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Deficits in vision and visual attention associated with motor performance of very preterm/very low birth weight children

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ABSTRACT

Aim: To extend understanding of impaired motor functioning of very preterm (VP)/very low birth weight (VLBW) children by investigating its relationship with visual attention, visual and visual-motor functioning.

Methods: Motor functioning (Movement Assessment Battery for Children, MABC-2; Manual Dexterity, Aiming & Catching, and Balance component), as well as visual attention (attention network and visual search tests), vision (oculomotor, visual sensory and perceptive functioning), visual-motor integration (Beery Visual Motor Integration), and neurological status (Touwen examination) were comprehensively assessed in a sample of 106 5.5-year-old VP/VLBW children. Stepwise linear regression analyses were conducted to investigate multivariate associations between deficits in visual attention, oculomotor, visual sensory, perceptive and visual-motor integration functioning, abnormal neurological status, neonatal risk factors, and MABC-2 scores.

Results: Abnormal MABC-2 Total or component scores occurred in 23–36% of VP/VLBW children. Visual and visual-motor functioning accounted for 9–11% of variance in MABC-2 Total, Manual Dexterity and Balance scores. Visual perceptive deficits only were associated with Aiming & Catching. Abnormal neurological status accounted for an additional 19–30% of variance in MABC-2 Total, Manual Dexterity and Balance scores, and 5% of variance in Aiming & Catching, and neonatal risk factors for 3–6% of variance in MABC-2 Total, Manual Dexterity and Balance scores.

Conclusion: Motor functioning is weakly associated with visual and visual-motor integration deficits and moderately associated with abnormal neurological status, indicating that motor performance reflects long term vulnerability following very preterm birth, and that visual deficits are of minor importance in understanding motor functioning of VP/VLBW children.

Abbreviations: ANT, Attention Network Test; BW, birth weight; CP, cerebral palsy; GA, gestational age; GMFCS, Gross Motor Function Classification System; MABC-2, Movement Assessment Battery for Children 2nd edition; VLBW, very low birth weight; VP, very preterm; VMI, visual-motor integration..

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1. Introduction

Poor motor skills are among the most prominent adverse developmental outcomes following very preterm birth (VP; <32 weeks gestation) or very low birth weight (VLBW; birth weight <1500 g; de Kieviet, Piek, Aarnoudse-Moens, & Oosterlaan, 2009). Motor problems vary from clumsiness to disabling cerebral palsy (Edwards et al., 2011) and negatively impact participation in daily activities, sports, and social adjustment (Dewey, Kaplan, Crawford, & Wilson, 2002). Therefore, extending current insights into factors underlying motor problems may aid the development of interventions.

Early development of motor skills relies on attention and visual information processing (Braddick & Atkinson, 2013). The onset of selective visual attention, stereoscopic vision and visual-spatial perception elicit the first reaching and grasping attempts, thereby enabling visual-motor action in infants (Braddick & Atkinson, 2013), and continue serving motor control from childhood to adulthood (Kravitz, Saleem, Baker, & Mishkin, 2011). VP/VLBW children are frequently affected by deficits in visual sensory, visual perceptive, as well as visual-motor integration functioning (Cooke, Foulder-Hughes, Newsham, & Clarke, 2004; Evensen et al., 2009; Geldof, van Wassenaer, de Kieviet, Kok, & Oosterlaan, 2012; Haugen, Nepstad, Standal, Elgen, & Markestad, 2012). These deficits may critically undermine motor functioning. Studies have identified associations between a range of visual sensory deficits and impaired manual dexterity (Evensen et al., 2009; Haugen et al., 2012). Furthermore, abnormalities of occipital-parietal-prefrontal networks (i.e. the dorsal visual stream) that serve visual-spatial analyses and visual-motor planning (Kravitz et al., 2011) are found in VP/VLBW children and may underpin the relationship between visual deficits and motor problems (Braddick, Atkinson, & Wattam-Bell, 2003). A recent study reported that motor dysfunctions in very preterm children were mediated by minor neurological dysfunction (Van Hus, Potharst, Jeukens-Visser, Kok, & Van Wassenaer-Leemhuis, 2014), suggesting that motor dysfunctions stem from perinatally acquired brain damage (Hadders-Algra, 2002). However, since Van Hus et al. (2014) did not include measures of visual and visual attention functioning, it remains unknown whether visual and visual attention deficits impact on motor performance over and above minor neurological dysfunctions.

The current study aimed to investigate whether deficits in visual attention, vision and visual-motor integration account for motor skills of VP/VLBW children over and above abnormal neurological status by (1) establishing motor abilities in a sample of VP/VLBW children, (2) establishing deficits in a range of visual attention, oculomotor, visual sensory, visual perceptive and visual-motor integration abilities, as well as neurological status, (3) explore the associations between deficits in visual attention, vision and visual-motor functioning, and motor performance, and (4) explore the additional predictive value of neurological status and neonatal risk factors on motor functioning.

2. Methods

2.1. Participants

A sample of 106 VP/VLBW children, born at gestational age (GA) <32 weeks and/or with birth weight (BW) <1500 g participated in this study. All children originally participated in a multicenter randomized controlled trial comparing a home-based intervention and care as usual (Koldewijn et al., 2009). Exclusion criteria at study entry were severe congenital abnormalities, severe maternal physical or mental illness/problems, not mastering the Dutch language and unavailability of an interpreter, and participation in other trials on post discharge management. At 5.5 years corrected age, 160 of 176 children participating in the trial were available for follow-up, of whom 136 (77%) agreed to participate (24 declined participation or were untraceable) and 106 successfully completed all assessments. Incomplete assessments were due to developmental delay or behavioral problems that crucially interfered with task execution ($n = 9$), declined participation in the second assessment day ($n = 3$), time constraints ($n = 12$), and technical problems ($n = 6$). Participating ($n = 106$) and non-participating children ($n = 70$) of the initial trial did not differ in terms of clinical and demographic characteristics at discharge (p-values >0.05), except that non-participating children more often lived in single parent households (9% and 21%, respectively, $p = 0.01$) and families speaking a non-Dutch primary language (10% and 31%, respectively, $p = 0.01$).

Perinatal and socio-demographic characteristics are depicted in Table 1. Perinatal characteristics were taken from the medical records at discharge. Socio-demographic data were obtained by parent questionnaire at the 5.5-year assessment. The measure of parental education was derived from the number of years post elementary education of both parents and classified as high (either parent >8 years), middle (both parents 6–8 years) or low (either parent <6 years; Potharst et al., 2011).

2.2. Measures

2.2.1. Motor assessment

Motor skills were evaluated using the Movement Assessment Battery for Children 2nd edition (MABC-2; Henderson, Sugden, Barnett, & Smits-Engelsman, 2007), encompassing three components measuring different aspects of motor functioning: Manual Dexterity, Aiming & Catching, and Balance. For each of the components and for the total test (sum of three component scores), the sums of points are transformed into age-adjusted standard scores with a mean (SD) of 10 (3), with higher scores indicating better performance. Standard scores ≤−1 SD of the normative mean are considered indicative of motor impairment (Geuze, Jongmans, Schoemaker, & Smits-Engelsman, 2001).