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Neuropsychological assessment and perinatal risk: A study amongst very premature born 4- and 5-year old children

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ABSTRACT

Background: Prematurity and its consequences are serious problems that can result in numerous neurosensory disabilities and cerebral cognitive dysfunctions. The Perinatal Risk Index (PERI) might provide a predictive measure of these problems.

Aim: This study compared the cognitive development of prematurely born children at 4 and 5 years of age with age-matched peers born at term. The secondary objective was to determine whether a correlation exists between perinatal risk and performance on neuropsychological tests among premature children.

Methods: A total of 54 children between four and five years of age were evaluated; 27 were born very premature (premature group; PG), and 27 were born at term (term group; TG). Executive function, attention, memory, language, visual perception, and spatial structuring were evaluated. Subtests from the Kaufman Assessment Battery for Children, the Rey Complex Figure Test, the McCarthy Scales of Children's Abilities, the Peabody Picture Vocabulary Test, Test A, Trails A and B, the spatial structuring questionnaire from the Child Neuropsychological Maturity Questionnaire, and the Wechsler Intelligence Scale for Children were used. A PERI score was also obtained for the PG.

Results: The PG showed significantly lower scores than the TG in all the studied cognitive domains. Visual-perceptive scores were significantly and negatively correlated with the PERI scores of the PG.

Conclusions: The PG showed neurocognitive deficits compared with the TG. The PERI can be used to predict the development of visual-perceptive abilities in children between four and five years of age.

Keywords: prematurity; neuropsychology; visual perceptive abilities; perinatal risk

1. INTRODUCTION

Prematurity, i.e., birth prior to gestational week 37, affects between 8 and 10% of all births (Bermudez et al., 2012). Spanish incidence of prematurity has increased by 36% over the last two decades, with a lower prevalence compared with the Europe mean (6.41% vs. 10%) ('Instituto Nacional de Estadistica', 2013), and it is the cause of 75% of all cases of perinatal mortality and 50% of all cases of disability in infancy (Bermudez et al., 2012; Glass et al., 2015).

A child is considered very premature when his or her birth weight is less than or equal to 1,500 g, when the birth occurs on or before gestational week 32 (Aylward, 2005), or both; thus, weight and gestational age are risk factors for postnatal alterations (Rellan Rodríguez, García de Ribera, & Aragón Garcia, 2008).

Prematurity is associated with complications such as intracranial haemorrhage, seizure, hydrocephaly, dysmorphic facial features, various central nervous system dysfunctions, and ophthalmic retinopathy of prematurity (Fernández-Carrocera, Guevara-Fuentes, & Salinas-Ramírez, 2011). Likewise, it is related to a higher incidence of neurosensory lesions such as periventricular leukomalacia and periventricular-intraventricular haemorrhage (Aylward, 2005).

Although the prevalence of serious disorders such as cerebral palsy has not increased over recent decades, the prevalence of neuropsychological problems has increased (Aylward, 2002), including of those related to executive function, verbal fluency, working memory, cognitive flexibility, visual-spatial and visual-motor processing, and attention and verbal memory performance (Bermudez et al., 2012; Burnett et al., 2015; Glass et al., 2015; Mulder, Pitchford, Hagger, & Marlow, 2009; Roldán-Tapia, Ramos-Lizana, Sánchez-Joya, Cánovas, & Bembibre-Serrano, 2013).

Nevertheless, the risk factors to which a premature child is exposed are not predictors of subsequent development *per se*. Rather, the major determinant is the presence of certain factors combined with certain characteristics in the premature infant such that risk increases with the number of environmental and biological risk factors (Chen et al., 2004; Torres Valdivieso, Gómez, Medina, & Pallás, 2008).

One tool for evaluating biological risk is the Perinatal Risk Inventory (PERI), which consists of a scale that measures 18 of these neonatal risk factors prior to discharge from the hospital. The PERI is used for its predictive value regarding pathologies and developmental anomalies (Pérez López, García Martínez, Sánchez Caravaca, García-Martínez, & Sánchez-Caravaca, 2009; Zaramella et al., 2008).

The current study sought to compare the cognitive development of prematurely born children born at four and five years of age with age-matched peers born at term. The secondary objective was to determine whether a correlation exists between perinatal risk and the neuropsychological test performance of premature children.

