SPECIAL ISSUE ARTICLE

Self-reported executive function problems in adults born very low birthweight

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Abstract

Background: Executive function difficulties are common among children born very preterm and/or very low birthweight (<1500 g; VLBW), but little is known about whether they persist into adulthood.

Objectives: Examine the nature and pattern of self-reported executive functioning at 23 and 28 years of age using data from a national cohort study of adults born VLBW and a comparison group of same-age full-term (FT) born adults. Also examined were associations between executive function difficulties and socio-economic outcomes.

Methods: All infants born VLBW in New Zealand during 1986 were prospectively included in an audit of retinopathy of prematurity ($n = 413$), with 250 (77% of survivors) followed to median age 28 years. A comparison group of FT adults was also recruited at age 23 and followed to 28 years ($n = 100$). Across both adult assessments, executive functioning was assessed using the Behaviour Rating Inventory of Executive Function—Adult Version (BRIEF-A) and analysed with semi-parametric models to examine the effects of age and group on executive function.

Results: At 23 and 28 years, VLBW adults had increased risk of executive function impairment compared with FT adults in behaviour regulation (relative risk [CI] 2.37, 95% confidence interval (CI)1.27, 4.45), meta-cognition (RR 6.03, 95% CI 2.18, 16.78) and global functioning (RR 3.20, 95% CI 1.40, 7.28). Impaired global executive functioning was associated with lower socio-economic status (regression estimate [b] = −0.43, 95% CI −0.59, −0.27) and a reduced likelihood of home ownership by age 28 years (RR 0.98, 95% CI 0.96, 1.00), even after controlling for sex, ethnicity and parental socio-economic backgrounds for both groups.

Conclusion(s): VLBW-born adults continue to experience more executive function difficulties in their everyday life relative to term controls at age 28 years. These difficulties were negatively associated with their socio-economic opportunities as young adults.

KEYWORDS
adult, BRIEF, executive function, outcome, very low birthweight, very preterm

1 | BACKGROUND

Executive function abilities are a broad set of cognitive processes that enable us to plan, focus attention, remember instructions and juggle multiple tasks successfully. These skills play a central role in the regulation of behaviour, information processing and decision making in our everyday life and social interactions with others.[1,2] Executive function can be measured using rating scales and psychometric assessments.[3,4] Self-report measures such as the Behaviour Rating Inventory of Executive Function (BRIEF) offer an ecologically valid measure of an individual's perceived everyday executive function.[5,6] In some populations with an increased risk of cognitive impairment, BRIEF scale scores have been shown to provide a sensitive measure of social and executive functioning problems in everyday situations and to be predictive of adult social adjustment such as stable employment, income and home ownership.[7,8]

Studies show that children born very preterm (VPT, <32 weeks gestation) and/or very low birthweight (VLBW, <1500 g) have more executive function problems than their full-term (FT) born peers, including both global and specific difficulties in inhibitory control, working memory and cognitive flexibility.[9–17] For example, two recent meta-analyses report standardised mean difference of 0.4–0.5 between VPT/VLBW and FT children across these executive function domains.[12,16] Several studies also suggest that these difficulties may persist into late adolescence.[9,12,14,17,18] Few studies have extended into the adult years[17,19–21] with often a narrow range of executive function outcomes considered.[20–22] One exception is a recent Helsinki study of 90 VLBW and 93 FT born adults assessed at ages 21 and 30 years using the self- and parent-reported BRIEF-A.[23] Results showed that parents reported more problems with executive function than their adult VLBW offspring, with the latter rating themselves similarly to FT adults. Unlike the self-report, parental evaluations correlated with scores on the trail-making test which assesses cognitive flexibility during a visual-motor task.[23]

These findings suggest that adult VLBW survivors may continue to experience difficulties with executive function in everyday life. This is generally consistent with existing research suggesting that executive impairments persist from the preschool through adolescent years.[18,24–26] However, it is also possible that given the protracted development of executive function into young adulthood,[18,24–26] as well as changes in social and environmental demands,[18,27–29] between-group differences in perceived problems associated with executive functioning may reduce with age. Thus, further replication in larger cohorts is needed, ideally with assessments at multiple age/time points.

Executive dysfunction may also affect social functioning and other aspects of daily life such as socio-economic prosperity and independence.[7,8] It is therefore important to study how ongoing executive function difficulties might relate to other aspects of adult functioning, over and above or in addition to, the effects of other potential confounding factors such as the participant's socio-demographic background. To address these research gaps, the specific aims of this paper were: (1) To characterise the self-reported executive functioning of a national cohort of adults born VLBW

Synopsis

Study question

To characterise adult very low birthweight survivors' perceptions of their everyday executive functioning at 23 and 28 years of age and examine associations with adult socio-economic outcomes.

