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ORIGINAL ARTICLE

# Visual function in adults born preterm with very low birth weight—A two-country birth cohort study

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## Abstract

**Purpose:** The purpose of the study was to investigate visual function and vision-related general health in adults that were born preterm with very low birth weight (VLBW: birth weight < 1500 g) in their 30s–40s.

**Methods:** We recruited 137 adults born preterm with VLBW and 158 term-born controls aged 31–43 years from two birth cohorts: the Helsinki Study of Very Low Birth Weight Adults (Finland) and the NTNU Low Birth Weight in a Lifetime Perspective study (Norway). We used neonatal data and measured refraction, best-corrected visual acuity (BCVA) using the Early Treatment Diabetic Retinopathy Study (ETDRS) chart, contrast sensitivity, visual fields, intraocular pressure (IOP), self-reported vision-targeted health status with the National Eye Institute Visual Function Questionnaire-25.

**Results:** VLBW adults had a lower BCVA ETDRS score than controls: mean (SD) better eye 86.7 (13.4) versus 90.2 (4.4), $p = 0.02$; mean (SD) worse eye 82.3 (14.9) versus 87.6 (4.6), $p = 0.003$. VLBW adults also had lower contrast sensitivity thresholds in several spatial frequencies and scored lower than controls in eight out of the 12 subscales of self-reported vision-targeted health status. Refraction, visual fields and IOP were similar between groups. Two VLBW participants were blind. None had been treated for retinopathy of prematurity.

**Conclusion:** We suggest that lower visual function and vision-related health represent life-long consequences of prematurity and VLBW in the studied 31- to 43-year-old cohort. The underlying mechanisms remain to be determined.

**KEYWORDS**
adult, contrast sensitivity, premature, preterm, very low birth weight, vision, visual function

Maarit Kulmala and Anna Perregaard Munch Jørgensen shared first authorship.

# 1 | INTRODUCTION

Survivors of preterm birth constitute a substantial and increasing part of the population, with 15 million children being born preterm per year worldwide (Chawanpaiboon et al., 2019). Even though the survival has considerably increased in high-resource settings during the recent decades, morbidity following preterm birth with very low birth weight (VLBW; birthweight < 1500 g) has not shown similar progress (Bell et al., 2022; Fanaroff et al., 2007; Stoll et al., 2010, 2015), leading to an increase in the number of newborns at risk of disease related to prematurity. The first generations of individuals born preterm with VLBW in the era of early neonatal intensive care are now in their 40s. While most lead healthy lives, on average what has been coined the 'preterm phenotype' (Kajantie et al., 2021) is characterised by higher cardiopulmonary disease risk factors including hypertension (Hovi et al., 2016), lower cognitive (Evensen et al., 2022) and motor abilities (Husby et al., 2013), introvert behaviour and anxiety (Pyhälä et al., 2017) and lower rates of self-reported physical activity (Evensen et al., 2022). Furthermore, loss of the major sensory function of vision is a part of this phenotype at least in young adulthood and could in part contribute to poorer motor skills and reduced physical activity (Evensen et al., 2009). The first observations of young adults born preterm suggest that up to 50% have reduced visual function, ~2% are blind and visual acuity (VA) is lower than in term-born peers (Darlow et al., 2018; Hellgren et al., 2016; Jain et al., 2022; Lindqvist et al., 2007; Marlow et al., 2005; Pétursdóttir et al., 2020; Thompson et al., 2014). This reduced visual function has been described even in the absence of retinopathy of prematurity (ROP). While the underlying mechanisms and sites of injury are unknown, it is conceivable that visual impairment is one of the life-long consequences of being born preterm and that it may impact function in other areas of life. However, very little is known about such impairments beyond childhood (Kajantie et al., 2021). We hypothesised that adults in their 30s–40s born preterm with VLBW had lower visual function and lower self-perceived vision-targeted health compared with term-born peers. We tested this hypothesis in a combined study of two cohorts of adults born preterm with VLBW and controls born at term between 1978 and 1988.