2. METHODS

2.1. Design

A comparative study was performed between January 2005 and December 2006 to examine children between four and five years of age (chronological age) who were born prematurely or at term. Within the very premature group (PG), a correlational study was performed between the scores obtained on neuropsychological tests and the PERI.

2.2. Participants

2.2.1. Premature Group (PG)

The PG included children born in the Torrecárdenas Hospital Complex of Almería (Spain) between 2000 and 2001. The inclusion criteria for the premature group were (i) born before gestational week 32, weight less than 1500 g at birth, or both; and (ii) aged between four and five years old at the time of evaluation.

Likewise, participants who met any of the following criteria were excluded: (i) those with the presence of severe sensorimotor or mental deficits, thus do not excluded participants with a mild sensorimotor deficits and cerebral palsy, according to medical criterial, and if this status do not interference in the assessment (ii) those not consenting to participate, or (iii) those attending only one evaluation session.

Sample selection was completed through a list of random numbers, which was used to select case pairs.

2.2.2. Neonates born at term group (TG)

The TG was composed of children born between 2000 and 2001 who attended various public schools in Almería. The inclusion criteria were (i) born after gestational week 37, (ii) birth weight of greater than 1500 g, and (iii) aged between four and five years at the time of evaluation.

The exclusion criteria were the same as those described above for the PG group.

The TG sample was obtained through intentional sampling with the goal of matching with the premature group with regard to child age, sex, and education level as well as the socioeducation level of the parents.

2.3. Variables and data collection tools

2.3.1. Sociodemographic variables

The sociodemographic variables obtained included sex, age (months), birth weight (g), gestational age, child's level of education (pre-school stage), and parental level of education (years of formal education).

2.3.2. Cognitive variables

The neuropsychological evaluation consisted of tests with recognised diagnostic value, usability, and scoring across the following cognitive domains: executive function, language, visual perception, learning, memory, and attention. The following tools were used:

- The Kaufman Assessment Battery for Children (Kaufman & Kaufman, 1997). This instrument is used to evaluate the cognitive ability and academic knowledge of participants between 2.5 and 12.5 years of age. This battery consists of two large scales: one for mental processing that includes scales of sequential and simultaneous processing, and another for academic knowledge.

- The Rey Complex Figure Test (Rey, 1997). This test examines participants' abilities to copy and reproduce complex geometric figures from memory and is used individually in children beginning at age four to detect cognitive difficulties.

- The McCarthy Scales of Children's Abilities (MSCA) (McCarthy, 1996). This test evaluates the cognitive abilities of children between 2.5 and 8.5 years of age.

- The Peabody Picture Vocabulary Test (Dunn, 1986). This test measures the degrees of vocabulary acquisition and scholastic aptitude; it also provides an index of mental age.

- Cancellation Test "A" (Strub & Black, 1985). This test measures the functions of alertness and sustained attention.

- Trail Making Test or Trails A and B (Reitan & Wolfson, 1985). This test requires that children trace lines with a pencil to successively connect 25 numbers distributed by chance on a letter-size page.

The numbers that are enclosed within a circle in Part A of the test, and 25 numbers and letters are presented in an alternating order in Part B of the test. Both tests are used to measure complex attention as well as visual tracking, motor velocity, and (in Part B) divided attention.

- The Child Neuropsychological Maturity Questionnaire (CUMANIN) (Portellano, Mateos, Martínez Arias, Granados, & Tapia, 2000). This test evaluates various areas of high importance to detect possible developmental difficulties between three and six years of age.

- The Wechsler Intelligence Scale for Children (Wechsler, 2005). This test assesses intelligence and intellectual aptitudes among children younger than 16 years of age.

One experienced evaluator performed all of the evaluations in the Paediatric Clinic of the Torrecárdenas Hospital Complex across two sessions during the same week. Testing required approximately 60 minutes with breaks between the assessments to avoid fatigue and mental tiredness in the children.

