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Predictive value of the Bayley Scales of Infant Development on development of very preterm/very low birth weight children: A meta-analysis

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ABSTRACT

Background and aims: The Bayley Scales of Infant Development (BSID) is the most widely used measure to assess neurodevelopment of very preterm (gestational age ≤32 weeks) and very low birth weight (VLBW, ≤1500 g) infants in the first three years of life. This meta-analysis determines the predictive value of the Mental Developmental Index (MDI) and the Psychomotor Developmental Index (PDI)/Motor Composite, collectively referred to as Bayley motor scale, of the BSID-I, -II and Bayley-III for later cognitive and motor functioning in very preterm/VLBW children.

Methods: Cochrane Library, PubMed, PsychINFO and CINAHL were searched for English-language peer-reviewed studies published before March 2013. Studies were included if they reported odds ratios or correlations between the MDI or Bayley motor scale scores obtained in the first three years of life, and standardized cognitive or motor assessment obtained later in life in very preterm/VLBW children. Meta-analytic methods were applied to aggregate available data.

Results: A total of 16 studies met inclusion criteria. Across 14 studies (n = 1330 children), MDI scores were strongly predictive for later cognitive functioning, $r = 0.61$ (95%CI: 0.57–0.64), explained variance 37%, $p < .001$. The relationship between MDI scores and later cognitive function was not mediated by birth weight ($p = .56$), gestational age ($p = .70$), and time interval between assessments ($p = .55$). Across five studies (n = 555 children), Bayley motor scale scores were moderately predictive for later motor function, $r = 0.34$ (95%CI: 0.26–0.42), explained variance 12%, $p < .001$.

Conclusions: In very preterm/VLBW children, MDI scores explain 37% of the variance in later cognitive functioning, whereas Bayley motor scale scores explain 12% of later motor function. Thus a large proportion of the variance remains unexplained, underlining the importance of enhancing prediction of developmental delay in very preterm children.

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1. Introduction

Advances in perinatal care have improved survival rates of very preterm (≤32 weeks gestation) and very low birth weight (VLBW ≤1500 g) infants. Very preterm birth and VLBW birth accounts for approximately 1–2% of all live births in Europe and the United States [1,2]. For a substantial group of very preterm/VLBW children widespread impairment in cognitive, motor and language functioning is reported [3–5]. These adverse outcomes persist throughout childhood and adolescence, stressing the importance of early screening to predict adverse development and enable referral to early interventions [6].

The Bayley Scales of Infant Development [7–9] (BSID), considered 'the best measure for the assessment of infants' [10], is the most widely used measure to assess developmental progress and is frequently regarded as the end point of follow-up in very preterm/VLBW children [11]. The BSID-I/BSID-II/Bayley-III test the mental and motor capacities of children. However, there is inconsistent evidence on the predictive value of the BSID-I/BSID-II/Bayley-III for long term development in very preterm/VLBW children, with some studies concluding that the BSID-I and -II have adequate predictive abilities for future functioning [12–20] and other studies concluding the opposite [21,22]. Furthermore, it is unclear to what extent factors associated with outcome at BSID assessment and follow-up, including birth weight (BW) [23], gestational age (GA) [3,23], age at assessment [24], interval between assessments [24], date of birth [25,26], gender [23], BSID version [8] and cerebral palsy (CP) [27] affect the predictive value of the BSID for the development of very preterm/VLBW children. As follow-up of very preterm/VLBW children is time-consuming and costly, the conflicting evidence on the predictive abilities of the BSID-I/BSID-II/Bayley-III questions its widespread application in clinical practice.

The aim of this study was to determine the predictive value of the mental and motor scales of the BSID-I/BSID-II/Bayley-III for later functioning of very preterm/VLBW children by aggregating all available evidence using meta-analytic methods. In addition, the role of BW, GA, age at BSID assessment, interval between assessments, date of birth, gender, BSID version, CP, and study quality in the predictive value of the BSID-I/BSID-II/Bayley-III were investigated.

2. Methods

The PRISMA guidelines for reporting meta-analyses published by Moher et al. [28] were used for the design, performance and report of this meta-analysis. The present study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures that we performed involving human subjects were approved by the medical ethical committee of the VU University Medical Center.

2.1. Study selection

The electronic databases Cochrane Library, PubMed, PsychINFO and CINAHL were searched for relevant articles published before March 2013, combining the search terms prematur*, preterm*, low birth weight, ELBW, VLBW, LBW, small for gestational age or SGA and Bayley Scales of Infant Development, BSID* or Bayley*III. Furthermore, we searched using the subject headings (MeSH and equivalents): "infant, premature", "infant, low birth weight", "premature birth" and "childbirth, premature". The following inclusion criteria were used: (1) The study concerned children born very preterm (GA ≤32 weeks) and/or with very low birth weight (BW ≤1500 g). (2) Children were tested using the BSID-I, BSID-II or Bayley-III and again assessed later in life using another standardized test of any aspect of development (i.e. not the BSID) to establish convergent (e.g. MDI and standardized test of cognitive function) and divergent (e.g. MDI and standardized test of motor function) predictive validity. (3) Predictive value of the BSID-I/BSID-II/Bayley-III was reported or calculable in terms of: sensitivity/specificity, positive predictive value/negative predictive value, relative risk/odds ratio, correlational and/or regression coefficients, relating the BSID-I/BSID-II/Bayley-III with the follow-up test. (4) The study was published in an English-language peer-reviewed journal. To maximize the number of available studies, and therefore the power of the meta-analysis, we did not include any restriction on the ages of subjects in the studies. Reference lists of selected articles were manually searched to identify other relevant studies and we contacted authors for additional data if necessary.

A flow diagram of the study identification and selection process is shown in Fig. 1. A total of 16 studies met inclusion criteria. Eight studies investigated the BSID-I [13,15–20,29–32], seven studies investigated the BSID-II [11,12,14,21,22,33,34] and one study investigated the Bayley-III [29]. The final sample for meta-analysis contained a total of 1792 very preterm/VLBW children. Fifteen studies used a prospective design, whereas one study [11] used a retrospective design. Study characteristics are shown in Table 1.

2.2. Bayley Scales of Infant Development

The BSID-I and BSID-II [7,8] comprises two scales including the Mental Developmental Index (MDI) and Psychomotor Developmental Index (PDI). The Bayley-III [9] comprises five scales, including a Cognitive, Language and Motor Composite. As just one [29] included study pertained to the Bayley-III, reporting outcomes for the Motor Composite scale, only the Motor Composite scale of the Bayley-III is discussed. The MDI provides an assessment of memory, problem solving, sensory perception, hand–eye coordination, imitation and early language. The PDI and the Motor Composite measure gross and fine motor skills, and are here referred to as the Bayley motor scale. The BSID-I, -II and Bayley-III differ in scaling, age range, content coverage, stimulus materials, psychometric properties, normative data, and clinical utility. The BSID-I can be assessed between the ages two and 30 months [7], whereas the BSID-II and Bayley-III may be administered to infants ranging between one and 42 months of age [8,9]. Normed scores on the BSID-I/BSID-II/Bayley-III have a mean of 100 and a standard deviation (SD) of 15 (BSID-II, Bayley-III) [8,9] or 16 (BSID-I) [7], with higher scores indicating better development. The psychometric properties of the BSID-I/BSID-II/Bayley-III have been established in typically developing children. Split-half reliability for the BSID-I is $r = 0.88$ for MDI and