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ORIGINAL ARTICLE

Comparison of neurological assessment and general movements of infants at risk at different time points

Comparação da avaliação neurológica e movimentos gerais de bebês de risco em diferentes momentos

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Abstract

Background: Brain development is a constant interaction between genetic, biological, and environmental factors. Its maturation process is extremely sensitive, and if it does not occur in sync, brain damage can occur in the immature brain, triggering a set of permanent movement and posture disorders. Thus, early diagnosis of developmental changes is essential for intervention to begin as soon as possible, optimizing results, improving functional skills, and reducing the damage to the future life of these babies, and serve as a basis for the actions of professional teams dedicated to stimulation and monitoring of child development. *Objectives*: To compare the neurological assessment and general movements of infants at risk at 40, 52, and 64 weeks of gestational age (GA). *Methods*: Infants at risk born in a reference maternal and child hospital were assessed for their neuromotor behavior using the "Hammersmith Neonatal Neurological Examination (HNNE)", "Hammersmith Infant Neurological Examination (HINE)" and "General Movements Assessment (GMA)" scales at 40, 52, and 64 weeks gestational age. Data will be correlated and analyzed descriptively. *Results*: 33 infants at risk were

assessed at 40, 52 and 64 weeks, i.e., up to six months of corrected age. Male gender (75.8%), a cesarean delivery (51.5%), and white race (60.6%) predominated. The Median Apgar score was nine, mean of five prenatal visits, and a mean GA of 35.8 weeks. Prematurity and congenital syphilis were the main diagnoses found. 30.3% of the patients underwent neuroimaging exams, especially brain ultrasounds, with normal results. There was a predominance of "altered evaluation" in HNNE and HINE at the three evaluative moments for term babies, especially for babies with congenital syphilis, and "adequate" for premature babies. In the GMA evaluation and regarding the presence of fidgety, there was a higher frequency of the "suboptimal" classification and most presented fidgety. In the longitudinal comparison between the three moments assessed using the HNNE/HINE scales, it was found that there was a significant difference between the first and the third evaluative moment ($p = 0.029$), where babies improved their classification. There were positive associations of results between the HNNE/HINE scales with scores in different variables. *Conclusion*: Infants at risk had altered scores on neurological assessments, indicating developmental delay. Children at risk or with delayed neurological development may present restrictions in activities and participation with compromised quality of life and even school learning. Therefore, it is extremely important to include standardized scales during neonatal screening in the routine of the Neonatal Intermediate Care Unit (NICU), as they are highly reliable and low-cost, so that early identification of neurological changes can be enabled, and thus intervene early, enhancing development.

Keywords: premature newborn; infant development; disability assessment; risk factors.

Resumo

Introdução: O desenvolvimento do cérebro acontece por uma constante interação entre fatores genéticos, biológicos e ambientais. Seu processo de maturação é extremamente sensível, e caso não ocorra em sintonia, podem ocorrer lesões cerebrais no encéfalo imaturo que desencadeiam um conjunto de desordens permanentes do movimento e da postura. Assim, percebe-se que o diagnóstico precoce de alterações do desenvolvimento é imprescindível para que a intervenção possa iniciar o quanto antes, otimizando os resultados, melhorando as competências funcionais, diminuindo os prejuízos na vida futura destes bebês, e serve para basear ações das equipes profissionais dedicadas à estimulação e ao acompanhamento do desenvolvimento infantil. *Objetivos*: Comparar a avaliação neurológica e os movimentos gerais de bebês de risco com 40, 52 e 64 semanas de idade gestacional (IG). *Métodos*: Bebês de risco nascidos em hospital materno infantil de referência foram avaliados quanto ao seu comportamento neuromotor através das escalas: “Hammersmith Neonatal Neurological

