

# NEUROPSYCHOLOGICAL DEVELOPMENT IN THE FIRST YEAR OF LIFE IN PRETERM AND FULL-TERM INFANTS: A COMPARATIVE LONGITUDINAL ANALYSIS

*DESENVOLVIMENTO NEUROPSICOLÓGICO NO PRIMEIRO ANO EM BEBÊS PRÉ-TERMO E A TERMO: ANÁLISE LONGITUDINAL COMPARATIVA*

*DESARROLLO NEUROPSICOLÓGICO EN EL PRIMER AÑO EN BEBÉS PREMATUROS Y A TÉRMINO: ANÁLISIS LONGITUDINAL COMPARATIVO*

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## RESUMO

A prematuridade apresenta riscos ao desenvolvimento biológico, o que pode trazer alterações cognitivas, sociais e emocionais. A avaliação neuropsicológica pode ajudar a compreender o desenvolvimento funcional dos prematuros. Este estudo buscou investigar o desenvolvimento neuropsicológico até um ano de idade, comparando bebês pré-termo e a termo por meio de avaliação neuropsicológica padronizada. A amostra consistiu em 21 prematuros (com idade corrigida) e 24 bebês a termo. A avaliação inicial, aos três meses, utilizou um inventário sociodemográfico; a Escala Bayley-III; e a Escala de Desenvolvimento do Comportamento Infantil no primeiro ano de vida (EDCC), com reavaliação aos seis, nove e 12 meses. Diferenças significativas entre os grupos foram encontradas na escala Bayley-III nos seguintes domínios: desenvolvimento cognitivo aos 12 meses, linguagem expressiva aos 9 e 12 meses, motricidade fina aos 12 meses, motricidade grossa aos 6 meses e desenvolvimento socioemocional aos 12 meses. Variáveis socioeconômicas, como renda familiar e participação em programas sociais, podem prever o desempenho motor fino. Ambos os instrumentos revelaram associações significativas em múltiplos momentos e grupos.

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No entanto, não foi observada correlação estatisticamente significativa entre as pontuações do EDCC e o comportamento socioemocional. No geral, os resultados são consistentes com as trajetórias de desenvolvimento esperadas e corroboram as diferenças presumidas entre os grupos. Espera-se que este estudo contribua para uma compreensão melhor das consequências da prematuridade no desenvolvimento e forneça evidências para orientar o planejamento de programas direcionados de intervenção precoce.

*Palavras-chave:* nascimento prematuro; avaliação neuropsicológica; psicologia do desenvolvimento.

## ABSTRACT

Preterm birth poses risks to biological development and may lead to cognitive, social, and emotional alterations. Neuropsychological tests can offer valuable insights into the developmental functioning of preterm infants during early infancy. This study aimed to examine neuropsychological development in the first year of life by comparing preterm and full-term infants using standardized assessment tools. The sample included 21 preterm infants (assessed using corrected age) and 24 full-term infants. Initial evaluations, at 3 months of age, employed a sociodemographic inventory; the Bayley Scales of Infant and Toddler Development (Bayley-III), and the Infant Behavior Development Scale in the first year of life (EDCC). Follow-up assessments were conducted at 6, 9, and 12 months. Significant group differences were found on Bayley-III in the following domains: cognitive development at 12 months, expressive language at 9 and 12 months, fine motor skills at 12 months, gross motor skills at 6 months, and social-emotional development at 12 months. Socioeconomic variables, such as household income and participation in social welfare programs, were predictive of fine motor outcomes. Both instruments revealed significant associations across multiple time points and groups. However, no statistically significant correlation was observed between EDCC scores and social-emotional behavior. Overall, the findings are consistent with expected developmental trajectories and support the hypothesized differences between groups. This study is expected to contribute to a deeper understanding of developmental consequences of preterm birth and to provide evidence to guide the design of early, targeted intervention programs.

*Keywords:* premature birth; neuropsychological tests; developmental psychology.

## RESUMEN

La prematuridad supone riesgos para el desarrollo biológico, lo que puede conducir a cambios cognitivos, sociales y emocionales. La evaluación neuropsicológica puede ayudar a comprender el desarrollo funcional de los bebés prematuros. Este estudio buscó investigar el desarrollo neuropsicológico hasta un año de edad, comparando bebés prematuros y nacidos a término a través de una evaluación neuropsicológica estandarizada. La muestra estuvo compuesta por 21 bebés prematuros (con edad corregida) y 24 bebés a término. La evaluación inicial, a los tres meses, utilizó un inventario sociodemográfico; la Escala Bayley-III; y la Escala de Desarrollo del Comportamiento Infantil en el primer año de vida (EDCC), con reevaluación a los seis, nueve y 12 meses. Se encontraron diferencias significativas entre los grupos en la escala Bayley-III en los siguientes dominios: desarrollo cognitivo a los 12 meses, lenguaje expresivo a los 9 y 12 meses, motricidad fina a los 12 meses, motricidad gruesa a los 6 meses y desarrollo socioemocional a los 12 meses. Variables socioeconómicas, como el ingreso familiar y la participación en programas sociales, pueden predecir el desempeño motor fino. Ambos instrumentos revelaron asociaciones significativas en múltiples momentos y grupos. Sin embargo, no se observó una correlación estadísticamente significativa entre las puntuaciones del EDCC y el comportamiento socioemocional. En general, los resultados son consistentes con las trayectorias de desarrollo esperadas y corroboran las supuestas diferencias entre los grupos. Se espera que este estudio contribuya a una mejor comprensión de las consecuencias de la prematuridad en el desarrollo y proporcione evidencias para guiar la planificación de programas direccionados de intervención temprana.

*Palabras clave:* nacimiento prematuro; evaluación neuropsicológica; psicología del desarrollo.

## Introduction

Cognitive functions develop throughout the first year of life, anticipating capacities associated with full brain maturation. These foundational skills for learning include executive function (Burstein et al., 2021), attention (Rueda, 2020), and memory (Ramsaran et al., 2019). By around 12 months, developmental differences among infants become more evident, particularly in symbolic and sign processing abilities (Levine et al., 2016). Environmental influences – social,

emotional, physical, and cultural – play a key role in shaping brain development (Rueda, 2020).