What's already known

Children and adolescents born very low birthweight perform poorer on executive function tasks compared with their full-term born peers. But the extent of these problems in adulthood is unclear.

What this study adds

Individuals born very low birthweight report higher rates of executive function impairment during early adulthood, but their perceived impacts on daily functioning decreased from 23 to 28 years. Adult self-reported executive difficulties were associated with lower socio-economic status and probability of home ownership by age 28.

relative to a comparison group of same-age adults born FT; (2) to examine the extent to which executive function problems changed or remained stable from median age 23–28 years; and (3) to assess associations between self-reported executive function difficulties and socio-economic outcomes at 28 years.

2 | METHODS

2.1 | Study population

Data were drawn from a prospective longitudinal study of a national cohort of VLBW survivors. All 413 infants born VLBW (<1500 g) and admitted to neonatal intensive care units (NICU) in New Zealand during 1986 were prospectively enrolled in an audit of retinopathy of prematurity,[30,31] with 338 (81.8%) surviving to discharge.[19,30–32] These individuals were subsequently followed up at ages 7–8, 22–23 and 26–30 years. At median ages 23 and 28 years, 230 (71.2%) and 250 (77.4%) of all survivors (n = 323) were followed up. In addition, at age 23, a comparison group of same-age FT-born adults (n = 69) were recruited via the national electoral roll or through peer nomination; and further increased to n = 100 for the age 28 follow-up. Further study recruitment and participation details are available in supplementary online material (see Figure S1) and previous publications.[30–32]

The neonatal and social background characteristics of the 250 VLBW adults followed up at age 28 years is summarised in Table 1.

The average birthweight for the VLBW cohort was 1134 g. Fifty-six per cent of the VLBW cohort had received a course of antenatal corticosteroids, 20.4% were diagnosed with bronchopulmonary dysplasia (an oxygen requirement at 36 weeks post-menstrual age), and 21.6% were diagnosed with retinopathy of prematurity.

2.2 | Procedures

Extensive neonatal and family social background data were collected for all VLBW participants during their NICU stay and at age 7–28 years. Biological sex was recorded at birth. Ethnicity was self-identified and classified as New Zealand European, Māori (New Zealand indigenous), Pacific Island descent or other. Retrospective assessments of parental education and occupational status during the participant's childhood were obtained at ages 23 and 28 years. Parental education was classified into three levels (no formal, secondary or tertiary qualifications) based on the highest educational attainment reported for either parent. Parental occupational status was classified using the 6-level classification provided by the 2006 New Zealand Socio-Economic Index,[33] again based on the highest occupational status of either parent, with 6 being the highest socio-economic level. Group comparisons showed very slight socio-demographic advantage among controls compared with VLBW (Table 1).

At ages 23 and 28 years, the BRIEF-A was completed as part of a comprehensive face-to-face interview about each respondent's health and personal circumstances.[31,32] Detailed socio-economic data and home ownership information were also collected at age 28. Key study measures are described below.

2.3 | Self-reported everyday executive functioning

The 75-item BRIEF-A provided a measure of self-reported executive dysfunction.[2,6] Items were rated from 1 (never) to 3 (often), and then combined to form 9 subscales: Inhibition, Shift, Emotion Control, Self-Monitor, Initiate, Working Memory, Plan/Organise, Task Monitor and Organisation of Materials. The composite Behaviour Regulation Index and Meta-cognition Index, in addition to an overall Global Executive Composite were also computed and used as the primary outcomes in the analyses. The Behaviour Regulation Index provided a measure of difficulties in an individual's self-awareness capacity, and meta-cognition provided a measure of decision-making difficulties. Raw scores were converted into age-standardised scores, with executive function impairment defined as a score >1.5 standard deviations (SD) above the normative population mean. The BRIEF-A is internally consistent, with Cronbach's α in the normative population ranging from 0.93 to 0.96 and in the current sample ranging from 0.72 to 0.91 (for the nine individual subscales). One-month test–retest reliability for indices was also good, ranging from 0.93 to 0.94. Self-reported BRIEF-A data were available for all participants at 23 years, and 96% of VLBW and 100% of FT adults at 28 years.