Examination (HNNE)", "Hammersmith Infant Neurological Examination (HINE)", "General Movements Assessment (GMA)" ao completarem 40, 52 e 64 semanas de IG. Os dados serão correlacionados e analisados de forma descritiva. *Resultados*: 33 bebês de risco foram avaliados nas 40, 52 e nas 64 semanas, ou seja, até os seis meses de idade corrigida. Predominou sexo masculino (75,8%), parto cesáreo (51,5%) e raça branca (60,6%). Apgar com mediana nove, média de cinco consultas pré-natal e média de IG de 35,8 semanas. Prematuridade e sífilis congênita foram os principais diagnósticos encontrados. 30,3% realizaram exame de neuroimagem, destacou-se a ecografia cerebral com resultados normais. Predominou "avaliação alterada" na HNNE e HINE nos três momentos avaliativos para bebês a termo, principalmente para bebês com sífilis congênita, e "adequada" para os prematuros. Na avaliação GMA e quanto à presença de fidgety, houve maior frequência da classificação "subótima" e a maioria apresentou fidgety. Na comparação longitudinal entre os três momentos avaliados utilizando as escalas HNNE/HINE, verificou-se que houve diferença significativa entre o primeiro e o terceiro momento avaliativo (p = 0,029), onde os bebês melhoraram a classificação. Houve associações positivas de resultados entre as escalas HNNE/HINE com pontuações em diferentes variáveis. *Conclusão*: Os bebês de risco apresentaram pontuações alteradas nas avaliações neurológicas, o que indica atraso no desenvolvimento. Crianças em risco ou atraso no desenvolvimento neurológico podem apresentar restrições em atividades e participação com comprometimento de sua qualidade de vida e até mesmo das aprendizagens escolares. Portanto, é de extrema importância a inclusão de escalas padronizadas durante a triagem neonatal na rotina da Unidade de Cuidado Intermediário Neonatal (UCIN), por serem altamente fidedignas e de baixo custo, de forma que possa oportunizar a identificação precoce de alterações neurológicas e assim intervir precocemente, potencializando o desenvolvimento.

Palavras-chave: recém-nascido prematuro; desenvolvimento infantil; avaliação da deficiência; fatores de risco.

Introduction

The development of the human brain is a complex, long-term process. It begins in the fifth gestational week, with the formation and closure of the neural tube, neuronal production, migration, and differentiation of these neurons, peaking in the midgestational period. The first generations of neurons do not travel to the cortical plate but stop at a transitional structure called the subcortical plate: a temporary structure of the developing brain, which will help in the adjustment of cortical activity [1]. The myelination process begins to intensify in the last gestational trimester, adding to the gradual disappearance

of the subcortical plate with the verticalization of neurons, becoming permanent circuits in the cortical plate, especially after the first three months of corrected age (CI) [2].

The greatest vulnerability occurs in the period considered neonatal, which is the first 27 days after birth [3]. Newborns (NBs) at risk are those who need to remain in the Neonatal Intensive Care Unit (NICU). They are low birth weight; prematurity; severe asphyxia; teenage or low education mother; residence in a risk area; history of the death of children under five years old in the family [4]. These babies require early assessment and treatment because they have a higher risk of unfavorable evolution, as well as a higher risk of morbidity and mortality [5,6]. With the evolution of science and technology, there was an increase in survival rates of infants discharged from NICUs, but with unknown long-term outcomes about their overall development.

In this context, neonatal follow-up emerged to ensure that these children receive early diagnosis and interventions that optimize their developmental potentials as early as possible [7,8], improving functional skills, and decreasing the damage to their future life. This follow-up must be formed by a multi-professional and interdisciplinary team [9].

Thus, we asked some questions to guide our study: Is it necessary to wait for some symptom of alteration in the baby's long-term assessment, because babies come to the intervention more than six months old? Or, considering that the trajectory of the baby at risk follows a coherence in this developmental process (classification/performance), will those who have an alteration at 40 weeks also have it at three and six months? Can we detect this alteration early? But when exactly? If our hypothesis is correct, that is, the baby who shows a change in the assessment at 40 weeks will also have this change at 52 and 64 weeks. Therefore, babies with changes at 40 weeks can already be referred for early intervention.

Given the above, this study aimed to compare the neurological assessment and general movements of babies at risk at 40, 52, and 64 weeks of gestational age (GA). We also sought to answer the questions described above.

Methods

This was a longitudinal study, with an independent non-probability convenience sample, involving all infants at risk admitted to the Neonatal Intermediate Care Unit (NICU) of Hospital Materno Infantil Presidente Vargas (HMIPV), located in Porto Alegre, RS, Brazil, a public reference for high-risk pregnancy care.

The sample size calculation was performed using an equation with proportions for an infinite population, with a significance level = (α 0.05) and a 10% error, besides the p-value = 0.1 (10%), which was taken from Nicolau *et al.* [10] because they had a

sample very similar to the target population of our investigation. We then chose to select the value of p = 10% because it was the percentage of the sample that showed motor performance below average for GA, similar to the result we expected to find in this research [10]. We assumed that the population we intended to represent could not be delimited. Considering the possibility of sample losses, loss adjustment/correction was calculated, and the estimated proportion of loss was 10%, thus reaching a sample of 39 NBs. Newborns with severe congenital malformations, unstable for the assessment, or those who could not participate in the three evaluative moments were excluded. Thus, 33 babies were included and 24 were excluded.

