Research Article / Araştırma Makalesi

The Consistency Between Motor Repertoire of Low Birth Weight/Preterm Infants and Results of Cranial Ultrasound Evaluation: A Cross-Sectional Study

Düşük Doğum Ağırlıklı/Erken Doğmuş Bebeklerin Motor Repertuvarı ile Kranyal Ultrason Değerlendirmesinin Sonuçları Arasındaki Tutarlılık: Kesitsel Bir Çalışma

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Abstract: The study aimed to investigate the results and early agreement of Prechtl analysis and cranial ultrasonography results in infants. In this cross-sectional retrospective study, we examined 64 babies who were born before 37 weeks gestational age with a birth weight under 2500 grams and were followed up between January 2015 and June 2017. We analyzed video footage taken during the weeks of the cases using Prechtl analysis to determine their movement patterns. We then compared the results of the motion analysis with the cranial ultrasonography examination results using Kappa test statistics to determine their compatibility. With the Prechtl analysis results, 57 (89.1%) of the cases were evaluated as 'normal general movements' and 7 (10.9%) as 'abnormal general movements'. While findings of pathology were detected as a result of cranial ultrasonography in 9 (14.1%) babies, no findings were observed in 55 (85.9%) babies. An 85.7% (kappa = 0.857) agreement was found between general movements results and cranial ultrasonography results. In risky babies with prematurity and low birth weight, early rehabilitation decisions as a result of general movements evaluation may contribute to reducing disability due to neurodevelopmental disorders.
Keywords: General movements; Premature birth; Prechtl analysis

Özet: Çalışmanın amacı, düşük doğum ağırlıklı ve erken doğmuş bebeklerde Prechtl analizi ve kranyal ultrasonografi sonuçlarının erken uyumunu ve sonuçlarını araştırmaktı. Bu kesitsel retrospektif çalışmada Ocak 2015 ile Haziran 2017 tarihleri arasında erken doğmuş (<37 hafta) ve düşük doğum ağırlıklı (<2500gr) doğan ve takip edilen 64 bebeği inceledik. Hareket kalıplarını belirlemek için Prechtl analizini kullanarak vakaların haftaları boyunca çekilen video görüntülerini analiz ettik. Daha sonra hareket analizi sonuçlarını kranyal ultrasonografi muayene sonuçlarıyla Kappa test istatistiklerini kullanarak karşılaştırarak uyumluluğunu belirledik. Prechtl analizi sonuçlarına göre olguların 57'si (%89,1) 'normal genel hareket', 7'si (%10,9) ise 'anormal genel hareket' olarak değerlendirildi. Bebeklerin 9'unda (%14,1) kraniyal ultrasonografi sonucunda patoloji bulgusu saptanırken, 55 (%85,9) bebekte herhangi bir bulguya rastlanmadı. Genel hareket analiz sonuçları ile kraniyal ultrasonografi sonuçları arasında %85,7 (kappa = 0,857) uyum bulundu. Prematüre ve düşük doğum ağırlıklı riskli bebeklerde genel hareketlerin değerlendirilmesi sonucunda erken rehabilitasyon kararları verilmesi nörogelişimsel bozukluklara bağlı engelliliğin azaltılmasına katkı sağlayabilir.
Anahtar Kelimeler: Genel hareketler; Prematüre doğum; Prechtl analizi

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1. Introduction

Babies with a history of prematurity and low birth weight are considered risky newborns. In these babies; many different medical problems can occur, such as respiratory distress syndrome, apnea of prematurity, bronchopulmonary dysplasia, retinopathy of prematurity, necrotizing enterocolitis, germinal matrix hemorrhages and periventricular leukomalacia (PVL). A history of prematurity and low birth weight are also important risk factors for cerebral palsy (CP) and other neurodevelopmental disorders. In these cases where a multidisciplinary approach is important, it offers early diagnosis, intervention, and rehabilitation opportunities (1, 2). The diagnosis of CP is basically based on history and clinical findings. Although there are different opinions about the age of diagnosis, it is recommended to wait at least 2 years of age (3). While imaging methods like cranial ultrasonography (USG) and brain magnetic resonance imaging (MRI) are essential for diagnosing CP, they are most reliable after myelination progresses around age two (4). Hence, early diagnostic methods are crucial. General movements (GMs) assessed via Prechtl analysis offer a promising alternative, as they can predict neurological disorders early and accurately.