2.4 | Parent/partner-reported everyday executive functioning

To validate participant's self-reported executive functioning at age 28, parents/partners also independently rated the participant's executive functioning and behavioural adjustment on a series of 10 custom-written items shown in Table S1. These items were designed

TABLE 1 Characteristics of the participants

Measure	Very low birthweight (n = 250)	Full term (n = 100)
Neonatal factors		
Birth weight, mean (SD), g	1134.0 (236.2)	3377.0 (583.5)[a]
Male sex, %	42.8	37.0
Gestation, mean (SD), weeks	29.2 (2.5)	–
Multiple births, %	24.4	0.0
Antenatal steroids, %	56.4	–
Oxygen therapy at 36 weeks, %	20.4	–
Retinopathy of prematurity, %	21.6	–
Any breast feeding, %	76.4	88.0
Social background factors		
Maternal age at childbirth, mean (SD), years	25.9 (5.2)	27.1 (4.5)
Māori/Pacific Island ethnicity, %	30.8	24.0
Parent with tertiary qualification, %	52.0	63.0
Family of professional/managerial SES, %	33.2	34.0

Abbreviations: SD, standard deviation; SES, socio-economic status.

[a]Based on parental recollection at age 28 years.

to align with each BRIEF-A subscale and were rated on a 5-point Likert scale with higher scores indicating poorer executive function. Confirmatory factor analysis of these items supported a single factor model reflecting global executive function. Therefore, for the purposes of this analysis, items were summed to provide a composite parent/partner-reported executive function score.[34] The resultant scale had good internal consistency ($\alpha = 0.78$). Independent parent/partner ratings were available for 210 VLBW and 96 FT adults at age 28 years.

2.5 | Socio-economic outcomes at 28 Years

Two measures were selected to describe socio-economic outcomes at age 28 years: (a) ownership of a house, flat or apartment, dichotomised into yes or no; (b) participant occupational status classified using the continuous scale version of the New Zealand Socio-Economic Index.[33] This scale ranges 10 to 90 with higher scores implying higher socio-economic status.

2.6 | Statistical analysis

Participant characteristics were described using summary level statistics (means, SDs, percentages) in Table 1. The self-rated BRIEF-A scores at age 23 and 28 years are summarised in Table 2. Internal consistency of the BRIEF-A subscale and composite scores and parent/partner-reported executive function was assessed using Cronbach's α. The smoothed densities of the BRIEF-A composites were estimated and plotted in Figure 1 for 23 years and Figure 2 for 28 years.

Concordance between self-report and parent/partner ratings of executive functioning at age 28 was examined by: comparing mean parent/partner ratings between (a) VLBW and FT adults (Table S2), and (b) individuals with and without self-identified impairment based on their global executive score (Table S3); and by calculating the product–moment correlation between self and parent/partner-reported global executive function. Mean comparisons were made using the *svyglm* function in R[35] with the observations weighted to account for missing data and potential bias due to selective attrition (see below).

Change in executive function scores from age 23 to 28 years was analysed with semi-parametric estimation with observations weighted to account for missing data and participant attrition.[36–38] The continuous outcome scores were fitted using the quasi-likelihood estimation with model robust standard errors, with the fitted parameters interpreted with reference to the BRIEF-A normative population SD (SD = 10) to provide a common effect size metric (Cohen's d). The dichotomous impairment (> normative mean ± 1.5SD) outcome was estimated using the quasi-Poisson model, with the conditional relative risk (RR) as the estimated measure of effect. In each model, group assignment and assessment age were included as predictors. Group by age interaction terms were

sequentially and separately included in the model to assess their impact on goodness of fit. Models were estimated using the survey package in R.[35] Supplementary analyses were performed to test the effects of clustering of multiple births within families. The results in Table S4 show essentially the same results as in Table 3.

Cross-sectional associations between global executive function problem scores and socio-economic outcomes at 28 years were analysed using generalised linear regression technique. A series of regression analyses were conducted to examine the extent to which (a) global executive dysfunction at age 28 were associated with home ownership and socio-economic Index scores; and (b) between-group differences in home ownership and socio-economic index were explained by between-group differences in global executive scores. Analyses were conducted before and after the inclusion of sex, ethnicity and parental socio-economic background (Table S5).

2.7 | Missing data

Comparisons of those VLBW assessed with remaining cohort members not assessed at each age (Table S6) showed some evidence of selective attrition, particularly at age 28; the assessed participants having lower mean birthweight, a sex imbalance and under-representation of those with prior neurosensory disability. In addition, not all controls were assessed at both ages due to the process of recruitment. To address issues of missing data/selective attrition an inverse probability weighting adjustment[37,38] was included in all analyses. Specifically, for each group a logistic regression model was fitted to predict probability of inclusion in the analysis cohort at each age. For VLBW prediction was based on the measures in Table S6; for FT, prediction was based on socio-demographic characteristics (sex, ethnicity, parental socio-economic status and education) of the full FT cohort. The inverse of this probability was then used in the fitted models.