The first assessment was performed at 40 weeks of the baby's GA in the NICU, when they were still hospitalized (Time 1). The NB should be stable, with no need for mechanical ventilation or intensive care. The second assessment (Time 2) was performed at 52 weeks (three months of HF) and the third time (Time 3) was done when the baby was at 64 weeks (six months of HF), both in the outpatient phase.

The electronic program Hospital Information System (SIHO) was used for the identification of patients and recording of care information after authorization from the institution. The variables studied at 40 weeks were: child's age, baby's gender, type of delivery, baby's race/color, Apgar score (1st and 5th minute), number of prenatal visits, gestational age at birth, prematurity (born before 37 weeks) [11], birth weight, and current weight. The form for characterizing the babies' clinical data was based on the theoretical model by Chiquetti *et al.* [12].

At time 1, the NB was referred by the NICU physiotherapy team. They were assessed in a room in the unit itself by an experienced physiotherapist blinded, trained, and certified to perform the tests, without knowledge of the baby's previous history so as not to be influenced. For the "neurological/neuromotor assessment" variables, the RNs were assessed using the Hammersmith Neonatal Neurological Examination (HNNE) and General Movements Assessment (GMA) scales.

The HNNE instrument is a screening test used to examine newborns at term age (age at probable delivery - 40 to 44 weeks) and diagnose risks for cerebral palsy (CP) [13]. It consists of 34 items subdivided into six categories: posture and tone (ten items); tone patterns (five items); reflexes (six items); spontaneous movements (three items); abnormal signs (three items); and orientation and behavior (seven items). The scoring is done by observing the NB and marking it on a table, which divides NBs into gestational age (25-27, 28-29, 30-31, 32-34 weeks, and term). It is important to note that the test considers the neurological assessment of the typical full-term baby from 34 weeks "only" for scoring. We continue to consider babies up to 37 weeks premature. In the end, the points are added and the NB is considered "optimal" or "normal assessment" when its

sum is equal to or greater than 30.5 points if the baby is full-term and 26 points if it is premature [13]. In case of scores below these cut-off points, the babies are considered "suboptimal" or "altered assessment" [14]. In this study, normal assessment" and "altered assessment" were used.

The GMA consists in evaluating the quality of general movements (GMs), i.e., it evaluates the central nervous system (CNS), where the observation of the NB's spontaneous movement is performed. It is recommended to be performed from the third day of life. The characteristic movements of newborns are transformed as they mature, progressing from twisting movements (Writing Movements) to irregular and elegant movements (Fidgety), bringing a harmonic and complex network of motor experimentation, gradually modified by voluntary atitudes [15].

To evaluate the GMs, the Gestalt (understanding the whole to understand the parts) of the complexity, variation, and fluidity of the movement is performed [16]. The RN with optimal classification will have "three plus" (+) in complexity and variability and "one plus" in fluency, while the suboptimal will have "two plus" in complexity and variability and fluency "one minus" (-). In mildly abnormal classification, the RN receives only "one plus" in complexity and variability and, in fluency, "one minus". In the abnormal classification, the RN in all three items, complexity, variability, and fluency identifies as "a minus". GMs are devoid of complexity and variation placing an infant at very high risk for CP. This implies that abnormal GMs are an indication for early physiotherapeutic intervention immediately [16]. The GMA was performed with the aid of filming the spontaneous movements of the NB for later analysis [15].

At Time 2, a reevaluation was scheduled at the hospital outpatient clinic and the Hammersmith Infant Neurological Examination (HINE) and the Fidgety assessment, which is part of the three-month GMA, were performed.

The HINE instrument is a neurological assessment method that was updated, revised, and standardized by Mercuri; Dubowitz [17]. The objective of the assessment is to examine, preferably, neonates and infants older than 44 weeks to diagnose risks for CP [18].

Moreover, a version of this instrument was validated for at-risk, Premature, and full-term NBs, which allowed the establishment of the variability of tone, movements, and behavior in different IGs and provided some general guidelines on what are the most common findings in each GA [19]. There are three versions of this assessment, being an expanded version of the HNNE (and the shortened version of the same instrument, focusing on the assessment of neonates); and the HINE version that assesses infants from 30 days of life up to 24 months.

The quality of GMs for older infants, from two to four months, is defined as fidgety (the so-called age of restless movements). These are movements where small muscles start to contract, generating elegant and continuous movements, like a dance. This new form of neuromotor assessment of infants up to two months old was developed based on the quality assessment of the GMs, classified as GMs with "normal assessment" (optimal or suboptimal and presence of the Fidgety) and "altered assessment" (slightly abnormal, definitely abnormal and decrease/absence of Fidgety) [15]. If at three months he does not present Fidgety, it may be an indication of risk for CP [15]. And finally, the babies returned to the re-evaluation at moment 3, where the HINE was repeated and the GMs were not used. According to Hadders-Algra, general movements only go up to five months [15].

