No Excess of Mathematics Anxiety in Adolescents Born Very Preterm

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Objective: To assess whether adolescents born very preterm (VP; <32 weeks’ gestation) have an excess of mathematics anxiety compared with their classmates born at term. Methods: This cohort study included 127 adolescents born VP (51% male, mean age 13.9 years, SD 0.7) and 95 term-born classmates (56% male, mean age 13.7 years, SD 0.7) who completed the Wechsler Individual Achievement Test Second UK Edition and the Mathematics Anxiety Scale-UK at the age of 11 to 15 years. Self-reported trait anxiety was assessed using a composite of 3 items from the Strengths and Difficulties Questionnaire. Results: Adolescents born VP had significantly poorer mathematics attainment than adolescents born at term (difference in means: −0.64 SD; 95% confidence interval −0.95 to −0.34). However, there were no between-group differences in self-reported mathematics anxiety or trait anxiety. There were significant moderate associations between mathematics anxiety and mathematics attainment for adolescents born VP (rho: −0.45) and at term (rho: −0.54), after controlling for trait anxiety. Conclusion: Adolescents born VP do not have heightened mathematics anxiety compared with their term-born classmates, despite poorer attainment in mathematics. Improving domain-general cognitive skills and scaffolding learning in the classroom may be more promising avenues for intervention than attempting to reduce mathematics anxiety.

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Children born very preterm (VP; <32 weeks’ gestation) have poorer academic attainment and a higher risk for special educational needs than their term-born peers.1–3 The increased risk for poorer attainment is observed across all school subjects but is especially evident in mathematics.4,5 In a meta-analysis of 17 studies, children born preterm (<37 weeks’ gestation) had standardized arithmetic scores 0.71 SD lower than term-born controls compared with deficits of 0.44 SD and 0.52 SD in reading and spelling, respectively.5 Previous studies have shown that domain-general cognitive skills, particularly poor working memory and visuospatial processing, as opposed to poor numerical representations, contribute to poorer mathematics attainment in children born VP.2 The relationship between domain-general cognitive skills and mathematics attainment is well-established in the general population.5

An additional factor associated with mathematics attainment is mathematics anxiety.6 Mathematics anxiety is defined as “a feeling of tension, apprehension, or fear that interferes with math performance” (Ashcraft, 2002).7 Mathematics anxiety is moderately correlated with mathematics attainment (r = −0.27 to −0.30),8,9 and children with a mathematics learning difficulty (MLD) are at increased risk for high mathematics anxiety (scores >90th percentile) compared with children without MLD (22% vs. 10%).10 However, there is heterogeneity in the profiles of mathematics anxiety in children with MLD because 78% do not have high mathematics anxiety.10

Mathematics anxiety is associated with trait anxiety (i.e., a stable or enduring tendency to experience anxiety across many situations) in secondary school students in the general population (r 0.37 to r 0.41),8 but it is also independently associated with mathematics attainment (r −0.22 to r −0.28) after controlling for trait anxiety.6 VP birth is also a risk factor for anxiety symptoms and disorders in middle childhood.11 For example, in a recent meta-analysis of parent and teacher reports, adolescents born
VP or with very low birth weight (VLBW; \( \leq 1500 \text{ g} \)) were at increased risk of clinically significant anxiety problems compared with children born at term (odds ratio 2.27; 95% confidence interval 1.15–4.47).\(^\text{12}\) In adolescence, findings are mixed: some studies have reported significantly higher parent ratings of anxiety/depression for VLBW adolescents compared with term-born controls or with normative data,\(^\text{13,14}\) whereas others have not found higher parent-reported anxiety/depression symptoms among extremely low birth weight (\( \leq 800 \text{ g} \)) adolescents.\(^\text{15}\) Likewise, self-reports of anxiety/depression symptoms in VLBW adolescents indicate no difference in depression/anxiety scores from controls.\(^\text{14}\) We are not aware of any studies that have explored mathematics anxiety in children born preterm.

Given the increased risk for anxiety after VP birth,\(^\text{12}\) the association between trait anxiety and mathematics anxiety in the general population,\(^\text{6}\) and the lower attainment in mathematics in VP adolescents,\(^\text{2}\) it was hypothesized that adolescents born VP will have higher levels of mathematics anxiety than their classmates born at term. It was also hypothesized that higher mathematics anxiety will be associated with poorer attainment in mathematics in both adolescents born VP and at term after adjusting for trait anxiety.

