Assessment of "general movements" in high-risk infants by Prechtl analysis during early intervention period in the first year of life

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SUMMARY: Mutlu A, Livanelioğlu A, Korkmaz A. Assessment of "general movements" in high-risk infants by Prechtl analysis during early intervention period in the first year of life. Turk J Pediatr 2010; 52: 630-637.

This study was performed to assess the neurological status of high-risk infants by "general movements" (GMs) method and to compare it with the findings of standard clinical neurological examination and neuroimaging findings during the early rehabilitation period. Neurodevelopmental examination was performed by a neonatologist at the corrected ages of 40 weeks, and 3, 6 and 12 months. Assessment of the physiotherapist included video recording of "Prechtl Analysis of GMs" from the first week of life to the corrected age of 5 months. All infants underwent an early physiotherapy program, and follow-up examinations continued until 12 months. A percentage of agreement of 0.86 was found between cranial ultrasound imaging results and GMs and of 0.78 between neurological examination and GMs. Prechtl analysis was found to be important for detecting neurological dysfunction and differentiating normal neurological development in high-risk infants during the early intervention period. This analysis can be used complementary to other diagnostic and imaging techniques in the follow-up of preterm infants.

Key words: high-risk preterm infant, general movements, Prechtl analysis, neurologic dysfunction, early intervention.

Prematurity and low birth weight are the most important risk factors for neurodevelopmental impairment in the newborn infant. The incidence of neurological morbidities such as peri-intraventricular hemorrhage (PV-IVH) and periventricular leukomalacia (PVL) is inversely related with gestational age and birth weight. Approximately 26% of infants with birth weight between 501–750 g and 12% between 751–1000 g develop severe forms of PV-IVH. These very low birth weight (VLBW) infants are at highest risk for adverse neurodevelopmental outcome such as cerebral palsy (CP), and thus long-term, multidisciplinary and neurodevelopmental follow-up of these infants is essential[1,2].

"General Movements" (GMs) method assesses the "spontaneous motor movements" instead of neonatal reflexes, muscle tone and reactions of the infants and can be performed by different health professionals such as pediatric neurologists, pediatricians, physiologists, and pediatric physiotherapists. The immature nervous system can produce spontaneous activities that all have characteristics of being endogenously generated and which are independent of sensory inputs[3]. The neural mechanism responsible for the spontaneous movements in infants is called the Central Pattern Generator (CPG) and is recognized easily when occurring (for example stretching, yawning)[4]. Spontaneous activities are more sensitive for indicating nervous system dysfunction when compared with the responses to the sensory inputs[5]. Since the GMs method is easy to perform, cheap, quick, non-invasive, and even non-intrusive, it is ideal for assessment of neural functions in infants. It is also of great significance for the assessment of fetal movements by ultrasound monitoring during the prenatal period[6]. The simplest way of assessing GMs is directly observing the movements with the unaided eye. However,

the assessment of the infant's spontaneous movements is improved by a replaying video recording and repeated playback[4].

Normal GMs can be observed in fetuses as young as 9 weeks postmenstrual age until 15 to 20 weeks postterm age. Normal GMs continue in a similar pattern until about the end of the second month postterm and are commonly referred to as "writhing movements". Major transformation in neural functions begins between the end of the second month and the beginning of the third month. At the age of 6 to 9 weeks postterm, the form and character of the GMs change from the writhing type to "fidgety movements"[4,7]. Both "writhing" and "fidgety movements" have normal versus abnormal judgement. There are two distinct periods in evaluating GMs:

1. Prenatal and preterm age - term age until postterm 8 weeks age

Normal GMs

a. *Prenatal and preterm age:* There are gross movements involving the whole body and they may last from a few seconds to several minutes or longer[7,8].

b. *Term age until postterm 8 weeks of 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[7,8].

Abnormal GMs: The movements of the different body parts do not occur in the complex way as seen in normal GMs during preterm, term and early postterm age (first 2 months of life). Types of abnormal GMs are defined as: *"Poor Repertoire GMs"* (PR), *"Cramped-Synchronized GMs"* (CS), *"Chaotic GMs"* (Ch) and *"Hypokinesia"* (H)[7,8].

2. 6–20 weeks of postterm age

Normal GMs: "Fidgety movements" (FMs) are circular movements of small amplitude and moderate speed and variable acceleration of neck, trunk and limbs in all directions[4]. Their absence predicts CP with a sensitivity of 95% and a specificity of 96%. FMs are excellent markers for a normal or abnormal neurological outcome[9].