2.8 | Ethics approval

Ethical approval for the study was obtained from the Upper South B Regional Ethics Committee (superseded by the Southern Health and Disability Committee), and all procedures conducted with written informed consent from all participants.

3 | RESULTS

3.1 | Self-reported executive functioning at ages 23 and 28 years

For each age assessment, Figures 1 and 2 summarise the score distributions for each study group on the Behaviour Regulation and Meta-cognition Indices as well as the Global Executive Composite.

TABLE 2 Comparison of mean (SD) BRIEF-A scores and rates (%) of impairment by age and group status

BRIEF-A measures	Very low birthweight			Full term		
	n	Mean (SD)	% Impaired	*n*	Mean (SD)	% Impaired
Behaviour regulation						
23 years	230	52.9 (12.5)	20.4	69	51.7 (9.3)	5.8
28 years	240	50.0 (11.7)	12.1	100	51.4 (9.4)	10.0
Metacognition						
23 years	230	51.0 (10.5)	13.9	69	50.1 (8.0)	1.5
28 years	240	48.8 (10.0)	9.6	100	48.4 (8.0)	4.0
Global executive						
23 years	230	52.0 (11.4)	17.0	69	50.8 (8.2)	4.4
28 years	240	49.3 (10.8)	10.4	100	49.7 (8.1)	6.0
BRIEF-A subscales						
Inhibition						
23 years	230	51.9 (11.3)	15.2	69	52.1 (8.7)	7.3
28 years	241	50.5 (11.5)	11.3	100	52.8 (10.0)	11.0
Shift						
23 years	230	53.5 (12.0)	14.8	69	52.7 (9.9)	8.7
28 years	241	52.0 (11.1)	10.4	100	50.9 (9.4)	8.0
Emotion control						
23 years	230	52.2 (11.8)	15.7	69	50.2 (8.8)	7.3
28 years	241	49.0 (10.9)	11.7	100	50.3 (9.9)	9.0
Self-monitor						
23 years	230	52.2 (12.6)	16.1	69	51.4 (10.9)	8.7
28 years	240	49.4 (12.5)	12.9	100	51.0 (10.8)	10.0
Initiate						
23 years	230	50.8 (10.5)	10.9	69	48.6 (8.4)	2.9
28 years	241	47.8 (9.3)	7.5	100	47.7 (8.7)	6.0
Working memory						
23 years	230	54.4 (11.8)	21.3	69	52.0 (10.0)	11.6
28 years	241	53.2 (12.2)	15.0	100	52.2 (9.7)	12.0
Plan/Organise						
23 years	230	50.4 (10.2)	10.4	69	49.5 (7.9)	5.8
28 years	240	49.6 (10.1)	9.2	100	48.0 (7.7)	4.0
Task monitor						
23 years	230	49.7 (11.0)	9.1	69	50.7 (9.2)	4.4
28 years	241	47.0 (10.5)	6.3	100	46.1 (8.1)	0.0
Organisation of materials						
23 years	230	48.7 (10.3)	7.4	69	49.2 (9.9)	5.8
28 years	241	46.4 (9.8)	5.8	100	48.1 (10.7)	8.0

Abbreviations: BRIEF-A, Behaviour Rating Inventory of Executive Function—Adult; SD, standard deviation.

As shown, although the majority of VLBW adults scored in the 'normal' range, their score distributions showed longer rightward tails for all composites, resulting in proportionately more VLBW than FT adults meeting criteria for executive function impairment (1.5 SD above the mean) at both ages.

These distributional properties were further reflected in Table 2, which shows the mean Behaviour Regulation,