Preterm infants frequently present structural brain alterations (Ramsaran et al., 2019), including reduced volumes in the white matter, middle temporal gyrus, amygdala, globus pallidus, and brainstem, and increased volumes in the primary visual, motor, and somatosensory cortices (Alexander et al., 2019). Longitudinal studies also report reductions in the subthalamic nuclei and right thalamus, especially in infants with pathologies at 18 months. These alterations are linked to a higher risk of behavioral and emotional disturbances later in development (Vanes et al., 2023).

Preterm birth remains prevalent in Brazil – approximately 11% – despite a decline over the past decade (WHO, 2023). Developmental trajectories often differ between full-term and preterm infants, leading to early delays (Dudink et al., 2015), particularly in cognitive function (Burstein et al., 2021; Coletti et al., 2015; Reis et al., 2012), language (Vandormael et al., 2019; Zambrana et al., 2021), and motor skills (Elmer et al., 2025; Formiga et al., 2015; Ko & Lim, 2023). Preterm infants are also at higher risk for behavioral symptoms and reduced social-emotional competence (Peralta-Carcelen et al., 2017). Neonatal characteristics can predict later neurodevelopment (Aho et al., 2021), though enriched environments may foster developmental gains (Hadaya et al., 2023).

In this context, parenting – especially maternal involvement – plays a key role in promoting better developmental outcomes (Coletti et al., 2015; Hass et al., 2022), as maternal characteristics and socioeconomic factors influence infant behavioral regulation (Costa Ribeiro et al., 2020). The benefits of kangaroo mother care are well documented, including infant physiological improvements and reduced postpartum depression (Cristóbal Cañadas et al., 2022). When combined with early intervention, it has been linked to improved cognitive, language, and motor development by 18 months (Silveira et al., 2024).

Comprehensive, longitudinal studies comparing preterm and full-term infant development remain scarce (Dias & Rubini, 2022). Such research is crucial for identifying early developmental risks that may affect neural circuit formation (Dudink et al., 2015). Early detection enables timely intervention, supporting optimal and integrative development (Hadaya et al., 2023). This study aims to compare the holistic neuropsychological development of preterm and full-term infants during the first year of life, identifying the possibilities and limitations associated with prematurity relative to typical developmental trajectories.

## Method

### *Participants*

The study included 21 preterm infants (with corrected age) and 24 full-term infants, all born to mothers over 15 years old. Inclusion criteria for the preterm group were gestational age under 37 weeks and birth weight below 2,500g (see Table 1). Gestational age was determined by the first day of the mother's last menstrual period (LMP). Due to the limited sample size, preterm infants were not subclassified by degree of prematurity and included all three standard categories based on gestational duration.

**Table 1 — Sociodemographic data**

| Variables                              | Full-Term<br><i>n</i> =24 |           | Preterm<br><i>n</i> =19 * |           |
|----------------------------------------|---------------------------|-----------|---------------------------|-----------|
|                                        | <i>M</i>                  | <i>SD</i> | <i>M</i>                  | <i>SD</i> |
| <b>Infant characteristics</b>          |                           |           |                           |           |
| Length of hospital stay (days)         | 0.29                      | 1.43      | 64.76                     | 40.06     |
| Gestational age (weeks) ** (corrected) | 39.46                     | 1.53      | 31.10                     | 2.98      |
| Birth weight (g)                       | 3,151.96                  | 454.72    | 1,476.90                  | 769.51    |
| Apgar score                            | 9.17                      | 0.56      | 8.60                      | 0.68      |
| <b>Sociodemographic data</b>           |                           |           |                           |           |
| Maternal age (years)                   | 24.00                     | 6.26      | 30.90                     | 6.56      |
| Maternal income (R\$)                  | 2,263.5                   | 1,272.3   | 3,161.5                   | 2,464.7   |
| Maternal educational level             |                           |           |                           |           |
| Incomplete elementary I                | 1                         | 4.2%      | 0                         | 0%        |
| Incomplete elementary II               | 3                         | 12.5%     | 2                         | 9.5%      |
| Complete elementary                    | 2                         | 8.3%      | 1                         | 4.8%      |
| Incomplete secondary school            | 6                         | 25.0%     | 1                         | 4.8%      |
| Complete secondary school              | 7                         | 29.2%     | 10                        | 47.6%     |
| Incomplete higher education            | 4                         | 16.7%     | 0                         | 9.5%      |
| Complete higher education              | 1                         | 4.2%      | 4                         | 19.0%     |
| Post-graduation                        | 0                         | 0%        | 1                         | 4.8%      |

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| Variables           | Full-Term<br><i>n</i> =24 |           | Preterm<br><i>n</i> =19 * |           |
|---------------------|---------------------------|-----------|---------------------------|-----------|
|                     | <i>M</i>                  | <i>SD</i> | <i>M</i>                  | <i>SD</i> |
| Social program ***  |                           |           |                           |           |
| Yes                 | 10                        | 41.7%     | 3                         | 14.3%     |
| No                  | 14                        | 58.3%     | 18                        | 85.7%     |
| Social support **** |                           |           |                           |           |
| Yes                 | 21                        | 87.5%     | 18                        | 85.7%     |
| No                  | 3                         | 12.5%     | 3                         | 14.3%     |

**Notes:**

\* Data missing for two families;

\*\* Gestational age range: 37–42 weeks (full-term), 26–36 weeks (preterm);

\*\*\* Indicates whether participants were enrolled in a government social welfare program (e.g., Bolsa Família);

\*\*\*\* Based on mothers' responses regarding whether they had access to any support network when needed to care for their infants.

In the preterm group, mean gestational age was 31.1 weeks ( $SD=3.0$ ), and mean birth weight was 1,476.9g ( $SD=769.5$ ). The average Apgar score was 8.60 ( $SD=0.68$ ). Hypertensive disorders were the leading cause of preterm birth (42.9%), and most deliveries were cesarean (71.4%). Mothers had a mean age of 30.9 years ( $SD=6.6$ ), with 47.6% having completed secondary education. Average family income was four minimum wages. Regarding social support, 14.3% received government assistance, and 85.7% reported having a support network for infant care.

