Title
Reliability of the Motor Optimality Score-Revised: A study of infants at elevated likelihood for adverse neurological outcomes

Journal
Acta Paediatrica, 112(6)

ISSN
0803-5253

Authors
Örtqvist, Maria
Marschik, Peter B
Toldo, Moreno
et al.

Publication Date
2023-06-01

DOI
10.1111/apa.16747

Peer reviewed

HHS Public Access
Author manuscript
Acta Paediatr. Author manuscript; available in PMC 2023 June 01.

Published in final edited form as:
Acta Paediatr. 2023 June ; 112(6): 1259–1265. doi:10.1111/apa.16747.

Reliability of the Motor Optimality Score-Revised: A study of infants at elevated likelihood for adverse neurological outcomes

Maria Örtqvist[1,2], **Peter B. Marschik**[3,4,5], **Moreno Toldo**[6], **Dajie Zhang**[3,4], **Viviana Fajardo-Martinez**[7], **Karin Nielsen-Saines**[7], **Ulrika Ådén**[1,8,9], **Christa Einspieler**[4]

[1]Department of Women's and Children's Health, Neonatal research unit, Karolinska Institutet, Stockholm, Sweden

[2]Functional Area Occupational Therapy & Physiotherapy, Allied Health Professionals Function, Karolinska University Hospital, Stockholm, Sweden

[3]Department of Child and Adolescent Psychiatry and Psychotherapy, SEE—Systemic Ethology and Developmental Science, University Medical Center Goettingen and Leibniz ScienceCampus Primate Cognition, Goettingen, Germany

[4]iDN—Interdisciplinary Developmental Neuroscience, Division of Phoniatrics, Medical University of Graz, Graz, Austria

[5]Center of Neurodevelopmental Disorders (KIND), Center for Psychiatry Research, Department of Women's and Children's Health, Karolinska Institutet & Child and Adolescent Psychiatry, Stockholm Health Care Services, Stockholm County Council, Stockholm, Sweden

[6]Department of Medical Rehabilitation, Kiran Society for Rehabilitation and Education of Children with Disabilities, Varanasi, India

[7]Department of Pediatrics, David Geffen School of Medicine, University of California, California, Los Angeles, USA

[8]Linköping University, Linköping, Sweden

[9]Crown Princess Victoria's Children's and Youth Hospital, University Hospital, Linköping, Sweden

Abstract

Aim: To assess the inter-assessor reliability of the Motor Optimality Score-Revised (MOS-R) when used in infants at elevated likelihood for adverse neurological outcome.

Methods: MOS-R were assessed in three groups of infants by two assessors/cohort. Infants were recruited from longitudinal projects in Sweden (infants born extremely preterm), India

Correspondence: Maria Örtqvist, Neonatal research unit, Department of Women's and Children's health, Karolinska Institutet, Stockholm 171 76, Sweden. maria.ortqvist@ki.se.

CONFLICT OF INTEREST STATEMENT
The authors declare the following financial interests/personal relationships, which may be considered as potential competing interests: Professor Christa Einspieler is a member and licensed tutor of the General Movements Trust; Professor Peter B Marschik is president of the General Movements Trust. The other authors have no conflicts to declare.

(infants born in low-resource communities) and the USA (infants prenatally exposed to SARS-CoV-2). Intraclass correlation coefficients (ICC) and kappa (κw) were applied. ICC of MOS-R subcategories and total scores were presented for cohorts together and separately and for age-spans: 9–12, 13–16 and 17–25-weeks post-term age.

Results: 252 infants were included (born extremely preterm *n* = 97, born in low-resource communities *n* = 97, prenatally SARS-CoV-2 exposed *n* = 58). Reliability of the total MOS-R was almost perfect (ICC: 0.98–0.99) for all cohorts, together and separately. Similar result was found for age-spans (ICC: 0.98–0.99). Substantial to perfect reliability was shown for the MOS-R subcategories (κw: 0.67–1.00), with *postural patterns* showing the lowest value 0.67.

Conclusion: The MOS-R can be used in high-risk populations with substantial to perfect reliability, both in regards of total/subcategory scores as well as in different age groups. However, the subcategory *postural patterns* as well as the clinical applicability of the MOS-R needs further study.

