls, with median scores of 24 (25th-75th percentiles: 23–26) and 26 (25th-75th percentiles: 26–28), respectively. By comparison, Fjørtoft et al. reported a median MOS of 26 points (25th-75th percentiles: 23–28) in 82 extremely preterm infants [13]. When comparing our scores on subscales that determine the MOS-R to those of Fjørtoft et al., the scores on observed movement patterns seem comparable. Differences that might explain the lower median MOS-R in our group of very preterm infants are: 1) lower frequency of an age-adequate movement repertoire, 2) lower numbers of normal postural patterns, and 3) lower frequency of a normal movement character in our group. Nevertheless, FMs were aberrant more often in the group of Fjørtoft et al. Of note, Fjørtoft et al. used a previous version of the MOS which was the most up-to-date version at the time of their publication. This may have led to subtle differences in how the MOS was determined, because over time the manual has been amended slightly. The subscale that may have been most subject to change is the subscale age-adequacy movement repertoire. Previously, the score on this scale was based on the number of concurrent movement patterns, whereas currently the achievement of age-related milestones such as hand-hand contact determines the score [7,12,21]. We do, however, believe that these differences are subtle and that the scores should be comparable. It is important to note that their group of extremely preterm infants of less than 28 weeks' GA and our group of very preterm infants of less than 30 weeks' GA may not be entirely comparable as the level of neurocognitive performance is inversely related to GA at birth [23]. In the Netherlands active treatment of preterm infants born before 24 weeks' GA is limited. In their study, Fjørtoft et al. found a median MOS of 28 (25th-75th percentiles: 28-28) in 87 healthy term controls. In another study, Fjørtoft et al. included a healthy term control group that also had a median MOS of 28 (25th-75th percentiles: 28-28) [24]. We consider our scores to be representative given that variation in neurodevelopmental performance occurs within the normal population [25]. Furthermore, a MOS(-R) of equal to or more than 25 points can be considered optimal [21].

In 4.5% of very preterm infants FMs, which are considered an important predictive subscale of the MOS-R, were absent. This percentage is rather low, compared to findings of Fjørtoft et al., who reported that FMs were absent in 19% of extremely preterm infants [13]. As mentioned before, our groups may not be entirely comparable. Yet, with a prevalence of 4.5% of absent FMs, together with the prevalence of abnormal FMs (5%), the odds ratio for having aberrant FMs is 4.59 for very preterm infants compared with term infants. This is also rather low compared with another study in 155 extremely preterm Australian infants. It reported an odds ratio of 8.5 (95% CI, 3.48–20.8) for aberrant FMs [14]. Once again, since we studied an older group in a different country, this may have influenced the prevalence of aberrant FMs in our cohort. For instance, in the Australian study infants diagnosed with congenital or genetic abnormalities were not excluded [14].

The very preterm infants obtained poorer scores on several subscales compared with term controls with odds ratios $\geq$2.97. We observed an age-adequate movement repertoire, which is based on the achievement of particular milestones such as antigravity movements, less often. Furthermore, subnormal postural patterns were seen, and the overall movement character was scored as smooth and fluent less often. We found no differences on the normality of observed movement patterns, which is in line with the findings of Fjørtoft et al. [13] The number of infants in whom the quantity of abnormal movement patterns was equal to or larger than normal movement patterns was very low in both groups. These findings suggest that movement patterns such as swipes and kicking are rarely affected and thus rarely scored as abnormal in both term and very preterm infants.

The most obvious explanation for our findings is the difference in GA at birth between the two groups and thereby the risk of neurological consequences. In our study, as we expected, the prevalence of aberrant FMs was higher amongst very preterm infants with PVL and IVH compared with very preterm infants without these abnormalities. Please note that out of the nine cases with IVH grade III/IV, five had normal FMs. One might find these findings surprising. Nevertheless, two studies reported that 34%–49% of preterm infants with an IVH of such a degree will not develop cerebral palsy [27,28], and thus they may have normal FMs. Furthermore, Einspieler et al. reported that in infants who later develop cerebral palsy, a low MOS is predictive of the level on the Gross Motor Function Classification System, even if FMs are found to be normal [7]. Still, we expected the presence of PVL, IVH, or cerebellar hemorrhage in some of the very preterm infants to be partly responsible for the lower scores obtained by the very preterm infants. However, after excluding these infants, odds ratios for lower scores in very preterm infants remained significant. Additional analyses revealed that the presence of other singular perinatal risk factors such as necrotizing enterocolitis or bronchopulmonary dysplasia were not directly related to scores on the MOS-R and its subscales. Thus, we believe that the total sum of risk factors related to very preterm birth and not specific severe cerebral abnormalities, are responsible for the poorer early motor repertoire represented by lower MOS-Rs.

Kwong et al. mentioned another interesting point that could

partly explain our findings and could be considered in future studies. In a longitudinal study on the FMs of extremely preterm infants who were studied from 12 to 17 weeks' PTA, they reported that the number of infants with aberrant FMs decreased with each week of increasing age [14]. This finding suggests that despite correction for preterm birth, the development of FMs in these infants may be delayed. Thus, due to assessing FMs in our very preterm infants at a median PTA of 12 weeks, we may have missed information on possible normalization of aberrant FMs later on. To prevent this from happening in clinical practice, it is recommended nowadays to repeat the assessment after one or two weeks in case aberrant FMs were seen. Still, in our current study, repeated statistical analyses with correction for the age at video recording rendered comparable findings.

We acknowledge several strengths and limitations to this study. One of the strengths is the relatively large sample of both very preterm and term infants. Another study of approximately the same sample size was performed in 155 extremely preterm and 185 term infants. In that case, however, only the types of FMs and not the MOS(-R) and its other subscales were studied [14]. Fjørtoft et al. did report on the complete MOS of extremely preterm infants, but in a smaller sample of 82 extremely preterm infants and 87 term controls [13]. Another strength is that all videos, of both term and very preterm infants, were scored according to the most recent version of the assessment of the early motor repertoire, using the MOS-R. Furthermore, in all cases consensus was achieved with the help of a single assessor.

We also recognize some limitations to our study. Our study was conducted at a single NICU, however baseline data for mortality and morbidity are comparable to those of other Dutch NICUs. [15,16], Another limitation is that the assessors were not blinded for GA at birth. Even though the original cohorts were not set-up to compare very preterm infants with term infants, the assessors were blinded to all clinical information except that they knew the study group to which the infant belonged.

To conclude, this study provides insight into the prevalence of aspects of the early motor repertoire in both very preterm and healthy term infants. The most important finding is that very preterm infants have lower MOS-Rs compared with term infants. Furthermore, they have a greater risk of aberrant FMs and score consistently lower on other subscales of the early motor repertoire, except for the normality of observed movement patterns. The results of our study can be used as reference data for future studies on the early motor repertoire.

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Declaration of competing interest

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