In the full-term (control) group, mean gestational age was 39.5 weeks ( $SD=1.5$ ), birth weight averaged 3,152.0g ( $SD=454.72$ ), and the Apgar score was 9.17 ( $SD=0.56$ ). Mothers had a mean age of 24.0 years ( $SD=6.3$ ), with 29.2% having completed secondary education. Average family income was 2.9 minimum wages. Regarding social programs, 41.7% received public assistance, and 85.7% reported having a support network for infant care.

Exclusion criteria included the presence of any neurological disorders, congenital anomalies, or genetic conditions. Some participants were lost to follow-up due to caregivers withdrawing from the study or relocating to different cities, making continued participation unfeasible. To ensure consistency in the timing of developmental assessments, a maximum window of 11 days before or after each target age was established.

## *Instruments*

**Sociodemographic Inventory** (adapted from Pinto, 2009): This instrument gathers data on socioeconomic and household characteristics, including place of residence, neighborhood, household income, number of residents, parity (e.g., primiparity), number of children, and parental information (age, education, occupation, and employment status). It also covers participation in social assistance programs, child-related daily routines, and average daily caregiving hours. Additionally, medical records provide neonatal data such as infant sex, gestational age, birth weight, and hospital stay duration.

**Bayley Scales of Infant and Toddler Development, third edition** (Bayley-III) (Bayley, 2006): This standardized tool assesses infant development through direct examiner–child interaction, covering cognitive, receptive and expressive language, fine and gross motor skills, and a social-emotional domain evaluated via caregiver questionnaire. It shows adequate internal consistency, with reliability coefficients above 0.7. This study used the Brazilian Portuguese version translated and adapted by Almeida (2009). Raw subscale scores are converted to scaled scores ( $M=10$ ,  $SD=3$ ), with composite scores generated for each domain ( $M=100$ ,  $SD=15$ ).

**Escala de Desenvolvimento do Comportamento Infantil no Primeiro Ano de Vida (EDCC)** [Infant Behavior Development Scale] (Pinto et al., 1997): This instrument evaluates behavioral development in the first year of life, focusing on behavioral rhythm and qualitative aspects through direct observation of 64 behaviors. It was standardized with Brazilian full-term infants not at developmental risk and uses distinct protocols for girls and boys based on behavioral stabilization, normalization, and emergence. The EDCC was used as a complementary measure due to the lack of a fully cross-culturally adapted version of the Bayley Scales for the Brazilian population.

## *General procedures and ethical considerations*

This observational, longitudinal, analytical, and prospective study was approved by the Research Ethics Committee of Universidade do Estado do Rio de Janeiro (UERJ), via Plataforma Brasil, and the Municipal Health Secretariat of Rio de Janeiro. All procedures complied with Resolution 466/2012 of the

Brazilian National Health Council (CNS). A pilot study was conducted prior to data collection to refine and validate the research procedures.

Participants were assessed at four time points during the first year of life, at 3, 6, 9 and 12 months of corrected age. At the first assessment, legal guardians signed an Informed Consent Form (ICF) detailing the study's objectives, procedures, voluntary participation, absence of risks, and data confidentiality. After consent, participants completed the sociodemographic and social-emotional questionnaires, and infants underwent developmental assessments. Activities were sequenced according to the infant's behavioral state to maximize engagement and performance, with evaluations conducted during alert and responsive periods to avoid interference from sleep or hunger. The only exception was the receptive and expressive language assessment, which followed the standardized test manual sequence.

The three subsequent evaluations were conducted by a trained psychologist, assisted by a trained undergraduate psychology student. Legal guardians were present throughout all assessments and, when appropriate, were invited to participate in the interaction under the researcher's guidance.

### *Data analysis*

Raw scores were calculated for each age and developmental scale, with corrected age applied to preterm infants based on their expected date of birth. Data normality was assessed using the Kolmogorov-Smirnov test, which indicated a normal distribution. Student's t-tests were used to compare preterm and full-term groups at each time point for cognition, communication, motor skills, and social-emotional development. At 12 months, the nonparametric Mann-Whitney U test was applied.

To examine the influence of caregiver-related variables, multiple linear regressions were conducted at 12 months for developmental domains showing significant group differences, with separate models for preterm and full-term infants. Scores from earlier assessments were included as predictors of 12-month outcomes. A repeated measures ANOVA was used for the longitudinal analysis.

To assess consistency between instruments across groups, Pearson's correlation coefficients were calculated for each developmental domain at all time points, except at 12 months, when Spearman's rank-order correlation was used. A significance level of  $p < 0.05$  was adopted. Analyses were performed using JASP version 0.19.3 (JASP Team, 2024).



## Results

Participant attrition occurred throughout the study, with 37% of the full-term group and 33% of the preterm group lost to follow-up by the final assessment. Descriptive statistics (means and standard deviations) for each group's performance are shown in Table 2. Figure 1 displays group differences in developmental outcomes, with mean scores and standard errors at 3, 6, 9, and 12 months.

To compare developmental outcomes between preterm and full-term groups, independent analyses were conducted at 3, 6, 9, and 12 months. When normality and homogeneity assumptions were met, Student's *t*-test and Cohen's *d* were used (0.20–0.49: small; 0.50–0.80: moderate;  $\geq 0.80$ : large). When assumptions were violated, the Mann-Whitney U test and Rank Biserial Correlation were applied (0.10–0.29: small; 0.30–0.50: moderate;  $\geq 0.50$ : large). At 3 months, no significant group differences were found. At 6 months, expressive language differed significantly (moderate effect). At 9 months, differences were found in cognition (large), expressive language (large), and gross motor skills (moderate). At 12 months, significant differences were observed in cognition (large), social-emotional development (moderate), expressive language (large), and fine motor skills (large). Table 3 summarizes these results.

