



Very low birth weight is associated with brain structure abnormalities and cognitive function impairments: A systematic review



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ABSTRACT

Very low birth weight (VLBW) children are at risk of structural brain abnormalities and neurocognitive deficits. Since survival rate of the very low birth weight infants has increased over the past decade, a better understanding of the long-term neurocognitive outcomes is needed. The present systematic review investigated the association between VLBW and cognitive function as well as brain structure. PubMed/Medline, Google Scholar, Scopus and Web of Science databases were searched up from January 2000 to January 2015. The study was restricted to the articles that were about VLBW and its association with cognitive function and brain structure. The initial search yielded 721 articles. There were 44 studies eligible for inclusion after applying the exclusion criteria: 24 follow-up, 14 cohort, and 6 longitudinal studies. Based on this systematic review, we suggest that VLBW is positively related to several cognitive problems and brain structure abnormalities. These findings provide evidence about the importance of early assessment of cognitive development and brain structure to identify at-risk children and provide their specific requirements as early as possible.

1. Introduction

Recent advances in the neonatal medicine have increased the rate of the survival of very low birth weight (< 1500 g) infants (De Amorim, De Castro Magalhães, Malloy-Diniz, & Campos, 2013; Henriksen et al., 2008; Rose et al., 2014). The overall number of infants born with VLBW is increasing in the United States, 1.28% in 1989 to 1.42% in 2015, as a result of better access to developed neonatal care (Martin, Hamilton, Osterman, Curtin, & Matthews, 2015). Further, low birth weight imposes enormous economic costs including medical and social services, special education, and decreased productivity in adulthood (Petrou, Sach, & Davidson, 2001; Tongo, Orimadegun, Ajayi, & Akinyinka, 2009).

Recently, several studies have focused on the long-term developmental outcomes of VLBW children (Allin et al., 2006; Hack et al., 2002; Mu et al., 2008; Skranes et al., 2007, 2013; Volpe, 2009; Weindrich, Laucht, & Schmidt, 2003). Studies have reported that VLBW children are at risk of structural brain abnormalities, neurocognitive deficits, and neuropsychological impairments and most of these deficits

persist into adulthood (Allin et al., 2006; Hack et al., 2002; Spittle et al., 2011; Williams, Lee, & Anderson, 2010). These children often have learning difficulties and poor school performance (Chaudhari, Otv, Chitale, Pandit, & Hoge, 2004; Mu et al., 2008), even in those with normal intelligence and without any neurological impairments (Hack et al., 2002). Moreover, children born very preterm or VLBW are prone to perinatal brain injury and have an increased risk of developing motor and cognitive impairments during childhood and adolescence (Litt, Taylor, Klein, & Hack, 2005; Løhaugen et al., 2010; Mu et al., 2008; Skranes et al., 2007, 2013; Volpe, 2009; Williamson, Jakobson, Saunders, & Troje, 2015). A number of macro-structural differences in the brain of preterm and VLBW born infants compared with the normal controls have been demonstrated previously (Nagy et al., 2003; Woodward, Edgin, Thompson, & Inder, 2005).

Cognitive development is a complex process affected by many factors including genetic and environmental factors and socioeconomic status (SES) of the family (Santos et al., 2008; Smith, Durkin, Hinton, Bellinger, & Kuhn, 2003). Several postnatal factors can have a direct favorable or destructive effect on neurodevelopment outcomes and

Abbreviations: VLBW, very low birth weight; EP, extremely preterm; ELBW, extremely low birth weight; NBW, normal birth weight; IQ, intelligence quotient; PIQ, performance IQ; VIQ, verbal IQ; FSIQ, full-scale IQ; WISC, Wechsler Intelligence Scale for Children; FA, fractional anisotropy; WM, white matter; GM, gray matter; SES, socioeconomic status

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control of these factors is complex and difficult (Kilbride, Thorstad, & Daily, 2004; McCormick, 1997).

To date, only a few studies have investigated long-term impacts of VLBW birth on cognitive performance and brain structure. In addition, there are many inconsistencies among the results possibly due to different applied methods and study designs, or small numbers of participants. It is also necessary to systematically review the reliability of findings within the literature. Since early detection of this at risk group may prevent neurodevelopmental problems, this review aimed to identify current gaps in knowledge and provide a comprehensive overview of the association of VLBW with brain structure, as well as cognitive function.

2. Method

2.1. Research strategy and data source

A systematic search of the articles was designed and conducted in 2015. Required information was obtained from PubMed, Google Scholar, Scopus, and Web of Science databases. We also used specific medical subject headings (MeSH) and keywords.

Search terms were “VLBW” (medical subject headings [MeSH]), cognition [key word], cognitive function [MeSH], brain volume [MeSH], brain structure [key word], connected by AND/OR search operator. The titles of potentially relevant references were reviewed.