2.3.3. Perinatal Risk

The PERI (Scheiner & Sexton, 1991) includes 18 items that evaluate the following: (1) Apgar test scores; (2) gestational age; (3) weight (appropriate for gestational age); (4) presence or absence of congenital infections; (5) existence of non-metabolic seizures; (6) presence/absence of meningitis; (7) cephalic growth (for preterm children hospitalised for at least 6 weeks); (8) cephalic growth (in term children hospitalised for more than 3 weeks); (9) electroencephalogram characteristics; (10) intracranial haemorrhage; (11) hydrocephaly; (12) central nervous system findings excluding hydrocephaly or intracranial haemorrhage; (13) dysmorphic facial features; (14) duration of ventilation; (15) polycythaemia; (16) hypoglycaemia; (17) hyperbilirubinemia; and (18) associated medical problems (not of the central nervous system).

The scores range between 0 and 3 points and denote severity. The total index creates a total score between 0 and 54 points that provides information regarding the biological risk for the child. The risk levels are characterised as (i) low (0 to 6 points); (ii) moderate (7 to 9 points); and (iii) high (10 or more points).(Scheiner & Sexton, 1991) The inventory achieves its highest predictive value starting at a score of 10 or higher because this scale is more sensitive when identifying future risks for neonates. Its sensitivity is 76%, its positive predictive value is 47.5%, and its negative predictive value is 92.9% (Pérez López et al., 2009).

The PERI was performed using data from the participants' medical records.

2.4. Statistical Analysis

The statistical analyses applied to the sociodemographic data included a contrast of averages and Student's t-test for independent samples. Regarding the neuropsychological test scores, the average and standard deviation (SD) were calculated, and the averages were compared with Student's t-test for independent samples or the non-parametric Mann-Whitney U test. To test the possible association between the qualitative variables analysed and group assignment, the chi-square test was used.

With regard to the PG, a descriptive statistical analysis was performed on the PERI, and Spearman's bivariate correlation was conducted between the PERI scores and the neuropsychological test scores. The strength of correlation was interpreted using the following guide for the absolute value of r_s: 0.00-0.19 (very weak), 0.20-0.39 (weak), 0.40-0.59 (moderate), 0.60-0.79(strong) and 0.80-1.0 (very strong) (statstutor, n.d.).

A p-value of 0.05 was considered significant. All analyses were performed using SPSS 19.0 for Windows.

2.5. Ethical Aspects

Informed consent was obtained from the parents or legal guardians of the participating children. The Provincial Education Delegation of Almería of the Government of Andalusia and the Research Subcommission of the Torrecárdenas Hospital Complex approved this study.

3. RESULTS

The sample was composed of 54 children: 27 in the PG and 27 in the TG. Figure 1 shows the detailed participant selection flowchart.

Figure 1. Participant selection flowchart

INSERT FIGURE 1 approximately here

Table 1 shows the major sociodemographic characteristics of the PG and TG. The TG was similar to the PG with regard to sex (17 boys and 10 girls in both groups), age (p=0.818), child education level (p=0.672), parental education level (p=0.272), and maternal education level (p=0.097).

INSERT TABLE 1 approximately here

Table 2 shows the scores obtained from the PG and TG on the different neuropsychological tests. Significant differences were observed for all the cognitive dimensions evaluated: attention, learning and memory, executive function, visual perception, and language. The scores of the PG were lower than those of the TG. The following subtests did not show significant differences: executive function (analogous matrices, p=0.135; opposites, p=0.600), language proficiency (expressive vocabulary, p=0.064), visual-perceptive proficiency (magic window, p=0.061; spatial structuring, p=0.600), and attentional function (attention, p=0.515).

INSERT TABLE 2 approximately here

Regarding the PG, perinatal risk was evaluated using the PERI. We observed that 44.44% (n=12) of this group presented with a low risk, 37.04% (n=10) presented with a moderate risk, and 18.52% (n=5) presented with a high risk. Correlational analysis between the PERI and the neuropsychological test scores showed a significant and negative correlation for the following tasks: a weak correlation with spatial structuring test (CUMANIN; ρ=-0.37, p=0.043), a moderate correlation with visual perception (CUMANIN; ρ=-0.473, p=0.017), and a strong correlation with the Rey Complex Figure test, principal elements (ρ=-0.647, p=0.043). No other significant correlations were obtained (p>0.05). As a result, the data revealed a correlation between the PERI and the indicated visual-perception tasks.

4. DISCUSSION

The results showed that premature children scored significantly lower than their full-term peers in all the studied cognitive domains. Likewise, a significant and negative correlation was found in the PG between the PERI and the visual-perception tasks but not the other tasks.