**Figure 1 — Performance of full-term and preterm infants in the cognitive, social-emotional, receptive and expressive language, fine motor and gross motor domains of the Bayley scale at 3, 6, 9, and 12 months (mean/average standard error)**

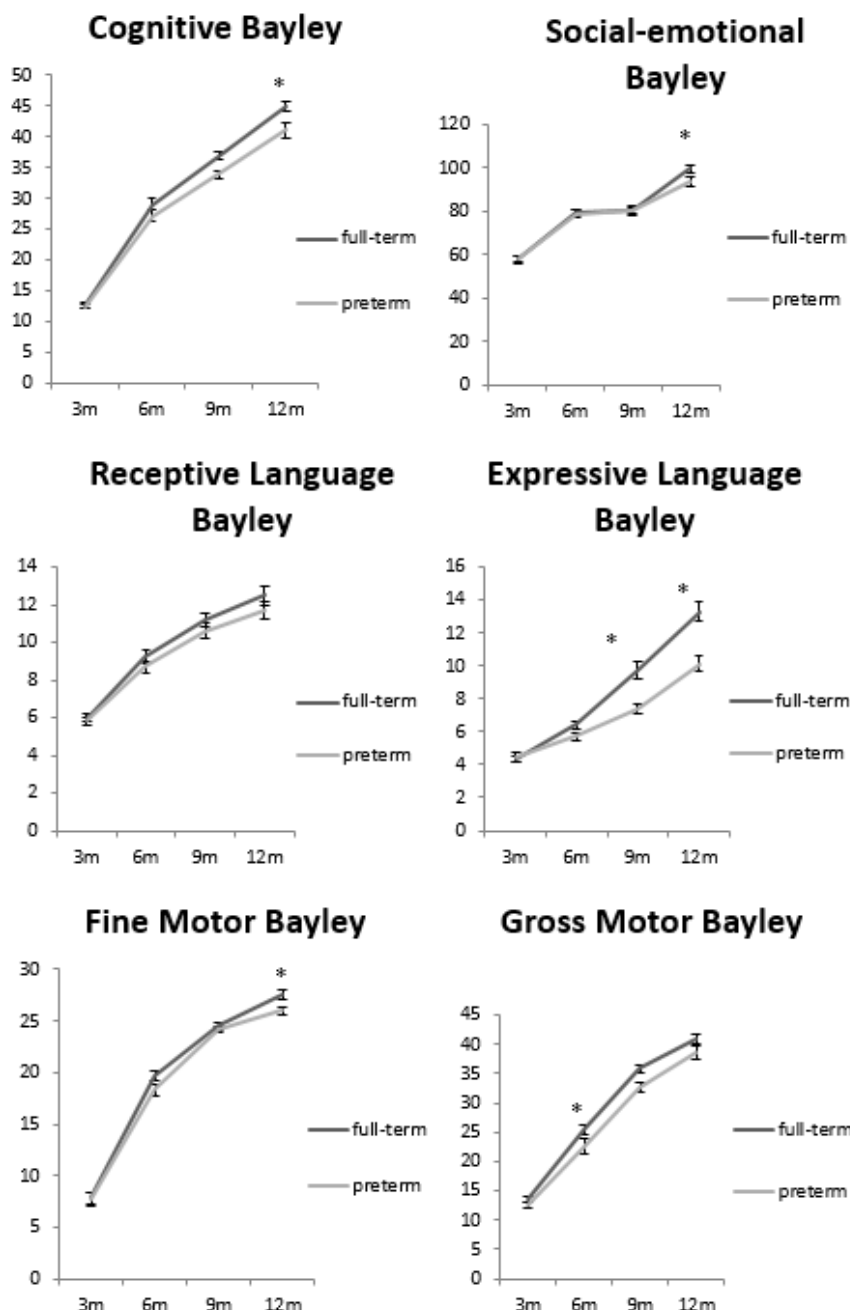


Table 2 — Pattern of infants' performance on the developmental scales

| Variables                                           | Full-Term (M/SD)            |                            |                            |                            | Preterm (M/SD)             |                            |                            |                            |
|-----------------------------------------------------|-----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|
|                                                     | 3 mths<br>n=24<br>(13F,11M) | 6 mths<br>n=19<br>(11F,8M) | 9 mths<br>n=17<br>(10F,7M) | 12 mths<br>n=15<br>(9F,6M) | 3 mths<br>n=21<br>(9F,12M) | 6 mths<br>n=20<br>(9F,11M) | 9 mths<br>n=19<br>(8F,11M) | 12 mths<br>n=14<br>(5F,9M) |
| <b>Infants' data at time of assessment</b>          |                             |                            |                            |                            |                            |                            |                            |                            |
| Age                                                 | 3.06<br>(0.19)<br>n=24      | 6.15<br>(0.38)<br>n=19     | 9.44<br>(0.44)<br>n=17     | 11.90<br>(0.80)<br>n=15    | 3.08<br>(0.40)<br>n=21     | 5.83<br>(0.39)<br>n=20     | 9.08<br>(0.64)<br>n=19     | 11.82<br>(0.47)<br>n=14    |
| Body mass                                           | 6.32<br>(0.83)<br>n=23      | 7.76<br>(1.13)<br>n=16     | 8.75<br>(1.24)<br>n=15     | 9.42<br>(1.28)<br>n=12     | 5.63<br>(1.11)<br>n=21     | 7.04<br>(1.40)<br>n=20     | 7.88<br>(1.23)<br>n=19     | 8.84<br>(1.18)<br>n=14     |
| Height                                              | 60.17<br>(1.84)<br>n=22     | 65.91<br>(2.53)<br>n=16    | 69.75<br>(2.78)<br>n=14    | 75.91<br>(5.82)<br>n=11    | 58.52<br>(3.22)<br>n=21    | 64.50<br>(3.08)<br>n=20    | 68.79<br>(3.37)<br>n=19    | 73.36<br>(4.37)<br>n=14    |
| <b>Infants' performance on developmental scales</b> |                             |                            |                            |                            |                            |                            |                            |                            |
| Bayley cognitive                                    | 12.50<br>(2.19)             | 29.11<br>(3.94)            | 36.88<br>(2.71)            | 44.93<br>(3.29)            | 12.38<br>(1.72)            | 27.25<br>(4.14)            | 33.95<br>(2.97)            | 41.14<br>(4.36)            |
| Bayley receptive language                           | 6.00<br>(0.93)              | 9.16<br>(1.50)             | 11.24<br>(1.44)            | 12.53<br>(2.03)            | 5.81<br>(1.03)             | 8.75<br>(1.37)             | 10.58<br>(1.77)            | 11.71<br>(1.77)            |
| Bayley expressive language                          | 4.29<br>(0.95)              | 6.42<br>(1.02)             | 9.71<br>(2.23)             | 13.29<br>(2.20)            | 4.52<br>(1.29)             | 5.70<br>(1.08)             | 7.37<br>(1.46)             | 10.07<br>(1.82)            |
| Bayley fine motor skills                            | 7.79<br>(2.48)              | 19.58<br>(2.03)            | 24.47<br>(1.70)            | 27.60<br>(1.80)            | 7.71<br>(2.85)             | 18.35<br>(2.60)            | 24.16<br>(1.57)            | 26.00<br>(1.36)            |
| Bayley gross motor skills                           | 13.46<br>(2.50)             | 25.53<br>(3.79)            | 35.76<br>(3.03)            | 40.87<br>(2.90)            | 12.48<br>(2.52)            | 22.50<br>(6.05)            | 32.58<br>(4.07)            | 38.57<br>(4.34)            |
| Bayley social-emotional development *               | 57.83<br>(7.18)             | 79.37<br>(6.05)            | 80.44<br>(6.02)            | 99.57<br>(6.20)            | 57.81<br>(7.08)            | 78.79<br>(6.90)            | 80.53<br>(10.25)           | 93.57<br>(8.18)            |
| EDCC scores **                                      | 8.96<br>(3.00)              | 33.37<br>(4.10)            | 46.29<br>(4.50)            | 57.07<br>(2.87)            | 8.95<br>(2.08)             | 29.70<br>(5.17)            | 43.47<br>(4.54)            | 53.14<br>(3.57)            |