# 2 | MATERIALS AND METHODS

## 2.1 | Study design

Participants were recruited from the Helsinki Study of Very Low Birth Weight Adults (HeSVA) in Finland (born in 1978–1985) and the NTNU Low Birth Weight in a Lifetime Perspective study (NTNU LBW Life) in Norway (born in 1986–1988). The HeSVA is a geographically defined birth cohort while the NTNU LBW Life study is a hospital-defined cohort of VLBW participants and geographically defined cohort of term-born controls. Ophthalmologic data collection was executed as a joint study with harmonised study protocols and methods at both sites (Helsinki, Finland and Trondheim, Norway) between 11 September 2019 and 22 January 2021. It included an eye examination and a measurement of self-reported vision-targeted health status via the National Eye Institute Visual Function Questionnaire-25 (NEI VFQ-25) and was part of a larger data collection that included somatic health, motor and physical tests and self-report questionnaires.

## 2.2 | Study participants

The HeSVA included 335 infants born 1978–1985, discharged alive from the neonatal intensive care unit in Helsinki University Central Hospital, the only tertiary hospital serving the province of Uusimaa, Finland. Of them, 255 living in greater Helsinki were invited to a study visit in 2004–2005, and 191 provided data. At that time, we recruited controls born at term not small for gestational age (birth weight for gestational age > −2 SD) group-matched for sex, age and birth hospital; of the 314 controls invited, 190 participated (Hovi et al., 2007; Kajantie et al., 2010). Prior to the present data collection, three VLBW participants had died and therefore 188 form the eligible group in the present study (Figure 1). Of the 188 eligible VLBW and 190 eligible controls, seven controls had refused further contact and 13 VLBWs and 17 controls had no address in Finland. This left us with 175 VLBW and 166 controls to invite, of whom 92 (53%) and 90 (54%) participated.

In the NTNU LBW Life study, all live-born VLBW infants admitted to the neonatal intensive care unit at St. Olavs Hospital, Trondheim University Hospital, Trondheim, Norway between 1986 and 1988 were included ($n = 121$). Of them, 33 died in the neonatal period and five were excluded due to congenital malformations, syndromes or multimorbidity. Term-born controls were born to mothers recruited to a multicentre study in pregnancy (Bakketeig et al., 1993). They were born after gestational week 37 with a birth weight > 10th percentile for gestational age, corrected for sex and parity ($n = 120$). Two were excluded due to congenital malformations. Of the 83 eligible VLBW and 118 eligible controls, one VLBW and three controls had previously refused contact, eight VLBW and nine controls had no known address and two in each group were living abroad. Of the 72 invited VLBW participants, 27 did not consent and 45 (63%) were assessed. Of the 104 invited participants, 36 did not consent and 68 (65%) were assessed.

In total, 295 out of the 517 invited participants from the two cohorts were recruited, 137 in the VLBW group and 158 in the control group, giving a follow-up rate of 57% (Figure 1).

## 2.3 | Background data

Neonatal background data had previously been collected from medical records in both study cohorts. The best obstetric estimate of gestational age was based on the last menstrual period if ultrasound confirmation was not available. In HeSVA, it was confirmed after birth by Dubowitz examination by a single neonatologist. At the time the participants were born, the screening programmes for retinopathy of prematurity (ROP) were yet