Abnormal GMs: FMs are never observed and are defined as: *"Absent FMs"* (F-) or are greatly exaggerated and defined as: *"Abnormal FMs"* (AF)[7].

In high-risk newborn infants, GMs can give important information about the nervous system dysfunction in the early weeks of life and provide an opportunity for the application of early interventions for early treatment[7]. Early rehabilitation is a period that should begin by the birth of the infant. Studies have stated that early rehabilitation effectively supported the developmental process in high-risk infants[10-12].

In this study, we aimed to assess the neurological status of high-risk infants by GMs method and to compare results with the findings of standard clinical neurological examination and neuroimaging findings during the early rehabilitation period.

Material and Methods

This study was performed at the Neonatology Unit, Department of Pediatrics, Faculty of Medicine and Department of Physical Therapy and Rehabilitation, Faculty of Health Sciences of Hacettepe University, Ankara, Turkey during 2005–2008. The study was approved by the Ethical Committee of the Faculty of Medicine, Hacettepe University (No: 17.03.2005, LUT 05/24). Informed consents were received from each patient's parents.

Study Group

The study group consisted of preterm (gestational age <37 weeks) and LBW (<2500 g) infants who were hospitalized at the Neonatal Intensive Care Unit (NICU) of Hacettepe University İhsan Doğramacı Children's Hospital during the study. Infants with congenital malformations and inherited metabolic diseases were excluded. Newborn infants who were intubated and under mechanical ventilation and who received anticonvulsive or sedative medications were also excluded.

Neonatal and Post-Neonatal Clinical Assessment

A neonatologist recorded prenatal and postnatal demographic and clinical characteristics of the infants and performed neurological examination

at corrected ages of 40 weeks and 3, 6 and 12 months. At corrected 40 weeks of age, the neurological examination of the newborn infants was assessed by Dubowitz method [13]. Routine cranial ultrasonography imagings were performed in the first 3 days of life and at corrected age of 40 weeks and 6 months by an experienced radiologist. After discharge from the NICU, all infants were followed by the same clinician in the Neonatal Outpatient Clinic.

The Assessment of the Physiotherapist

A physiotherapist, who was blind to the prenatal and postnatal history of the infant, video-recorded the spontaneous motor activities (GMs) of the infants first in the first week of life. The infants then had 2–5 video recordings until corrected age of 5 months. The first recording examined "preterm writhing movements", the 2nd and 3rd recordings examined "postterm writhing movements", and the 4th and 5th recordings examined FMs. The video recording periods were as follows: a "preterm period recording", "term period recording", "postterm period recording until 8 weeks" for "writhing movements" and "postterm 9–20 weeks period" for FMs[7]. The technical characteristics of the video recording were as follows:

Table I. Demographic and Clinical Characteristics of the Infants

Demographic characteristics	
Gender (Male/Female), n	16/12
Gestational age (week), mean±SD	30.9 ± 2.6
Birth weight (g), mean±SD	1488 ± 420
Mode of pregnancy, n (%)	
Natural	18 (64.3)
Assisted reproductive technology	10 (35.7)
Multiple pregnancy, n (%)	10 (35.7)
Twin	4 (14.3)
Triplet	6 (21.4)
Mode of birth, n (%)	
Vaginal	6 (21.4)
Cesarean section	22 (78.6)
Apgar score, mean±SD	
1st minute	7.1 ± 1.4
5th minute	8.5 ± 0.9
Clinical morbidities, n (%)	
Respiratory distress syndrome	10 (35.7)
Pneumonia	1 (3.6)
Patent ductus arteriosus	8 (28.6)
Necrotizing enterocolitis	4 (14.3)
Neonatal sepsis	3 (10.7)
Retinopathy of prematurity	2 (7.1)
Other	11 (39.3)
Cranial USG findings:	
Normal	26 (92.9)
Intraventricular hemorrhage and/or periventricular leukomalacia	2 (7.1)
Duration of hospitalization (day), mean±SD	22.9 ± 15.8

a. Position and behavioral state of the infants: The video recording was performed in a separate room in the NICU. The infants were in supine position in the incubator or on the bed depending on their ages. Any stimulus that may affect GMs was avoided, such as communication with parents or the NICU staff. The infants wore thin bodies with arms and legs bare or they wore only diapers. The incubator or room temperature was regulated according to the body weight, postnatal age and clothing of the infants. State behavior of the infants was taken into consideration while recording. Recording of infants whose gestational ages were greater than 36 weeks was performed in active wakefulness (State IV). In younger infants, recording was done when bouts of the activity occurred[11]. Recording was interrupted when the infants cried, hiccupped or experienced irritation. The infants did not receive sedative medication.

