



# Consequences of Correcting Intelligence Quotient for Prematurity at Age 5 Years

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**Objectives** To determine the effects of correcting for prematurity on full scale IQ (FSIQ), verbal IQ (VIQ), performance IQ (PIQ), and processing speed quotient (PSQ) scores, and to investigate whether differences between corrected and uncorrected FSIQ are associated with gestational age (GA), FSIQ, and age at assessment.

**Study design** Single-center consecutive cohort study. Data were analyzed from 275 very preterm children (GA <30 weeks), born between January 2006 and December 2009 and assessed at 5 years corrected age as part of the neonatal long-term follow-up program, at the Emma Children's Hospital in Amsterdam, The Netherlands. Outcome measures were FSIQ, VIQ, PIQ, and PSQ, calculated for uncorrected and corrected age. Paired sample *t* tests, repeated measures ANOVA, and ANCOVA were performed to explore differences between corrected and uncorrected IQ.

**Results** Differences between corrected and uncorrected FSIQ, VIQ, PIQ, and PSQ ranged from 0-15 IQ points. All corrected IQ scores were significantly higher than uncorrected IQ scores (all *P* values <.001). Differences were larger at lower GAs, for higher IQ scores, and if time of assessment lay near the starting point of a 3-month age band of the Wechsler Preschool and Primary Scale of Intelligence-Third Edition-Dutch Version.

**Conclusions** Given the great variation observed in differences between corrected and uncorrected IQ scores, an international standard as to what age correction is appropriate should be pursued. (*J Pediatr* 2016;173:90-5).

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Greater than 50% of very preterm (VP) children (gestational age [GA] <30 weeks) have mild to severe cognitive disabilities at early school-age.<sup>1-4</sup> These problems are of great individual and societal relevance and are subject to intense scientific study.<sup>5-8</sup> IQ measures are used to determine the level of cognitive functioning. Scores <85 are used internationally to define mild learning disability and are associated with the need for educational support, whereas scores <70, which are used to define intellectual disability, indicate the need for special education.<sup>9-11</sup>

There is an ongoing debate whether IQ scores obtained during the first years of life should be corrected for prematurity and, if so, up to what age.<sup>9,11-20</sup> Correcting for prematurity may mask developmental deviance<sup>12</sup> and, consequently, can delay access to educational support.<sup>13</sup> However, not correcting for prematurity may lead to underestimation of VP children's abilities, as well as to unnecessary referrals. Currently, empirical studies differ greatly as to what, if any, age correction is applied, and a proper description about such is not always provided, thus, greatly hindering comparability between studies.<sup>5,21-23</sup>

The American Academy of Pediatrics recommends the use of corrected scores for preterm children up to 3 years of age.<sup>24</sup> The general assumption is that beyond 3 years of age, the difference between corrected and uncorrected IQ scores becomes insignificant and can be disregarded. That assumption, however, is based on outdated research.<sup>25,26</sup> Moreover, the GA of viability continues to decrease because of improved neonatal care,<sup>27</sup> and commonly used cognitive tests have since then been revised.<sup>28</sup> Indeed, a recent study from the Victorian research group in Australia suggests this assumption to be incorrect, demonstrating that a discrepancy between corrected and uncorrected IQ scores still exists beyond 3 years of age and that this discrepancy was larger for lower GA and higher IQ.<sup>9</sup> However, their results were based on a theoretical model, using normative data from several intelligence tests derived from nonclinical groups. This approach required the assumption that no difference exists between nonclinical children and VP children in terms of performances across more specific IQ measures (verbal IQ [VIQ], performance IQ [PIQ], and processing speed quotient [PSQ]). However, given the complexity of deficits in VP children, the extent

FSIQ	Full scale IQ
GA	Gestational age
PIQ	Performance IQ
PSQ	Processing speed quotient
VIQ	Verbal IQ
VP	Very preterm
WPPSI-III-NL	Wechsler Preschool and Primary Scale of Intelligence-Third Edition-Dutch Version

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of the discrepancy between corrected and uncorrected IQ scores may diverge across these specific IQ measures. As such, empirical data are needed to validate these results.

The current study was designed with the primary aim of determining the effects of correction for prematurity on full scale IQ (FSIQ), VIQ, PIQ, and PSQ in a large cohort of VP children, at the corrected age of 5 years. In addition, we investigated whether differences between corrected and uncorrected FSIQ scores are associated with GA, FSIQ, and age at assessment.

## Methods

The present study is a single-center, consecutive cohort study. All surviving VP children (GA <30 weeks) born between January 2006 and December 2009 and admitted to the Neonatal Intensive Care Unit of the Emma Children's Hospital, Academic Medical Center, Amsterdam, The Netherlands, were eligible for inclusion. The Medical Ethical Committee of the Academic Medical Center approved the study protocol.