The results obtained confirm prior studies showing that very premature children score significantly lower than those born at term (Mikkola et al., 2005; Narberhaus et al., 2007; Olsén et al., 1998). It is important to study cognitive difficulties between the ages of four and five years because cognitive function is generally facilitated by a set of executive functions that significantly develop at approximately four years old (Pérez & Capilla, 2008).

The literature concerning prematurity and cognitive deficits has mostly addressed children under three years of age (Rose, Jankowski, Feldman, & Van Rossem, 2005), those in primary school, and adolescents (Marlow, Wolke, Bracewell, & Samara, 2005), and few studies have investigated four and five year olds.

Regarding the cognitive domains affected, prior studies have revealed a generalised cognitive compromise. Specifically, children three to four years in age often have deficits in visual perception, visual construction, sustained attention, spatial memory, and language (Caravale, Tozzi, Albino, & Vicari, 2005). Likewise, seven year olds often have neuropsychological deficits in executive function, verbal fluency, memory, flexibility, and visual-spatial and visual-motor processing (Bermudez et al., 2012).

Other studies, such as that performed by Aylward (2005), have shown more specific cognitive domains, revealing that problems with visual perception or executive function tend to appear when a child is born very premature. Similarly, premature children with periventricular leukomalacia present with problems in visual perception (Sans et al., 2002), as do those with little structural damage (Braddick & Atkinson, 2011). These results are congruent with the present study, which found a negative correlation between the PERI and visual-perceptive development.

Identifying difficulties in visual perception at an early age is of great interest because these difficulties might determine the future acquisition of the abilities necessary for normal cognitive development such as the development of literacy and, as a result, the acquisition of knowledge (Merchán Price & Henao, 2011).

In agreement with other authors (Burnett et al., 2015; Mulder et al., 2009), our results revealed differences in attention and executive function in children born prematurely compared with children born at term. The results regarding memory coincide with those of Briscoe, Gathercole, and Marlow (2001) who observed deficits in premature five year olds.

Although the PG did not present with cerebral injury of any kind, their delayed development on the neuropsychological tasks compared with the TG reveals the need for a predictive scale or instrument for a child's future development. In this regard, previous studies (Pérez López et al., 2009; Zaramella et al., 2008) have used motor and developmental scales as general predictors of cognitive capacity and motor development, taking into account neurological status and using pre-discharge evaluations of the child. Mental and psychomotor progress also appear to be related to the risk level of a child at birth, in addition to other environmental variables.

In this sense, various studies (Dorling, Field, & Manktelow, 2005; Pasman, Rotteveel, Maassen, de Graaf, & Kollée, 1998; Spittle et al., 2014; Zaramella et al., 2008) have indicated that the PERI is useful for assessing a child's risk through their subsequent development and for rapidly and reliably predicting the child's future development. The current study found a negative correlation between the PERI and the development of visual-perceptive abilities at four and five years of age, which might influence the process of learning to read, an important skill for academic performance.

However, the current study is not without its limitations, which include the lack of a sample-size calculation and the small number of participants. As such, the obtained results should be interpreted cautiously, and additional studies should be performed on this topic with larger sample sizes to reliably contrast the proposed objectives. Furthermore, obtaining data from medical records to calculate the PERI represents a limitation because, in some cases, the data were insufficient. Thus, prospective studies are recommended.

5. CONCLUSIONS

Children who are born prematurely have less developed executive, visual-perceptive, learning, memory, language, and attention abilities at four and five years of age than their age-matched peers born at term. Likewise, using the PERI to perform an evaluation at hospital discharge appears to predict their subsequent development on visual-perceptive tasks, the delayed development of which might interfere with later literacy learning. Therefore, it might be useful to evaluate visual-perceptive performance using a standard protocol to help plan future interventions for prematurely born children.