Keywords

general movement assessment; high-risk infants; motor optimality score-revised; preterm birth; reliability; Sars-CoV-2

1 | INTRODUCTION

Early identification of neurodevelopmental impairments in vulnerable infant populations remains challenging but is crucial for implementation of early interventions to improve outcomes. Today the Prechtl General Movements Assessment (GMA) is applied both in clinical and research settings for evaluation of infants with varying medical backgrounds, particularly high-risk infants born preterm and/or with brain injury, as well as those with genetic and metabolic diseases.[1–5] In the guidelines for early detection of infants at high risk for cerebral palsy (CP) (<5 months of age), Novak et al.[6] recommend that high-risk infants be assessed via GMA in combination with brain imaging and the Hammersmith Infant Neurological Examination. The most predictive period to assess general movements (GMs) is between 9–20 weeks post-term age, the so-called fidgety movement period.[7,8] In recent years it has been shown that apart from the absence of fidgety movements, the quantity and quality of other observed movement patterns also add important information about severity of impairment.[7,9] Equally important, it has been shown that the presence of normal fidgety movements is not a guarantee for normal development, especially when it comes to non-CP outcomes.[9] To handle this, a more detailed additional assessment of an infant's motor repertoire during this period, describing the quantity and quality of observed movement patterns can be performed by applying the Motor Optimality Score (MOS).[7,10] A reduced MOS has shown to be associated with a wide variety of different medical conditions such as preterm birth,[11] CP (including type and severity),[7,12] gross and fine motor development,[13] risk of minor neurological dysfunction,[14] language impairments,[15,16] cognitive impairments,[17,18] cystic fibrosis,[19] Prader-Willi Syndrome,[5] and Down Syndrome.[4] Infants born extremely preterm have shown greater deviating movements and postural patterns compared to infants born at term.[20,21]

The MOS was developed by Prechtl, Einspieler and Bos[10] and was recently revised (MOS-R).[7] The MOS-R is based on five different subcategories; (i) temporal organisation of fidgety movements, (ii) observed movement patterns (other than fidgety movements), (iii) age-adequate movement repertoire, (iv) observed postural patterns and (v) movement character. Unlike the MOS, the revised version (MOS-R) provides a detailed description of normal and atypical movement patterns to be scored, and criteria how to score the age-adequacy of the motor repertoire. Moreover, four movement patterns of the original version[10] have been deleted (saccadic arm movements, hand-to-face contact, cha-cha-cha movements and hand-to-knee contact) whereas hand-to-toe contact has been added and the variability of finger postures now includes asymmetry.

Similarly, to many other developmental assessment methods, the MOS-R is built upon pattern recognition; therefore, inter-assessor reliability evaluation is crucial when the tool is employed across different populations.

Inter-assessor reliability of the original version of the MOS has previously shown to be high when used in different populations (intraclass correlation coefficient (ICC): 0.80–0.98,[13,22,23] κw: 0.87–0.91).[14] A few studies have also presented inter-assessor reliability data for the total MOS-R (ICC: 0.86–0.96).[22,24,25] Details regarding reliability across different subcategories, however, and whether its use at different age-spans influences assessor agreement are less known.

The main aim of this study was, therefore, to evaluate the inter-assessor reliability values of the MOS-R at 3–5 months corrected age, total and subcategory scores, when used in a large cohort of three independent high-risk infant populations. Participants had an elevated likelihood for adverse neurological outcomes and were filmed for the MOS-R assessments in different settings. An additional aim was to evaluate if the inter-assessor reliability differed when assessing infants at different age-spans.

