Original Article

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The Prechtl's General Movement Assessment, Hammersmith Infant Neurological Examination and Sensory Profile-2 in Prediction of Cerebral Palsy at Two Years of Age in High-risk Infants: A Retrospective Study

Yüksek Riskli Bebeklerde İki Yaşında Serebral Palsi Tahmininde Prechtl Genel Hareket Değerlendirmesi, Hammersmith Bebek Nörolojik Muayenesi ve Bebek Duyu Profili-2: Retrospektif Bir Çalışma

Hatice ADIGÜZEL[1], Halil İbrahim ÇELİK[2], Yusuf Ünal SARIKABADAYI[3], Nevin ERGUN[4], Bülent ELBASAN[5]

[1]Kahramanmaraş Sütçü İmam University Faculty of Health Sciences, Department of Physiotherapy and Rehabilitation, Kahramanmaraş, Türkiye
[2]Bilge Çocuk Special Education and Rehabilitation Center, Ankara, Türkiye
[3]Sanko University Faculty of Medicine, Department of Pediatrics, Gaziantep, Türkiye
[4]Sanko University Faculty of Health Sciences, Department of Physiotherapy and Rehabilitation, Gaziantep, Türkiye
[5]Gazi University Faculty of Health Sciences, Department of Physiotherapy and Rehabilitation, Ankara, Türkiye

ABSTRACT

Objective: The predictive values of the general movements assessment (GMA), the Hammersmith infant neurological examination (HINE), and the infant sensory profile-2 (ISP-2) were investigated for the diagnosis of cerebral palsy (CP) in high-risk infants at two years age.

Methods: Thirty-four high-risk infants with a mean gestational age of 33.1±4.2, who were followed up in the physiotherapy unit after discharge from the neonatal intensive care unit, were recruited. Prechtl's GMA results were collected for infants at 3rd month. The ISP-2 and HINE were used to evaluate neurological and sensory processing at 3rd month for once, respectively. A pediatric neurologist who was blinded to all testing made the diagnosis of CP at two years of age based on neuroimaging and clinical tests. The GMA, HINE, and ISP-2's predictive values were assessed seperately and sequentially (with two and three stage testings).

ÖZ

Amaç: Bu çalışmada yüksek riskli bebeklerde iki yaşında serebral palsi (SP) tanısı için genel hareket değerlendirmesi (GMA), Hammersmith infant nörolojik muayene (HINE) ve bebek duyusal profili-2'nin (ISP-2) prediktif değerleri araştırıldı.

Yöntemler: Yenidoğan yoğun bakım ünitesinden taburcu olduktan sonra fizyoterapi ünitesinde takip edilen, ortalama gebelik yaşı 33,1±4,2 olan 34 yüksek riskli bebek çalışmaya alındı. Bebekler için demografik veriler, doğum öncesi risk faktörleri ve üçüncü ayda Prechtl'in GMA sonuçları toplandı. Nörolojik muayene ve duyusal işlemeyi değerlendirmek için sırasıyla HINE ve ISP-2 anketi üçüncü ayda bir kez yapıldı. GMA, HINE ve ISP-2'nin prediktif değerleri sıralı (tek-iki-üç aşamalı) değerlendirildi.Tüm testlere kör olan bir pediatrik nörolog, nörogörüntüleme ve klinik testlere dayanarak iki yaşında SP tanısını koydu.

Address for Correspondence: Hatice Adıgüzel, Kahramanmaraş Sütçü İmam University Faculty of Health Sciences, Department of Physiotherapy and Rehabilitation, Kahramanmaraş, Türkiye
E-mail: fzthatis@gmail.com **ORCID ID:** orcid.org/0000-0001-9323-839X

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ABSTRACT

Results: The mean birth weight of the infants was 1993.7±889.3 grams (g), the 3rd month HINE and ISP-2 total score averages were 56.9±9.3 and 53.8±13, respectively. In order to diagnose CP, it was important to consider the predictive values of the GMA (absent FMs) (sensitivity: 100%; specificity: 96.15%, p<0.001; 95% confidence interval: 80.36-99.9), HINE (sensitivity: 87.5%; specificity: 80.77%; p=0.004), and the combination of both GMA and HINE (sensitivity: 87.5%; specificity: 100%; p<0.001). The combination of ISP-2, GMA, and HINE was significant in identifying CP diagnosis (sensitivity: 62.5%, specificity: 100%, p=0.002) despite the ISP-2's unremarkable predictive performance (sensitivity: 75%, specificity: 61.54%, p=0.123).