Data were collected and analyzed using the Statistical Package for the Social Sciences (SPSS) software, version 28.0. Quantitative variables were described by the mean and standard deviation or median and interquartile range, depending on the data distribution. Categorical variables were described by absolute and relative frequencies. To compare means, the t-student test was applied. In the case of asymmetry, the Mann-Whitney test was used. When comparing proportions, the chi-square or Fisher's exact tests were applied. The comparison of HNNE/HINE between 40, 52, and 64 weeks was evaluated by Cochran's test in conjunction with Bonferroni's test. The significance level adopted was 5% ($p \leq 0.05$).

The study was submitted and approved by the Comitê de Ética da UFRGS, opinion number: 4.873.085 (CAAE: 4 7510821.1.0000.5347) and by the Research Ethics Committee of HMIPV, co-participating institution, opinion number: 4.900.00 (CAAE: 47510821.1.3001.5329), and the guardians signed a Termo de Consentimento Livre e Esclarecido (TCLE).

Results

We analyzed 33 NBs identified as being at risk, according to the criteria defined by the Ministry of Health (MOH) [4], admitted to the NICU. The characterization of the sample is shown in Table I.

Table II shows the diagnosis of hospitalization and some characteristics, including the indication of physical therapy during hospitalization and the time of treatment.

It is important to note that two of the three NBs with altered neuroimaging reports were premature (classified as extreme preterm and moderate preterm) and both had intracranial hemorrhage, one of them also associated with the presence of

hydrocephalus. Of these, one of the infants scored 27, and two scored 19 points on the HNNE. The mentioned infants had scores below the cutoff values.

Table I - *Characterization of NBs at risk admitted to the NICU*

Variables*	n=33
Gender – n (%)	
Male	25 (75,8)
Female	8 (24,2)
Type of childbirth – n (%)	
Vaginal	16 (48,5)
Cesarean	17 (51,5)
Race – n (%)	
White	20 (60,6)
Brown	7 (21,2)
Black	6 (18,2)
Apgar – median (P25-P75)	
1st minute	8 (6,5 – 8)
5th minute	9 (8 – 9)
Maternal age (years) – median ± DP	25,3 ± 6,6
Number of prenatal visits– median (P25-P75)	5 (3 – 7)
IG at birth (weeks) – média ± DP	35,8 ± 4,1
Full term – n (%)	17 (51,5)
Prematurity – n (%)	16 (48,5)
Classification by GA - n (%)	
Extreme (< 28 weeks)	3 (9,1)
Very (< 32 weeks)	2 (6,1)
Moderately (32 to < 34 weeks)	1 (3,0)
Late (34 to < 37 weeks)	10 (30,3)
Birth weight (g) – median ± DP	2551 ± 983
Nutricional status – n (%)	
SGA	9 (27,3)
AGA	21 (63,6)
LGA	3 (9,1)

NBs = newborns; NICU: neonatal intermediate care unit; GA = Gestational Age; SGA = Small for gestational age; AGA = Adequate for gestational age; LGA = large for gestational age

Table III shows the main outcomes of the neurological assessments and GMA. A longitudinal comparison of performance in the assessments is shown in figure 1. It was found that there was a significant difference between the moments ($p = 0.029$), with the difference occurring from the first moment to the last ($p = 0.010$) because from the first assessment to the second and from the second to the third, the differences were not significant ($p = 0.460$ and $p = 0.065$, respectively).

When associating the sample characterization variables with 40-week HNNE, statistically significant results for altered HNNE were found: vaginal delivery, higher GA, higher birth weight, presence of a medical diagnosis of congenital syphilis (CS), and altered report on imaging exam. They also presented subjects with a lower number of premature, very low birth weights and length of stay in the NICU. It is observed, however, that 73.7 (14) of the infants born at term were classified with the "altered assessment" in the HNNE, while only 26.3 (five) of the preterm infants scored below their cutoff points.