Meta-cognition and Global Executive Composite scores for the two groups, as well as the proportion with clinically significant executive function problems at 23 and 28 years. Results showed that VLBW and FT adults reported generally similar composite scores. However, VLBW adults were consistently more likely than FT adults to meet criteria for impairment across all composite outcomes at both ages. However, for both mean scale scores and
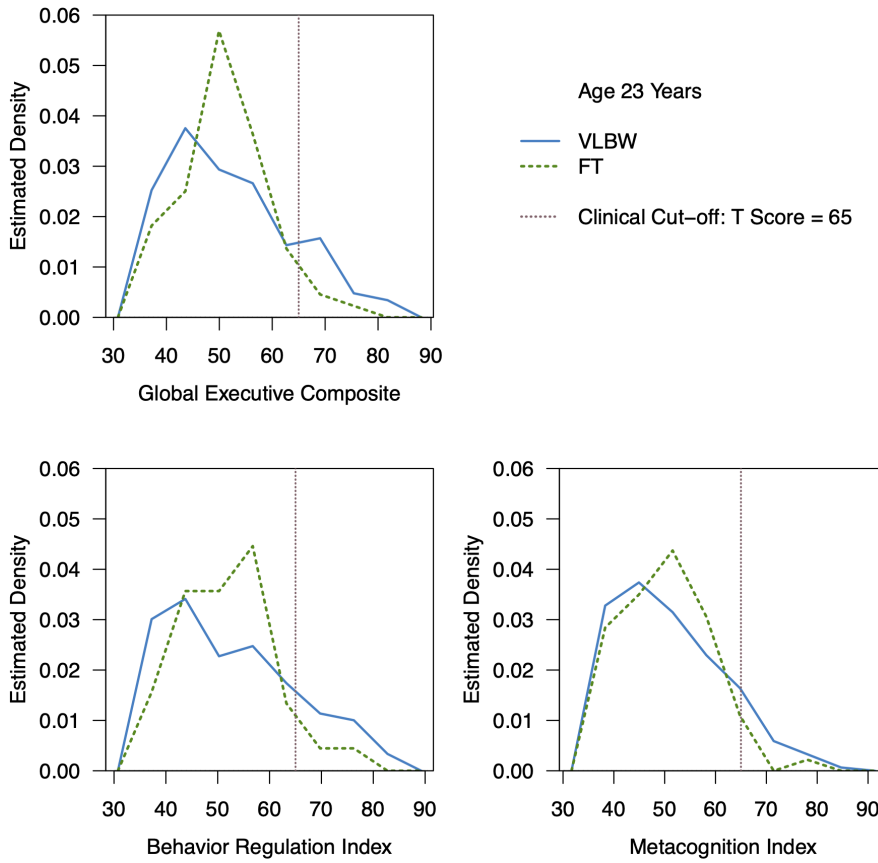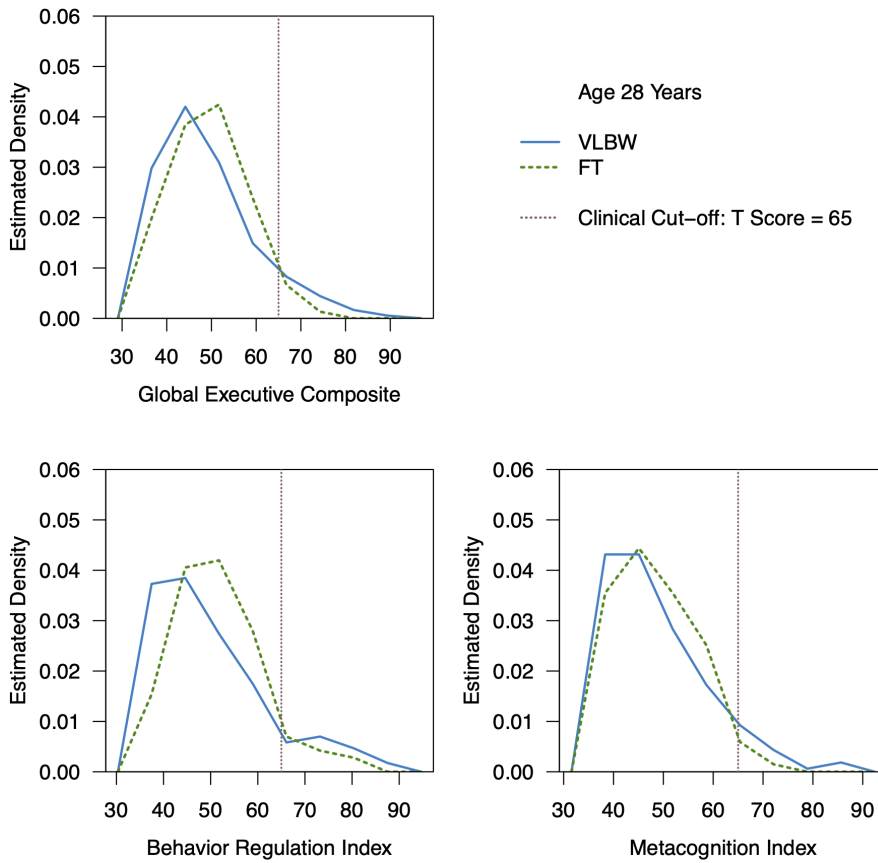
TABLE 3 Weighted semi-parametric regression models for BRIEF-A composite mean scores and rates of impairment