b. Position of the camera and duration of the recording: The video camera was Sony, DCR-HC17E, Japan. The best view of the infant was obtained by filming mid-sagittally or laterally from above. The video camera was stabilized on a foot with a height of 1.5 meter. No video recording was performed in the first 3 days of life as there are many physiological and behavioral state fluctuations in this period in newborn infants. The recording period was 30–60 minutes for the preterm and 30 minutes for the term and postterm period[7].

c. GMs assessment: The analysis was done from the tape in a silent, quiet room. The examining physiotherapist did not assess for longer than 45 minutes without taking a break; she watched normal GMs between the

assessment sessions in order to "re-calibrate" her "Gestalt perception". For this purpose, a tape with the gold standard per age group was at hand. High speed replaying of the tape was used as it had a positive role in decision[7]. Infants had at least 2 and at most 5 recordings. Thus, an individual developmental trajectory was developed for each infant indicating the neurological dysfunction or normal neurological outcome.

d. Neurological assessment: Muscle tone was evaluated by Modified Ashworth Scale[14] and motor development by Gross Motor Function Measurement (GMFM)[15] at a corrected age of 12 months. At a corrected age of 12 months, standing with support, independent standing, walking with support, and independent walking of the infants were determined and GMFM scores were also calculated.

e. Early rehabilitation program: The early rehabilitation program included teaching families about the exercise program according to the principles of Neurodevelopmental Treatment (NDT)[11], and consisted of regular follow-up evaluations in order to determine the next exercise program according to the development of the infant[10-12].

Statistical Analysis

Results were expressed as percentage value or mean±SD. The percentage of agreement between the neurological examination of the neonatologist, GMs assessment of the physiotherapist and cranial ultrasonography findings was tested by "Cohen Adjusted Kappa" (PABAK). The percentage agreement ratio of 0.20 was accepted as non-significant, 0.21–0.40 as minimal agreement, 0.41–0.60 as moderate agreement, 0.61–0.80 as significant agreement, and 0.81–1.00 as complete agreement[16].

Results

Initially, the study included 50 infants. However, due to the infants who were lost to follow-up or who died after discharge from the hospital, a total of 28 high-risk infants could be included in the study. The demographic and clinical characteristics of the infants are given in Table I.

Only 19, 13, 9 and 8 infants could be examined neurologically at the corrected ages of 40 weeks and 3, 6 and 12 months, respectively. At corrected age of 40 weeks, only one infant was suspected of having future CP; however, he was diagnosed as normal later. No infants were diagnosed as having CP. Clinical neurological examination findings of the infants at corrected ages of 40 weeks and 3, 6 and 12 months are given in Table II.

At corrected 12 months of age, 11 infants did not have independent walking and of the other infants, 4 walked with support. Motor development levels and GMFM scores of the infants are presented in Table III.

General Movements (GMs) results of the infants are shown in Table IV. Ten (35.7%) infants had 5 GMs video recordings, while 4 (14.3%) had 4 recordings, 9 (32.1%) had 3 recordings, and 5 (17.9%) had 2 recordings. Eleven (39.3%) infants showed normal movement patterns in all recordings and qualified as "neurologically normal". However, 17 infants (60.7%) showed abnormal movements (PR and CS) in preterm and writhing movements, but 15 (53.6%) had normal FMs later and qualified as "neurologically normal". Two (7.1%) infants were qualified as "neurologically abnormal" (8th and 18th infants, Table IV). One of these two "neurologically abnormal" infants had 3 recordings; 2 recordings indicated hypokinetic and 1 recording CS GMs. However, FMs and other follow-up examinations could not be performed as the infant died later due to sepsis. The other infant with a gestational age of 28 weeks and a birth weight of 970 g had consistent CS movement, and FMs were absent in the fidgety period and qualified as "neurologically abnormal". In addition to persistent abnormal GMs, the infant had abnormal neurological signs (weak head control, hypertonicity, no reaction to voice or light, increased deep tendon reflexes). She underwent a Denver Screening Test at corrected age of 12 months and her gross motor movements were found "suspicious-abnormal". The GMs evaluation of all infants is shown in Table IV.