Assessments were aimed to be scheduled within 3 months after the child had reached the corrected age of 5 years. Because of practical constraints, not all assessments could be scheduled within this timeframe; 134 children (49%) were assessed within this timeframe. All children were assessed between corrected ages of 4 years, 10 months, and 5 years, 10 months. IQ was assessed by trained child psychologists using the standardized instructions provided. The child psychologists were not blinded to the degree of prematurity, neonatal history, previous testing, or corrected and uncorrected age of the children. The test was administered for the child's corrected age.

### Outcome Measures

IQ was measured using the Dutch version of the third edition of the Wechsler Preschool and Primary Scale of Intelligence-Third Edition-Dutch Version (WPPSI-III-NL),<sup>28</sup> including the 7 core subtests Block Design, Information, Matrix Reasoning, Vocabulary, Picture Concepts, Word Reasoning, and Coding.<sup>28</sup> The additional subtest, Symbol Search, was also administered. The reliability of these subtests ranges from 0.83-0.91.<sup>29</sup> The FSIQ, VIQ, PIQ, and PSQ were calculated using instructions provided in the manual. In this study, the abbreviation "IQ" refers to all IQ measures (ie, FSIQ, VIQ, PIQ, and PSQ).

The WPPSI-III-NL scaled scores were calculated using continuous norming procedures. Norm groups were established, which for 4- and 5-year-olds were comprised of 4 age bands per year. Thus, these age bands spanned 3 months each, ranging from 4 years, 0 months, and 0 days, to 5 years, 11 months, and 30 days, respectively.<sup>29</sup> For 5-year-old children born more than 3 months prematurely (ie, GA <27 weeks and 2 days [ $27^{+2}$  weeks]), corrected and uncorrected age will logically consistently fall within different age bands. Uncorrected and corrected ages of children born

less than 3 months prematurely (ie, GA  $\geq 27^{+2}$  weeks) will only fall within the same age band if the corrected and uncorrected age at assessment lie near the starting point and end point of that age band, respectively. The chance of corrected and uncorrected age belonging to the same age band increases with increasing GA.

To illustrate the above, we extricate the first WPPSI-III-NL norm group for 5-year-olds, which ranges from 5 years, 0 months, and 0 days, to 5 years, 2 months, and 29 days. The highest GA in our cohort was  $29^{+6}$  weeks. The corrected and uncorrected ages of children with GA of  $29^{+6}$  weeks (born 2 months and 11 days prematurely) will belong both to this 3-month age band if the assessment took place within the first 18 days of the child reaching the corrected age of 5 years (ie, a range of 18 days). This range decreases as the GA decreases until the GA of  $27^{+2}$  is reached. This denotes the point at which the corrected and uncorrected age will only concurrently lie within this 3-month age band if the assessment took place on the exact day of the child reaching the corrected age of 5 years. Thus, for all VP children in our cohort, regardless of their GA, the uncorrected age lies within a subsequent 3-month age band if the corrected age at assessment is more than 18 days after the first day of a 3-month age band.

To investigate the difference between corrected and uncorrected IQ scores, FSIQ, VIQ, PIQ, and PSQ difference scores were calculated for each child by subtracting the score based on the uncorrected age from the score based on the corrected age. The percentages of children with a score <85 and a score <70 were calculated, based on corrected as well as uncorrected scores. Subsequently, to test whether differences vary across FSIQ, all children were divided into 3 uncorrected FSIQ groups: (1) <70; (2) 70-84; and (3)  $\geq 85$ . Because uncorrected FSIQ scores are most frequently used for children beyond age 3 years in clinical practice, groups were based on uncorrected FSIQ scores.

### Statistical Analyses

To assess whether corrected FSIQ, VIQ, PIQ, and PSQ scores differ from their uncorrected counterparts, paired sample *t* tests were conducted. Next, the hypothesis that the difference between corrected and uncorrected FSIQ scores will increase as GA decreases and FSIQ scores increase was tested using a repeated measures ANOVA with GA group and FSIQ group as between subject factors. Building on the aforementioned details of scoring the WPPSI-III-NL, the sample was first divided into 2 GA groups: (1) < $27^{+2}$  weeks; and (2)  $\geq 27^{+2}$  weeks. These 2 groups were then divided into 3 uncorrected FSIQ groups: (1) FSIQ <70; (2) 70-84; and (3)  $\geq 85$ . Subsequently, we investigated whether the relation between GA group and FSIQ difference scores, was different for each FSIQ group.

Lastly, we investigated the effect of age at assessment on the uncorrected FSIQ in the subgroup of children for whom age corrected and uncorrected age might fall within the same 3 months age-band ( $\geq 27^{+2}$  weeks GA). From this sample, we selected children who were assessed within the

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