**Notes:**

F: female; M: male; EDCC: Escala de Desenvolvimento do Comportamento Infantil [Infant Behavior Development Scale];

\* One preterm infant missing at 6 months (5%), one full-term infant missing at 9 months (6%), one full-term infant missing at 12 months (7%); \*\* One full-term infant missing at 12 months (7%).

Table 3 — Summary of independent sample comparison results

| Time   | Variable            | Group     | <i>M</i> | Test         | <i>t</i> or <i>U</i> | <i>p</i> | Kind of effect size | Effect size |
|--------|---------------------|-----------|----------|--------------|----------------------|----------|---------------------|-------------|
| 3 mths | Cognitive           | Preterm   | 12.38    | Student      | -0.20                | 0.840    | Cohen's <i>d</i>    | -0.06       |
|        |                     | Full-Term | 12.50    |              |                      |          |                     |             |
|        | Socio-emotional     | Preterm   | 57.81    | Mann-Whitney | 247.00               | 0.920    | Rank-Biserial       | -0.02       |
|        |                     | Full-Term | 57.83    |              |                      |          |                     |             |
|        | Receptive language  | Preterm   | 5.81     | Mann-Whitney | 224.00               | 0.510    | Rank-Biserial       | -0.11       |
|        |                     | Full-Term | 6.00     |              |                      |          |                     |             |
|        | Expressive language | Preterm   | 4.52     | Student      | 0.69                 | 0.490    | Cohen's <i>d</i>    | 0.21        |
|        |                     | Full-Term | 4.29     |              |                      |          |                     |             |
|        | Fine motor skills   | Preterm   | 7.71     | Student      | -0.10                | 0.920    | Cohen's <i>d</i>    | -0.03       |
|        |                     | Full-Term | 7.79     |              |                      |          |                     |             |
|        | Gross motor skills  | Preterm   | 12.48    | Student      | -1.31                | 0.200    | Cohen's <i>d</i>    | -0.39       |
|        |                     | Full-Term | 13.46    |              |                      |          |                     |             |
| 6 mths | Cognitive           | Preterm   | 27.25    | Student      | -1.43                | 0.161    | Cohen's <i>d</i>    | -0.46       |
|        |                     | Full-Term | 29.11    |              |                      |          |                     |             |
|        | Socio-emotional     | Preterm   | 78.79    | Mann-Whitney | 168.00               | 0.724    | Rank-Biserial       | -0.07       |
|        |                     | Full-Term | 79.37    |              |                      |          |                     |             |
|        | Receptive language  | Preterm   | 8.75     | Student      | -0.89                | 0.381    | Cohen's <i>d</i>    | -0.28       |
|        |                     | Full-Term | 9.16     |              |                      |          |                     |             |
|        | Expressive language | Preterm   | 5.70     | Mann-Whitney | 121.50               | 0.047    | Rank-Biserial       | -0.36       |
|        |                     | Full-Term | 6.42     |              |                      |          |                     |             |
|        | Fine motor skills   | Preterm   | 18.35    | Student      | -1.64                | 0.110    | Cohen's <i>d</i>    | -0.52       |
|        |                     | Full-Term | 19.58    |              |                      |          |                     |             |
|        | Gross motor skills  | Preterm   | 22.50    | Student      | -1.86                | 0.071    | Cohen's <i>d</i>    | -0.60       |
|        |                     | Full-Term | 25.53    |              |                      |          |                     |             |