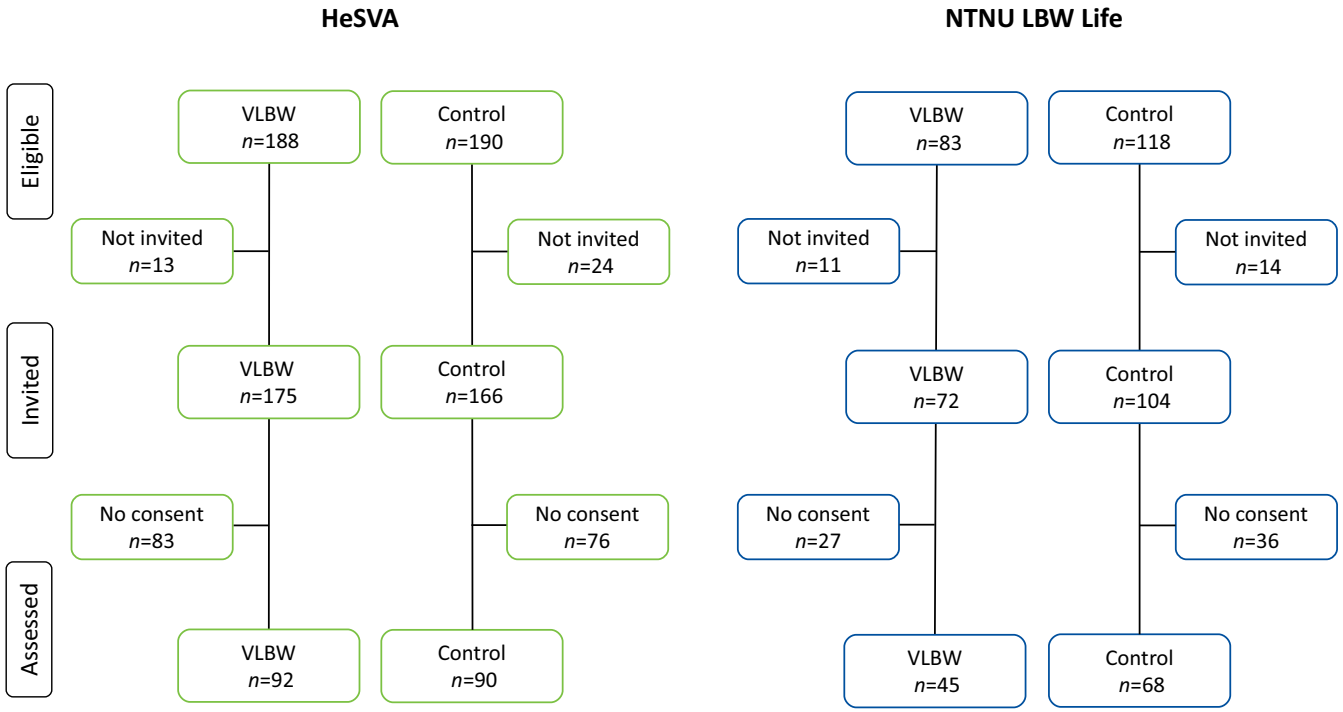


**FIGURE 1** Flow diagram of study participants in the Helsinki Study of Very Low Birth Weight Adults and the NTNU Low Birth Weight in a Lifetime Perspective study. Left: Flow diagram of the HeSVA cohort. HeSVA includes 335 infants born 1978–1985, discharged alive from the neonatal intensive care unit in Helsinki University Central Hospital, the only tertiary hospital serving the province of Uusimaa, Finland. Of them, 255 living in greater Helsinki were invited to a study visit in 2004–2005, and 191 provided data. Prior to the present data collection, three had died and therefore 188 form the eligible group in the present study. In 2004–2005, controls born at term not small for gestational age (birth weight for gestational age > −2 SD) group-matched for sex, age and birth hospital were recruited. Of the 314 controls invited, 190 participated. These 190 form the eligible group in the present study. Of the 188 eligible VLBW and 190 eligible controls, seven controls had refused further contact and 13 VLBWs and 17 controls had no address in Finland. This left us with 175 VLBW and 166 controls to invite, of whom 92 (53%) and 90 (54%) participated. Right: Flow diagram of the NTNU LBW Life cohort. In the NTNU LBW Life all live-born VLBW infants admitted to the neonatal intensive care unit at St. Olavs hospital, Trondheim University Hospital, Trondheim, Norway between 1986 and 1988 were included ($n = 121$). Of them, 33 died in the neonatal period and 5 were excluded due to multimorbidity, leaving 83 as eligible to participate in the present study. Term-born controls born after gestational week 37 with a birth weight > 10th percentile were included at birth ($n = 120$). Two were excluded due to multimorbidity, leaving 118 as eligible to participate in the present study. Of the 83 eligible VLBW and 118 eligible controls, one VLBW and three controls had previously refused contact and 10 VLBW and 11 controls had no address in Norway. Of the 72 invited VLBW participants, 27 did not consent and 45 (63%) were assessed. Of the 118 eligible controls, 3 had previously refused contact and 11 had no address in Norway. Of the 104 invited participants, 36 did not consent and 68 (65%) were assessed. HeSVA, Helsinki Study of Very Low Birth Weight Adults; NTNU LBW Life, NTNU Low Birth Weight in a Lifetime Perspective study; VLBW, very low birth weight.

not in effect in Finland and Norway, and data on ROP were not available in medical records to an extent that allowed analyses. None of the participants had been treated for ROP. Neurosensory impairments were defined as cerebral palsy, blindness, deafness (HeSVA) or hearing aid (NTNU LBW Life), intellectual disability (HeSVA) or IQ < 70 at 19, 14 or 5 years (NTNU LBW Life).

