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GMA can be successfully implemented in a non-academic outpatient setting. In our clinical routine scenario, GMA allowed for adequate prediction of neurodevelopment in infants born preterm, thereby allaying concerns about diagnostic accuracy in non-academic settings.

What this paper adds

For nearly a decade, the assessment of general movements (GM) at 3 months' corrected age has been well recognised as a clinical, non-invasive method to predict neurodevelopment and cerebral palsy (CP) in infants born preterm. Yet GM assessment (GMA) tends to be used in academic contexts rather than in non-academic out-patient centres, which in contrast see the majority of infants born preterm for follow-up. This could be because the organisational effort behind GMA is perceived as high for a relatively small group of patients. Moreover, the implementation of GMA in non-academic settings has

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Table 1
Lessons learned during one-year implementation period of general movement assessment (GMA) in non-academic settings.

Barrier category	Barrier to implementation	Problem description	Solutions/tips to overcome barrier
Common to implementation of new diagnostic tools using videotaping	Organising infant appointments at 1 and 3 months	33% of appointments too late	€ Training of staff, including importance of timely GMA € Integration of videotapes into physiotherapy appointments on infant handling, which appeared attractive for parents
	Implementing videotaping and GM video assessment into the daily routine	€ 33% of videos not transferred to server € videotaping not performed on all appointments	€ Two video cameras at central and easily accessible location € Fixed rules for labelling adopted € Shifting responsibility of video storage and labelling from medical doctors to physiotherapists € Physiotherapists also responsible for documenting GM rating results in a common document
	Video archiving according to the medical data protection law	German law demands archiving of video data for at least ten years	€ Implementation of a separate terabyte hard disc, an automatic 24 h short storage system € a long-term archive protected by a “rewall
	Getting informed consent of parents for videotaping and storage	Parents initially were not convinced about value of GMA	Information on GMA as € reliable indicator of the infant•s neurological condition € indicating whether the infant needs early intervention or not
Speci“c for GMA	Obtaining technically adequate video recordings of GMA	15% of video recordings inadequate (infant	

are subdivided into mildly abnormal GM, which are characterised by insuf“cient variation and complexity, and de“nitely abnormal GM, which are virtually devoid of variation and complexity. De“nitely abnormal GM are frequently also associated with absence of “dgety movements (Hamer et al., 2011). Mildly abnormal GM are considered to re”ect a normal, but non-optimal function of the nervous system. They are only weakly associated with adverse developmental outcome (Hadders-Algra,

- Parents declined GM assess

Table 2
Description of •clinical routine scenarioŽ analysis sample characteristics according to GM status at 3 months (or 1 month, when 3 months were not available).

	Total sample	GM quality normal	GM quality mildly abnormal	GM quality de“nitely abnormal	P-value
N[a]	122	16	74	32	
N per GM group in%		13.1%	60.7%	26.2%	
Mean birth weight [g] (SD)	1171 (366)	1279 (375)	1179 (367)	1101 (356)	0.35[b]
Gestation [weeks + days]	28.4 + 3.7	29.5 + 3.1	28.4 +4s B 668.9108 Tm (N)Tj ET /GS1 gs BT 4.4633 0 0 4.4633 89.8239		

Table 3b
Odds ratios for the association between GM assessment at 1 or 3 months (•clinical routine scenarioŽ) and atypical neurological outcome at 2 years of age from logistic regression.

Logistic regression		1 OR raw (95%CI)	2 Adjusted for ROP OR adj $_{ROP}$ (95%CI)	3 Adjusted for IVH OR adj $_{IVH}$ (95%CI)	4 Adjusted for PVL OR adj $_{PVL}$ (95%CI)	5 Adjusted for NEC OR adj $_{NEC}$ (95%CI)
	GM de“nitely abnormal	**13.2 (1.56;112.5)**	**10.05 (1.14;88.55)**	**11.6 (1.34;99.8)**	**9.53 (1.1;84.1)**	**10.95 (1.24;96.95)**
	GM mildly abnormal	2.6 (0.31;21.89)	2.1 (0.24;17.87)	2.2 (0.25;18.38)	2.6 (0.30;21.58)	2.7 (0.24;6.87)
	Constant	0.07 (0.01;0.50)	0.1 (0.01;0.8)	0.08 (0.01;0.64)	0.1 (0.012;0.7)	0.08 (0.009;0.67)
	Variance explained (PseudoR)	11.7%	14.69%	18.9%	8.0%	14.2%

Column 1 represents raw odds ratios, columns 2…5present odds ratios adjusted to the presence of ROP,IVH, PVL and NEC.
Abbreviations : PVL (periventricular leucomalicia), ROP(retinopathy of prematurity), NEC (necrotising enterocolitis), IVH (intraventricular haemorrhage), MDI (mental developmental index, PDI (psychomotor developmental index. Bold values indicate statistically signi“cant differences.

Table 4
Predictive properties of GM quality at 1 or 3 months for atypical neurological outcome and CP at 2 years.

	Atypical neurological outcome		CP	
	Presence of mildly or de“nitely abnormal GM	Presence of de“nitely abnormal GM at 1 or 3 months	Presence of de“nitely abnormal GM	Presence of de“nitely abnormal GM at 3 months only
Sensitivity (95% CI)	96.3% (81;99.9)	55.6% (35.3;74.5)	85.7% (42.1; 99.6)	100% (54.1; 100)
Speci“city (95% CI)	15.8% (9.12;24.7)	82.1% (72.9;89.2)	77% (68.1;84.4)	77.6 (68; 85.4)
Positive predictive value (95% CI)	24.5% (16.7;33.8)	46.9% (29.1;65.3)	18.8% (7.21;36.4)	21.4% (8.3; 41)
Negative predictive value (95% CI)	93.8% (69.8;99.8)	86.7% (77.9;92.9)	98.9% (93.8; 100)	100% (95.3; 100)
Accuracy (correct classi“cation rate)	33.6%	76.2%	77.5%	78.8%

than infants with normal GM (Table 3b). The latter association was still relevant and signi“cant when adjusting for medical history parameters such as ROP,IVH, PVL and NEC (Table 3b).

Only 18.8% of children with de“nitely abnormal GM in our •clinical routine scenarioŽ were diagnosed with CP,implying a sensitivity of de“nitely abnormal GMA for CP of 85.7% (Table 4). Sensitivity of de“nitely abnormal GMA at 1 or 3 months• CA for atypical neurological outcome was 55.6%, while speci“city and negative predictive values were 82.1% and 86.7%, respectively. Further diagnostic test criteria for the presence of either mildly or de“nitely abnormal GM can be found in Table 4

When comparing tools to predict developmental outcome at an early age, predictive accuracy, costs, risks and resources should be taken into account. MRI scans and cranial ultrasound exams are costly and time-consuming, in addition to requiring the attention of experts and occasionally anaesthesia (Malec, Sidonio, Smith, & Cooper, 2014). A neurological assessment at term also necessitates a specially trained and experienced neonatologist or neuropaediatrician. In contrast, the totally non-invasive GM videotaping and assessment may be performed by trained physiotherapists in less than 20 min per infant.

Simultaneously, we showed that this practical method was highly predictive for later neurodevelopmental outcomes: Besides a 100% sensitivity for CP (Table 4, GMA at 3 months), our clinical routine scenario showed that definitely abnormal GM were associated with substantially lower MDI and PDI and a largely increased odds of atypical neurological outcome at two years of age, irrespective of

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