**METHODS**

**Participants**

Participants comprised adolescents in the Premature Infants’ Skills in Mathematics (PRISM) cohort. Previously, 117 children born very preterm (VP < 32 weeks’ gestation) and admitted to neonatal care in 2 UK centers (University Hospitals of Leicester NHS Trust & University College London Hospital) were recruited to the PRISM study at the age of 8 to 10 years, of which 115 were assessed. Recruited children were representative of the total population of VP births (\( n = 266 \)) for gestational age, birth weight, sex, and deprivation.\(^\text{2}\) A control group of 77 children born at term were recruited from age- and sex-matched classmates of the VP children. Detailed information about the cohort has been published previously.\(^\text{2}\)

For this study, these children were invited to participate in a follow-up assessment in adolescence. Of the original cohort, the parents of 87 (76%) VP adolescents provided consent for their participation, of which 83 were assessed (Fig. 1), and the parents of 51 (67%) term-born controls provided consent. For VP adolescents for whom the parent of the original control did not provide consent, for whom there was no original control, or for whom the control had moved to a different school, a new/additional control was selected using the same procedure as in the original study.\(^\text{2}\) Thirty-one new controls were recruited in this way, resulting in a total of 82 controls, of whom 78 were assessed (Fig. 1).

For the original cohort, there was no significant difference between VP children who did and did not participate in this study in gestational age (\( p = 0.580 \)), birth weight (\( p = 0.369 \)), nonverbal intelligence quotient (IQ) (\( p = 0.082 \)), or sex (\( p = 1.00 \)). However, VP children who were reassessed had lower rates of deprivation (37%) than those who did not participate (62%; \( p = 0.042 \)). For controls, there was no significant difference between children who did and did not participate in this study in deprivation (\( p = 0.157 \)) and sex (\( p = 0.636 \)). However, children who were reassessed had higher nonverbal IQ (M = 109.90, SD = 14.70) than those who were not (M = 98.36, SD = 20.44; \( p = 0.012 \)).

To increase power for cross-sectional analyses, an additional 48 adolescents born <32 weeks’ gestation were recruited from admissions to neonatal care in a third UK center (Nottingham University Hospitals NHS Trust). Of 165 births, 135 were invited to participate, of whom the parents of 48 (36%) provided consent (Fig. 1). Of these, 2 adolescents attending special schools were excluded, and assessments could not be scheduled for a further 2, leaving a total of 44 additional VP adolescents.

Compared with the remaining VP population (\( N = 121 \)), there were no significant differences in gestational age (\( p = 0.271 \)), birth weight (\( p = 0.457 \)), deprivation (\( p = 0.576 \)), or sex (\( p = 0.981 \)). An additional 18 classmates born at term and matched on age and sex to one of these VP adolescents were recruited. Of these, 1 was excluded because they had been living abroad, leaving 17 additional controls.

In total, the assessed cohort comprised 127 VP adolescents and 95 controls aged 11.82 to 15.17 years. Data were collected between January 2016 and January 2017.

**Procedure**

Informed parental consent and assent was obtained for all adolescents. Participants were assessed in school (68%) or at home (32%) by one of 2 psychologists who were blind to group membership.

**Measures**

**Mathematics Attainment**

The Wechsler Individual Achievement Test Second UK Edition\(^\text{16}\) was used to assess attainment in mathematics. This examiner administered test yields an age-standardized mathematics composite score (mean 100, SD 15). Higher scores indicate better attainment.

**Mathematics Anxiety**

Adolescents completed the Mathematics Anxiety Scale-UK (MAS-UK\(^\text{17}\)). This questionnaire was developed using an undergraduate population in the United Kingdom. It comprises 23 items on a 5-point Likert scale (see Table S1, Supplemental Digital Content 1, http://links.lww.com/JDBP/A274), with responses ranging from 1 (not at all) to 5 (very much) from which a total score was computed (range 23–115). Three factors—mathematics evaluation anxiety, everyday/social mathematics anxiety, and mathematics observation anxiety—describe the content of the scale. The MAS-UK demonstrates good construct validity. In the validation study, there was no correlation between a measure of general trait anxiety
and mathematical performance. However, mathematical anxiety as measured by the MAS-UK total score was significantly negatively correlated with performance in mathematics. Internal consistency for the total score was excellent (Cronbach’s alpha: VP 0.94; controls 0.93). For 7 participants with 1 item missing, data for the missing item were imputed from the average of 22 completed items. Higher scores indicate higher mathematics anxiety.