When the results of clinical neurological examination, GMs assessment and cranial ultrasonography were compared, complete agreement (PABAK=0.86) was found between GMs and cranial ultrasonography findings, while important agreement was observed

Table II. Clinical Neurological Examination Findings of the Infants

Corrected age	40 weeks	3 months	6 months	12 months
	n=19	n=13	n=9	n = 8
Motor disorder, n (%)	5 (26.3)	2 (15.4)	1 (11.1)	-
Muscle tone disorder, n (%)	3 (15.8)	2 (15.4)	2 (22.2)	1 (12.5)
Pathological DTR, n (%)				
Upper extremity	1 (5.3)	1 (7.7)	1 (11.1)	-
Lower extremity	1 (5.3)	1 (7.7)	2 (22.2)	-
Cerebral palsy, n (%)	1 (5.3)	-	-	-

DTR: Deep tendon reflex.

between clinical neurological examination and GMs (PABAK=0.78).

Discussion

In this study, GMs method was used to identify high-risk preterm infants with neurological impairment for the first time in Turkey, and a high degree of agreement was found between the results of this method and neurological and neuroimaging findings.

Literature supports that 8–10% of the preterm infants have CP and 40% of children with CP were born preterm[1,2]. Therefore, in high-risk infants, early identification of any neurological dysfunction has a great impact for the initiation of therapy and good prognosis[5].

General Movements (GMs) demonstrated high validity, reliability and sensitivity, which were similar in all age groups (preterm, term, first month, second month, third month) and specificity increased with age. Intra-individual consistency of GMs was also found to be high. In the first months, as motor abilities are very restricted, it is not easy to assess motor milestones[7,17-19]. Spontaneous motor movements are the expression of the functional motor development in the earliest period and form a basis for the further motor milestones[18].

General Movements (GMs) depend on Gestalt perception of the observers. Therefore, there have been some foresights that the method was subjective. However, the inter-tester reliability was found as 90%[20]. In our study, "gold standard" recordings of the GMs were watched, compared and decided; thus, bias of the observer's decision was eliminated.

Repeated recordings of GMs are more valuable in the neurodevelopmental follow-up of the infants rather than a single GMs recording[7,21]. The most important advantage of the method is that a developmental trajectory can be obtained for each individual, indicating a consistency or inconsistency of the normal or the abnormal findings. Ferrari et al.[5,22] proved that neurological outcomes of the infants with similar developmental trajectories were also similar. In addition, one GMs recording in the FM period between 9–20 weeks was found to be more effective. In high-risk infants, absent FMs predict CP by 85–98%[9]. In our cases, we

Table III. Motor Developmental Levels and GMFM Scores of Infants at Corrected Age of 12 Months

Motor developmental level	
Standing with support, n (%)	3 (10.7)
Independent standing, n (%)	4 (14.3)
Walking with support, n (%)	4 (14.3)
Independent walking, n (%)	17 (61.7)
GMFM Scores, mean±SD	
Supine-prone	98.9 ± 1.7
Sitting	90.2 ± 9.5
Crawling-kneeling	82.9 ± 17.6
Standing	47.6 ± 22.3
Walking	35.9 ± 19.1
Total score	71.1 ± 11.7

GMFM: Gross Motor Function Measurement.

Table IV. GMs Results of the Infants

	1st Record	2nd Record	3rd Record	4th Record	5th Record	Result
Time	34.8±3.9 wk	41.5±3.1 wk	47.0±2.4 wk	52.7±2.2 wk	57.5±2.3 wk	
Case No						
1	N	N	N	N	N	N
2	*N*	*CS*	*PR*	*N*	*N*	*N*
3	*CS*	*N*	*N*	*N*	*N*	*N*
4	*PR*	*N*	*N*	*N*	*N*	*N*
5	*PR*	*PR*	-	*N*	*N*	*N*
6	N	N	N	N	N	N
7	*CS*	*N*	-	*N*	-	*N*
8	**-**	**CS**	**CS**	**F-**	**F-**	**AN**
9	*PR*	*PR*	-	*N*	-	*N*
10	N	N	-	-	-	N
11	*PR*	*N*	-	-	-	*N*
12	N	-	N	-	-	N
13	N	-	N	-	-	N
14	*PR*	-	*N*	-	-	*N*
15	*PR*	*N*	*N*	*N*	-	*N*
16	*N*	*PR*	*N*	*N*	*N*	*N*
17	*PR*	*PR*	*N*	-	-	*N*
18	**H**	**H**	**CS**	**-**	**-**	**AN**
19	-	*PR*	*PR*	*N*	*N*	*N*
20	N	N	N	N	N	N
21	*PR*	*CS*	*PR*	*N*	*N*	*N*
22	-	-	N	N	N	N
23	N	N	N	N	N	N
24	*PR*	*PR*	*N*	*N*	*N*	*N*
25	-	-	*CS*	*N*	*N*	*N*
26	-	-	N	N	N	N
27	-	-	N	N	N	N
28	-	N	N	N	N	N

