West Kazakhstan Medical Journal
Volume 65, Issue no. 4, DOI 10.18502/wkmj.v65i4.14681
Production and Hosting by Knowledge E

Review Article

Future Prospects for Assessment of General Movements in Developing Countries

Zhanna Zhussupova[1]*, Dinmukhamed Ayaganov[1], Gulmira Zharmakhanova[1], and Ayten Mamedbayli[2]

[1]Neurology Department, West Kazakhstan Marat Ospanov Medical University, Aktobe, Kazakhstan
[2]Neurology Department, Azerbaijan Medical University, Baku, Azerbaijan

ORCID:
Zhanna Zhussupova: https://orcid.org/0000-0001-7024-9125
Dinmukhamed Ayaganov: https://orcid.org/0000-0002-1694-8301
Gulmira Zharmakhanova: https://orcid.org/0000-0003-1618-6041
Ayten Mamedbayli: https://orcid.org/0000-0003-1364-9848

Abstract

The well-being of children is crucial for a nation's demographic, economic, and intellectual prospects. Developing countries face an increasing number of children with disabilities, primarily attributed to congenital developmental defects, neurological disorders, and other health issues. Neurological disorders pose significant challenges to realizing the full potential of children and society. Early intervention is essential for improving functional outcomes in infants with neurological impairments. General Movements (GM) assessment, a predictor of subsequent neurological outcomes, plays a vital role in early detection. However, its widespread implementation in developing countries is limited. This article explores the history of GM assessment, its current state in developing countries, and the potential for mobile applications to revolutionize early assessments and interventions in developing countries.

Keywords: general movements assessment, neurological disorders, early intervention, children with disabilities, Kazakhstan, mobile applications

Corresponding Author: Zhanna Zhussupova; email: zh.zhusupova@zkmu.kz

Received November 5 2023
Accepted November 7 2023
Published December 21 2023

Production and Hosting by Knowledge E

1. Introduction

Preserving children's health is an integral component of national security. Children's health is considered the cornerstone of a country's demographic, economic, and intellectual potential. In the contemporary stage of societal development, addressing the issues of childhood disability and their rehabilitation stands as one of the priority focal points of Kazakhstan's social policy. The relevance of the disability problem and the organization of rehabilitation assistance is underscored by its scale. According to UN experts, the global prevalence of disabilities accounts for 15% of the world's total population.

According to the official data from the Ministry of Labor and Social Protection of the Population of the Republic of Kazakhstan, in 2021, a total of 98,254 children with disabilities were registered throughout the country.

The dynamics of disability among the child population over 5 years, based on absolute data regarding the number of children with special needs, show a 17.7% increase. In 2017, there were 83,462 registered children with disabilities, while in 2021, this number rose to 98,254 children with disabilities.

One of the factors contributing to this situation is the contemporary level of medical development, which enables the preservation of the lives of severely premature newborns, children with neuroinfections, severe nervous system injuries, and congenital developmental defects.

A comparative analysis of diseases leading to primary disability among the child population for the years 2017–2021 reveals that the leading positions are occupied by congenital developmental defects, deformities, chromosomal anomalies (2020: 30.3%, 2017: 32.5%), diseases of the nervous system (2020: 22%, 2017: 23.7%), mental disorders (2020: 16.3%, 2017: 11.1%), and endocrine disorders (2020 - 6%, 2017 - 4.8%) [1].

Thus, neurological disorders and disability jeopardize the realization of the full social and economic potential at the family and state levels. There is compelling evidence that early intervention improves functional outcomes for infants with neurological impairments and is economically efficient as it reduces the frequency and severity of subsequent impairments [2–5].

Unfortunately, in developing countries, there are no early detection and intervention programs. Therefore, it is crucial to have the ability to recognize early markers of neurological disorders and refer infants in need of neurological assessments. The above necessitates the need for a detailed and in-depth study of the evolution of generalized movements. Therefore, this study aims to investigate the current state of general movements assessment and explore future prospects for our country.

2. The History of Development of the Integrity Assessment of the Young Nervous System

General movements (GM) are endogenously generated patterns of movement in fetuses and young children. The quality of GM reflects the integrity of the young nervous system and serves as a predictor of subsequent neurological outcomes [1, 2]. There is a story related to the discovery of general movement assessment.