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| Time    | Variable            | Group     | <i>M</i> | Test         | <i>t</i> or <i>U</i> | <i>p</i> | Kind of effect size | Effect size |
|---------|---------------------|-----------|----------|--------------|----------------------|----------|---------------------|-------------|
| 9 mths  | Cognitive           | Preterm   | 33.95    | Student      | -3.08                | 0.004    | Cohen's <i>d</i>    | -1.03       |
|         |                     | Full-Term | 36.88    |              |                      |          |                     |             |
|         | Socio-emotional     | Preterm   | 80.53    | Mann-Whitney | 143.00               | 0.776    | Rank-Biserial       | -0.06       |
|         |                     | Full-Term | 80.44    |              |                      |          |                     |             |
|         | Receptive language  | Preterm   | 10.58    | Student      | -1.21                | 0.234    | Cohen's <i>d</i>    | -0.40       |
|         |                     | Full-Term | 11.24    |              |                      |          |                     |             |
|         | Expressive language | Preterm   | 7.37     | Student      | -3.76                | <0.001   | Cohen's <i>d</i>    | -1.26       |
|         |                     | Full-Term | 9.71     |              |                      |          |                     |             |
|         | Fine motor skills   | Preterm   | 24.16    | Student      | -0.57                | 0.57     | Cohen's <i>d</i>    | -0.19       |
|         |                     | Full-Term | 24.47    |              |                      |          |                     |             |
| 12 mths | Gross motor skills  | Preterm   | 32.58    | Mann-Whitney | 83.00                | 0.013    | Rank-Biserial       | -0.49       |
|         |                     | Full-Term | 35.77    |              |                      |          |                     |             |
|         | Cognitive           | Preterm   | 41.14    | Student      | -2.66                | 0.013    | Cohen's <i>d</i>    | -0.99       |
|         |                     | Full-Term | 44.93    |              |                      |          |                     |             |
|         | Socio-emotional     | Preterm   | 93.57    | Mann-Whitney | 47.50                | 0.021    | Rank-Biserial       | -0.52       |
|         |                     | Full-Term | 99.57    |              |                      |          |                     |             |
|         | Receptive language  | Preterm   | 11.71    | Student      | -1.15                | 0.259    | Cohen's <i>d</i>    | -0.43       |
|         |                     | Full-Term | 12.53    |              |                      |          |                     |             |
|         | Expressive language | Preterm   | 10.07    | Student      | -4.22                | <0.001   | Cohen's <i>d</i>    | -1.59       |
|         |                     | Full-Term | 13.29    |              |                      |          |                     |             |
|         | Fine motor skills   | Preterm   | 26.00    | Student      | -2.68                | 0.012    | Cohen's <i>d</i>    | -1.00       |
|         |                     | Full-Term | 27.60    |              |                      |          |                     |             |
|         | Gross motor skills  | Preterm   | 38.57    | Student      | -1.68                | 0.104    | Cohen's <i>d</i>    | -0.63       |
|         |                     | Full-Term | 40.87    |              |                      |          |                     |             |

**Notes:**Effect sizes are reported as Cohen's *d* for parametric comparisons and Rank-Biserial Correlation for nonparametric comparisons; Time: assessment point.

Multiple regression analyses were conducted to examine whether maternal and contextual variables – maternal age, education, income, participation in social programs, social support, and type of delivery – predicted developmental outcomes at 12 months based on the Bayley-III scores. In the preterm group, no statistically significant associations were found for any of the outcome domains: cognitive ( $R^2=0.03$ ,  $F=1.07$ ,  $p=0.46$ ), receptive language ( $R^2=-0.50$ ,  $F=0.27$ ,  $p=0.93$ ), expressive language ( $R^2=0.54$ ,  $F=3.52$ ,  $p=0.06$ ), fine motor ( $R^2=-0.30$ ,  $F=0.49$ ,  $p=0.79$ ), social-emotional ( $R^2=-0.47$ ,  $F=0.31$ ,  $p=0.91$ ). In the full-term group, the variables also did not significantly predict most outcomes: cognitive ( $R^2=0.01$ ,  $F=1.02$ ,  $p=0.48$ ), receptive language ( $R^2=-0.26$ ,  $F=0.56$ ,  $p=0.75$ ), expressive language ( $R^2=-0.13$ ,  $F=0.77$ ,  $p=0.62$ ), social-emotional ( $R^2=-0.28$ ,  $F=0.56$ ,  $p=0.75$ ). However, a significant model emerged for the fine motor domain ( $R^2=-0.70$ ,  $F=6.16$ ,  $p<0.05$ ). In this group, family income ( $\beta=0.83$ ,  $p<0.01$ ) and participation in social programs ( $\beta=-0.96$ ,  $p<0.01$ ) were significant predictors of fine motor performance. The other variables were not statistically significant: maternal age ( $\beta=-0.42$ ,  $p=0.15$ ), education ( $\beta=0.14$ ,  $p=0.64$ ), social support ( $\beta=0.36$ ,  $p=0.09$ ), and type of delivery ( $\beta=0.38$ ,  $p=0.07$ ).

In the preterm group, the analysis of the models' independent variables revealed no statistical difference. However, while predicting the participation in social programs on the cognitive outcomes of the Bayley Scale, when controlled by maternal age, maternal education, income, social support, and type of delivery, some statistical significance was found ( $\beta=0.96$ ,  $p<0.05$ ). Other variables also revealed differences, such as the mother's age in the prediction of expressive language scores ( $\beta=-0.67$ ,  $p<0.05$ ) and, among full-term infants, social support was associated with cognitive outcomes in the Bayley Scale ( $\beta=0.77$ ,  $p<0.05$ ).

While testing these independent variables in a univariate, simple linear regression model, none of the analyses revealed statistical significance in the preterm group. In the full-term group, only participation in social programs significantly predicted fine motor skills ( $\beta=-0.55$ ,  $p<0.05$ ). Therefore, these findings suggest that the effect of these variables is detectable only when controlling the effects of the other variables within the model.

A significant effect of time was observed in the development of preterm infants on the Bayley cognitive scale [ $F(2,30)=250.56$ ,  $p<0.01$ ]. Additional tests ( $p<0.01$ ) confirmed that these differences followed the direction predicted. Receptive language also demonstrated a significant effect [ $F(2,33)=54.35$ ,  $p<0.01$ ], although no difference was found between time points 9 and 12 months. Expressive language presented a significant effect [ $F(3,35)=53.16$ ,  $p<0.05$ ] with differences observed between all time points ( $p<0.01$ ). Similarly,

fine motor skills [ $F(2.28)=292.65$ ,  $p<0.05$ ] demonstrated differences between all time points ( $p<0.01$ ), along with gross motor skills [ $F(2.30)=188.09$ ,  $p<0.05$ ] ( $p<0.01$ ) and EDCC scores [ $F(3.37)=429.74$ ,  $p<0.05$ ] ( $p<0.01$ ). However, for social-emotional development [ $F(2.20)=69.11$ ,  $p<0.05$ ] no difference was found between time points 6 and 9 months.