GM: General movements. N: Normal. PR: Poor repertoire. CS: Cramped-synchronized. Ch: Chaotic. H: Hypokinetic. AF: Abnormal fidgety. F -: Absent fidgety. AN: Abnormal.

tried to provide a maximum recording period (5 times) as well as at least one recording in the FM period. An infant showing "persistent CS" and "absent" FM is a very good candidate for early rehabilitation. However, in our study, all infants underwent a home exercise program during the early rehabilitation period due to ethical principles.

The researches on GMs proved that infants with persistent abnormal GMs during preterm and postterm 20 weeks (CS, F-) developed CP[5,23]. These abnormal movements (CS, F-) point out the severe neurological dysfunction or persistent motor disorders[5,24]. Abnormal movement seen in the earliest period demonstrates that motor delay is severe[24,25].

General Movements (GMs) predict the neurological dysfunction as well as the type of CP. Therefore, it provides the opportunity to determine the focus in early rehabilitation. Einspieler et al.[26] found that early symptoms in GMs of dyskinetic CP differed from those of spastic type of CP. Infants who had neurological dysfunction such as CP and mental motor retardation had 90–100% abnormal GMs, while infants who had normal development had normal GMs[27]. The common result of their study and ours was that infants who had persistent abnormal GMs had neurological dysfunction and those who had normal GMs had normal neurological development.

One of the infants with persistent abnormal GMs could not be followed up as the infant

died. The other infant who had minor neurological dysfunction was a 28-week gestational age infant with a birth weight of 970 g. She underwent a Denver Screening Test at corrected age of 12 months and her gross motor movements were found "suspicious-abnormal". This condition was revealed by our GMs results at the 5th month. In the early period, she had abnormal GMs (CS, F-) persistently.

Predictive value of GMs in the neurological and developmental process was detected higher than of the neurological assessment and cranial ultrasonography findings[4,5,17,21,28-30]. In our study, the infant who showed minor neurological dysfunction at the end of the first year had persistent abnormal GMs and had abnormal neurological signs (weak head control, hypertonicity, no reaction to voice or light, increased deep tendon reflexes). Cioni et al.[21] found 78–83% compliance between neurological assessment and GMs. In our study, the number of infants decreased in the follow-up period. Therefore, GMs results (as the GMs decision could be made after 20 weeks) were compared with the sixth month neurological examination results. Only nine infants had clinical neurological examination at corrected age of 6 months. Their neurological examination results and GMs results were compared and important compliance was found, supporting the previous literature.

Prechtl et al.[8] studied 130 infants with 26–41 weeks gestational age and concluded that abnormal GMs results correlated with abnormal cranial ultrasonography results. In our study, comparison of the results of GMs and cranial ultrasonography was done in 28 infants and complete compliance was found (PABAK=0.86). Our results were consistent with Prechtl et al.'s results. Laptook et al.[31] found that 30% of preterm infants who had normal cranial ultrasonography developed CP or mental retardation later. In our study, one infant with normal cranial ultrasonography in the first month of life showed abnormal GMs at the end of the fifth month. The common result of all studies comparing GMs with other neurological and neuroimaging techniques was that GMs could be complementary to other diagnostic and follow-up procedures. Combining the results of these techniques, the outcome could be more easily predicted for individual cases[29,30,32,33].

Many studies have shown that early rehabilitation programs affected motor development positively[34,35]. Considering the ethical dimension, this study did not include a control group and both infants with normal and abnormal GMs underwent an early physiotherapy program. Follow-up was established by a home exercise program and family education. However, GMs can be added as a useful assessment method in early rehabilitation.

This study included a follow-up period until corrected age of 12 months. It is very well known that long-term neurodevelopmental follow-up is essential in high-risk infants[21]. Long-term follow-up of the study population is under consideration in the future.

As a final conclusion, GMs assessment facilitates the selection of high-risk infants in the early intervention period and contributes to other neurological assessments and imaging techniques for the determination of the developmental prognosis of the infants. Long-term, multicenter studies, which also cover the prenatal period, are required in our country.

Acknowledgements

The first author is deeply grateful to Dr. Heinz Prechtl and Dr. Christa Einspieler from the Medical University of Graz, Austria for training in Prechtl's Method on the Qualitative Assessment of General Movements and for their continuous kind support.

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