Conlusion: Early follow-up of high-risk of infants may enable early diagnosis of CP and referral to early intervention by clinical application and combination of GMA and HINE.

Keywords: General movement assessment, Hammersmith infant neurological examination, infant sensory profile-2, cerebral palsy, high risk infant

ÖZ

Bulgular: Bebeklerin ortalama doğum ağırlığı 1993,7±889,3 gram (gr), 3. ay ve sırasıyla HINE ve ISP-2 toplam puan ortalamaları 56,9±9.3 ve 53,8±13 idi. SP tanısı koymak için GMA (FM olmaması) (sensitivite: %100; spesifite: %96,15, p<0,001; %95 güven aralığı: 80,36-99,9), HINE'nin (sensitivite: 87,5 spesifite: %80,77; p=0,004) ya da GMA ile HINE kombinasyonunun (sensitivite: %87,5; spesifite: %100; p<0,001) prediktif değerlerinin yüksek olduğu, ISP-2, GMA ve HINE kombinasyonunun sensitivite: %62,5, spesifite: %100, p=0,002), ISP-2'nin tek kullanıldığında dikkat çeken prediktif performansına rağmen sensitivite: %75, spesifite: %61,54, p=0,123) SP tanısını belirlemede anlamlı olduğu bulundu.

Sonuç: Yüksek riskli bebeklerin takibiyle SP'nin erken tanısının; klinik uygulama, GMA ve HINE kombinasyonuyla yapılması erken müdahaleye yönlendirmeye olanak sağlayabilir.

Anahtar Kelimeler: Genel hareket değerlendirmesi, Hammersmith bebek nörolojik muayenesi, bebek duyu profili-2, serebral palsi, yüksek riskli bebek

Introduction

High-risk infants may encounter many problems in terms of neuromotor, cognitive, sensory and psychosocial developments (1-4). Cerebral palsy (CP), which is known as a disease with neurosensorimotor impairment, can also be observed in high-risk infants (5,6). The possibility to access early intervention to improve neurosensorimotor functions is provided by the early diagnosis of CP (5,7,8). Around the world, 1 in 10 newborns are born preterm each year, and those who are born very preterm (VPT) have the highest rates of neurodevelopmental disabilities (8). Up to 50% of infants with VPT experience mild to severe motor impairments such as CP (9,10).

Clinical diagnosis of CP can delay until 2 years of age (5,11,12). The guidelines state that high-risk of infants should be evaluated before the age of five months utilizing magnetic resonance imaging (MRI) neuroimaging, Prechtl's general movement assessment (GMA) for motor assessment, and the Hammersmith infant neurological examination (HINE) for neurological examination (5,11,12). Absence of fidgety movements (FMs) according to Prechtl's GMA in early infancy and total score of HINE <57 at 3 months have high predictive value in the diagnosis of CP (5,6,13-15). Early intervention is crucial for newborns who are at high risk for neurological or sensory abnormalities. By encouraging the empowerment of the family, early intervention can promote neuroplasticity while promoting the development of the motor and sensory systems (11). It is advised to use the GMA, HINE at high risk of infants to diagnose neurodevelopmental abnormalities (5,6,11,14-16). With high specificity and sensitivity, neurodevelopmental problems can be early predicted by these assesments (11). But there is not enough study which shows the relationship between the predictive power of the sensory processing disorders with neurodevelopmental disorders like CP. Kara et al. (17) stated sensory processing was linked to motor development in preterm infants at 1-4 months of corrected age (CA), using the infant sensory profile-2 (ISP-2).

The ISP-2 gives professionals a tool to record children's sensory processing patterns starting at early age, and Dunn has indicated that ISP-2 provides information as to whether a follow-up is necessary (18).