General movements are the most common and complex pattern of spontaneous movements noticed in babies. These movements were first described by Prechtl et al. (5) in preterm babies. GMs are sequential movements of the whole body, including arms, legs, neck, and trunk, and continue from the 9th postmenstrual week to the 5th or 6th postterm month. The densities, forces, and speeds of these movements show increasing and decreasing characteristics. They have a gradual beginning and end, are fluid, complex, and variable in nature. Any changes in the quality and shape of this movement pattern are an important marker for neurological dysfunctions in fetuses and preterm infants (6, 7).

Before birth, babies exhibit different types of movements that are classified into preterm or fetal GMs and writhing movements, which occur between term and post-term 6 to 9 weeks. After the 9th week post-term, fidgety movements (FMs) appear and continue until 5-6 months post-term (6).

In the evaluation of GMs with Prechtl analysis, the characteristics of the movements are taken into account. Movements should involve the entire body and have a complex, fluid, and changing pattern(7). According to Prechtl analysis, GMs that lack specific features are classified as "abnormal". There are five different types of abnormal GMs: chaotic (Ch), cramped synchronized (CS), and poor repertoire (PR), which are typically observed during the preterm or term periods, and absence of fidgety movements (F-) and abnormal FMs, which are commonly observed during the post-term period (8).

Compared to other methods like MRI or USG, the “general movements” assessment is faster, non-invasive, and low-cost (7). For the evaluation of CP, it is recommended to use an MRI that is taken after the age of 2 years, as the process of myelination continues in the first few years after birth (4). On the other hand, GM evaluation can predict neurological disorders such as CP early and accurately. The analyses for GM evaluation are performed up to the 20th week post-term (8).

Our study aims to analyze video recordings made in the first 4 months of post-term to determine the movement patterns of babies who were born with low birth weight and a history of preterm birth, according to their gestational age. We will utilize Prechtl analysis to determine their movement patterns and investigate the early compatibility of the results obtained with cranial ultrasound examination results.

2. Material and methods

2.1 Patient recruitment and inclusion criteria

The retrospective cross-sectional study was conducted at Trakya University, Faculty of Medicine, Physical Therapy and Rehabilitation outpatient clinic between January 2015 and June 2019. The Scientific Research Ethics Committee approved the study protocol (TUTF-GOBAEK 2017/254).

Written informed consent was obtained from all parents/caregivers of the patients included in the study. The study was conducted in accordance with the principles of the Declaration of Helsinki. The information on the cases was obtained from the documents stored in the polyclinic's archives.

The inclusion criteria were: being preterm babies born before 37 weeks with a birth weight under 2,500 grams, having complete and assessable demographic information, video recordings, and cranial USG reports in their files. The study excluded infants who were born with normal weight and gestational period, had major congenital malformations, metabolic diseases, or needed mechanical ventilation with intubation. Additionally, infants who received anticonvulsant or sedative treatment were also excluded based on recorded information.

2.2 Demographic data

We collected demographic data including age, gender, gestational age, birth weight, type of birth (cesarean section or normal), and multiple pregnancy history. We grouped cases by birth weight into three categories: Low birth weight (LBW) (2500-1501 g), very low birth weight (VLBW) (1500-1001 g), and extremely low birth weight (ELBW) (<1000 g). Additionally, we classified cases by gestational age into three groups: borderline premature (36-37 weeks), moderately premature (32-35 weeks), and extremely premature (24-31 weeks).

2.3 Evaluation process of video records

Recorded videos of babies taken for the evaluation of GMs during outpatient clinic admissions and stored in the polyclinic archive were evaluated retrospectively. Videos of the babies taken from birth (excluding the first 3 days) until the 5th month postterm were evaluated. GMs evaluations were conducted based on a minimum of 2 and a maximum of 4 video recordings. In video recordings taken at gestational ages of 29-31 weeks, 32-37 weeks, and 38-44 weeks, "preterm and writhing" GMs were evaluated, while in recordings taken at 48-56 weeks, FMs were assessed for movement patterns. The evaluation process was conducted in a quiet environment to eliminate any outside factors that could interfere with the observer's perception. A minimum of 45 minutes was taken between two video evaluations to ensure accuracy. To avoid influencing the results, the babies' existing risk factors and cranial USG results were not examined before the evaluation.

The inclusion criteria for evaluated video recordings were:

-During the video recording, the baby was lying on its back on a surface with plain colors that did not affect visual perception.