Measure	Mean scores B (95% CI)	Impairment RR (95% CI)
Behaviour regulation		
Age (28 vs. 23)	−1.70 (−3.12, −0.28)	0.77 (0.54, 1.08)
Group (VLBW vs. FT)	0.24 (−1.88, 2.37)	2.37 (1.27, 4.45)
Metacognition		
Age (28 vs. 23)	−1.69 (−2.88, −0.49)	0.85 (0.55, 1.30)
Group (VLBW vs. FT)	1.08 (−0.73, 2.90)	6.03 (2.18, 16.78)
Global executive		
Age (28 vs. 23)	−1.82 (−3.13, −0.52)	0.75 (0.51, 1.11)
Group (VLBW vs. FT)	0.82 (−1.09, 2.72)	3.20 (1.40, 7.28)

Note: Weights were computed using sex, ethnicity, birthweight, parental education and socio-economic status as predictors for both groups. For VLBW, additional information on perinatal and mid-childhood functioning at 7–8 years was used (see Table S6 for a full list of variables).

Abbreviations: VLBW, very low Birthweight; FT, full term; B, Weighted estimate of regression coefficient; RR, Weighted estimate of conditional relative risk; CI, confidence interval.

rates of impairment there were weak indications of improvements in composite scores from age 23 to age 28 for VLBW, with this being more pronounced for clinical impairment rates (e.g. percentage of VLBW adults impaired in global executive function was reduced from 17.0% to 10.4%). Similar trends were observed when rates of impairment were compared on each of the 10 subscales of the BRIEF-A in Table 2.

To examine the extent to which each participant's perceptions of their own executive functioning might be corroborated by parental/partner observations, their ratings were compared. Based on the parent/partner ratings, the effects were generally in the direction of weaker executive functioning in VLBW compared with FT supporting the validity of self-reported executive function ratings (Table S2). A generally similar, but weaker, pattern of results was found in Table S3. This analysis, based on the total combined cohort, compared parental/partner executive function ratings between those participants who reported experiencing impaired executive functioning and those who did not. Reflecting these findings, the correlation between respondents self-reported overall executive composite score and their parent/partner-reported total executive function score was 0.34 (95% CI: 0.23, 0.44) in the whole cohort.

3.2 | Executive functioning from age 23 to age 28 years

To test for group and age effects on self-reported executive functioning over time, the repeated measures data summarised in Table 2 were analysed using weighted semi-parametric estimation. The mean composite scores and the percentage impaired were modelled separately as a function of age and group status (see Table 3). In the continuous outcome models, there was a consistent reduction in mean scores (i.e. fewer behavioural symptoms) from age 23 to 28; using the BRIEF-A normative population SD (SD = 10) as reference, the mean difference estimates (range −1.69 to −1.82) equate to a Cohen's d of between 0.17 and 0.18. However, between-group differences were very modest ($d = 0.02$–0.11). In the dichotomous outcome model, adults born VLBW were 2.37–6.03 times more likely to perceive their executive functioning difficulties to be in the impaired range compared with adults born FT across all three composite measures. There were only modest reductions in risks of impairment with age (RRs 0.75–0.85). Extension of the fitted models to test for age by group interactions showed a significant interaction for behavioural regulation reflecting a greater reduction in impairment with age among VLBW than FT. For VLBW, the risk of impairment in behavioural regulation at age 28 was 0.25 (95% CI: 0.07, 0.87) times that of the risk at 23. There was no evidence of group by age interactions for other outcomes.

3.3 | Executive function and socio-economic outcomes at age 28

At age 28 years, VLBW adults obtained lower mean socio-economic index scores than FT adults (mean (SD): VLBW 42.1 (16.8) vs FT 48.9 (16.2)) and were less likely to own their own home (VLBW 18.8% vs FT 30.0%). Cross-sectional analyses reported in Table S5 show negative associations between global executive scores and both outcomes, reflecting general tendencies for both rates of home ownership and mean socio-economic index to decline with increasing global executive scores (increasing impairment). These findings are illustrated graphically in Figure 3, which shows the fitted regression lines from the regression model for each association, estimated separately by group. To highlight the effects of group and global executive scores, the fitted lines are evaluated at the constant levels of sex, ethnicity and parental socio-economic
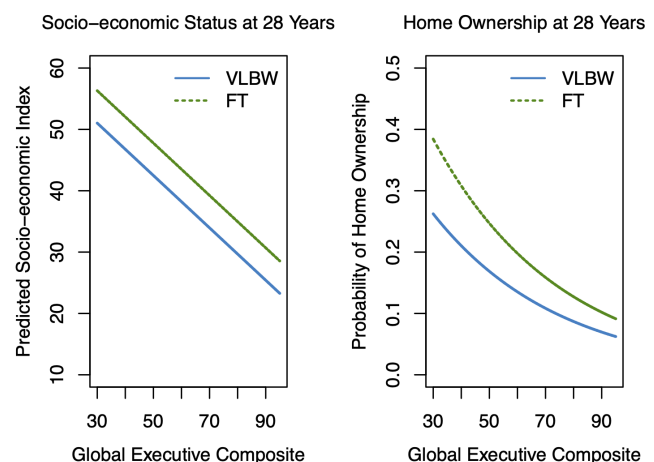
FIGURE 3 Executive function and socio-economic outcomes at 28 years