High risk of infants encounter many sensory stimuli in the neonatal intensive care unit (NICU), which are not present in the uterus, such as extremely noise, shiny lights, and painful medical applications. Infants' physiological reactions are impacted during this crucial time for brain development, and this can have a severe impact on their motor, neurological, and sensory developments, which can result in sensory processing problems (17). In particular, preterm newborns may experience sensory processing difficulties in addition to developmental disorders (17,19). However, studies on early spontaneous movements, neurological examination, and sensory processing are scarce (17,19).

Sensory processing is the neurological regulation of the stimulus coming with vestibular, proprioceptive, kinesthetic, visual, auditory, tactile, oral, olfactory inputs, and responding with appropriate reactions and behaviors (20). These processes show adequate development with natural stimuli from infancy. The infant's normal sensory and motor development may suffer as a result of decreased spontaneous movements for any reason and excessive sensory stimulation in the NICU. This can affect developing brain and the natural development of sensory systems. Studies revealed a significant difference in the sensory profiles of preterm infants compared to the terms (21,22). Looking at the long-term impact, children with sensory processing problems show weakness in fine and gross motor skills, and delays and losses in balance and coordination. Weak sensory processing in the preschool period can also lead to problems with distraction,

advocacy, language, and visuospatial skills (23). Various academic success problems, emotional difficulties, and poor interaction skills with peers can be seen at school age (24).

There are few studies evaluating the connection between motor development in newborns from the neonatal period and sensory processing factors (17,19,21). These infants at risk of biological vulnerability and neurological injury require neurodevelopmental follow-up after discharge. The purpose of this study was to assess the accuracy of GMA, HINE, and ISP-2, both alone and in combination, in predicting the diagnosis of CP in high-risk infants at two years of age.

Methods

Study Design

A retrospective methodological study.

Participants

We conducted a retrospective study on high-risk infants who were delivered in different hospitals in Gaziantep, Türkiye between 2016 and 2020 and were referred to the Lokman Hekim University Faculty of Health Sciences Department of Physiotherapy and Rehabilitation for post discharge follow-up. All parents signed written informed consent.

All clinical data, including demographic characteristics, prenatal, and postnatal history were obtained from medical records. The inclusion criteria were as follows; perinatal asphyxia, stage 3 hypoxic ischemic encephalopathy (HIE), intracranial hemorrhage (ICH) (level 2, 3, or 4), periventricular hemorrhage (PVH), cystic periventricular leukomalacia (PVL), kernicterus, bronchopulmonary dysplasia (BPD), respiratory distress syndrome (RDS), long-term oxygen support (7 days), >24 hours on mechanical ventilator (MV) support, retinopathy of prematurity (ROP), neonatal sepsis, 5th minute Apgar Score <3, necrotizing enterocolitis (NEC), preterm/multiple births <1500 g, and gestational age (GA) <32 weeks. Infants with genetic, metabolic, or congenital disorders were not included.

GA at birth, date of birth, sex, HINE, GMA, and ISP-2 scores at 3 months, as well as 2-year outcome, which comprised typical development or CP diagnosis, were the minimum necessary data for inclusion. The evaluation of 60 records resulted in the inclusion of 34 infants (14 girls and 20 males) (Figure 1). The GMA, HINE, and ISP-2's predictive values were assessed seperately and, sequentially (with two and three stage testingstwo-stage). testing and three stage testing. The Non-interventional Clinical Research Ethics Committee of Lokman Hekim University approved the study (approval no: 2022/95, date: 31.05.2022). Also the study was conducted in accordance with the Helsinki Declaration. Clinical Trial study registry identifier is NCT05217199.

Outcome measures

General Movement Assessment

We obtained the results of GMA of fidgety periods using Prechtl's method. The Prechtl's method is a valid and reliable