## 2.4 | Eye examination

Eye examinations were carried out by an ophthalmologist masked to group (MK in Finland and AJ in Norway). The right eye was examined before the left eye. Two VLBW participants were legally blind (visual acuity <20/200 Snellen) due to retrolental fibroplasia and could not undergo assessment of visual field, contrast sensitivity or refractive error. Spherical equivalent was calculated from subjective refraction. Astigmatism was recorded as an absolute cylinder and categorised into mild (0–0.75 D), moderate (1.0–2.25 D) or severe (>2.5 D). Subjective refraction was performed after autorefraction, and best-corrected visual acuity (BCVA) was obtained at 4 m according to the Early Treatment Diabetic Retinopathy Study (ETDRS) protocol (Brown et al., 2006) at standardised illumination. Both ETDRS letter scores and logarithm of the minimum angle of resolution (LogMAR) values were noted. Better eye was defined as the eye with the highest ETDRS letter score. If the letter score was equal in both eyes, the right eye was chosen as the better eye. Contrast sensitivity was tested with the best refractive correction at a constant mean luminance of 85 cd/m$^2$ using two different protocols due to different instrument availability at the two study sites: in HeSVA the functional acuity contrast test (F.A.C.T) using Functional Vision Analyser (Vistech, Optec Vision Tester, Stereo Optical Co., Chicago, IL) was applied and in NTNU LBW Life the CSV 1000E (Vector Vision, Haag-Streit). The F.A.C.T tests contrast sensitivity at five different spatial frequencies (1.5, 3, 6, 12 and 18 cycles per degree: [cpd]) with 9 levels of contrast, while the CSV 1000E tests at four spatial frequencies (3, 6, 12 and 18 cpd) with 8 levels of contrast. The lowest level of contrast that the participants could see was noted as the contrast sensitivity threshold. The F.A.C.T test was performed two to three times, whereas the CSV 1000E test was performed once. Contrast sensitivity of the NTNU LBW Life and

HeSVA cohorts were analysed separately because data of these instruments could not be compared interchangeably (Ulrich & Palmowski-Wolfe, 2019). Visual fields were tested using the macula 10–2 programmes of the Octopus 900 (Haag-Streit) in HeSVA and of the Humphrey Visual Field Analyser (Carl Zeiss Meditec AG) in NTNU LBW Life. One eye was tested at a time. Exclusion criteria were false negative or positive >15% and fixation losses>15%. Mean deficit/deviation (MD), pattern standard deviation (PSD) and square root of loss variance (sLV) were recorded. Intraocular pressure was measured with a rebound tonometer (iCare, Icare Oy).

### 2.5 | Self-reported vision-targeted health status

Self-reported vision-targeted health status was assessed with the National Eye Institute Visual Function Questionnaire-25 (NEI VFQ-25) (Mangione et al., 1998a, 1998b, 2001). The NEI VFQ-25 consists of 25 questions classified into 12 subscales: general health, general vision, ocular pain, near activities, distance activities, social functioning, mental health, role difficulties, dependency, driving, colour vision and peripheral vision. Each subscale was scored as an average of the list items in the subscale transformed to a 0–100 scale, where 100 represents the best possible score and 0 the worst. Information on whether the participant held a drivers' licence or not was obtained as part of the NEI VFQ-25 questionnaire. Questionnaires were mailed to participants prior to the study day and were completed on-site, returned via mail or completed online.

### 2.6 | Statistical analyses

Statistical analyses were performed using the SPSS software 28.0.0.0(190) (IBM SPSS Statistics). Normality was assessed by visual inspection of histograms and Q-Q plots of residuals. Due to some deviations from normality, bootstrapping was applied with B=2000 samples and bias-corrected and accelerated (BCa) method. General linear modelling was used to analyse the data, adjusted for age, sex and cohort (HeSVA or NTNU LBW Life). A $p$-value<0.05 was considered statistically significant. Participants (10 VLBW and 6 control) who had undergone refractive or cataract surgery were excluded from the analyses of refractive error and intraocular pressure (IOP). One VLBW participant with visual field (VF) defects due to traumatic brain injury in adulthood was excluded from VF analyses.