Table II - *Hospitalization diagnosis and specific characteristics*

Variables*	n =33
Diagnosis of hospitalization– n (%)	
Prematurity	16 (48,5)
Congenital syphilis	14 (42,4)
Jaundice	10 (30,3)
Low birth weight	8 (24,2)
Early Respiratory Dysfunction	7 (21,2)
Very low birth weight	4 (12,1)
SGA	4 (12,1)
HMD	4 (12,1)
Cerebral Hemorrhage	2 (6,1)
Late Sepsis	2 (6,1)
Imaging exam* – n (%)	10 (30,3)
Report – n (%)	
Altered	3 (30,0)
Normal	7 (70,0)
Physiotherapy – n (%)	9 (27,3)
Motor Physiotherapy time (days) - median (P25 – P75)	11 (7,5 – 14)
NICU length of stay (days) - median–median (P25-P75)	16 (11 – 38)

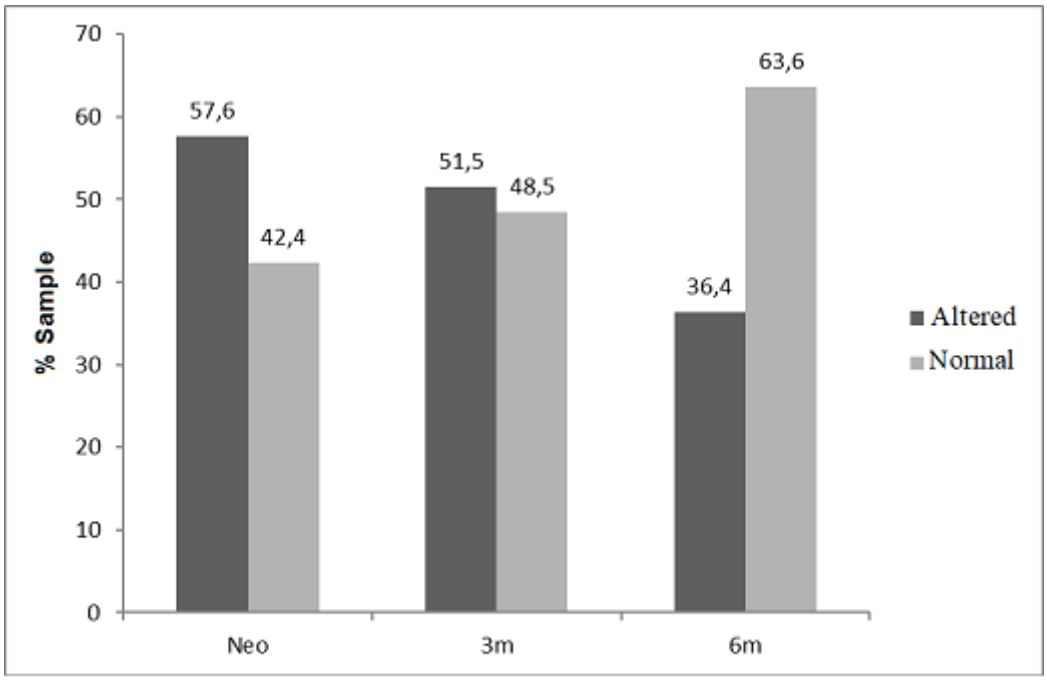
SGA = Small for gestational age; HMD = Hyaline membrane disease. *all brain echography

Table III - *Outcomes of neurological assessments and GMA*

Variables*	N = 33
HNNE Classification – n (%)	
Preterm with a low score (< 34 wks)	3 (9,1)
Preterm with adequate score (< 34 wks)	11 (33,3)
Full term with a low score (34 > wk)	16 (48,5)
Full-term with adequate score (34 > wk)	3 (9,1)
HINE Score 3 months – n (%)	
Preterm (< 32 wks) with a low score	2 (6,1)
Preterm (< 32 wk) with an adequate score	4 (12,1)
Preterm (33-36 wks) with a low score	3 (9,1)
Preterm (33-36 wks) with an adequate score	7 (21,2)
Low scoring pre-term	12 (36,4)
Adequate score pre-term	5 (15,2)
HINE Score 6 months – n (%)	
Preterm (< 32 wks) with a low score	2 (6,1)
Preterm (< 32 sem) with an adequate score	4 (12,1)
Preterm (33-36 sem) with a low score	1 (3,0)
Preterm (33-36 sem) with an adequate score	10 (30,3)
Low scoring aterm	9 (27,3)
Adequete scoring aterm	7 (21,2)
GMA – n (%)	
Good (40 weeks)	4 (12,1)
Suboptimal (40 weeks)	21 (63,6)
Pre- pathological (40 weeks)	8 (24,2)
Has Fidgetys – n (%) (52 weeks)	26 (78,8)

HNNE = Hammersmith Neonatal Neurological Examination; HINE = Hammersmith Infant Neurological Assessment; GMA = General Movements Assessment

A longitudinal comparison of performance on the assessments is shown in figure 1. It was found that there was a significant difference between the moments (p = 0.029), with the difference occurring from the first moment to the last (p = 0.010) because from the first assessment to the second and from the second to the third, the differences were not significant (p = 0.460 and p = 0.065, respectively).