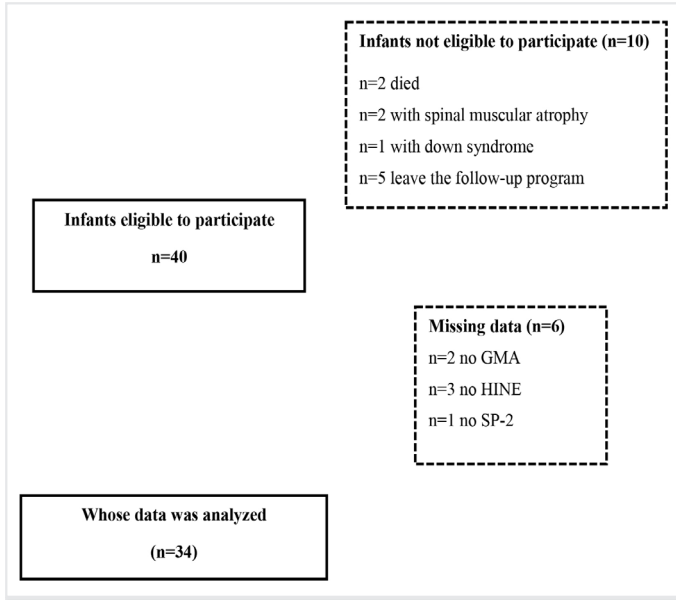

Figure 1. Flow diagram of study participants

GMA: General movement analysis, HINE: Hammersmith Infant neurological examination, SP-2: Sensory profile

video observation that uses gestalt perception to examine video recordings of spontaneous movements and reveal information about the functional integrity of the developing nervous system. Especially, GMA based on FMs, which typically occur between 3-5 months post-term age, is the most sensitive and specific indicator for later disabilities. Normal FMs are described as modest amplitude circular movements of the neck, trunk, and extremities moving at moderate speeds in all directions with varied acceleration. FMs are divided into three categories: normal, absent, and aberrant FMs (6,13,16). In present study, the 3-min-long video recordings taken during the fidgety period were evaluated by two certified experienced pediatric physiotherapists (B.E and H.A.) in basic and advanced GMA, who were blinded to the participants' clinical histories and neurological conditions at 3rd months. These physiotherapists evaluated each patient separately. They scored differently, but all of the scorings had interobserver agreement. When more than 1 record of GMA classification was available, the one closest to 12 weeks post-term was retrieved.

Hammersmith Infant Neurological Examination

The HINE is a reliable tool for the clinical neurological examination of newborns between the ages of 2 and 24 months. HINE has 26 items that test 26 various aspects of neurological functions, such as reflexes, posture, motions, and cranial nerve functions. Each item is scored between 0 and 3, and the individual scores are summed to create the global score. The overall score can vary from 0 to 78. To predict CP, international guidelines suggest a cut-off score of 57 at three months of age (5,14,25). The clinical records of infants were used to gather the HINE scores for this study, which were completed by pediatric

physiotherapists with at least 10 years of expertise in the field. HINE was scored at 3rd months once.

Infant Sensory Profile-2 (ISP-2)

The ISP-2, which is a parent-reported questionnaire, describes the sensory processing skills of infants from zero to six months, is a component of the sensory profile-2. It contains 25 items that assess different aspects of sensory processing. Each item is given a score between one and five, and the aggregate of the individual scores yields the raw score. It is a reliable and valid tool for sensory processing disorders of infants (18,23,24,26). Based on norm reference values, raw scores between 41 and 61 were classified as typical sensory development, while other scores were classified as atypical in the present study. The ISP-2 was scored at 3rd months once.

Diagnosis of CP

Based on neuroimaging and clinical evaluations at 2 years of age, a pediatric neurologist who was blinded to all assessments diagnosed CP. The neuroimaging scans were classified into one of seven primary patterns of abnormality as defined and described by Ashwal et al.'s (27) study. The classification categories were normal, periventricular white matter injury (PWMI), diffuse encephalopathy, focal ischaemic or haemorrhagic lesions, brain malformations, infection, and miscellaneous or unclassifiable lesions.

Statistical analysis

The GMA, HINE, and ISP-2 evaluations were dichotomized; for GMA, FMs (normal) or absent FMs (aberrant); for HINE, normal (scores ≥57) or abnormal (scores ≤57); and for ISP-2; typical (scores between 41 and 61) or atypical (scores ≤41 or ≥61). The accuracy of the assessment tools in accurately identifying those with and without CP was examined using receiver operating characteristics (ROC) analyses. Sensitivity, specificity, overall accuracy, area under the curve, and 95% confidence intervals were calculated. The ROC analysis was conducted with dependent (outcome) variable as typical development versus CP and independent (predictor) variables as GMA (normal versus aberrant), HINE (normal versus abnormal), and ISP-2 (typical versus atypical). Statistical significance was set as $p<0.05$. All statistical analyses were conducted with SPSS Statistics version 26 (IBM Inc, Chicago, IL, USA).