As far as we know, this is the first research to be carried out on Spanish children between four and five years of age who were born very prematurely. In this sense, we have used exhaustive and validated tests for the assessment. In addition, we compared the results obtained in the premature group with a matched control group who were born full term. Our results provide evidence of cognitive development in executive function, attention, memory, language, visual perception, and spatial structuring in children born very premature. This research suggests the need to assess certain cognitive abilities in very premature children, in which important deficits for school performance can be detected and treated, such as visual-perceptive deficits. In this way, the main contribution of this research is to report that the PERI could be a predictive index of the visual-perceptive abilities of very prematurely born four- and five-year-old children compared to the development of children born full term. Thus, the main clinical implication is the use of PERI at the moment the child is born, given its predictive utility to detect which individuals are at a greater risk of having a general maturational delay or a cognitive dysfunction that may interfere in their learning. Therefore, it could be possible to begin an early therapy such as stimulation, however, more research is needed and it would be important to perform the PERI on children after birth and when admitted to the neonatology unit.

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6. REFERENCES

Aylward, G. P. (2002). Cognitive and neuropsychological outcomes: More than IQ scores. *Mental Retardation and Developmental Disabilities Research Reviews*, *8*(4), 234–240. https://doi.org/10.1002/mrdd.10043

Aylward, G. P. (2005). Neurodevelopmental outcomes of infants born prematurely. *Journal of Developmental and Behavioral Pediatrics : JDBP*, *26*(6), 427–440. https://doi.org/10.1097/00004703-200512000-00008

Bermudez, O. G., Cruz-Quintana, F., Sosa, M. Á., Mañas, M., Cruz, J. de la, & Pérez-García, M. (2012). Alteraciones Neuropsicológicas y Emocionales en Niños Prematuros de muy Bajo Peso al Nacer. *Revista Argentina de Ciencias Del Comportamiento*. Retrieved from http://revistas.unc.edu.ar/index.php/racc/article/view/5169

Braddick, O., & Atkinson, J. (2011). Development of human visual function. *Vision Research*, *51*(13), 1588–609. https://doi.org/10.1016/j.visres.2011.02.018

Briscoe, J., Gathercole, S. E., & Marlow, N. (2001). Everyday memory and cognitive ability in children born very prematurely. *Journal of Child Psychology and Psychiatry, and Allied Disciplines*, *42*(6), 749–754. https://doi.org/10.1111/1469-7610.00771

Burnett, A. C., Scratch, S. E., Lee, K. J., Cheong, J., Searle, K., Hutchinson, E., … Anderson, P. J. (2015). Executive Function in Adolescents Born. *Pediatrics*, *135*(4).

Caravale, B., Tozzi, C., Albino, G., & Vicari, S. (2005). Cognitive development in low risk preterm infants at 3-4 years of life. *Archives of Disease in Childhood. Fetal and Neonatal Edition*, *90*(6), F474–F479. https://doi.org/10.1136/adc.2004.070284

Chen, P. S., Jeng, S. F., Tsou, K. S. I., Wang, A. H., Hsu, C. H. J., Lu, L., … Taipei Long-Term Developmental Follow-Up Group for Preterm, I. (2004). Developmental function of very-low-birth-weight infants and full-term infants in early childhood. *Journal of the Formosan Medical Association*, *103*(1), 23–31. Retrieved from http://ovidsp.ovid.com/ovidweb.cgi?T=JS&CSC=Y&NEWS=N&PAGE=fulltext&D=med5&AN=15026854%5Cnhttp://202.120.227.56:3210/sfxlcl3?sid=OVID:medline&id=pmid:15026854&id=doi:&issn=0929-6646&isbn=&volume=103&issue=1&spage=23&pages=23-31&date=2004&title=Journal+of+the

Dorling, J. S., Field, D. J., & Manktelow, B. (2005). Neonatal disease severity scoring systems. *Archives of*

Disease in Childhood. Fetal and Neonatal Edition, *90*(1), F11-6. https://doi.org/10.1136/adc.2003.048488

Dunn, Ll. M. (1986). *Test de vocabulario en imágenes Peabody (TVIP)*. (S. Pereda Marin, Trans.). Madrid: Mempsa.