-Video recording for term babies must be taken when awake, but this was not taken into account for preterm babies.

-The accuracy of the recording duration was decided according to the week in which the baby was present. Recordings made between 30-60 minutes for the preterm period and between 5-10 minutes for the post-term period were evaluated. The specified durations for video recordings were selected based on previous research indicating these time frames are optimal for capturing representative general movements (6,7).

-Video recording of the baby wearing the correct clothing: naked or only in a diaper. Term babies who were dressed in a way that left their arms and legs exposed.

The following video recordings were excluded:

-Video recordings taken within the first 3 days after birth or between weeks 6 and 8 (corrected age).

-Camera records where the camera is not positioned at the baby's feet and viewing the baby from above during video recording

-Video recordings made in cases of crying, restlessness, or the presence of a pacifier.

-If the family gave a sound warning or touched the baby during the video recording.

-If there was a mirror, toy, or another doll next to the baby during the video recording.

2.4 Evaluation of general movements

The data from each video was recorded in charts. According to the evaluation of the general movements two groups were created:

-Normal GMs: Cases in which normal movements were observed in all footage or cases in which abnormal GMs were observed in the first shots but normal GMs were seen in subsequent video images and as a result, they were evaluated as “normal”.

-Abnormal GMs: Cases with abnormal GMs seen in all video evaluations or cases in which normal GMs were observed in the first record but abnormal GMs were seen in subsequent video images and as a result, they were evaluated as “abnormal”.

2.5 Evaluation of cranial USG results

Cranial USG results of the babies were accessed from the polyclinic files and those with at least two cranial USG results were evaluated. The cranial ultrasound findings of infants were reported as "normal" or pathological, including periventricular leukomalacia and/or germinal matrix hemorrhages (stage 1-3).

-The case with normal cranial USG results or with pathology in the first USG but normal in subsequent USGs was classified as the "normal cranial USG" group.

-The case with abnormal cranial USG results or normal in the first USG but abnormal in subsequent USGs was classified as the "abnormal cranial USG" group.

Compatibility between GM's evaluation and cranial USG results was assessed using Kappa test statistics to determine the level of agreement between the two methods. Additionally, the study analyzed GMs distribution based on prematurity and birth weight.

2.6 Statistical analysis

Results are expressed as mean ± standard deviation or number (%). Kappa test statistics were used to examine whether there was agreement between GMs analysis results and cranial USG results. Kappa coefficient can take a value between -1 and +1. Kappa coefficient value; <0.20 indicates insignificant agreement, between 0.21-0.40 indicates poor agreement, between 0.41-0.60 indicates moderate agreement, between 0.61-0.80 indicates significant agreement, and between 0.81-1.00 indicates excellent agreement (9). The Fischer exact test, univariate regression, and multivariate logistic regression analyses were used to reveal independent risk factors (gestational age, birth weight, gender, mode of delivery and multiple gestation births) for the abnormal GMs analysis results. A p-value of less than 0.05 was accepted as the limit for statistical significance.

3. Results

3.1 Patients

A total of 64 cases with a history of preterm and low birth weight were included who were admitted to our outpatient clinic and who met the inclusion criteria were included in the study. Out of the total cases, 34 (53.1%) were males and 30 (46.9%) were females. The median (IQR) week of birth was 32 (29-34). The mean birth weight was 1600.9±491.5 grams. Out of all the cases, 59 (92.2%) of them had undergone a cesarean delivery, while only 5 (7.8%) had a normal vaginal birth. The study revealed that 15 babies (23.4%) had a history of being born as twins, and 3 of them (4.7%) were born as triplets. However, one of the twins was excluded from the study due to incomplete data accessibility. The baseline demographics and clinical characteristics of the patients are summarized in Table 1.

Table 1. Demographical and clinical characteristics of the patients

	Total (n=64)
Gender *n (%)*	
Female	30 (46.9)
Male	34 (53.1)
Birth weight *(g) mean±SD*	1600.9±491.5
Birth weight categories *n (%)*	
Low birth weight (2500-1501 g)	37 (57.8)
Very low birth weight (1500-1001 g)	18 (28.1)
Extremely low birth weight (<1000 g)	9 (14.1)
Gestational age *median (IQR), weeks*	32 (29-34)
Gestational age groups *n (%)*	
Borderline premature (36-37 weeks)	27 (42.2)
Moderately premature (32-35 weeks)	27 (42.2)
Extremely premature (24-31 weeks)	10 (15.6)
Mode of delivery *n (%)*	
Cesarean section	59 (92.2)
Vaginal delivery	5 (7.8)
Singletons *n (%)*	46 (71.9)
Multiple gestation births *n (%)*	
Twins	15 (23.4)
Triplets	3 (4.7)

3.2 Cranial USG results

Results of cranial USG were obtained and recorded for 64 cases, with at least two USG scans performed for each case. It was observed that the first cranial USG scans were performed within the first week after birth. Both (the first and the last) USG results were found to be normal in 50 cases, both USG results were abnormal in 9 cases, and only the first USG result was abnormal in 5 cases.