	40 semanas HNNE n (%)	52 semanas HINE n (%)	64 semanas HINE n (%)	p
Normal	14 (42,4)	16 (48,5)	21 (63,6)	0,029
Alterado	19 (57,6)[b]	17 (51,5)[b]	12 (36,4)[a]	

[a,b]Letras iguais não diferem pelo teste de Bonferroni a 5% de significância
HNNE = Hammersmith Neonatal Neurological Examination; HINE = Hammersmith Infant Neurological Assessment

Figure 1 - *Comparison between the HNNE/HINE assessment scales at all evaluated time points*

When associating the sample characterization variables with the 40-week HNNE, the babies had a significantly higher vaginal delivery, higher gestational age, higher birth weight, presence of a medical diagnosis of congenital syphilis, and altered report on the imaging exam. They also had lower prematurity, very low birth weight, and length of stay in the NICU. It was observed, however, that 73.7 (14) of the full-term babies were classified with the "altered assessment" of HNNE, while only 26.3 (5) of the preterm babies scored below their cutoff points (Table IV).

In the association of the HINE assessment classified as "altered" of the 52-week infants with the characterization of the sample, there was a significant result for the higher presence of early respiratory dysfunction (PRD) (0.039), very low birth weight (0.044), and clinical diagnosis of CS (0.020).

Infants with altered HINE results at 64 weeks exhibited significantly higher altered imaging reports (p = 0.033). Infants with pre-pathologic HINE results were also found to have a significantly higher medical diagnosis of hyaline membrane disease (p = 0.036) and a lower presence of fidgety (0.042). There was no statistically significant association of variables with the presence of fidgety.

Table IV - *Association of variables of the sample characterization with the classification of the HNNE at 40 weeks*

Variables	Normal	Altered	p
Gender – n (%)			0,416
Male	12 (85,7)	13 (68,4)	
Female	2 (14,3)	6 (31,6)	
Type of childbirth – n (%)			**0,020**
Vaginal	3 (21,4)	13 (68,4)	
Cesarean	11 (78,6)	6 (31,6)	
Race – n (%)			0,388
White	7 (50,0)	13 (68,4)	
Brown	3 (21,4)	4 (21,1)	
Black	4 (28,6)	2 (10,5)	
Apgar – median (P25-P75)			
1st minute	8 (7 – 8)	8 (5 – 9)	0,377
5th minute	9 (8 – 9)	9 (8 – 9)	0,358
Maternal age (years) – median ± DP	24,9 ± 6,1	25,5 ± 7,1	0,803
Number of prenatal visits – median (P25-P75)	6 (3,5 – 7)	4 (3 – 6)	0,363
GA at birth (weeks) – median ± DP	33,5 ± 4,2	37,5 ± 3,2	**0,004**
Full term – n (%)	3 (21,4)	14 (73,7)	**0,009**
Prematurity – n (%)	11 (78,6)	5 (26,3)	**0,009**
Classification by GA - n (%)			0,373
Extreme	2 (14,3)	1 (5,3)	
Very	2 (14,3)	0 (0,0)	
Moderately	0 (0,0)	1 (5,3)	
Later	7 (50,0)	3 (15,8)	
Birth weight (g) – median ± DP	2111 ± 1046	2875 ± 818	**0,025**
Nutritional status – n(%)			0,356
SGG	5 (35,7)	4 (21,1)	
AGA	7 (50,0)	14 (73,7)	
LGA	2 (14,3)	1 (5,3)	
Diagnosis of hospitalization – n (%)			
Prematurity	11 (78,6)	5 (26,3)	**0,009**
Congenital syphilis	1 (7,1)	13 (68,4)	**0,002**
Jaundice	5 (35,7)	5 (26,3)	0,707
Low birth weigh	5 (35,7)	3 (15,8)	0,238
Early Respiration Dysfunction	5 (35,7)	2 (10,5)	0,106
Very low birth weight	4 (28,6)	0 (0,0)	**0,024**
SGA	3 (21,4)	1 (5,3)	0,288
HMD	1 (7,1)	3 (15,8)	0,620
Imaging Exam* – n (%)	7 (50,0)	3 (15,8)	0,057
Report – n (%)			**0,008**
Altered	0 (0,0)	3 (100)	
Normal	7 (100)	0 (0,0)	
Physiotherapy – n (%)	6 (42,9)	3 (15,8)	0,122
Motor Physiotherapy time (days) - median (P25 – P75)	9,5 (7 – 12,5)	14 (10 – 22)	0,167
NICU length of stay (days) – median – median (P25-P75)	28 (18 – 57,5)	12 (11 – 16)	**0,004**