Fernández-Carrocera, L. A., Guevara-Fuentes, C. A., & Salinas-Ramírez, V. (2011). Factores de riesgo asociados a mortalidad en neonatos menores de 1500 g utilizando la escala CRIB II. *Boletín Médico Del Hospital Infantil de México*, *68*(5), 356–362. Retrieved from http://www.scielo.org.mx/scielo.php?script=sci_arttext&pid=S1665-11462011000500004&lng=es&nrm=iso&tlng=es

Glass, H. C., Costarino, A. T., Stayer, S. A., Brett, C. M., Cladis, F., & Davis, P. J. (2015). Outcomes for Extremely Premature Infants. *Anesthesia & Analgesia*, *120*(6), 1337–1351. https://doi.org/10.1213/ANE.0000000000000705

Instituto Nacional de Estadistica. (2013). Retrieved from http://www.ine.es/welcome.shtml

Kaufman, A. S., & Kaufman, N. L. (1997). *K-ABC. Batería de Evaluación de Kaufman para Niños*. (E. Conde & N. Seisdedos, Trans.). Madrid: TEA Ediciones.

Marlow, N., Wolke, D., Bracewell, M. A., & Samara, M. (2005). Neurologic and Developmental Disability at Six Years of Age after Extremely Preterm Birth. *The New England Journal of Medicine*, *352*(1), 9–19. https://doi.org/10.1056/NEJMoa041367

McCarthy, D. (1996). *Escalas McCarthy de Aptitudes y Psicomotricidad para niños* (5th ed.). Madrid: TEA Ediciones.

Merchán Price, M. S., & Henao, J. (2011). Influencia de la percepción visual en el aprendizaje. *Ciencia Y Tecnología Para La Salud Visual Y Ocular, ISSN 1692-8415, ISSN-E 2389-8801, Nº. 1, 2011, Págs. 93-101*, (1), 93–101.

Mikkola, K., Ritari, N., Tommiska, V., Salokorpi, T., Lehtonen, L., Tammela, O., … Fellman, V. (2005). Neurodevelopmental outcome at 5 years of age of a national cohort of extremely low birth weight infants who were born in 1996-1997. *Pediatrics*, *116*(6), 1391–400. https://doi.org/10.1542/peds.2005-0171

Mulder, H., Pitchford, N. J., Hagger, M. S., & Marlow, N. (2009). Development of Executive Function and Attention in Preterm Children: A Systematic Review. *Developmental Neuropsychology*, *34*(4), 393–

421. https://doi.org/10.1080/87565640902964524

Narberhaus, A., Pueyo-Benito, R., Segarra-Castells, M. D., Perapoch-Lopez, J., Botet-Mussons, F., & Junque, C. (2007). Disfunciones cognitivas a largo plazo relacionadas con la prematuridad. *Rev Neurol*, *45*(4), 224–228. https://doi.org/rn2007128 [pii]

Olsén, P., Vainionpää, L., Pääkkö, E., Korkman, M., Pyhtinen, J., & Järvelin, M. R. (1998). Psychological findings in preterm children related to neurologic status and magnetic resonance imaging. *Pediatrics*, *102*(2), 329–336. https://doi.org/10.1542/peds.102.2.329

Pasman, J. W., Rotteveel, J. J., Maassen, B., de Graaf, R., & Kollée, L. A. (1998). Neonatal risk factors and risk scores including auditory evoked responses. *European Journal of Pediatrics*, *157*(3), 230–5. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/9537491

Pérez, E., & Capilla, A. (2008). Neuropsicología infantil. In J. Tirapu, M. Ríos, & F. Maestú (Eds.), *Manual de Neuropsicología*. Barcelona: Viguera.

Pérez López, J., García Martínez, M., Sánchez Caravaca, J., García-Martínez, M. de la P., & Sánchez-Caravaca, J. (2009). RIESGO PERINATAL Y DESARROLLO PSICOLÓGICO EN UN GRUPO DE NIÑOS PREMATUROS. *International Journal of Developmental and Educational Psychology*, *1*(1), 657–666. Retrieved from http://infad.eu/RevistaINFAD/2009/n1/volumen1/INFAD_010121_657-666.pdf

Portellano, J. A., Mateos, R., Martínez Arias, M., Granados, M. J., & Tapia, A. (2000). *Cuestionario de Madurez Neuropsicológica Infantil*. Madrid: TEA Ediciones.

Reitan, R. M., & Wolfson, D. (1985). *The Halstead–Reitan Neuropsycholgical Test Battery: Therapy and clinical interpretation*. Tucson, AZ: Neuropsychological Press.