**Trait Anxiety**

Trait anxiety was assessed using the self-report version of the Strengths and Difficulties Questionnaire (SDQ), from which a total score for 3 items assessing anxiety (items 8, 16, and 24) was computed. Higher scores indicate higher levels of anxiety. Items were scored on a 3-point Likert scale (“Not True” = 0, “Somewhat True” = 1, and “Certainly True” = 2), so anxiety scores ranged from 0 to 6. Cronbach’s alpha for the self-report trait anxiety score was 0.79 for the VP group and 0.70 for the control group.

Parent-reported anxiety was calculated using scores on the same items from the parent report version of the SDQ. Cronbach’s alpha for the parent-reported anxiety score was 0.71 for the VP group and 0.69 for the control group. The SDQ has a strong 5-factor structure, whereby items 8, 16, and 24 load solely onto 1 factor. The SDQ is widely used in research and clinical practice and has excellent psychometric properties for identifying children with behavioral and emotional difficulties in both clinical and community populations.

**Socioeconomic Status**

As an indicator of socioeconomic status, the postal code of the parents’ residence at the time of assessment was used to derive an Index of Multiple Deprivation (IMD) score. The IMD is a measure of relative deprivation comparing each neighborhood with all others in England. The IMD is based on the postcode of residence for lower-layer super output areas that cover an average of 1500 residents. It is a composite indicator covering 7 domains of deprivation (income, employment, education, health, crime, barriers to housing and services, and living environment). Higher scores indicate higher levels of deprivation. Using IMD scores, participants were classified in one of 3 levels of deprivation using national statistics (least, middle, or most deprived area of the United Kingdom).

**Nonverbal IQ**

Nonverbal IQ was assessed using the Raven’s Standard Progressive Matrices from which an age-standardized score was derived (mean: 100, SD: 15). Higher scores indicate higher IQ.

**Statistical Analyses**

Mathematics anxiety and trait anxiety scores were skewed in both groups; therefore, Mann-Whitney U tests were used to assess between-group differences in these outcomes. An independent sample t test was used to test for between-group differences in mathematics attainment and continuous outcomes in Table 1. Between-group differences in categorical outcomes (IMD deprivation classification and academic year group) were assessed using $\chi^2$. The relationship between mathematics anxiety and mathematics attainment was nonlinear; therefore, nonparametric bivariate Spearman rho with 95% confidence intervals (95% CIs) and partial correlations were used to explore the relationship controlling for trait anxiety. Rho coefficients with 95% CI for bivariate and partial

Figure 1. Flow chart of recruitment of children born very preterm and term-born controls. PRISM, Premature Infants’ Skills in Mathematics.
Spearman rho were computed using bootstrapping with 1000 replications in R (version 3.6.1) using the cor.test and spearman.ci functions (using the RVAideMemoires package) and pcor.test. All other analyses were conducted in SPSS version 25. Cohen’s d values were computed using an online calculator. Correlations were considered weak, correlations 0.30 to 0.49 moderate, and correlations ≥0.50 strong. The numbers of participants with missing data are reported in table notes.

**Ethical Approval**

This study was approved by the Derbyshire National Health Service Research Ethics Committee (Ref 15/EM/0284).

**RESULTS**

**Sample Characteristics**

There was no significant difference in the distribution of sex between the very preterm (VP) and term-born groups. Furthermore, there were no significant differences in the Index of Multiple Deprivation scores, nonverbal intelligence quotient, age, or academic year at assessment (Table 1).

**Mathematics Attainment**

Adolescents born VP had significantly poorer mathematics attainment than adolescents born term (−10.95 points; 95% confidence interval −16.18 to −5.73) (Table 2).

