Effect of prematurity and low birth weight in visual abilities and school performance

T. Perez-Roche [a,b], I. Altemir [a,b], G. Giménez [a,b], E. Prieto [a,b], I. González [a,b], J.L. Peña-Segura [c], O. Castillo [a,b], V. Pueyo [a,b,d],*

[a] Instituto de Investigación Sanitaria de Aragón (IIS Aragón), Zaragoza, Spain
[b] Ophthalmology Department, Paediatric Ophthalmology Unit, Hospital Universitario Miguel Servet, Zaragoza, Spain
[c] Child Neurology Unit, Hospital Universitario Miguel Servet, Zaragoza, Spain
[d] Red de Salud Materno Infantil y Desarrollo – SAMID, Spain

ABSTRACT

Background: Prematurity and low birth weight are known risk factors for cognitive and developmental impairments, and school failure. Visual perceptual and visual motor skills seem to be among the most affected cognitive domains in these children.
Aims: To assess the influence of prematurity and low birth weight in visual cognitive skills and school performance.
Methods: We performed a prospective cohort study, which included 80 boys and girls in an age range from 5 to 13. Subjects were grouped by gestational age at birth (preterm, <37 weeks; term, 37–42 weeks) and birth weight (small for gestational age (SGA), <10th centile; appropriate weight for gestational age (AGA), ≥10th centile). Each child underwent full ophthalmologic assessment and standardized testing of visual cognitive abilities (Test of Visual Perceptual Skills and Test of Visual Analysis Skills). Parents completed a questionnaire on school performance in children.
Results: Figure-ground skill and visual motor integration were significantly decreased in the preterm birth group, compared with term control subjects (figure-ground: 45.7 vs 66.5, p = 0.012; visual motor integration, TVAS: (9.9 vs 11.8, p = 0.018), while outcomes of visual memory (29.0 vs 47.7, p = 0.012), form constancy (33.3 vs 52.8, p = 0.019), figure-ground (37.4 vs 65.6, p = 0.001), and visual closure (43.7 vs 62.6 p = 0.016) testing were lower in the SGA (vs AGA) group. Visual cognitive difficulties corresponded with worse performance in mathematics (r = 0.414, p = 0.004) and reading (r = 0.343, p = 0.018).
Conclusion: Specific patterns of visual perceptual and visual motor deficits are displayed by children born preterm or SGA, which hinder mathematics and reading performance.

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What this paper adds?

This study reports specific patterns of impairment in visual perceptual and visual motor skills in preterm and small for gestational age children at school age. While preterm infants exhibit dorsal stream involvement (affecting figure-ground and visual motor skills), low birth weight results in a more diffuse damage (with decreased visual memory, form constancy, figure-ground, visual closure and visual motor outcomes).

Impaired visual cognitive skills are associated with poor school performance in mathematics and reading.

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* Corresponding author at: Hospital Universitario Miguel Servet, Ophthalmology Department, Pso. Isabel la Católica 3, 50009, Zaragoza, Spain.
E-mail address: vpueyo@unizar.es (V. Pueyo).

1. Introduction

Prematurity and low birth weight are known risk factors for suboptimal neurodevelopment, especially with respect to cognitive and executive skills (Tolsa et al., 2004). Since both entities are associated in many infants their mid and long-term consequences are difficult to separate from each other.

Recent evidence suggests that, not only early preterm infants but also moderately and late preterm babies are at increased risk of neurologic impairments, developmental disabilities, school failure, and behavior and psychiatric problems (Vohr, 2013). Fetal growth restriction is a failure to achieve the endorsed growth potential due to placental insufficiency (Figueras & Gratacós, 2014). Among preterm infants, low birth weight is one of the main adverse conditions for neurobehavioral and neurocognitive outcomes (McCarton, Wallace, Divon, & Vaughan, 1996). However, also full-term babies with growth restriction have recently been reported to have lower neurodevelopment scores compared to normal-sized infants (Levine et al., 2015).

Heightened survival rates have underscored the minor deficiencies that subsequently emerge throughout early childhood and during school-age years, especially neurosensory deficits. A global approach must therefore take into account the impact of prematurity and low birth weight not only on perinatal and early childhood outcomes but also on daily lives of children and their academic achievements.

Higher visual functions include visual perception (elaboration of sensory information for recognition) and visual motor integration (controlled acts such as reaching, grasping, or general locomotion). In terms of perceptual skills, basic abilities (visual discrimination or visual memory) and complex abilities (visual closure and figure-ground distinction) are usually distinguished. Complex skills require greater degrees of visual integration and are acquired later in neurodevelopment. Injury to areas of the brain responsible for visual cognitive integration may be severely disabling, especially if experienced during the perinatal period when vulnerability is greatest.

Visual cognitive skills in preterm infants have been studied extensively (Geldof, van Wassenaer, de Kieviet, Kok, & Oosterlaan, 2011; Ortibus, De Cock, & Lagae, 2011), and so have long-term outcomes of schooling in progress (Bhutta, Cleves, Casey, Cradock, & Anand, 2002; Breslau, Johnson, & Lucia, 2001). However, few studies have addressed the influence of visual abilities on academic performance, considering prematurity and birth weight centile as different factors.

This paper attempts to correlate the degree of visual perceptual and visual motor skills with school performance throughout childhood, and to identify specific patterns of visual cognitive deficits related to preterm birth or low birth weight.

2. Material and methods

2.1. Participants

A cohort of children was monitored from birth until school age. The group was composed by children from 5 to 13 years, all of them collected in the Paediatric Ophthalmology Unit of the Universitary Hospital Miguel Servet. The cases were patients from clinics and the controls were siblings or friends of them. Study participants were stratified by gestational age at birth and by birth weight. Prematurity was considered as gestational age at birth lower than 37 week. Infants with a birth weight <10th centile according to local standards (Figueras et al., 2008) were considered as small for gestational age (SGA), while those with a birth weight ≥10th centile were appropriate for gestational age (AGA). A control group of full-term infants was selected through matching with the preterm subjects by age and gender.

Congenital malformations, cerebral palsy, significant refractive errors (spherical equivalent refraction >6 diopters), or eye movement disorders (nystagmus, strabismus) were grounds for exclusion.

2.2. Assessment battery

All participants were evaluated according to protocol, including clinical history, full ophthalmologic examination (visual acuity, stereoacuity, ocular health, refraction and funduscopy), and standardized tests of visual cognitive abilities (Test of Visual Perceptual Skills [TVPS-3] and Test of Visual Analysis Skills [TVAS]). Examiners blinded to the study group and perinatal outcomes performed all evaluations.

The TVPS-3 is a motor-free visual perceptual test gauging seven specific abilities, each via corresponding subtest (Martin, 2006) as follows: 1) visual discrimination, selecting a figure identical to a reference figure; 2) visual memory, memorizing a figure briefly for later recall; 3) spatial relationships, indicating a match among variably oriented identical figures; 4) form constancy, selecting a figure of same shape as reference figure but differing in size or spatial orientation; 5) sequential memory, recalling an escalating series of figures in order; 6) figure-ground perception, finding a figure within a complex background; and 7) visual closure, figure recognition despite incompleteness of view. Each subtest from the TVPS-3 includes 16 black and white plates presented in order of difficulty, starting with visual discrimination and terminating with visual closure. The test provides age-equivalent centiles for subtest and overall scores.

Subjects also completed the TVAS, which assesses visual motor integration through reproduction of increasingly difficult geometric shapes (Rosner & Fern, 1983).