The origins of the design for this novel neurological assessment method can be traced back to the early 1980s when the field of research into intrauterine development was still in its early stages. During that era, when ultrasound technology had not yet reached a level of sophistication enabling the observation of fetal movements, Professor Prechtl pioneered a fresh perspective for evaluating the integrity of the developing nervous system. He embarked on initial observational investigations using unaided vision with preterm infants who were not subjected to any stimuli, with the primary aim of understanding their natural behavior at rest. This endeavor ultimately allowed for the identification of distinctive fetal movement patterns [7]. At that time, this approach was considered unconventional and regrettably, it continues to be so today. A cohort of premature infants with minimal risk factors was thoughtfully chosen to ensure comparability with their full-term counterparts. These infants displayed a diverse array of spontaneous movements, easily distinguishable upon repetition. In order to label one of the most conspicuous and intricate patterns of observed motions, the term "General Movements" (GMs) was introduced [7]. Writhing-type movements, akin to grandmaster chess players, become apparent from the outset through the second month following the conclusion of the semester. Subsequently, a novel subtype emerged, characterized as "restless grandmasters"[6]. These agitated movements, as detailed in Table 1, gradually manifest during the second month, peak in intensity around 3–4 months, and then gradually wane towards the close of the 5th month in both infants born at full term and those born prematurely but adjusted for their gestational age. It's worth noting that these restive grandmasters make their appearance during the transformation previously mentioned at the third month.

3. What are General Movements?

Among the wide array of spontaneous motor patterns, the so-called generalized movements stand out as the most commonly replicated and intricate motor sequences. Irwin [8, 9] possibly referred to these GMs as "mass movements" in his research, although he did not offer a comprehensive account of these motions. It was Prechtl and colleagues [7, 10, 11] who introduced the term "general movements" for this specific motor pattern during their observational study of spontaneous mobility in a meticulously chosen group of low-risk preterm newborns. Subsequent studies that explored various fetal movements established that GMs initially manifest at 9 weeks postmenstrual age [12–14]. These general movements then continue to be present throughout the entire prenatal period [15-18] until around 5–6 months of life following birth [19].

In the context of GM, the complete body engages in a diverse series of motions that encompass the arms, legs, neck, and trunk. These movements exhibit constant variations in terms of their frequency, intensity, and the speed at which they occur, commencing and concluding in a gradual and seamless manner. Rotations around limb axes and subtle alterations in movement direction bestow upon GM a quality of adaptability and grace, creating a perception of intricacy and diversity [15, 20, 21].

While the terminology GM is employed when discussing fetuses and premature infants, at 6–9 weeks following the standard gestational age, the phrase ’writhing movements’ is used to characterize this specific type of motion [7, 19, 22]. Despite the presence of age-related minor distinctions, GM generally exhibit a comparable movement structure from early intrauterine development through the end of the second month of postnatal life (see Figure **1**)

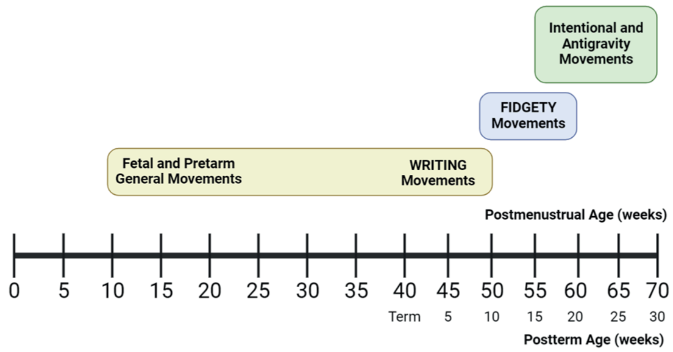

Figure 1: Developmental course of general movements.

Following a comprehensive examination of the typical structure of GMs, an additional study was carried out involving preterm infants belonging to a high-risk category. An assessment aimed at identifying expected quantitative distinctions in the occurrence of various spontaneous movement patterns did not uncover any substantial differences; to the contrary, the data pointed towards a complete convergence of data points [8]. What particularly captured the attention of observers, however, was the observation that the movements of infants within the high-risk group appeared to exhibit dissimilarities when compared to those of their low-risk counterparts. This observation was rather intuitive and, at that time, proved challenging to articulate precisely. Nevertheless, it served as a compelling point of departure for subsequent research, now taking advantage of the supplementary capability for video recording of movements, greatly facilitating a more thorough analysis.