**Mathematics Anxiety**

There was no significant difference in mathematics anxiety between adolescents born VP and adolescents born at term (U = 5648.0, p = 0.417; Table 2). At item level, adolescents born VP had significantly higher scores on only 2 of the 23 items (Items 11 & 20; See Supplementary Digital Content 1, http://links.lww.com/JDBP/A274), but the differences on these items were no longer significant after Bonferroni correction. There was no significant difference in mathematics anxiety between children assessed at home or in school (school assessments: mean 49.46 [SD 18.43]; home assessments: mean 49.18 [SD 16.04]; p = 0.914). Thus, the testing environment did not affect the rates of mathematics anxiety.

**Trait Anxiety**

Self-reported trait anxiety did not differ significantly between adolescents born VP and at term (U = 5482.0, p = 0.237; Table 2); however, parents reported significantly higher trait anxiety in adolescents born VP compared with adolescents born at term (U = 4402.5, p = 0.005). Self-reported trait anxiety was moderately associated with mathematics anxiety in...
both adolescents born VP (rho 0.39) and at term (rho 0.40) (Table 3).

### Relationship Between Mathematics Anxiety and Mathematics Attainment

There were significant strong associations between mathematics anxiety and mathematics attainment for adolescents born VP and for term-born controls. These associations remained significant (moderate/strong effect sizes) after controlling for trait anxiety in both groups (Table 3).

### DISCUSSION

This is the first study to explore mathematics anxiety in adolescents born very preterm (VP). Contrary to our hypothesis, there was no significant difference in mathematics anxiety between adolescents born VP and their term-born peers. The negative correlation between mathematics anxiety and mathematics attainment in both adolescents born VP and at term remained significant once trait anxiety was controlled for. These results suggest that the relationship between mathematics anxiety and attainment evidenced in secondary school students in the general population is mirrored in the VP population.6

The lack of a significant excess of self-reported mathematics anxiety in adolescents born VP was contrary to our expectations, but it is reassuring that this was not found to be an additional risk factor for this already vulnerable population. Our results also provide reassurance that learning opportunities may not be reduced for VP adolescents because of avoidance of mathematical tasks because of higher levels of mathematics anxiety.8 Our results provide further evidence of a dissociation between poor mathematical performance and mathematics anxiety in groups with low mathematics attainment.10

Mathematics anxiety may result from the dissociation between an adolescent’s performance and their own or other’s expectations. Strong negative correlations are found between children’s and adolescents’ perceived ability and performance and affective reactions toward mathematics, such as fear, nervousness and dread.25 Children with poorer mathematics attainment may have lower expectations of their own attainment.10 It could therefore be posited that mathematics anxiety is not evidenced when an individual’s expectation of their performance is concordant with their actual performance. In addition, it may be that adolescents who attach little importance to mathematics do not experience mathematics anxiety.25

It could be speculated that adolescents born VP overestimate their mathematics performance, and therefore, there is not an excessive gap between their perceived performance and actual performance compared with adolescents born at term. This may explain the lack of mathematics anxiety in adolescents born VP but requires further research. Adolescents with a specific learning difficulty, predominantly in mathematics, have been shown to overestimate their performance in mathematics compared with adolescents born at term. This perception of performance is concordant with their actual performance,26 but for adolescents born VP, their perceived performance, expectations, and importance attributed to mathematics are unknown. In a previous study, preterm adolescents who had impaired executive function on neuropsychological tests compared with term-born peers did not report more difficulties than their peers on a self-report measure of executive function in daily life.27

### Table 2. Between-Group Comparisons of Mathematics Attainment, Mathematics Anxiety, and Trait Anxiety

| Mathematics Attainment | Term-Born Controls n = 95 | VP Adolescents n = 127 | p     | Cohen’s d |
|-------------------------|---------------------------|------------------------|-------|-----------|
| Mathematics attainment | WIAT-II composite score   | Mean (SD)              | 107.46 (17.10) | 96.51 (21.19) | <0.001 | −0.57 |
| Numerical operations:   | WIAT-II subscale score    | Mean (SD)              | 109.65 (18.51) | 99.07 (22.57) | <0.001 | −0.51 |
| Mathematics reasoning:  | WIAT-II subscale score    | Mean (SD)              | 103.24 (15.57) | 94.59 (15.74) | <0.001 | −0.55 |
| Mathematics anxiety     | Median (IQR)              | 47.0 (34.0–57.0)       | 45.0 (36.0–63.0) | 0.417 | 0.11 |
| Trait anxiety: Self-report | Median (IQR)             | 2.0 (1.0–3.0)         | 2.0 (1.0–3.0) | 0.237 | 0.16 |
| Trait anxiety: Parent report | Median (IQR)           | 1.0 (0–2.0)           | 1.0 (0–3.0) | 0.005 | 0.37 |