Results

The clinical and demographic characteristics of the infants were summarized in Table 1. The current study included 34 high-risk infants with a mean GA of 33.1±4.2 weeks. At age two in CA, eight infants (or 23.5%) had CP. In contrast to the 25 newborns who showed normal FMs at post-term age of 12 weeks, 8 infants had no (absent) FMs, according to the GMA data. At 12 weeks post-term, the mean HINE and ISP-2 scores were 56.9 and 53.8, respectively. According to the diagnostic, CP was present in all of the newborns (n=8) without FMs. Seven (58.3%) of the 12 infants with HINE scores below the threshold of 57 and six (33.3%) of the 18 children with impaired sensory processing had CP (Table 2).

Table 3 displays the GMA, HINE, and ISP-2's predictive values assessed seperately and, sequentially (with two and three stage testings two-stage), testing and three stage testing, seperately, sequential (two-stage) testing and three stage testing. In order to diagnose CP, it was important to consider the predictive abilities of the GMA (without FMs) (sensitivity=100%, specificity=96.15%, p=0.001), HINE (sensitivity=87.5%, specificity=80.77%, p=0.004), and the combination of both GMA and HINE (sensitivity=87.5%, specificity=100%, p=0.001). The combination of ISP-2, GMA, and HINE was significant in identifying CP diagnosis (sensitivity=62.5%, specificity=100%, p=0.002) despite the ISP-2's unremarkable predictive performance (sensitivity=75%, specificity=61.54%, p=0.123) (Figure 2, Table 3).

Table 1. Clinical and demographic characteristics (n=34)

Age (month), mean (SD)	**2.56 (0.16)**
Male, n (%)	20 (58.8)
Female, n (%)	14 (41.2)
Term birth, n (%)	8 (22.8)
Gestational age (weeks), mean (SD)	33.1 (4.2)
Birth weight (g), mean (SD)	1993.7 (889.3)
Preterm birth, n (%)	25 (73.5)
Multiple birth (yes), n (%)	13 (38.2)
NICU duration (d), mean (SD)	41.1 (26.4)
Perinatal pathologies	**n (%)**
PVL	4 (12.12)
Asphyxia	6 (18.18)
RDS	10 (30.3)
CLD	4 (12.12)
Pneumonia	1 (3.03)
Hyperbilirubinemia	3 (9.09)
Sepsis	3 (9.09)
PDA	1 (3.03)
SGA	1 (3.03)
Clinical characteristics	
Absent fidgety, n (%)	9 (26.5)
HINE total score at 3 months, mean (SD)	56.9 (9.3)
HINE scores <57 at 3 months, n (%)	12 (35.3)
ISP-2 total score, mean (SD)	53.8 (13.0)
ISP-2 total score 41 to 61, n (%)	16 (47.1)
CP diagnosis, n (%)	8 (23.5)

g: Gram, d: Day, NICU: Neonatal intensive care unit, PVL: Periventricular Leukomalacia, RDS: Respiratory distress syndrome, CLD: Chronic lung disease, SGA: Small for gestational age, PDA: Patent ductus arteriosus, HINE: Hammersmith infant neurological examination, CP: Cerebral palsy, ISP-2: Infant sensory profile-2, SD: Standard deviation

Table 2. GMA, HINE, ISP-2, and two-year outcome results of infants

Case	Fidgety (+: Normal and -: absent)	HINE (+: normal and -: abnormal)	ISP-2 (+: typical and -: atypical)	CP diagnosis
1	+	+	+	No
2	+	-	-	No
3	+	+	+	No
4	+	+	+	No
5	+	+	+	No
6	+	+	+	No
7	-	-	-	Yes
8	+	+	-	No
9	+	+	-	No
10	+	+	-	No
11	-	-	-	Yes
12	-	-	-	Yes
13	+	+	+	No
14	+	+	-	No
15	+	+	+	No
16	+	+	+	No
17	+	-	+	No
18	-	-	-	Yes
19	+	+	-	No
20	-	+	-	Yes
21	+	-	-	No
22	+	-	+	No
23	+	+	+	No
24	+	+	+	No
25	+	+	-	No
26	-	-	+	Yes
27	+	+	-	No
28	-	+	+	No
29	+	-	+	No
30	+	+	+	No
31	+	+	-	No
32	-	-	+	Yes
33	-	-	-	Yes
34	+	+	+	No