Rellan Rodríguez, S., García de Ribera, C., & Aragón Garcia, M. (2008). El recién nacido prematuro. In Asociación Española de Pediatría & Sociedad Española de Neonatología (Eds.), *Protocolos de Neonatología* (pp. 66–77). Retrieved from http://www.aeped.es/sites/default/files/documentos/8_1.pdf

Rey, A. (1997). *Test de copia de una figura compleja*. (M. V. Cruz, N. Seisdedos, & A. Cordero, Trans.) (6th ed.). Madrid: TEA Ediciones.

Roldán-Tapia, M. D., Ramos-Lizana, J., Sánchez-Joya, M. del M., Cánovas, R., & Bembibre-Serrano, J. (2013). The Relation between Low Birth Weight in Preterm Children and Their Attentional Abilities. *International Journal of Advances in Psychology*, *2*(1).

Rose, S. a., Jankowski, J. J., Feldman, J. F., & Van Rossem, R. (2005). Pathways from prematurity and infant abilities to later cognition. *Child Development*, *76*(6), 1172–1184. https://doi.org/10.1111/j.1467-8624.2005.00843.x

Sans, A., Boix, C., López-Sala, A., Póo, P., Abenia, P., Maristany, M., & Campistol, J. (2002). [Visuo-constructive disorders in periventricular leukomalacia]. *Revista de Neurologia*, *34 Suppl 1*, S34-7. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/12447787

Scheiner, A. P., & Sexton, M. E. (1991). Prediction of developmental outcome using a perinatal risk inventory. *Pediatrics*, *88*(88), 1135–1143. Retrieved from http://www.scopus.com/inward/record.url?eid=2-s2.0-0025718949&partnerID=tZOtx3y1

Spittle, A. J., Thompson, D. K., Brown, N. C., Treyvaud, K., Cheong, J. L. Y., Lee, K. J., … Anderson, P. J. (2014). Neurobehaviour between birth and 40 weeks' gestation in infants born. *BMC Pediatrics*, *14*, 111. https://doi.org/10.1186/1471-2431-14-111

statstutor. (n.d.). Spearman's correlation. Retrieved from http://www.statstutor.ac.uk/resources/uploaded/spearmans.pdf

Strub, R. L., & Black, F. W. (1985). *The Mental Status Examination in Neurology* (2nd ed.). Philadelphia: F.A. Davis.

Torres Valdivieso, M., Gómez, E., Medina, M., & Pallás, C. (2008). Programas de seguimiento para neonatos de alto riesgo. In Asociación Española de Pediatría & Sociedad Española de Neonatología (Eds.), *Protocolos de Neonatología* (pp. 278–284). Retrieved from http://www.aeped.es/sites/default/files/documentos/29.pdf

Wechsler, D. (2005). *Escala de inteligencia de Wechsler para niños- IV*. Madrid: TEA Ediciones.

Zaramella, P., Freato, F., Milan, A., Grisafi, D., Vianello, A., & Chiandetti, L. (2008). Comparison between the perinatal risk inventory and the nursery neurobiological risk score for predicting development in high-risk newborn infants. *Early Human Development*, *84*(5), 311–7. https://doi.org/10.1016/j.earlhumdev.2007.08.003

Table 1. Sociodemographic characteristics of the PG (n=27) and TG (n=27)

Participant characteristics		PG (n=27)		TG (n=27)	
		n (%)	Average±SD	n (%)	Average±SD
Sex	Male	17 (62.96)		17 (62.96)	
	Female	10 (37.04)		10 (37.04)	
Age (months)	4 years	17 (62.96)	62±7.02	17 (62.96)	61.63±6.39
	5 years	10 (37.04)		10 (37.04)	
Weight (g)	≤1500 g	20 (74.07)	1,330±330	0 (0.00)	3,007±571
	1501 g-2500 g	7 (25.93)		1 (3.70)	
	>2500 g	0 (0.00)		26 (96.30)	
Very mild sensorimotor deficits and cerebral palsy (%)		3 (11.11)		0 (0.00)	
Gestational Week	≤28 weeks	8 (29.63)	29.37±2.27	0 (0.00)	39.22±2.01
	29-31 weeks	19 (70.37)		0 (0.00)	
	≥37 weeks	0 (0.00)		27 (100.00)	
Education level (Pre-school education course)	1st cycle	2 (7.41)	2.49±0.61	2 (7.41)	2.54±0.50
	2nd cycle	15 (55.56)		14 (51.85)	
	3rd cycle	10 (37.04)		11 (40.74)	
Paternal education level (Years of study)			12.26±3.53		13.26±4.00
Maternal education level (Years of study)			12.23±3.49		13.83±4.40