3.3 Results of evaluation process of video records

At least 2 and at most 4 video images of the cases were obtained. There were 4 video recordings for 17 of the cases, 3 for 27, and 2 for 20 of the cases.

3.4 Results of evaluation of general movements

Table 2 presents the evaluation results of all cases. As a result of GMs evaluation from video recordings, abnormal features were observed in all recordings in 7 of 64 cases (10.9%) and were evaluated as abnormal GMs. The evaluation of 57 cases (89.1%) resulted in normal GMs. According to the evaluation, 46 of the 57 cases with normal GMs results received normal results in all recordings, while 11 cases had normal results in the subsequent imaging despite showing abnormal features in the first imaging (Table 3). In 11 of the 13 cases in which a PR movement pattern was observed in the preterm and/or writhing period, a normal movement pattern developed in the following periods.

Table 2. GMs assessment results of all patients

Case no	1.record 29-31 weeks	2.record 32-37 weeks	3.record 38-44 weeks	4.record 48-56 weeks	Result
1	-	N	N	N	N
2	-	N	N	N	N
3	-	PR	PR	N	N
4	-	PR	N	N	N
5	-	N	-	N	N
6	-	CS	CS	F-	AN
7	-	N	-	N	N
8	-	N	N	-	N
9	-	N	N	N	N
10	-	N	-	N	N
11	N	N	N	N	N
12	N	N	N	N	N
13	-	N	N	-	N
14	-	N	N	N	N
15	-	CS	CS	F-	AN
16	-	-	N	N	N
17	-	N	N	N	N
18	-	N	N	N	N
19	-	-	N	N	N
20	-	N	-	N	N
21	-	N	N	N	N
22	-	CS	-	F-	AN
23	-	N	N	N	N
24	N	N	N	N	N
25	-	N	N	-	N
26	-	PR	-	N	N

N: Normal, AN: Abnormal, PR: Poor Repertoire, CS: Cramped-Synchronized, F-: Absent Fidgety, GMs: General movements

Table 2. (continued) GMs assessment results of all patients

27	N	N	N	N	N
28	-	N	N	N	N
29	-	-	N	N	N
30	-	PR	N	N	N
31	-	N	N	-	N
32	-	N	N	N	N
33	-	PR	CS	F-	AN
34	CS	CS	CS	F-	AN
35	-	N	-	N	N
36	N	N	N	N	N
37	-	PR	PR	N	N
38	-	N	N	N	N
39	PR	CS	CS	F-	AN
40	-	N	N	N	N
41	-	N	N	-	N
42	PR	CS	N	N	N
43	N	N	N	N	N
44	PR	N	N	N	N
45	-	N	N	-	N
46	CS	CS	CS	F-	AN
47	N	N	N	N	N
48	-	-	N	N	N
49	-	N	N	N	N
50	-	-	N	N	N
51	-	N	N	N	N
52	-	PR	PR	N	N
53	-	PR	-	N	N

54	N	N	N	N	N
55	PR	PR	N	N	N
56	N	N	N	N	N
57	-	N	-	N	N
58	-	PR	CS	N	N
59	N	N	N	N	N
60	-	N	N	N	N
61	N	N	N	N	N
62	-	N	N	N	N
63	-	N	N	N	N
64	-	N	N	N	N

N: Normal, AN: Abnormal, PR: Poor Repertoire, CS: Cramped-Synchronized, F-: Absent Fidgety, GMs: General movements.

Table 3. The results of "General movements" analysis

	1N2N (n=46)	**1AN2N** (n=11)	**1AN2AN** (n=7)	**GMs results (n) %**
Normal GMs	46	11	0	(57) %89.1
Abnormal GMs	0	0	7	(7) % 10.9
%	%70.1	%19	%10.9	(64) %100

N: Normal, AN: Abnormal, GMs: General movements

Excellent (kappa = 0.857) agreement was found between GMs evaluation results and cranial USG results (Table 4).