GMA: General movement analysis, HINE: Hammersmith infant neurological examination, CP: Cerebral palsy, ISP-2: Infant sensory profile-2

Discussion

This study revealed that high risk infants had abnormal early spontaneous movements, divergency in neurological examination, and atypical sensory processing in the first three months of life. To the best of our knowledge, this is the first study to investigate the relationship between GMA and sensory processing in the first few months of life using GMA, HINE, and ISP-2. In addition, this study is the first study to determine the predictabilityof CP at two years of age with the use of these three tests in the early period. This study showed that the specificity of GMA, which is crucial for identifying children without CP, was improved when GMA and HINE were combined. ISP-2 was added to the combination of GMA and HINE, but this did not increase predictive power. But, the use of the ISP-2 test in this study enabled the detection of early sensory disorders in high risk infants. In the current study, it was determined that the clinical implementation of GMA, HINE, and ISP-2 together in the early period of follow-up of high risk of infants might enable early detection of the risks of neurodevelopmental and sensory processing disorders and refer them for early intervention. There was debate regarding earlier research that looked at sensory processing and motor development before the age of one (17,21,28).

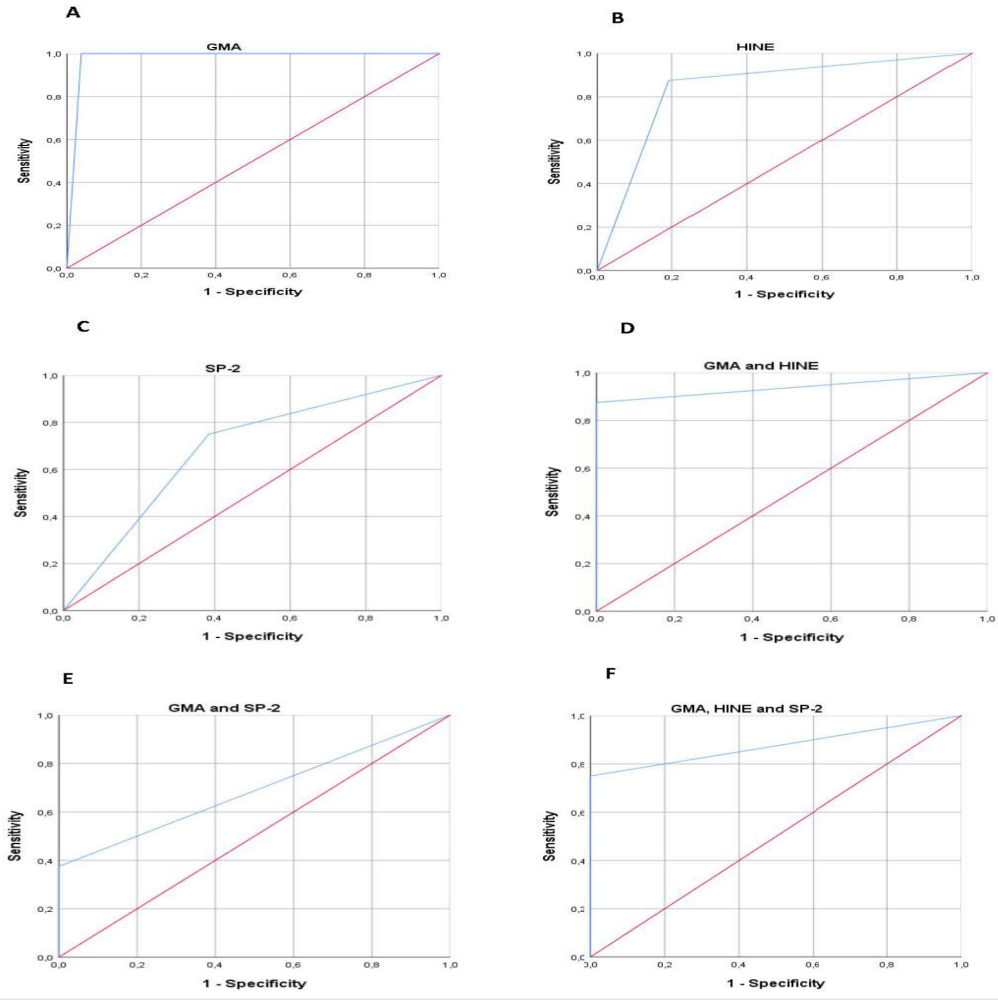

Figure 2. The ROC curves for each assessment tool individually and in combination