2 | METHODS

2.1 | Participants

The following infant subsets were included: (1) 97 infants born extremely preterm (EPT) from a cohort of an on-going large randomised clinical trial in the Stockholm Preterm Interaction-Based Intervention (SPIBI).[26] The SPIBI recruits infants born EPT (GA<28 weeks) from neonatal units in Stockholm, Sweden. Infants from both the intervention and control group with complete MOS-R data at 3 months corrected age were included in analyses for the purpose of this study. (2) 97 infants from an on-going project of the General Movement Assessment in Neonates for Early Identification and Intervention, Social Support and Health Awareness (G.A.N.E.S.H.) project.[27] The G.A.N.E.S.H. project is a 3-year observational cohort study comprising 2000 infants born across four rural districts of Uttar Pradesh, India, low-resource communities with a high prevalence of maternal and infant malnutrition. The included infants were selected in subsequent order and matched to the recording age of the EPT group. (3) 58 infants from a longitudinal on-going study at a single tertiary care centre in Los Angeles, California, USA, prenatally exposed to SARS-CoV-2 during pregnancy between March 2020 to November 2021.[28] All participant demographic and clinical characteristics from included participants in the different cohorts are presented in Table 1.

2.2 | Design

Fidgety movements, other observed movement and postural patterns were assessed in detail using the MOS-R in all three cohorts. All assessors were blinded to medical histories and later neurodevelopmental outcomes. Prior to the assessment, the definitions used for specific MOS-R items were thoroughly discussed.

All infants born EPT from the SPIBI cohort were recorded at a single occasion using a camera with tripod in a home setting by an experienced physiotherapist, in line with the GMA procedure.[10] Assessment of the recordings were performed separately by two certified and experienced assessors (CE and MÖ); but in the same room on October 2021. CE is a licensed tutor of the GM Trust and inventor of the MOS-R and MÖ is a certified advanced assessor in using the Prechtl GMA both in clinical and research settings.

In the low-resource setting cohort from the G.A.N.E.S.H. project, GMA-certified community health workers, video recorded all participating infants at 3–5 months of age. Infants were recorded using smartphones in the parents' home, in health camps or in primary health centers.[27] Assessment of the MOS-R were performed independently during the period of January 2020 to December 2021 by two experienced assessors (CE and MT). MT is a neurologist and certified advanced assessor with great experience assessing MOS-R.

The third subset of infants prenatally exposed to SARS-CoV-2 were recorded using smartphones and videotaped for 2 to 3 min in their home setting or during a clinic visit at 3 to 5 months of age. MOS-R assessments were performed by two certified advanced assessors (CE and DZ) independently during a two-month period (November 2021 to December 2021). DZ is an experienced assessor and performs GMA analyses regularly in different research settings.

2.3 | Motor optimality score—revised (MOS-R)

The MOS-R is based on five subcategories: (i) temporal organisation of fidgety movements (maximum 12 points); (ii) observed movement patterns (other than fidgety movements; maximum four points); (iii) age-adequate movement repertoire (maximum four points); (iv) observed postural patterns (maximum four points); and (v) movement character (maximum four points). The assessment is summarised in a MOS-R with a maximum of 28 (best possible performance) and a minimum of five points. A MOS-R from 25 to 28 is considered optimal, from 20 to 24 mildly reduced, from 9 to 19 moderately reduced, and from 5 to 8 severely reduced.[7,11,29] Infants with a MOS-R <20 require intervention as do all infants with a mildly reduced MOS-R if asymmetries are present.[7,27]

2.4 | Statistical analysis

Data were analysed using SPSS Statistics, version 26.0 (IBM Corp, Armonk, NY). A significance level of 0.05 (two tailed) was used. Inter-assessor agreement of the five subcategories was identified by weighted kappa statistics since data is ordinal. For the total MOS-R an intraclass correlation coefficient (ICC2.1) absolute agreement was used to evaluate pairwise agreement of sum scores among observers, both for the cohorts separately and when assessing all infants together at different age-spans. ICCs is based on the repeated measures analysis of variance (ANOVA) and allows comparison of two or more repeated measurements. The weighted kappa (κw) results were interpreted according to guidelines adapted from Landis and Koch,[30] with a κ value of 0.20 defining poor agreement, 0.21–0.40 as fair, 0.41–0.60 as moderate, 0.61–0.80 as substantial, and between 0.81–1.00 as an almost perfect agreement.[30]

3 | RESULTS

Inter-assessor reliability in the assessment of the total MOS-R ranged from ICC: 0.98–0.99 (95% CI: 0.97–0.99) for all three cohorts, which can be interpreted as an almost perfect agreement (Table 2). In all three cohorts, a substantial to perfect inter-assessor agreement was found for all five subcategories (κw: 0.67–1.00), with postural patterns showing the lowest *κw* values of 0.67–0.86 (substantial to almost perfect) and fidgety movements the highest values 0.93–1.0 (almost perfect) (Table 3). When evaluating the three cohorts together, the inter-assessor reliability was still found to be very high, ICC: 0.99 (0.98–0.99). This was also the case when analysing the assessment of MOS-R at different ages, see Table 4.