It became essential to carry out precise observations exclusively through video recordings, as this was the sole means to ensure the requisite objectivity and dependability. After reviewing the initial observational studies involving infants from the low-risk group using video recordings [9, 10], Professor Prechtl's team launched a multicenter investigation encompassing infants with well-documented brain injuries using ultrasound imaging. This study undeniably affirmed my suspicions regarding qualitative distinctions in GMS among normally developing infants versus those who were not, while also affirming the absence of quantitative variances in the incidence of spontaneous movements. When the integrity of the nervous system is compromised, GMS relinquish their intricate and variable character and assume a uniform and impoverished quality.

The methodological advancement entailed a thorough assessment of GMS quality [11]. It is important to note that this approach is applicable to ultrasound video recordings of fetal movements in utero, as well as for premature infants in incubators and small preterm infants in cribs, up to approximately 20 weeks of age. Beyond this age, alternative criteria come into play for the transition to grandmasters. To ensure the effective training of individuals in this evaluation method, the General Movements Foundation was established in 1997. An illustrative video, encompassing both typical and atypical GM characteristics, was introduced in 1997 and serves as a standard for comparative purposes. Einspieler [12] and collaborators [13] provide comprehensive definitions and assessment standards that have been approved by the GM Trust (refer to Table 1). Proficiency in this method can be readily acquired through a 5-day training program organized by the GM Trust Foundation.

The novelty of this new approach lies in its remarkable capacity for precise prognostication concerning future normal development, minor neurological issues, or the occurrence of cerebral palsy (CP). This level of predictive accuracy is unprecedented.

4. The Current State of General Movements Assessment Implementation in Kazakhstan

According to recent research, GMA is recommended for the early detection of neurological disorders, including cognitive and motor impairments [34–42]. However, in Kazakhstan, it is not widely practiced. This is primarily due to the limited availability of GMA training courses, with only a few assessors being certified for GMA reliability. In Kazakhstan, GMA training courses have been conducted only once. A basic training course took place in July 2018, with the participation of 45 Kazakhstan doctors who underwent certification. Only one doctor has completed GMA courses abroad.

TABLE 1: The definition of GMs and their abnormal appearance is officially agreed upon by the GM Trust.

	Normal General Movements	Abnormal General Movements
Prenatal and pretermage	Gross movements, involving whole body. They may last from a few seconds to several minutes or longer. Variable sequence of arm, leg, neck, and trunk movements. Wax and wane in intensity; force, and speed, and have a gradual beginning and end. Majority of sequences of extension and flexion movements of arms and legs are complex, with superimposed rotations and often slight changes in the direction of the movement. These added components make the movements fluent and elegant and create the impression of complexity and variability.	Poor repertoire of general movements: the sequence of the successive movement components is monotonous and the movements of the different body parts do not occur in the complex way as seen in normal GMs. Cramped-synchronized general movements: these appear rigid and lack normal smooth and fluent character; all limb and trunk muscles contract and relax almost simultaneously.
Term age until 8 weeks ' post-term age	Writhing movements are characterized by small-to-moderate amplitude and by slow to moderate speed. Fast and large extension movements may occasionally break through, particularly in the arms. Typically; such movements are elliptical in form; this component creates the impression of a writhing quality of movement.	Absent fidgety movements: fidgety movements are never observed from ages 6 to 20 weeks postterm. Other movements can, however, be commonly observed. Abnormal fidgety movements: look like normal fidgety movements except that their amplitude, speed, and jerkiness are moderately or greatly exaggerated.
6–20 weeks ' post-term age	Fidgety movements are circular movements of small amplitude and moderate speed and variable acceleration of neck, trunk, and limbs in all directions. They are continual in the awake infant, except during focused attention. They may be concurrent with other gross movements, such as kicking, wigglingoscillating13 and swiping of the arms 13 or pleasure bursts. Fidgety movements may be seen as early as 6 weeks postterm but usually occur around 9 weeks and are then present until15 to about 20 weeks. This age range holds true for term as well as for preterm infants after correcting the age. Initially; they occur as isolated events (score: +); they gradually increase in frequency (score: + +) and then decrease once again (score: +).	Absent fidgety movements: fidgety movements are never observed from ages 6 to 20 weeks postterm. Other movements can, however, be commonly observed. Abnormal fidgety movements: look like normal fidgety movements except that their amplitude, speed, and jerkiness are moderately or greatly exaggerated.