GA = Gestational Age; SGA = Small for gestational age; AGA: Adequate for age; LGA: Large for gestational age

Discussion

The study compared the neurological assessment and general movements of at-risk infants at 40, 52, and 64 weeks GA. Early identification of infants at risk for neurodevelopmental disabilities or delays is important to ensure early intervention at an age when brain plasticity is high [20]. Therefore, specific and more sensitive assessment

instruments were used for these age groups [21,22]. We hypothesize that the baby with an altered assessment at 40 weeks would remain so in the next evaluations as well, which would enable early detection of abnormalities, allowing early intervention [23].

The results point to the prevalence of the male gender, which can be explained by the fact that males have a slower maturation during fetal development compared to females [24].

Considering prenatal care, the results showed an average of five consultations. The low compliance is in agreement with the study by Formiga *et al.* [25], in which of 540 babies at risk, the mean number of prenatal visits was 5.47. RNs with less than six prenatal visits had 1.3 times more risk of hospital admissions [26].

The research found that mothers did not reach the number of prenatal consultations recommended by the MS (minimum six) [27]. Women of low socioeconomic status are susceptible to fewer prenatal consultations, which could justify the findings of this study when we associate the context of vulnerability of the public attended [28].

Regarding infants, 51.5% were born at term; however, part of the admissions that occurred in the NICU are babies coming from the NICU. Most babies admitted to NICUs have other risk factors other than prematurity and are little studied. Often, they are related to complications that can chronify, such as respiratory problems, more severe CNs injuries, surgeries, and congenital infections of the mother [29].

Regarding hospitalization diagnoses, they point to prematurity as the most prevalent, followed by CS, jaundice, low birth weight, and PRD. Prematurity, low birth weight, and PRD are the main causes of hospitalization in the neonatal unit [30,31]. However, the diagnosis of CS stands out, but it does not appear as an expressive diagnosis in NICUs [32]. Nevertheless, the MS epidemiological bulletin shows that, in the last ten years, there has been an increase in these rates and the state of RS had rates higher than the national rate, with 12.9 cases/1,000 live births [33]. The data is worrisome and motivates us to study these babies in depth.

Neuroimaging exams were performed on 10 NBs at risk assessed; among these, all underwent Brain Echography (BE). The number of NBs who underwent the exam is not by the data found in the literature, where there is a strong recommendation for the use of neuroimaging in RNs at risk, as well as standardized neurological and motor evaluations [21]. It is recommended that hospitals give priority to skilled people and a good quality ultrasound scanner so that babies can have access to this exam [16].

The neuroimaging exams predominated normal results; only three reports described alterations. Two NBs with altered reports were premature, which is in agreement with the literature [34]. The NBs with altered test results scored below the

HNNE/HINE cutoff points in the three evaluative moments, as well as being classified in the GMA as "pre-pathological". The study confirms the high predictive value of the scales in infants at risk, according to findings in larger samples [35,36], where early intervention is recommended.

As for the neurological evaluations, there was a predominance of "altered" classification in the first two evaluations, and scores above the cutoff point prevailed in the last one. Therefore, it was found that there was a significant difference between the first and last assessments (p=0.029).

The performance obtained from the NBs is in agreement with other studies that showed median scores of the HINE scale with intervals for infants younger than 12 months. Haataja *et al.* [37] reported that mean HINE scores increased with age over four weeks in 74 healthy-term infants. Also, in another investigation, scores were higher at six months than at three months of age. Assessment at older ages would likely result in a more accurate measure of the neurodevelopmental trajectory [38,39].

This corroborates with the study in which absolute numbers that for HNNE findings, most preterm NBs were considered adequate (n = 11). They remain the same number at three months (n = 11) with the HINE and increase at six months (n=14). In term infants, most were altered at 40 weeks (n=16), decreasing at three months (n=12) and more so at six months (n = 9).

HNNE/HINE brings results beyond motor impairment, but also for cognitive impairment [39]. Splitte *et al.* [14] showed that suboptimal scores at the neonatal stage are associated with a higher likelihood of cognitive delay at two years. Likewise, Romeo *et al.* [39] observed a significant correlation between cognitive performance scores with the HINE at three, six, nine, and 12 months, with a better correlation starting at six months. Some of the items are age-dependent, corroborating the aforementioned findings that scores would increase with age and be more sensitive over time.