Table 2. Average neuropsychological test scores grouped by cognitive domains for the PG (n=27) and TG (n=27) and the between-group mean comparisons

	Test	Average (SD) PG	Average (SD) TG	*p*	Test	Average (SD) PG	Average (SD) TG	*p*
EXECUTIVE FUNCTION	Arithmetic (K-ABC)	99.25±13.83	108.31±9.70	0.002*	Child drawing (MSCA)	9.57±4.22	11.68±3.47	0.025*
	Riddles (K-ABC)	104.8±15.86	114.48±10.58	0.004*	Opposites (MSCA)	9.25±2.95	10.65±3.17	0.600
	Analogous matrices (K-ABC)	9.9±4.06	11.45±1.93	0.135	Fluency (MSCA)	13.85±4.57	16.57±4.61	0.016*
LANGUAGE	Faces and places (K-ABC)	97.14±13.11	104.57±13.92	0.025*	Peabody picture vocabulary test	5.89± 1.56	6.91± 1.43	0.006*
	Expressive vocabulary (K-ABC)	89.8±20.18	104.2±20.65	0.064				
VISUAL-PERCEPTIVE ABILITY	Magic window (K-ABC)	10.33±3.37	12.33±2.09	0.061	Rey figure copying, number of primary elements.	48.97±36.22	75.4±27.33	0.001*
	Gestalt closure (K-ABC)	9.42±3.19	11.22±2.37	0.009*	Rey figure copying, number of secondary elements	40.77±29.3	66.94±26.42	<0.001*
	Triangles (K-ABC)	10.45±3.03	13.31±3.65	0.001*	Rey figure copying quality	49.05±34.18	70.37±30.06	0.007*
	Spatial structuring (CUMANIN)	64.85±30.90	78.05±26.66	0.060	Rey figure copying, overlap	2.77±2.38	4.22±2.05	0.008*
	Visual-perception (CUMANIN)	53.48±29.62	74.68±20.73	0.001*				

	Test	Average (SD) PG	Average (SD) TG	*p*	Test	Average (SD) PG	Average (SD) TG	*p*
LEARNING AND MEMORY	Facial recognition (K-ABC)	10.4±1.91	12.4±2.32	0.016*	Rey figure, number of secondary elements. 5’	37.85±26.35	63.34±26.77	<0.001*
	Hand movements (K-ABC)	9.91±3.72	12.68±2.39	0.000*	Rey figure, quality. 5’	44.48±32.97	64.54± 28.19	0.008*
	Number repetition (K-ABC)	9.71±2.76	12.05±2.93	0.001*	Rey figure, overlap. 5’	2.11±1.92	3.28±2.03	0.016*
	Word order (K-ABC)	9.02±3.18	10.51±2.70	0.039*	Rey figure, number of primary elements. 15’	44.14±27.29	65.65±26.42	0.001*
	Spatial memory (K-ABC)	8.75±2.48	10.55±2.85	0.040*	Rey figure, number of secondary elements. 15’	37.57±26.07	61.37±25.96	<0.001*
	Backward digits (Wechsler Intelligence Scale for Children)	2.00±0.56	2.70±0.80	0.004*	Rey figure quality. 15’	45.65±31.94	59.82±27.15	0.050*
	Rey figure, number of primary elements 5’	41.02±27.89	66.28±26.19	0.000*	Rey figure, overlap. 15’	2.28±2.02	3.28±1.70	0.029*
ATTENTION	Cancellation Test “A”	0.51±0.50	0.91±0.28	0.010*	Trails colours A	0.65±0.48	1±0.00	<0.001*
	Attention (CUMANIN)	29.31±22.12	26,00±20.24	0.515	Trails colours B	0.37±0.49	0.68±0.47	0.017*

*p<0.05; PG: premature group; TG: term group; MSCA: McCarthy Scales of Children’s Abilities; K-ABC: Kaufman Assessment Battery for Children; CUMANIN: Child Neuropsychological Maturity Questionnaire.