4 | DISCUSSION

The aim of the present study was to evaluate the inter-assessor reliability of the recently revised MOS-R, including subcategories and in the use across different age-spans, in three independent groups of infants with different medical histories and origin. The results demonstrated an almost perfect agreement between assessors for the total MOS-R scores, both when evaluating the three cohorts separately and merged together. Slightly lower values were found for the subcategory *postural pattern*; however, results were still interpreted as substantial to perfect reliability according to the guidelines adapted from Landis and Koch.[30] The category of *fidgety movements* scored the highest agreement in all three subcohorts. No difference in inter-assessor reliability was found when assessing the MOS-R across different age-spans. It is worth noting for the subcategory movement character is that the kappa was perfect (κw: 1.0) in the EPT cohort, but slightly lower (κw: 0.75 and 0.86) in the other two cohorts. One reason for this might be less variation in the EPT cohort for this category, with the majority (94%) showing an atypical movement character.

As mentioned in the introduction, previous work has evaluated the reliability of the original MOS[5,13,14,22,23] or reported reliability data for the total MOS-R when used in smaller infant cohorts with different medical histories.[22,25] However, to the best of our knowledge, this is the first study to evaluate MOS-R inter-assessor reliability, with the inclusion of subcategories and different age groups, in a larger infant cohort with different medical backgrounds.

In 2009, Fjortoft et al.[23] evaluated the inter-assessor reliability when using the MOS in a similar setting to that of our study. In both studies, scorers were present in the same room when assessing the recordings and all items were discussed prior to scoring. Their results showed a moderate to very high reliability for the subcategories *fidgety movements* (κw: 0.75–0.91), *movement character* (κw: 0.54–0.84), *movement patterns* (κw: 0.51–0.84) and *age-adequate movement repertoire* (κw: 0.51–0.69). The section *postural pattern*, however, showed a much lower agreement (κw: 0.39–0.56). Inter-assessor reliability of the total MOS was very high (ICC: 0.80–0.94). In comparison to our results, the reliability values in the 2009 study were lower overall. Our analysis showed an almost perfect agreement for all categories in all three cohorts both separately and merged together, except in the low-resource setting cohort for the specific category postural pattern and movement character, where agreement was slightly lower but still interpreted as substantial. The reasons why our study and the results by Fjortoft et al.[23] differ might be several. One important consideration is that two different versions of the assessment were used in the two studies, and this may explain some of the discrepancies. In the MOS-R the subcategory *postural pattern* is more clearly defined than in the previous version. Another issue is that the items in the subcategory *postural pattern* are fewer and, therefore, may have a higher impact on disagreement, as in the case for example of one or two items in the subcategory *movement patterns*. This means that a disagreement in only one pattern in *postural pattern* can make a substantial difference in the total score of that specific subscore.

Our experience from different clinical and research settings is that it might be easier to assess the subcategory *age-adequate movement repertoire* in infants 9–12 weeks as in this case only four normal patterns are required. It also seems easier to assess the repertoire in infants older than 16 weeks, as they either present all required patterns or have very few age-adequate patterns. Anecdotally, our team has found that in GM courses, GMA trainees often have more difficulty agreeing on the age-adequate repertoire when it comes to the assessment of infants in the age range between 13–16 weeks. This was, however, not confirmed in our analysis of the total MOS-R, since the reliability in all three age groups was very high (0.98–0.99). One reason for this might be that all assessors in the present study were at advanced level and all items were thoroughly discussed prior to scoring, which ensured consistency in the approach. Unfortunately, when merging the three groups, individual analyses of the subcategories could not be performed due to statistical limitations, as the data did not fulfil two of the obligatory criteria for Fleiss kappa, namely the uniqueness of raters and randomly assigned cohorts.