status using the proportions of male and indigenous Māori/Pacific adults in the cohort and parental socio-economic status centred at the mean. The figure clearly illustrates the negative associations of global executive composite with both outcomes and the consistently poorer socio-economic outcomes of VLBW compared with FT adults.

4 | COMMENT

4.1 | Principal findings

Results from this follow-up of a national cohort suggest that most VLBW adults perceived that they were functioning well in terms of their executive functioning in everyday contexts. Across both study groups (VLBW and FT), there was a small improvement in composite executive function scores from 23 to 28 years, with a corresponding decrease in the proportion of adults meeting criteria for executive function impairment. By age 28 years, VLBW adults, on average, scored similarly to their FT-born adult peers. However, there was a consistent group difference in impairment rates from 23 to 28 years with a higher proportion of VLBW adults experiencing clinically significant executive function impairment compared with FT adults. Additionally, the VLBW adults had lower average socio-economic index scores and were less likely to own homes than FT adults at age 28 years. The self-perceived global executive difficulties were associated with both lower socio-economic index scores and likelihood of home ownership.

4.2 | Strengths of the study

The relevance and validity of these study findings are supported by several study strengths. This is a population-based study that assessed VLBW survivors at an older age than most other studies, important due to the late maturation of executive function skills. One of very few meta-analyses on VLBW and/or VPT adult outcomes included a very limited number of studies involving cohorts aged over 25 years.[15] Our study also examined executive functioning to 26–30 years in relation to important socio-economic outcomes such as occupation and home ownership. Moreover, repeated measurement shed light on the developmental change in global executive function over time. The measure used here demonstrated strong psychometric properties, and the internal consistency proved adequate for this study cohort. Self-report measures of self-regulation generally have high test–retest reliability and may assess different aspects of executive function from behavioural task-based measures.[3,39] The BRIEF-A scale provides an ecologically valid measure of an individual's perceived executive function problems in an everyday context.[40] It is also shown to be superior in predicting impairments across measures of occupational adjustment than performance-based measures.[7] This proved to be an important strength when examining the second aim of the study, which looked at the associations between executing functioning and occupation-based socio-economic outcomes.

4.3 | Limitations of the data

The current study also has several limitations. Despite comparatively high participant retention, not all of the original cohort were followed to age 28 years, potentially introducing unmeasured bias in effect estimations. The data were assumed to be missing at random although this assumption cannot be empirically verified. Second, repeated executive function measures were only available at two time points that were quite close in time limiting our investigation to the studied age group. Longer term follow-up assessments of executive functioning would further help ascertain patterns of variation across time and evaluate the impact of ageing and its associated brain changes on executive function. Examination of how self-reported executive functioning relates to performance in standardised testing conditions would also be helpful since it is possible that each may potentially measure different but overlapping cognitive and behavioural aspects of executive function.[18,23] Despite these limitations, our findings suggest the need for ongoing evaluation and support of executive function during adulthood to minimise the impact on health and socio-economic well-being. Our findings also emphasise the importance of monitoring and supporting the development of executive function at younger ages when these skills may be more malleable to improvement and before they adversely affect the educational trajectories and life course opportunities of children born VPT/VLBW.

4.4 | Interpretation

Our results show that by age 28 years, the VLBW adults perceived themselves to be functioning in a similar manner to their FT adult peers based on their global everyday executive functioning scores. This is consistent with findings from the Helsinki Cohort which also found similar self-reported executive functioning between VLBW and FT-born adults.[23] It is worth noting that rates of impairment in both groups were lower than those found in previous studies.[26,41] Since the cohort was nationally representative, the cohort was not particularly from socially deprived backgrounds, and a wide range of socio-economic backgrounds were represented as suggested by the reasonably good proportion of parents who had tertiary qualifications. Another potential explanation could be the use of test norms for defining impairment rather than the mean of FT comparison group which would be more representative of our control population. However, replication of analyses defining impairment based on the score distribution of the FT group revealed impairment rates in a similar range as those based on normative data. In addition, 1.5SD above the mean for a normally distributed variable suggests an impairment rate of around 6–7% of the control population confirming that our rates are within the plausible range.