Consequently, the existing state of affairs in Kazakhstan is marked by the absence of assured precision in GMA, along with constrained real-world utilization. A modest group of certified assessors has been in contact, collectively endeavoring to uphold the precision of GMA. These conditions have a notable impact on the retention of GMA expertise. Within Kazakhstan, healthcare and rehabilitation professionals encounter obstacles when seeking to acquire proficiency in GMA assessment. This is compounded by the fact that even when they make efforts to engage in GMA practice, only a selected few experts can sustain their assessment competencies. Consequently, opportunities for experts to authenticate the precision of their own GMA findings are limited.

5. Mobile Solutions, Applications for the Assessment of Generalized Movements, Represent the Future Prospect for Developing Countries

Currently, three user-oriented mobile applications, namely Baby Moves, NeuroMotion, and InMotion (Figure **2**), have garnered favorable reviews from parents due to their user-friendly interfaces [43–46]. The inter-rater reliability, based on video recordings obtained through these smartphone applications, is comparable to that of traditional assessment methods. When assessors evaluated videos recorded with the Baby Moves app, they achieved a high intraclass correlation coefficient of 0.77 (with a 95% confidence interval ranging from 0.75 to 0.80) for fidgety movements [43, 44, 47, 48]. The NeuroMotion app produced videos with k-alpha statistics agreement ranging from 0.48 to 0.72, and all assessors achieved substantial levels of agreement, from moderate to nearly perfect [49].

Among these applications, Baby Moves stands out as the most extensively studied, having been employed in diverse population groups, including extremely preterm, moderate to late preterm, healthy full-term infants, and those with hypoxic-ischemic encephalopathy. Some studies are linked to collaborative research on Victorian infants from 2016, cohort 2017.

GMApp has been utilized in studies involving neurotypical cohorts, preterm cohorts, and cohorts with reported prenatal Zika virus and Chikungunya infections [50, 51]. Notably, these applications have been adapted for use in various languages, such as Baby Moves in English, Spanish, Italian, and Arabic; GMApp in English, German, and Portuguese; NeuroMotion in English and Swedish; and InMotion in English and Norwegian.

Recent advancements and investigations in the realm of machine learning methodologies indicate the potential for future realization of fully automated evaluations integrated with artificial intelligence to support clinical decision-making [52].

What may initially seem like a straightforward mobile application conceals the intricate challenge of constructing a “smartphone-server” system capable of providing worldwide coverage. This endeavor necessitates collaborative efforts to establish a resilient tool and a suitable environment to facilitate the forthcoming mobile landscape of GMA. While mobile applications prove particularly valuable for observational appraisals, such