There is a need for expertise and proper training for MOS-R performance. All assessors in the study had formal advanced training of the GM trust and were experienced assessors with distinct clinical and research backgrounds. The assessors also had experience assessing videos together, since one of the assessors (CE) was the same across cohorts and also the tutor of the other scorers. This could be regarded as a limitation with respect to clinical applicability.

Even though the analysis of the MOS-R requires an advanced scorer and is somewhat more time-consuming than the assessment of fidgety movements alone, there is great advantage in the performance of a detailed assessment of an infant's motor repertoire. The MOS-R can give a more specific motor profile and guide clinicians when planning targeted treatment and early interventions. Depending on findings of the MOS-R, for example if an asymmetry is noted, an atypical postural pattern is observed, or if the infant presents a lack of age-adequate movements, different treatment approaches can be applied. The use of the MOS-R as a screening tool has been shown to improve the prediction of infants with early adverse motor performance who are at increased risk of long-term adverse neurodevelopmental outcomes.[9,11]

While the MOS-R has the above-mentioned limitations for implementation in clinical routine assessments, there are a number of strengths that render this tool highly advantageous in the risk assessment of vulnerable infant populations.[9] Strengths of the current study include the large sample size of infants from multiple locations and a diverse range of high-risk conditions enabling a variability in MOS-R scores. The fact that assessors were blinded to medical history and outcome was also an advantage. In all three cohorts, video recordings were performed according to state-of-the art guidelines and recommendations.[10] Different video-set ups using both video cameras with a tripod or smartphones in home settings strengthens our study since this approach mimics that of clinical outpatient and field settings for data acquisition. Nevertheless, future studies evaluating MOS-R and its clinical applicability when used by assessors with various levels of expertise and in neonatal screening programs are warranted. Additionally, studies evaluating the inter-rater reliability of specific items important to certain diagnoses such as, for example asymmetry of segmental movements or circular arm movements would also be of great importance.

5 | CONCLUSION

This study evaluated the inter-assessor reliability of the MOS-R when used in three independent high-risk populations (preterm birth, malnutrition, Sars-CoV-2). Our findings show an almost perfect agreement between assessors for the total MOS-R score across different age groups. Slightly lower reliability values were found for the subcategory *postural pattern*; however, they were still found to be substantial to perfect. Even though reliability values are high, we suggest that the subcategory *postural patterns* needs further refinement in future studies. In addition, further studies should evaluate the use of MOS-R and its clinical applicability when implemented by assessors with varying degrees of expertise.

ACKNOWLEDGEMENTS

We are grateful to all children and parents who participated in the study. On behalf of the SPIBI group, especially we would like to thank Erika Baraldi recruiting all the families to the SPIBI study and Marie Johansson for collecting all the recordings. We would also like to thank the community health workers at KIRAN society, Madhopur, Varanasi, for recording the infants in the low-resource setting cohort from the G.A.N.E.S.H. project and the COMP study team.

FUNDING INFORMATION

The sponsors had no role in the study design, collection, interpretation or analysis of data, writing the report or the decision to submit the article for publication. **MÖ** was supported by Region Stockholm (clinical research appointment), Swedish governmental funding of clinical research (ALF **FoUI-954 851**), Promobilia Foundation Sweden, Sällskapet Barnavård, Kronprinsessan Lovisas förening för barnasjukvård/Stiftelsen Axel Tielmans minnesfond and the Jerring foundation**. PBM** and **DZ** were supported by the Volkswagenfoundation (IDENTIFIED), the Leibniz Foundation (LSC Audacity Award), the Laerdal Foundation, the Austrian Science Fund (FWF—KLI811), DFG—SFB 1528 (C03) and the BMBF (CP-Diadem project). CE and MT were supported by the Laerdal Foundation. **UÅ** was supported by grants from the Swedish Medical Research Council the regional agreement on medical training and clinical research (ALF) between Stockholm County Council and the Karolinska Institutet, the Swedish Order of Freemasons in Stockholm, the Swedish Medical Society, the Swedish Brain Foundation, the Cocozza foundation and the Philipson Foundation. **KNS** and **VF** were supported by the Simons Foundation SFARI program:

Funding information

Jerring foundation; Kronprinsessan Lovisas förening för barnasjukvård/Stiftelsen Axel Tielmans minnesfond; Promobilia Foundation Sweden; Region Stockholm (clinical research appointment); Sällskapet Barnavård; Swedish governmental funding of clinical research; Swedish Medical Research Council the regional agreement on medical training and clinical research (ALF) between Stockholm County Council and the Karolinska Institutet; the Austrian Science Fund, Grant/Award Number: (FWF - KLI811), DFG - SFB 1528 (C03); the BMBF (CP-Diadem project); the Cocozza foundation; the Laerdal Foundation; the Leibniz Foundation (LSC Audacity Award); the Philipson Foundation; the Simons Foundation SFARI program; the Swedish Brain Foundation; the Swedish Medical Society; the Swedish Order of Freemasons in Stockholm; Volkswagenfoundation

Abbreviations:

ANOVA	repeated measures analysis of variance
CI	confidence interval
CP	cerebral palsy
EPT	extremely preterm
GA	gestational age
G.A.N.E.S.H.	General Movement Assessment in Neonates for Early Identification and Intervention, Social Support and Health Awareness
GMA	general movement assessment
GMs	general movements
ICC	intraclass correlation coefficients
MOS	Motor Optimality Score
MOS-R	Motor Optimality Score-Revised
SARS-CoV-2	severe acute respiratory syndrome coronavirus 2
SPIBI	Stockholm Preterm Interaction-Based Intervention
κw	kappa

REFERENCES

1. Einspieler C, Kerr AM, Prechtl HFR. Abnormal general movements in girls with Rett disorder: the first four months of life. Brain and Development. 2005;27(SUPPL. 1):8–13.
2. Einspieler C, Sigafoos J, Bartl-Pokorny KD, Landa R, Marschik PB, Bölte S. Highlighting the first 5 months of life: general movements in infants later diagnosed with autism spectrum disorder or Rett syndrome. Res Autism Spectr Disord. 2014;8(3):286–291. [PubMed: 29770159]