In the full-term group, effects were found on the Bayley cognitive scale [ $F(2.34)=348.89$ ,  $p<0.05$ ]. Receptive language also showed significant differences [ $F(2.31)=72.20$ ,  $p<0.01$ ], although no difference was found between time points 9 and 12 months. Expressive language showed a significant effect [ $F(2.28)=72.70$ ,  $p<0.05$ ] between all time points ( $p<0.01$ ). Fine motor skills [ $F(2.33)=222.45$ ,  $p<0.05$ ] and gross motor skills [ $F(2.34)=366.50$ ,  $p<0.05$ ] also showed significant gains between all time points ( $p<0.01$ ). Social-emotional development was significant overall [ $F(2.25)=265.88$ ,  $p<0.05$ ], but no difference was found between time points 6 and 9 months. EDCC scores [ $F(3.36)=477.89$ ,  $p<0.05$ ] also demonstrated significant changes between all time points. Results from both instruments revealed consistent patterns across groups. Some of the patterns observed were at 3 months in receptive language and fine motor skills; at 6 months in cognitive and gross motor skills; at 9 months in expressive language and gross motor skills; and at 12 months in expressive language.

## Discussion

This study assessed the overall neuropsychological development of preterm and full-term infants during the first year using a standardized assessment. Cognition was the most frequently examined skill (Burstein et al., 2021; Coletti et al., 2015; Reis et al., 2012). All group differences emerged at 12 months, as in the present study, suggesting cognition may distinguish full-term from preterm infants at that age.

Memory-related differences have been observed among preterm subgroups at 6 months, with less stability in males (Reis et al., 2012), though such differences were not detected with the instrument used in this study. One hypothesis for the cognitive disparity at 12 months involves myelination, which increases nerve impulse speed. Hippocampal neurobiological mechanisms supporting memory remain under development in early life (Ramsaran et al., 2019).

Within cognition, distinct abilities such as attention are notable. Burstein et al. (2021), in a systematic review with meta-analysis, found that pre-term birth is linked to impairments in visual attention, including target fixation

and tracking, visual habituation, recognition memory, and focused attention – functions crucial for engagement and social interaction. This study examined developmental traits underlying future cognitive skills. Unlike Burstein et al. (2021), the present findings show that even preterm infants display habituation responses, such as distinguishing familiar from unfamiliar stimuli (as assessed by cognitive items of the Bayley Scale), indicating the presence of memory as another relevant cognitive function.

Social-emotional development was similar between groups up to 12 months, suggesting a developmental window in preterm infants that warrants attention to prevent later differences. Markers such as optimal auditory orientation at term may predict better performance at age 2 and higher verbal IQs, reflecting aspects of social cognition (Aho et al., 2021). Moreover, social-emotional skills are closely linked to cognitive and language development (Hass et al., 2022; Peralta-Carcelen et al., 2017; Vandormael et al., 2019; Zambrana et al., 2021).

Receptive language behaviors showed minimal change over the months. One explanation is that preterm infants may receive increased stimulation from more sensitive mothers, supported by follow-up programs. In contrast, full-term infants may be more influenced by external factors or individual traits. Maternal sensitivity and socioeconomic status may predict infants' behavioral regulation capacity (Costa Ribeiro et al., 2020).

Although this lack of differences aligns with the reviewed studies, the hypothesis was specifically examined in light of Zambrana et al. (2021), who reported a language lag in preterm infants during the first year, though without specifying the domain assessed. Similarly, infants in Reis et al. (2012) showed lower language performance, impacting mental development index scores, but the specific type of language affected remains unclear.

At 12 months, brain regions linked to receptive and expressive language – such as the angular gyrus, Broca's area, and the perisylvian network – reach a developmental peak (Thompson & Nelson, 2001). The present study's findings on expressive language align with existing literature.

Differences in gross motor performance were observed between infants aged 1 to 12 months. Formiga et al. (2015), in a Brazilian study, emphasized the need for age-specific assessments to avoid overestimating motor risks. Although this study followed that guideline, results varied over time. As motor development progresses through multiple stages and is shaped by social, emotional, physical, and cultural factors (Elmer et al., 2025; Hadaya et al., 2023; Ko & Lim, 2023),



the variation may reflect insufficient stimulation in full-term infants or adequate stimulation in preterm ones.

Preterm birth is associated with alterations in several brain regions (Alexander et al., 2019). While some studies find no significant group differences at 12 months (Coletti et al., 2015), literature reports many similarities during this period (Vanes et al., 2023). As development progresses, more complex intellectual functions emerge and reshape behavior, linked to the maturation of the prefrontal cortex, which follows a prolonged trajectory (Thompson & Nelson, 2001). Consequently, specific domain functioning becomes clearer after 12 months.

In addition, other hypotheses may account for variabilities observed at the end of the first year of life. This phase is marked by greater skill sophistication, characterized by more collaborative interaction and heightened identification through imitation (Ko & Lim, 2023). Greater visual acuity in this stage may also be related to attention development, which becomes full-fledged at this time (Burstein et al., 2021). These observations raise the question of whether this stage features the expression of earlier neurodevelopmental alterations or if it represents a moment when differences are more clearly established.

Results indicated that preterm infants develop in a quite similar pattern to full-term infants, despite some differences. Even when birth occurs at the stages of increased dendritic and axonal growth (around the sixth gestational month), brain myelination, olfactory system maturation, apoptosis, and dendritic pruning (around the seventh gestational month), auditory system maturation, and the emergence of attentional responses (around the eighth month), these processes are not necessarily disrupted. The fact that neuronal migration is already complete by the sixth gestational month (Oates, 2012) seems to contribute to continued development. The concept of neuroplasticity offers an explanation for the differences observed, particularly highlighting greater potential of neural adaptation in early life. Development unfolds, with adaptations and differences across different brain structures and areas, with alternating periods of accelerated and slower growth (Thompson & Nelson, 2001).