The titles and abstracts of the all studies retrieved from the electronic database were screened by two independent reviewers to determine eligible studies. Then full texts of the remaining studies were retrieved and relevant articles were identified. We excluded duplicates and articles with weak relevance to our objectives from subsequent searches. In addition to the electronic search, reference lists of the identified articles were searched for additional applicable studies [Fig. 1].

2.2. Inclusion criteria

Inclusion criteria of our study were: original research articles published in English in the last 15 years (January 2000 to January 2015) that established an association between VLBW and cognition or brain structure, and used cohort, longitudinal and follow-up methods. The dependent variables in this review were cognition and brain volume and/or structure, and the independent variable was VLBW.

2.3. Exclusion criteria

Studies were excluded if they met the following criteria; (i) animal study, (ii) no data on the association between birth weight and cognition, (iii) review articles, thesis, books, (iv) presence of neurologic impairments (Cerebral Palsy, deafness/hearing loss, blindness, dyspraxia and epilepsy), (v) no matched control, and (vi) no full text available.

3. Results

This review assessed the results of 44 studies which had investigated the association between VLBW and cognition, as well as brain structure/volume. The study selection process is described in Fig. 1. In the initial step, 721 articles were found. Of these, 312 articles were excluded based on the title. Then remaining 409 records were assessed based on the title and abstract. After precise extraction of required data from these studies, 43 studies met the eligibility criteria and full texts of these articles were retrieved for further assessments. The searches in the reference lists of the included articles yielded one more article. The main study design of these 44 researches was follow-up (n = 24), however 14 cohort and 6 longitudinal studies were also included. Characteristics of the included studies such as the methodology used, age at assessment, sample size and country are described in Table 1. Studies were conducted in 14 countries: Norway (n = 15), Australia

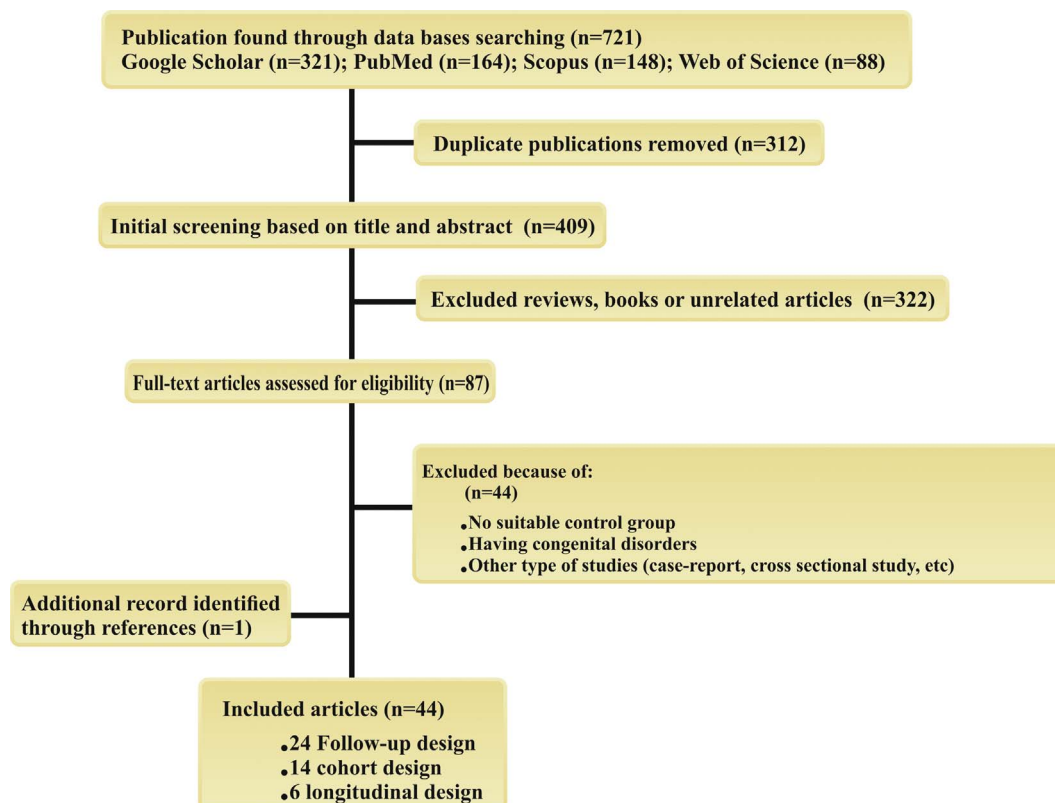


Fig. 1. Search strategy to find original studies assessing the association of VLBW and brain structure and cognitive function.

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