3. Einspieler C, Hirota H, Yuge M, Dejima S, Marschik PB. Early behavioural manifestation of Smith-Magenis syndrome in a 4-month-old boy. Dev Neurorehabil. 2012;15(4):313–316. [PubMed: 22724898]
4. Herrero D, Einspieler C, Panvequio Aizawa CY, et al. The motor repertoire in 3-to 5-month old infants with Down syndrome. Res Dev Disabil. 2017;67:1–8. [PubMed: 28586709]
5. Wang J, Shen X, Yang H, et al. Inter- and intra-observer reliability of the "assessment of motor repertoire—3 to 5 months" based on video recordings of infants with Prader-Willi syndrome. BMC Pediatr. 2022;22(1):1–8. [PubMed: 34980043]
6. Novak I, Morgan C, Adde L, et al. Early, accurate diagnosis and early intervention in cerebral palsy: advances in diagnosis and treatment. JAMA Pediatr. 2017;171(9):897–907. [PubMed: 28715518]
7. Einspieler C, Bos AF, Krieber-Tomantschger M, et al. Cerebral palsy: early markers of clinical phenotype and functional outcome. J Clin Med. 2019;8(10):1616. [PubMed: 31590221]
8. Einspieler C, Peharz R, Marschik PB. Fidgety movements—tiny in appearance, but huge in impact. J Pediatr. 2016;92(3):S64–S70.
9. Crowle C, Jackman M, Morgan C. The general movements motor optimality score in high-risk infants: a systematic scoping review. Pediatr Phys Ther. 2022;35(1–25):2–26. [PubMed: 36288244]
10. Einspieler C, Prechtl HF, Bos AF, Ferrarri F. Prechtl's Method on the Qualitative Assessment of General Movements in Preterm, Term and Young Infants. MacKeith Press; 2004.
11. Örtqvist M, Einspieler C, Ådén U. Early prediction of neurodevelopmental outcomes at 12 years in children born extremely preterm. Pediatr Res. 2022;91(6):1522–1529. [PubMed: 33972686]
12. Bruggink JLM, Cioni G, Einspieler C, Maathuis CGB, Pascale R, Bos AF. Early motor repertoire is related to level of self-mobility in children with cerebral palsy at school age. Dev Med Child Neurol. 2009;51(11):878–885. [PubMed: 19416326]
13. Zang FF, Yang H, Han Q, et al. Very low birth weight infants in China: the predictive value of the motor repertoire at 3 to 5 months for the motor performance at 12 months. Early Hum Dev. 2016;100:27–32. [PubMed: 27391870]
14. Bruggink JLM, Einspieler C, Butcher PR, Stremmelaar EF, Prechtl HFR, Bos AF. Quantitative aspects of the early motor repertoire in preterm infants: do they predict minor neurological dysfunction at school age? Early Hum Dev. 2009;85(1):25–36. [PubMed: 18691834]
15. Einspieler C, Utsch F, Brasil P, et al. Association of infants exposed to prenatal Zika virus infection with their clinical, neurologic, and developmental status evaluated via the general movement assessment tool. JAMA Netw Open. 2019;2(1):e187235. [PubMed: 30657537]
16. Salavati S, Einspieler C, Vagelli G, et al. The association between the early motor repertoire and language development in term children born after normal pregnancy. Early Hum Dev. 2017;111:30–35. [PubMed: 28549271]
17. Bruggink JLM, Van Braeckel KN, Bos AF. The early motor repertoire of children born preterm is associated with intelligence at school age. Pediatrics. 2010;125(6):e1356–e1363. [PubMed: 20457678]
18. Fjørtoft T, Grunewaldt KH, Løhaugen GCC, Mørkved S, Skranes J, Evensen KAI. Assessment of motor behaviour in high-risk-infants at 3 months predicts motor and cognitive outcomes in 10 years old children. Early Hum Dev. 2013;89(10):787–793. [PubMed: 23850484]
19. Tekerlek H, Mutlu A, Inal-Ince D, et al. Motor repertoire is age-inadequate in infants with cystic fibrosis. Pediatr Res. 2021;89(5):1291–1296. [PubMed: 32717740]
20. Spittle AJ, Thompson DK, Olsen JE, Kwong A, Treyvaud K. Predictors of long-term neurodevelopmental outcomes of children born extremely preterm. Semin Perinatol. 2021;45(8):151482. [PubMed: 34456065]
21. Örtqvist M, Einspieler C, Marschik PB, Ådén U. Movements and posture in infants born extremely preterm in comparison to term-born controls. Early Hum Dev. 2021;154:105304. [PubMed: 33556691]
22. Kahraman A, Bügüşan S, Erdogan D, Mutlu A. Analysis of spontaneous movements in infants with torticollis. Pediatr Phys Ther. 2022;34(1):17–21. [PubMed: 34873118]
23. Fjørtoft T, Einspieler C, Adde L, Strand LI. Inter-observer reliability of the "assessment of motor repertoire—3 to 5 months" based on video recordings of infants. Early Hum Dev. 2009;85(5):297–302. [PubMed: 19138831]

24. Kwong AKL, Boyd RN, Chatfield MD, Ware RS, Colditz PB, George JM. Early motor repertoire of very preterm infants and relationships with 2-year neurodevelopment. J Clin Med. 2022;11(7):1833. [PubMed: 35407440]

25. Rodijk LH, Bos AF, Verkade HJ, de Kleine RH, Hulscher JBF, Bruggink JLM. Early motor repertoire in infants with biliary atresia: a nationwide prospective cohort study. J Pediatr Gastroenterol Nutr. 2021;72(4):592–596. [PubMed: 33346571]

26. Baraldi E, Allodi MW, Löwing K, Smedler AC, Westrup B, Ådén U. Stockholm preterm interaction-based intervention (SPIBI)—study protocol for an RCT of a 12-month parallel-group post-discharge program for extremely preterm infants and their parents. BMC Pediatr. 2020;20(1):1–17. [PubMed: 31900152]

27. Toldo M, Varishthananda S, Einspieler C, et al. Enhancing early detection of neurological and developmental disorders and provision of intervention in low-resource settings in Uttar Pradesh, India: study protocol of the G.a.N.E.S.H. programme. BMJ Open. 2020;10(11):1–10.