GMA: General movement analysis, HINE: Hammersmith Infant neurological examination, SP-2: Sensory profile, ROC: Receiver operating characteristics

Table 3. Predictive accuracy of the GMA, HINE, and SP-2 for CP diagnosis

Predictor of CP	Sensitivity % (CI 95%)	Specificity % (CI 95%)	Accuracy % (CI 95%)	AUC (CI 95%)	p-value
GMA (Absent FMs)	100 (63.06-100)	96.15 (80.36-99.9)	97.06 (84.67-99.93)	0.981 (0.936-1,000)	**<0.001**
HINE (Abnormal)	87.5 (47.35-99.68)	80.77 (60.65-93.45)	82.35 (65.47-93.24)	0.841 (0.679-1,000)	**0.004**
ISP-2 (Atypical)	75 (34.91-96.81)	61.54 (40.57-79.77)	64.71 (46.49-80.25)	0.683 (0.473-0.892)	0.123
GMA and HINE	87.5 (47.35-99.68)	100 (86.77-100)	97.06 (84.67-99.93)	0.938 (0.801-1,000)	**<0.001**
GMA and ISP-2	75 (34.91-96.81)	100 (86.77-100)	94.12 (80.32-99.28)	0.688 (0.444-0.931)	0.113
GMA and HINE and ISP-2	62.5 (24.46-91.48)	100 (86.77-100)	91.18 (76.32-98.14)	0.875 (0.691-1,000)	**0.002**

GMA: General movement analysis, HINE: Hammersmith Infant neurological examination, CP: Cerebral palsy, ISP-2: Infant sensory profile-2, CP: Cerebral palsy, CI: Confidence interval, AUC: Area under the curve

The GMA (absent FMs) had the highest CP prediction accuracy with high sensitivity and specificity in the current study. Although the combination of the tools did not improve the overall accuracy of GMA, it did improve the specificity of the GMA. Also, infants with atypical sensory processing and abnormal HINE score in the third month were diagnosed as having CP at two years CA with lower sensitivity and specificity more than GMA.

In the previous studies, it was stated that neonatal MRI, GMA and HINE had the best predictive values of CP diagnosis in the corrected 5th months of life (5,11,12,25). According to Novak et al.'s (5) study, term MRI performed before to the corrected 5th month had a sensitivity rate of 86% to 89% for diagnosing neurodevelopmental problems like CP. GMA is another method that is frequently used to predict CP. According to Prechtl et al. (29), the assessment of FMs could predict neurological outcome with 96% specificity and 95% sensitivity (11,16). According to Kwong et al. (15), GMA during the fidgety period had 97% sensitivity and 89% specificity for prediction of CP diagnostic. Similarly, according to Morgan et al. (11), FMs' sensitivity and specificity ratings for detecting neurodevelopmental problems in infants at risk were 95% and 97%, respectively. In the current study, the GMA (absent FMs) had the highest prediction accuracy with 95% sensitivity and 96% specificity. In this respect, our results were similar to these studies. GMA requires basic and advanced training and is also based on visual perception. When detecting neurodevelopmental diseases like CP, it has a strong predictive power. However, there are few clinics in our country, which limits the possibility of early diagnosis and, thus, early intervention. Both recent research and the most recent analysis indicate that GMA usage in our nation should increase. We believe that appropriate rules should be created and that GMA usage in our nation should be increased.

Neurological examination is important in infants with high risk of CP. It is shown that HINE cut-off scores in the first year of life can predict the first signs of CP. Romeo et al. (25) showed that there were various neuromotor development problems investigated by HINE in infants with high risk of CP in the first years of life (30). Novak et al. (5) and Romeo et al. (25) stated that cut-off scores of HINE (scores less than 57) were predictive for CP in the 3rd months of life. Similar to these studies, we found that the infants having the HINE total scores <57 in the 3rd months were diagnosed as having CP in the CA of two years. HINE (total score <57) had high predictive accuracy with 87% sensitivity and 80% specificity similar to these studies. These results show that the use of HINE for early diagnosis is necessary in the follow-up units from an early age should be expanded in the diagnosis of early CP. Turkish version of HINE is available and should be used more in the clinics for different health professionals in Türkiye (31).