Of note, despite most of the VLBW cohort perceiving themselves as functioning as well as the FT adults by age 28, there was a clear sub-group who were experiencing relatively high levels of executive dysfunction in an everyday context. Hence, both types of outcomes should be considered when assessing the extent of difficulties for VLBW survivors. Our results suggest that VLBW adults continue to experience executive functioning difficulties, and those with more problems are generally able to recognise these difficulties within themselves as suggested by the concordance between participant's self-reported impairment and the reports of their parents or partners.

Although the group differences in impairment rates seem to persist, both groups report improved functioning with increasing age when executive functioning scores were examined. This may reflect (a) actual improvement in executive function; (b) selective processes associated with lifestyle changes post school years that are in line with abilities and competencies or (c) some combination of a and b. It is well documented that VLBW survivors are less likely to engage in risk taking behaviours than their peers.[28,29] Parental monitoring is also heightened[27] which may mean that their lives may be somewhat differently structured and that their daily activities may involve less cognitively demanding tasks.[18] In line with this possibility, adults born VLBW have been found more likely to be unemployed and have lower average personal income suggesting different demands and opportunities in life, an important finding supported by our study.[42] The differences in outcomes between self-report and parent or direct assessment show that it is important to consider multiple types of assessments.[28,29,41,43,44] Supplementing neuropsychological measures with self-assessment is also recommended, especially given that the dimensional self-assessment covers subclinical ranges of symptoms and behaviours that cannot be measured through other means.[44] It is also important to give voice to these individuals' own perceptions of their well-being and quality of life.

Difficulties in executive functioning can lead to maladaptive behaviours and outcomes, which can in turn impact academic, social and communication skills and influence general quality of life.[12,45,46] Some previous reports on VLBW adult outcomes have highlighted lower educational attainment, earning potential and greater reliance on social welfare and benefits[21,47–52] causing concern that this may lead to longer term social disparities between VLBW adults and their FT-born peers. Consistent with these findings, we also found that by age 28, VLBW adults had, on average, lower socio-economic status and were less likely to own a home compared with their FT counterparts. Furthermore, VLBW adults' executive functioning was related to their socio-economic outcomes at age 28 years after accounting for the effects of sex and ethnic differences, as well as family of origin socio-economic background. These findings highlight the importance of everyday executive functioning skills,[21] and the possibility that ongoing challenges may exacerbate, or at least maintain, the earlier gap in developmental trajectories between VLBW and FT-born individuals.[24,25,53]

Although survival has improved greatly for infants born VPT/VLBW,[54,55] adult outcomes show long-term disadvantages in executive functioning, which in turn, may reduce chances for social and economic prosperity and independence. This result is concerning given recent findings that executive function impairment based on parent-rated BRIEF-A were worse among more contemporary populations of extremely preterm or low birthweight school-age children than older cohorts in the state of Victoria, Australia.[13] Together, these findings suggest that executive functioning is an important aspect of behavioural and cognitive functioning worthy of ongoing monitoring alongside efforts to mitigate the longer term adverse effects of VPT/VLBW birth.

5 | CONCLUSIONS

Our study demonstrated that most VLBW adult survivors score similarly to FT adults in self-reported executive functioning, but there was also a pattern of greater variability in their scores. The analyses addressing this variation indicate potentially continued disadvantages in perceived executive function between VLBW and FT-born adults with a greater proportion of VLBW adults experiencing impaired global executive function. However, the results also suggest a general improvement in perceived executive functioning for both groups from age 23 to 28 years. The executive functioning difficulties were also related to socio-economic outcomes at 28 years with a greater level of dysfunction associated with lower socio-economic status and chance of home ownership. The adults born VLBW, on average, scored lower on the socio-economic index than the FT born peers and these differences remained after taking into consideration one's perceived executive functioning. Longer term follow-up studies are needed to confirm these findings and to examine the developmental trajectory of executive function problems as this population age.

CONFLICT OF INTEREST

The authors have no potential or perceived conflict of interest relevant to this work to disclose.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

FINANCIAL DISCLOSURE

The authors have no financial relationships relevant to this work to disclose.

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