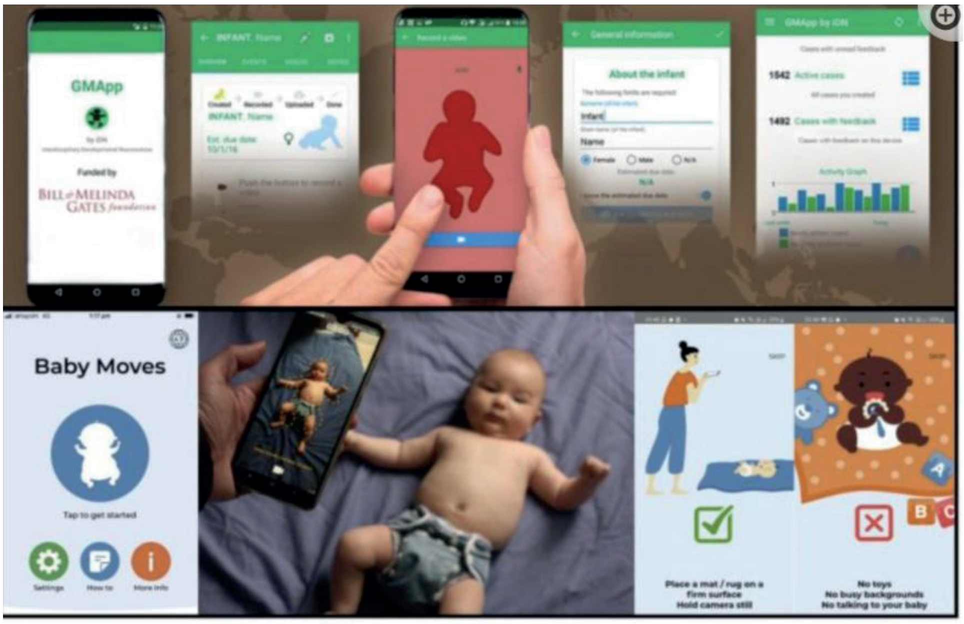

Figure 2: General Movement apps: (upper box) Screenshots of GMApp, including baby silhouette and statistics; (lower box) Baby silhouette of Baby Moves.

as GMA, there exist a variety of issues demanding attention. The continuous refinement of user instructions and recording equipment has notably improved the quality and user-friendliness of recording GM through these applications. Developers of these applications urge current innovators to foster cooperation and leverage existing applications as a cornerstone for constructing an adaptable integrated framework tailored to future GM assessment infrastructure [53].

The developers of these applications suggest that future app developments should explore the potential integration of GMA into clinical processes and research workflows. This integration would streamline the timely transmission of video data to GMA experts, allowing for feedback from patients and their families within the context of clinical management. Researchers utilizing GMApp have tested a similar approach using the OEOC (Observer-Expert-Observer-Caregiver) feedback loop, enabling healthcare professionals without prior GMA training to coordinate these evaluations. Additionally, these feedback loops can serve as a mean for providing individual GMA training to healthcare personnel and for devising strategies to enhance the effectiveness and scalability of assessments. In particular, when screening for cerebral palsy in its early stages, it is recommended to combine GMA with brain neuroimaging and physical neurological examinations [54]. The integration of GMA data with other early assessments is essential for optimizing clinical efficiency and assessment precision.

6. Conclusion

In summary, GMA is increasingly gaining popularity and is being more widely utilized as an assessment tool in clinical and research settings. The potential use of smartphone applications holds promise for emerging economies, especially in the context of observational evaluations such as GMA. Applications like GM Trust's GMApp, Baby Moves, and NeuroMotion have the potential to significantly benefit families with children at a high risk of developing disabilities in our developing nations. The swift progress in telemedicine, electronic healthcare, and mobile healthcare is being incorporated into our healthcare systems. To enhance global adoption and sustainability, it is crucial to collaborate and adapt these innovations to suit local systems.

Furthermore, it should not be overlooked that the training of healthcare professionals in the assessment of general movements is imperative.

References

[1] Resolution of the Government of the Republic of Kazakhstan, [On approval of the Concept of Healthcare development of the Republic of Kazakhstan until 2026]. 2022.

[2] Novak, I., et al., Early, accurate diagnosis and early intervention in cerebral palsy: Advances in diagnosis and treatment. *JAMA Pediatr*, 2017. 171(9): 897-907.

[3] Morgan, C., et al. GAME (Goals - activity - motor enrichment): Protocol of a single blind randomised controlled trial of motor training, parent education and environmental enrichment for infants at high risk of cerebral palsy. *BMC Neurol*. 2014; 14(1).

[4] Morgan, C., et al. Sensitivity and specificity of general movements assessment for diagnostic accuracy of detecting cerebral palsy early in an Australian context. *J Paediatr Child Health*. 2016; 52(1): 54-59.

[5] Morgan, C., et al. The pooled diagnostic accuracy of neuroimaging, general movements, and neurological examination for diagnosing cerebral palsy early in high-risk infants: A case control study. *J Clin Med*. 2019; 8(11).

[6] Oppenheim, R.W. Ontogenic adaptations in neural and behavioural development toward a more ecological developmental psychobiology. *Clin Dev Med*. 1984(94): 16-30.

[7] Prechtl, H.F., et al. Postures, motility and respiration of low-risk pre-term infants. *Dev Med Child Neurol*. 1979; 21(1): 3-27.

[8] Bax, M. The Choreiform Syndrome and other Work done by Heinz Prechtl. Dev Med Child Neurol. 1961; 3(4): 317-318.

[9] Berge, B.S.t., The Influence of the Placenta on Cerebral Injuries. Dev Med Child Neurol. 1961; 3(4): 323-331.