Sensory processing disorders are seen frequently in high risk infants (17,19,21,22,28). Inappropriate sensory stimulation in NICU may cause sensory processing difficulties causing developmental delays. According to a neurobehavioral evaluation of preterm newborns, according to Smith et al. (32), increased stressors like medical procedures or stimulation in the NICU cause the frontal and parietal brain lobes to shrink and cause abnormal motor behavior. In preterm newborns, Chorna et al. (33) discovered that aberrant sensory sensitivity throughout the first year was linked to inferior developmental outcomes at two years of age. Additionally, Eeles et al. (34) demonstrated a relationship between sensory processing and developmental milestones in preterm children at age two. Using the ISP-2, Kara et al. (17) revealed that sensory processing was related to motor development in preterm infants at 1 and 4 months of corrected age. Similar to these studies, ISP-2 scale revealed atypical sensory processing disorders in high risk infants, but it didn't have predictive accuracy for CP diagnosis. Therefore, ISP-2 should be used in the follow-up clinics, or NICU for detection of sensory disorders. The use of the combination of GMA, HINE and ISP-2 doesn't provide early diagnosis of CP but can guide rehabilitation at early ages. The triple combination of these tests did not have high predictive accuracy, sensitivity and specificity for CP diagnosis. But we suggest that not only assessing motor development, but also sensory processing may be considered necessary as a predictor of developmental abnormality.

Owing to alterations in this process during the first few months of a preterm infant's life owing to the NICU environment, it is believed that rates of sensory processing issues may be higher in preterm newborns. According to Chorna et al. (33), the rate of sensory processing issues was 82% in newborns with GA30 weeks, 60% according to Celik et al. (21) and 73.33% according to Cabral et al. (28) in children born <37 GA, and 46.6% according to Bart et al. (35) in late preterm infants. Similar to these studies, 73% of infants were preterm in this study. But atypical sensory processing difficulties were observed in all preterm and term infants. These results suggest that motor development may be related to atypical sensory development in preterm infants.

Study Limitations

Potential limitations of this study were the use of the version of ISP-2 parent questionnaire. Although parents' characteristics were thought to play a role in their answers, it was reported that less time was spent in the assessment, and daily life activities could be questioned (33). In addition to sensory evaluation with a family questionnaire, further studies are needed in which the infants between 7-18 months are directly evaluated and followed up with tests such as the test of sensory functions in infants. Also, this study was conducted with high risk infants. So, the results of this study can not be generalized to all preterm infants. Another limitation of this study was that some data of the parents, such as educational level and employment status, were missed.

Conclusion

The best method for predicting CP at age two in high risk infants is to interpret GMA and to combine GMA and HINE assessments when they are young. Additionally, the addition of GMA to HINE enhances GMA's specificity, which is crucial

for CP prediction. Early infant follow-up units may be able to identify infants who are at risk for sensory processing problems and refer them for early intervention programs thanks to the clinical implementation of ISP-2.

Written informed consent was obtained from all parents of all infants who were included in this study.

Ethics

Ethics Committee Approval: The Non-interventional Clinical Research Ethics Committee of Lokman Hekim University approved the study (approval no: 2022/95, date: 31.05.2022). Also the study was conducted in accordance with the Helsinki Declaration.

Informed Consent: Written informed consent was obtained from all parents of all infants who were included in this study.

Footnotes

Authorship Contributions

Surgical and Medical Practices: Y.U.S., Concept: H.A., H.İ.Ç., Y.U.S., N.E., B.E., Design: H.A., H.İ.Ç., Y.U.S., N.E., B.E., Data Collection or Processing: H.A., H.İ.Ç., Analysis or Interpretation: H.A., H.İ.Ç., Y.U.S., N.E., B.E., Literature Search: H.A., H.İ.Ç., Writing: H.A., H.İ.Ç.

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