Table 4. Comparison of GMs evaluation results and cranial USG results

	Normal USG (n=55)	**Abnormal USG (n=9)**
Normal GMs (n=57)	55	2
Abnormal GMs (n=7)	0	7

GMs: General movements, USG: Ultrasonography, kappa test (kappa= 0.857)

The univariate regression and multivariate logistic regression analyses showed that gestational age, birth weight, gender, mode of delivery and multiple gestation births were not a significantly associated with the abnormal GMs analysis results.

4. Discussion

General movements are a major expression of the young developing brain; they form the cornerstone of early development (10). Starting with Heinz Prechtl's works, it has been underlined in the literature to date that assessing the quality of general movements can aid in diagnosing developmental disorders, such as CP early (11). Hadders et al. (12) also made a different classification for GMs quality, based on complexity and variability. According to this; normal optimal, normal suboptimal, slightly abnormal and markedly abnormal GMs classes have been identified. In this evaluation, fluency was taken as the least important component. In current study, we determined abnormal GMs patterns according to Prechtl analysis, as it was the first to be described and is frequently used in studies. In the current study, we detected PR or CS in 18 cases and F- abnormal GMs pattern in 7 cases.

There are many studies in the literature that highlight the predictive ability of "general movements" evaluation for CP and other neurological disorders. Bosanquet et al (11),

showed in their study that GMs were a strong predictor of CP with 98% sensitivity and 91% specificity. In various studies on GMs, sensitivity is defined as between 95% and 100%, and specificity is between 96% and 98% (13,14). On the other hand, there are also studies showing that these rates vary according to preterm, term, and post-term periods. In some studies; although sensitivity and specificity are high in the preterm and term periods, it has been shown to reach the highest values in post-term 8-20. weeks (15-17).

Nakajima et al. (18), examined the neurological results of 18 preterm babies with PR movements at the ages of 8-10 years and found that six babies developed CP, 6 babies developed mild neurological abnormalities, and 6 babies showed normal neurological development. In conclusion, they showed that detailed scoring of the PR abnormal movement pattern was not associated with neurological outcomes. In the current study, it was observed that a normal movement pattern developed in the following period in 11 of 13 cases in which an abnormal GMs PR pattern was detected.

According to a study by Ferrari et al. (15), CS movements have a specificity of 92.5%-100% in preterm babies and can be used as an important predictor of CP. Our retrospective study observed CS movement in 9 cases, out of which 7 cases showed an F-pattern in their video records during the "fidgety" period. However, since we did not have any follow-up data on the cases over 2 years of age and whether they had a definitive CP diagnosis, we could not calculate the sensitivity and specificity values of GMs patterns. It is important to note that close follow-up is necessary, particularly in cases with CS movements, as they may have a high rate of F-pattern during the "fidgety" period.

When the literature is examined; It has been observed that normal movements in the "fidgety" period are associated with normal neurological outcomes, and especially the F-pattern is associated with abnormal neurological outcomes, especially CP(6, 8). Burger and Louw examined 17 studies in their systematic review to examine the data on the degree to which GMs analysis predicts neurological outcomes in 12-24 months (19). Based on the results of 5 studies that examined the predictive value of GMs only in postterm 8-20. weeks very high sensitivity (93%-100%) and specificity (92%-99%) values were reported. A high association (sensitivity 92%, specificity 82%) was shown between the quality of GMs at 8-20 weeks post-term (FMs period) and neurodevelopmental outcomes in infants in 15 of 17 studies. In conclusion; It has been stated that assessment of GMs, especially in the FMs period, can be used as a prognostic method to identify babies in which neurological disorders may develop.

Darsaklis et al.(20), examined 39 studies in their systematic review and gave the comparison results of "fidgety" and "writhing" period prediction values. As a result of the data obtained, it was stated that the detection of F- and/or abnormal FMs patterns at the corrected 12th week predicted adverse outcomes better than abnormal writhing period findings. It's possible that the lower prediction rate in the first periods is due to the fact that any abnormal movement patterns observed during the preterm or writhing period might return to normal before, or during, the fidgety period (7). The high estimated values in the “fidgety” period can also be associated with the fact that this period is simultaneous with the period when cortical activity shifts from the “subplate” structure to the cortical area (10). In the current study, consistent with the literature, normal FMs were detected in 61.11% of the cases with abnormal movements in the preterm or writhing period.