[10] Harris, A.J. Lateral dominance and reading disability. *J Learn Disabil*. 1979; 12(5): 337-343.

[11] Oppenheim, R.W. Ontogenetic adaptations and retrogressive processes in the development of the nervous system and behavior: A neuroembryological perspective. Maturation and development: *Biol Psychol Perspect*. 1981: 73-109.

[12] de Vries, J.I.P., G.H.A. Visser, and H.F.R. Prechtl. The emergence of fetal behaviour. I. Qualitative aspects. *Early Hum Dev*. 1982; 7(4): 301-322.

[13] Leijon, I. and O. Finnström. Correlation between neurological examination and behavioural assessment of the newborn infant. *Early Hum Dev*. 1982; 7(2): 119-130.

[14] Lievaart, M. and P.A. de Jong. Neonatal morbidity in deliveries conducted by midwives and gynecologists. A study of the system of obstetric care prevailing in The Netherlands. *Am J Obstet Gynecol*. 1982; 144(4): 376-386.

[15] Prechtl, HF. Motor behaviour of preterm infants. Continuity of neural functions from prenatal to postnatal life. *Clin Dev Med* 1991: 79-92.

[16] Mulder, E.J.H. and G.H.A. Visser, Growth and motor development in fetuses of women with type-1 diabetes. II. Emergence of specific movement patterns. *Early Hum Dev.* 1991; 25(2): 107-115.

[17] Roodenburg, P.J., et al. Classification and quantitative aspects of fetal movements during the second half of normal pregnancy. *Early Hum Dev*. 1991; 25(1): 19-35.

[18] Eishima, K. The effects of obstetric conditions on neonatal behaviour in Japanese infants. *Early Hum Dev*. 1992; 28(3): 253-263.

[19] Hopkins, B. A qualitative approach to the development of movements during early infancy. H.F.R. Prechtl (Ed.), Continuity of neural functions from prenatal to postnatal life. 1984. p: 179-197.

[20] Cioni, G. and H.F. Prechtl. Preterm and early postterm motor behaviour in low-risk premature infants. *Early Hum Dev*. 1990; 23(3): 159-191.

[21] Ferrari, F., G. Cioni, and H. Prechtl. Qualitative changes of general movements in preterm infants with brain lesions. *Early Hum Dev*. 1990; 23(3): 193-231.

[22] Prechtl, H.F. Continuity of neural functions from prenatal to postnatal life. 1984: Cambridge University Press.

[23] Cioni, G., F. Ferrari, and H.F. Prechtl, Posture and spontaneous motility in fullterm infants. *Early Hum Dev*. 1989; 18(4): 247-262.

[24] Prechtl, H.F.R. Spontaneous Motor Activity as a Diagnostic Tool: Functional Assessment of the Young Nervous System. A Scientific Illustration of Prechtl's Method. 1997: GM Trust.

[25] Einspieler, C., et al., The qualitative assessment of general movements in preterm, term and young infants - Review of the methodology. *Early Hum Dev*. 1997; 50(1): 47-60.

[26] Einspieler, C., et al., The qualitative assessment of general movements in preterm, term and young infants—review of the methodology. *Early Hum Dev*. 1997; 50(1): 47-60.

[27] Prechtl, H.F.R. and C. Einspieler, Is neurological assessment of the fetus possible? *Eur J Obstet Gynecol Reprod Biol*. 199; 75(1): 81-84.

[28] Prechtl, H.F., et al., An early marker for neurological deficits after perinatal brain lesions. *Lancet*. 1997; 349(9062): 1361-1363.

[29] Prechtl, H.F.R. and B. Hopkins, Developmental transformations of spontaneous movements in early infancy. *Early Hum Dev*. 1986; 14(3-4): 233-238.

[30] Prechtl, H.F.R., 3 Developmental neurology of the fetus. *Bailliere Clin. Obstet. Gynaecol*, 1988. 2(1): 21-36.

[31] Cioni, G., et al., Comparison between observation of spontaneous movements and neurologic examination in preterm infants. *J Pediatr*. 1997; 130(5): 704-711.

[32] Cioni, G., et al., Which better predicts later outcome in fullterm infants: Quality of general movements or neurological examination? *Early Hum Dev*. 1997; 50(1): 71-85.