28. Fajardo M, Zhang D, Paiola S, et al. Neuromotor repertoires in infants exposed to maternal COVID-19 during pregnancy: a cohort study. BMJ Open. 2023;13(1):e069194.

29. Salavati S, Bos AF, Doyle LW, Anderson PJ, Spittle AJ. Very preterm early motor repertoire and neurodevelopmental outcomes at 8 years. Pediatrics. 2021;148(3):1–11.

30. Landis J, Koch G. The measurement of observer agreement for categorical data. Biometrics. 1977;33(1):159–174. [PubMed: 843571]

Key Notes

- The Motor Optimality Score-Revised (MOS-R), can be used in infants at elevated likelihood for adverse neurological outcome with an almost perfect reliability.
- The MOS-R subcategory *postural patterns* needs more attention in future studies.
- The clinical applicability of the MOS-R needs to be further evaluated.

TABLE 1

Demographic and clinical characteristics of infants evaluated with the MOS-R.

	Extremely preterm born cohort	Low-resource setting cohort	SARS-CoV-2 cohort
Number, *n*	97	97	58
Sex male/female, *n*	54/43	47/50	31/27
GA, week, mean ± SD, (min-max)	25 ± 1 (22–27)	39 ± 1 (34–42)	37 ± 2 (27–41)
Birth weight, gram, mean ± SD, (min-max)	825 ± 197 (448–1326)	2801 ± 484 (1700–4000)[a]	2798 ± 902 (950–4621)
Recording age post-term, week mean ± SD, (min-max)	13 ± 2 (10–21)	13 ± 2 (9–19)	15 ± 4 (10–25)

[a]Data missing for four infants due to home or field delivery.

Author Manuscript

Author Manuscript

Author Manuscript

TABLE 2

Intraclass correlation coefficients (ICC; 95% confidence interval) of inter-assessor reliability (2 scorers in each cohort) of the MOS-R when used in three different populations.

MOS-R total score (median)	ICC; 95% confidence interval	*p*-Value
Extremely preterm cohort ($n = 97$)	0.98 (0.97–0.99)	<0.001
Low-resource setting cohort ($n = 97$)	0.98 (0.97–0.99)	<0.001
SARS-CoV-2 cohort ($n = 58$)	0.99 (0.98–0.99)	<0.001

TABLE 3

Weighted kappa (κw: 95% confidence interval) of inter-assessor reliability of the subscales of the MOS-R (2 scorers in each cohort) when used in three different populations.

Subscales of the MOS-R	Extremely preterm cohort (*n* = 97)	Low-resource setting cohort (*n* = 97)	SARS-CoV-2 cohort (*n* = 58)
(i) Fidgety movements	0.93 (0.85–1.00)	1.00	1.00
(ii) Movement patterns	0.97 (0.92–1.00)	0.89 (0.71–1.00)	0.91 (0.78–1.00)
(iii) Age-adequacy (repertoire)	0.99 (0.96–1.00)	0.94 (0.89–0.99)	0.98 (0.94–1.00)
(iv) Postural patterns	0.86 (0.77–0.94)	0.67 (0.55–0.79)	0.88 (0.79–0.97)
(v) Movement character	1.00	0.75 (0.62–0.88)	0.86 (0.70–1.00)

TABLE 4

Intraclass correlation coefficients (ICC; 95% confidence interval) of inter-assessor reliability of the MOS-R when used in all infants at different age-spans (post-term age).

Recording age groups	ICC; 95% CI
9–12 weeks (*n* = 93)	0.99 (0.99–1.00)
13–16 weeks (*n* = 132)	0.98 (0.97–0.99)
17–25 weeks (*n* = 27)	0.98 (0.96–0.99)