Regarding the regression findings, variables such as higher income and receipt of government aid may have represented favorable conditions that contribute to these positive outcomes. Coletti et al. (2015) identified associations between performance on the Bayley Scale at 12 months and both neonatal and sociodemographic data. In this paper, weight gain among late preterm infants was associated with better language scores, as well as higher maternal education

attainment. Conversely, a correlation was observed between lower language scores and the mothers' lower level of schooling, in addition to severe psychosocial risk (Silveira & Enumo, 2012). However, results across studies were not always consistent. Reis et al. (2012) did not observe environmental effects on the development of preterm infants – similar to the present study. Thus, it is understood that the influence of socioeconomic status on development is not uniformly observed, often due to its distal relationship or the presence of other associated variables that may overshadow such effects (Costa Ribeiro et al., 2020).

Regarding the value of the scores for each age found in performance evaluations at 12 months, the same patterns were observed across both groups. This consistency was evidenced in receptive language, where no differences were identified between both groups from time points 9 to 12 months. The increase in white matter and brain growth – especially in the frontal regions – occurs most rapidly in the first two years of life (Oates, 2012). These characteristics are associated with the emergence of more complex skills. Although these processes were investigated in this study, receptive language was the only area where no differences were verified between groups. From this sample, it may be inferred that developmental continuation may have occurred as a function of biologically predicted growth.

According to these findings, the Brazilian instrument EDCC demonstrates a strong correlation with most domains of the Bayley's assessment scales, being suitable to assess the performance of infants aged 1 to 12 months. Positive outcomes were observed in cognition, language, and motor skills.

Some hypotheses were confirmed in this study. Findings showed that infants born at term demonstrated a better performance in cognition at 12 months; expressive language at 9 and 12 months; fine motor skills at 12 months; gross motor skills at 6 months; social-emotional skills at 12 months; and overall EDCC performance at 12 months. The only regression model confirmed was that the endpoint of fine motor skills of infants born at term was predicted by family income and maternal participation in social welfare programs. Regarding the scores, almost all of them displayed changes over time, and consistency between instruments was observed for some time points across nearly all Bayley Scales. However, other hypotheses were not supported. No differences emerged between the groups in receptive language and no changes were observed over two time points in receptive language and social-emotional skills. Additionally, no consistency was found between EDCC and Bayley social-emotional scale.

It is worth noting that the preterm group consisted of high-risk infants without neurological or congenital impairments and with relatively high Apgar

scores. Thus, both groups had comparable health conditions. Difficulties in conducting a study with longitudinal design were encountered, including the possibility of external biases that may reduce comparability, the duration and higher expenses of data collection, and sample mortality. However, the advantage of conducting the collection and developmental analysis in alignment with specific times enabled both their analysis and conclusive interpretation of the findings.

This study had some limitations. The group studied does not represent a sample of the general population, but rather a substrate of a specific context with unique characteristics. The subgroups analyzed belong to distinct clinical segments. Preterm infants were accompanied in a university hospital which serves as a reference center for preterm births in the state of Rio de Janeiro. In this setting, mothers and their infants receive follow-up care (by a multidisciplinary team of pediatricians, a speech therapist, a nutritionist, a nurse, a physical therapist, a psychologist, and medical residents), even though follow-up is often offered in the private healthcare system. Therefore, this hospital receives mothers from diverse socioeconomic backgrounds, in contrast with the health center, that provides follow-up services to the general population. This fact corroborates the argument by Cristóbal Cañadas et al. (2022) and Silveira et al. (2024) which, based on plasticity, suggests that it is possible to understand how infants develop in relation to their surrounding environment.

Another limiting factor of this study is the scarcity of standardized instruments to assess this age group. Although the Bayley Scale is considered the most comprehensive instrument available according to literature, the lack of a Brazilian adaptation demanded the inclusion of a national screening instrument.

From the findings obtained, it became possible to expand the knowledge of preterm infants' characteristics in comparison to their full-term peers. In several instances, preterm infants exhibited lower performance in some skills. However, the developmental curves of both groups appeared parallel and similar. In addition to the specific outcomes obtained, evidence showed the possibility of satisfactory developmental outcomes in preterm infants with adequate stimulation, and the minimization of possible delays that may exist. In this regard, this study contributes to the field by offering an integrated evaluation of functions in preterm infants, in comparison to the full-term cohort, with data that may subsidize interventions aimed at preterm infants and their families.

An emerging hypothesis to be tested in future studies is that the systematic monitoring of this group by the healthcare team may have functioned as an

intervention to promote development. However, in longitudinal surveys, it is ethically unfeasible to control possible influences of this kind of follow-up.

The knowledge of the healthcare professionals supporting these families, in addition to their commitment to providing adequate information throughout this period, was of paramount importance. The experience of conducting this research suggests that improvements may be obtained through intervention programs. Therefore, based on the evidence and observations presented in this study, we suggest that appropriate interventions be tailored to the needs of preterm infants and their families.

## Final considerations

Grounded in the concepts of evolutionary developmental psychology and neuropsychology, this research identified differences between the groups accompanied, in general, at 12 months of age, with the preterm group performing below their full-term counterparts. However, apparently parallel and similar developmental curves suggest developmental progress over time. Further studies are necessary to test whether these differences are temporary or persist across other developmental stages.

Despite the limitations and difficulties, this paper offers two main contributions. First, it indicates the importance of the quality of social interaction. The different outcomes in the latter part of the first year of life indicate that social interaction favored maturational differences more than anatomical physiological deprivation. Second, the data underscores the importance of the interaction/configuration of biological and social factors. These insights hold particular relevance for clinical practice, especially in neuropsychological assessment and stimulation. Further investigations are necessary in order to extend and refine the measures.

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## Contribution of each author for the article

**Luciana Brooking:** Literature review, data collection and analysis, manuscript writing.

**Patricia Lorena Quiterio:** Literature review, manuscript writing.

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