*Owing to unreturned questionnaires, control n = 91. *Owing to unreturned questionnaires, VP n = 123. IQR, interquartile range; VP, very preterm; WIAT-II, Wechsler Individual Achievement Test Second UK Edition.

### Table 3. Spearman Rho Bivariate and Partial Correlations Between Mathematics Anxiety and Mathematics Attainment in VP Adolescents and Term-Born Controls

| Mathematics anxiety | Rho 95% CI | Self-Reported Trait Anxiety | Rho 95% CI | Mathematics Attainment Controlling for Trait Anxiety | Rho 95% CI |
|---------------------|-----------|-----------------------------|-----------|-----------------------------------------------------|-----------|
| Controls (N = 95)   | −0.50**   | −0.65; −0.34                | 0.40**    | 0.20; 0.58                                          | −0.54**   | −0.66; −0.38 |
| VP (N = 127)        | −0.50**   | −0.62; −0.37                | 0.39**    | 0.24; 0.53                                          | −0.45**   | −0.58; −0.30 |

*p < 0.001. CI, confidence interval; VP, very preterm.
The same pattern of findings was evidenced with trait anxiety in this study, in which there were no differences between the VP and term-born adolescents on self-reported trait anxiety, but higher parent-reported trait anxiety was observed for the VP adolescents. This pattern of findings is supported by previous literature in which parents of very low birth weight (VLBW) adolescents aged 14 years provided higher ratings of depression/anxiety compared with parents of adolescents born at term, whereas VLBW adolescents’ self-reports did not differ from those of the term-born adolescents. In another study, self-reported anxiety/depression scores were lower for male adolescents with VLBW compared with normative data, indicating fewer symptoms than adolescents in the general population.

One hypothesis is that mathematics does not induce heightened anxiety among VP adolescents because of low importance being attributed to mathematics. Because it was not possible to examine this in this study, this is a potential avenue for future research. To test this hypothesis, motivation for and importance attributed to mathematics needs to be assessed alongside mathematics anxiety. To corroborate self-reports of mathematics anxiety, physiological assessments of anxiety when presented with mathematical stimuli could also be explored, see Ashcraft et al.

Our findings suggest that interventions aimed at reducing mathematics anxiety in adolescents born VP are unlikely to improve their mathematics attainment. Alternative approaches to intervention could focus on adapting teaching to account for deficits in working memory, such as using teaching strategies that reduce the student’s working memory load and supporting students to develop their own strategies to optimize their learning. 

It should be noted that the Mathematics Anxiety Scale-UK was validated with an undergraduate population, and therefore, its application to adolescents aged 13 years may be limited. A general challenge facing research in mathematics anxiety is the lack of a priori definition of high mathematics anxiety. Researchers have identified high mathematics anxiety as scores 1 SD above the mean or scores above the 90th percentile. However, without a standardized definition, it is difficult to identify the prevalence of mathematics anxiety in the general population and compare this with the VP population. It should also be noted that the measure of trait anxiety in this study was based on 3 items of the Strengths and Difficulties Questionnaire. Future studies could incorporate more detailed measures of generalized anxiety. Loss to follow-up of children from the original Premature Infants’ Skills in Mathematics Study cohort may also represent a limitation of this study. As noted, 76% of the original VP children and 67% of term-born controls were rerecruited in adolescence. VP children reassessed had similar characteristics to those who were lost to follow-up but were less likely to live in areas of high deprivation. Similarly, controls assessed in adolescence had similar characteristics to controls lost to follow-up but had higher intelligence quotient. As such, we may have underestimated the adverse impact of VP birth, but such effects are likely to be minimal.

In conclusion, adolescents born VP do not have heightened mathematics anxiety compared with their term-born classmates, despite having significantly poorer mathematical attainment. Further research is needed to explore the value that VP adolescents attribute to mathematics to further understand this finding.

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