When evaluating general movements, it is recommended to take multiple videos from different periods instead of relying on a single shot. This increases the predictive value of the evaluation (6). To ensure an accurate analysis, a specific follow-up chart should be created for each baby. In our study, we evaluated babies who had 2-4 video recordings. However, since our study is retrospective and we can only evaluate the accessible footage, we are unable to determine the "fidgety" period results of 6 out of 64 cases. When evaluating general movements, it is

recommended to take multiple videos from different periods instead of relying on a single shot. This increases the predictive value of the evaluation (6). To ensure an accurate analysis, a specific follow-up chart should be created for each baby. In our study, we evaluated babies who had 2-4 video recordings. However, since our study is retrospective and we can only evaluate the accessible footage, we are unable to determine the "fidgety" period results of 6 out of 64 cases.

Upon examination of the literature, studies have shown a correlation between abnormal GM results and minor neurological dysfunctions. Hadders et al.(12), showed that the atypical GMs pattern observed during the "fidgety" period is linked to the development of minor neurological dysfunctions as well as attention deficit and hyperactivity disorders. For this reason, infants with any abnormal GM patterns should receive follow-up care for possible neurological disorders, and if necessary, be included in early rehab programs.

The first years of life, when neuroplasticity is very active, are critical for effective early rehabilitation practices. Novak et al.(21), conducted a systematic review to evaluate methods for early diagnosis and intervention of CP. It has been suggested that infants who do not engage their motor cortex actively may experience loss of cortical connections. This highlights the importance of early intervention methods that encourage active movement. These methods, based on developmental processes, have been found to have positive effects on cognitive functions, particularly up to the age of three (22). For this reason, identifying risky babies who need early rehabilitation, especially through GMs analysis, is important to achieve positive neurodevelopmental results.

There are scientific studies that investigate the correlation between the evaluation of GMs and cranial imaging techniques. In a study conducted by Ivanov et al. (23), where 35 infants were examined prospectively, normal FMs were found in 31 of the cases while an F-pattern was observed in 4 of them. The researchers stated that cases with normal FMs had normal or minor cranial USG abnormalities while severe abnormalities were observed in the cranial USG of cases with the F-pattern. The study concluded that the results of both evaluations were highly similar, with an accuracy rate of over 91%.

In a study conducted by Mutlu et al. (24), 28 preterm babies were evaluated and it was found that there was complete agreement between the GMs analysis results and cranial USG results. Consistent with the findings of the literature, the current study revealed excellent agreement (kappa=0.857) between the GMs analysis results and cranial USG results of 64 cases.

Novak et al. (21), conducted a systematic review to identify the most effective methods for early, accurate, and definitive diagnosis of CP. They identified three methods with the best predictive validity to detect CP before five months of age. These methods and their sensitivity rates are: GMs evaluation with Prechtl analysis (98% sensitivity), Hammersmith infant neurological evaluation (90% sensitivity), and neonatal MRI (86-89% sensitivity)f.

The present study has some limitations. All of the infant in our cohort were analyzed only retrospectively and the number of subjects was relatively small. So, we will expand the sample size to and extend the follow-up time to make the results more reliable in the future.

5. Conclusion

The study concluded that there was excellent agreement between the results of GMs analysis and cranial USG. GMs analysis can significantly contribute to the evaluation of babies with risk factors such as prematurity and low birth weight in terms of neurological disorders that may develop. It is believed that GMs analysis can benefit the long-term follow-up of at-risk babies and even direct them to early rehabilitation, thereby reducing the disabilities caused by neurological disorders that may develop.

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Ethics

Ethics Committee Approval: The study was approved by Trakya University Noninterventional Clinical Research Ethical Committee (TUTF-GOBAEK 2017/254).

Informed Consent: The authors declared that it was not considered necessary to get consent from the patients because the study was a retrospective data analysis.

Authorship Contributions: Concept: HT, CA, FT. Design: HT, CA, FT, HÖ, YK. Data Collection or Processing: CA, FT, HÖ, YK. Analysis or Interpretation: HT, CA, FT, HÖ, YK. Literature Search: HT, CA. Writing: CA, FT.

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Clinical Relevance: GMs analysis may be one strategy to help evaluation of preterm infants of neurological disorders that may develop. This analysis can benefit to direct preterm infants to early rehabilitation, there by reducing the disabilities caused by neurological disorders.