[33] Ferrari, F., et al., Posture, spontaneous movements, and behavioural state organisation in infants affected by brain malformations. *Early Hum Dev*. 1997; 50(1): 87-113.

[34] Goel, D., et al., General Movement assessment and neurodevelopmental trajectory in extremely preterm infants with hypothyroxinaemia of prematurity (THOP). *Early Hum Dev*. 2020; 144.

[35] Goyen, T.A., et al., Sensitivity and specificity of general movements assessment for detecting cerebral palsy in an Australian context: 2-year outcomes. *J Paediatr Child Health*. 2020; 56(9): 1414-1418.

[36] Pascal, A., et al., Motor outcome after perinatal stroke and early prediction of unilateral spastic cerebral palsy. *Eur J Paediatr Neurol*. 2020; 29: 54-61.

[37] Sokołów, M., et al., Early intervention and its short-term effect on the temporal organization of fidgety movements. *Early Hum Dev*. 2020; 151.

[38] Wu, Y.C., et al., Atypical general movements in the general population: Prevalence over the last 15 years and associated factors. *Acta Paediatrica*. *Int J Pediatr.* 2020; 109(12): 2762-2769.

[39] Wu, Y.C., et al., Typical general movements at 2 to 4 months: Movement complexity, fidgety movements, and their associations with risk factors and SINDA scores. *Early Hum Dev*. 2020; 149.

[40] Wang, H., et al. Value of general movements assessment in predicting neuromotor development outcomes in neonates with neonatal respiratory distress syndrome: A prospective cohort Study. *Clin Exp Obstet Gynecol*. 2023; 50(7).

[41] Wang, J., et al. Early markers of neurodevelopmental disorders based on general movements for very preterm infants: Study protocol for a multicentre prospective cohort study in a clinical setting in China. *BMJ Open*. 2023; 13(5).

[42] Yardimci-Lokmanoglu, B.N., et al. Early spontaneous movements and sensory processing in preterm infants. *Am J Occup Ther*. 2023; 77(3).

[43] Kwong, A.K.L., et al. The Baby Moves smartphone app for General Movements Assessment: Engagement amongst extremely preterm and term-born infants in a state-wide geographical study. *J Paediatr Child Health*. 2019; 55(5): 548-554.

[44] Spittle, A.J., et al. The baby moves prospective cohort study protocol: Using a smartphone application with the general movements assessment to predict neurodevelopmental outcomes at age 2 years for extremely preterm or extremely low birthweight infants. *BMJ Open*. 2016; 6(10).

[45] Inubashiri, E., et al. A new approach for quantitative assessment of fetal general movements in the early second trimester of pregnancy using four-dimensional ultrasound. *J Med Ultrasound*. 2021; 48(3): 335-344.

[46] King, A.R., et al. Early detection of cerebral palsy in high-risk infants: Translation of evidence into practice in an Australian hospital. *J Paediatr Child Health*. 2021; 57(2): 246-250.

[47] Kwong, A.K.L., et al. Occurrence of and temporal trends in fidgety general movements in infants born extremely preterm/extremely low birthweight and term-born controls. *Early Hum Dev*. 2019; 135: 11-15.

[48] Kwong, A.K.L., et al.. Early motor repertoire of very preterm infants and relationships with 2-Year neurodevelopment. *J Clin Med*, 2022. 11(7).

[49] Svensson, K.A., et al., Usability and inter-rater reliability of the NeuroMotion app: A tool in General Movements Assessments. *Eur J Paediatr Neurol*, 2021. 33: 29-35.

[50] Einspieler, C., R. Peharz, and P.B. Marschik, Fidgety movements–tiny in appearance, but huge in impact. *J Pediatr*. 2016; 92: 64-70.

[51] Einspieler, C., 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.

[52] Silva, N., et al., The future of General Movement Assessment: The role of computer vision and machine learning–A scoping review. *Res Dev Disabil*. 2021; 110: 103854.

[53] Marschik, P.B., et al., Mobile Solutions for Clinical Surveillance and Evaluation in Infancy—General Movement Apps. *J Clin Med*. 2023; 12(10): 3576.

[54] Einspieler, C., et al., Cerebral palsy: Early markers of clinical phenotype and functional outcome. *J Clin Med*. 2019; 8(10).