As for the analysis of the GMs, the "suboptimal" classification prevailed, followed by "pre-pathological". The relationship between the GMs and the Fidgety, showed similarity and continuity between them, as there was a prevalence of infants classified as "excellent/suboptimal" in the first month of life and the third month most of them had Fidgety.

The performance of preterm infants was higher than that of term infants in the three assessments performed, indicating that most of them had "normal assessment". Corroborating our findings, a study found that the mean HNNE of premature babies was above the cutoff points [40].

There was a significant correlation between CS diagnosis with "altered" assessment at 40 weeks and 52 weeks. Most full-term babies born by vaginal delivery

and that had their evaluations "altered" had the diagnosis of CS, this demonstrates the relationship of the disease with important motor losses. Thus, the baby with CS should be followed early as soon as the diagnosis is made, even if born at term.

It was found that GA and higher weight were also significantly related to "altered" HNNE. The results signal the tendency of the term at-risk NB to have worse scores than preterm infants when evaluated at HF in a NICU. It could also be observed that most babies classified as "altered" in the HNNE had a shorter NICU stay, which can be related to the greater number of term NBs.

There is a worrisome fact, physiotherapy was performed in only 27.3% of NBs, and besides the fact that few babies were assisted by these professionals, it was found that half of the preterm infants in the sample were not accompanied by this team. The evidence points out that babies born very prematurely have a high chance of presenting neuromotor development delays [41]. Regardless of being premature or not, the physical therapist is a professional who monitors the development of babies at risk, and should always be called upon.

This data, however, can be explained by the lack of a physical therapist in the unit, a specific characteristic of the hospital where the research was carried out. In addition, the physical therapy follow-up is conditioned to a medical prescription, contrary to the article (10) - COFFITO resolution 80. Unfortunately, this context is still found in the country [42].

The physiotherapist plays an important role in the care/assessment of these children and necessary post-discharge referrals if they have any neurodevelopmental delay [43]. The infants identified with changes in the evaluations were enrolled in physical therapy in the unit where they were or referred to an early stimulation service; in addition, the families were instructed about sensory-motor stimulation activities.

Some questions were asked to guide our study. Is it necessary to wait for some later symptom of developmental change? The research verified, once the baby at risk presents an alteration at 40 weeks, it should already be referred to early intervention, since it is in the first months of life that the capacity for adaptation and neuroplasticity happens quickly and sharply. If only nature acts on the baby, without intervention, the windows of opportunity may be closed. Furthermore, the research demonstrated a significant association between the evaluations performed (HNNE $p = 0.008$, HINE $p = 0.033$) and the neuroimaging exam report.

Does the trajectory of the at-risk baby follow a coherence in this developmental process (grading/performance) at 40, 52, and 64 weeks, can it be detected early? In the comparison of the babies' performance there was a significant difference between the first moment and the third moment, that is, babies at six months were classified with

adequate scores, but the number of altered babies is still large. Babies with altered HNNE/HINE and GMA at the three-time points are the most compromised and with a high chance of developing CP [22].

The combination of a neonatal brain MRI at term equivalent age with GMs and HNNE/HINE has high predictive power for PC [22]. Early detection would allow the initiation of intervention. But when exactly? As early as possible, so that windows of opportunity are not closed [44]. Evaluation at 40 weeks is recommended, before discharge and, in case of change, referral for intervention.

Some limitations should be considered for this study. Data were collected in a single hospital, limiting external validity, but important for the improvement of similar services, the difficulty of information in the analyzed medical records, such as sociodemographic, maternal, and paternal data to complement the sample characterization. A low number of patients in physical therapy limited the association of early motor stimulation with the other variables. Difficulty in contacting the families and low socioeconomic status prevented reevaluation.

Conclusion

The profile of babies at risk was mostly male, white race/color, with Apgar within the normal range, born by cesarean section, and with a lower than expected number of prenatal visits. Prematurity was the main diagnosis, followed by CS. Full-term babies were more compromised in all three assessment times compared to premature babies. The NB with altered assessment at 40 weeks should already be referred for intervention, especially those who showed changes in the three evaluative moments. These are babies with CS, respiratory dysfunction, very low birth weight, neuroimaging alterations, GMA classified as pre-pathological, and absence of Fidgety. Babies not mentioned tended to recover at 64 weeks, a factor known as catch-up. Early referral is suggested for all who presented with altered neurological assessment or with altered general movements. Those who showed more complex, variable, and fluid movements had Fidgety present at three months of IC.

Conflict of interest
The authors report no conflicts of interest

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Conception and design of the study, data analysis, interpretation; Statistical analysis and manuscript writing: Morinel CS; *Critical review of the manuscript for important intellectual content*: Gerzson LR, Almeida CS

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