### 2.7 | Ethics

The study complied with the guidelines of the Declaration of Helsinki and was approved by the Regional Committee for Medical Research Ethics in Central Norway (23879) and the Ethics Committee IV of Helsinki University Hospital (HUS/1157) in Finland. The study had institutional approval by Helsinki University Hospital, Helsinki (Finland) and St. Olavs Hospital, Trondheim University Hospital (Norway). Written informed consent was obtained from all participants.

## 3 | RESULTS

Gestational ages were similar between the cohorts (Table 1). Two participants had obtained a diagnosis of retrolental fibroplasia at the age of 6 months (HeSVA) and were legally blind as adults. The proportion of participants who did not hold a driver's licence was 21% in the VLBW group and 8% in the control group ($p$=0.001).

### 3.1 | Refraction and best-corrected visual acuity

Mean ETDRS score was lower for both better and worse eye in the VLBW group compared with the control group (Table 2). In the VLBW group, 27 out of the 124 (22%) participants had an ETDRS letter score below 85 in their

**TABLE 1** Background characteristics of the very low birth weight (VLBW) and control group in the Helsinki Study of Very Low Birth Weight Adults and the NTNU Low Birth Weight Life in a Lifetime Perspective study.

| | VLBW *n*=137 | Control *n*=158 |
|---|---|---|
| Maternal age (years), mean (SD) | 29.7 (4.7) | 30.1 (4.8) |
| Gestational diabetes, yes | 0 | 1 |
| Multiple pregnancy, *n* (%) | 23 (17) | – |
| Birth weight (g), mean (SD) | 1150 (224) | 3645 (475) |
| Birth length (cm), mean (SD) | 37.2 (2.9) | 50.7 (1.8) |
| Head circumference at birth (cm), mean (SD) | 26.5 (2.2) | 35.2 (1.2) |
| Apgar 1 min, mean (SD) | 5.7 (2.5) | 8.7 (0.8) |
| Apgar 5 min, mean (SD) | 7.7 (2.1) | 9.8 (2.5) |
| Gestational age<28 weeks, *n* (%) | 40 (29) | – |
| Gestational age (weeks), mean (SD) | 29.5 (2.5) | 40.0 (1.2) |
| Patent ductus arteriosus, yes | 5 | – |
| Ventilation (days), median (interquartile range) | 3 (0–12) | – |
| Supplemental oxygen (days), median (interquartile range) | 9 (1–34) | – |
| RDS, *n* (%) | 79 (58) | – |
| BPD>36 postmenstrual weeks, yes | 13 | – |
| Sepsis, yes | 12 | – |
| HeSVA, *n* (%) | 92 (67) | 90 (57) |
| NTNU LBW Life, *n* (%) | 45 (33) | 68 (43) |
| Female, *n* (%) | 78 (57) | 93 (59) |
| Neurosensory impairment, *n* (%) | 15 (11) | 1 (0.006) |
| Age at follow-up (years), mean (SD) | 36.2 (3.2) | 35.7 (3.2) |
| HeSVA age at follow-up (years), mean (SD) | 38.0 (2.2) | 38.1 (2.3) |
| NTNU LBW Life age at follow-up (years), mean (SD) | 32.4 (0.7) | 32.6 (0.5) |

Abbreviations: BPD, bronchopulmonary dysplasia; HeSVA, Helsinki Study of Very Low Birth Weight Adults; NTNU LBW Life, NTNU Low Birth Weight in a Lifetime Perspective study; PROM, premature rupture of membrane; RDS, respiratory distress syndrome; VLBW, very low birth weight.

better eye, while in the control group the number was 17 out of 149 (11%). An ETRDS letter score of 85 is equivalent to LogMAR 0.0 or Snellen visual acuity of 1.0. The mean ETDRS score for those with a BCVA ETDRS below 85 was 71.9 letters in VLBW and 82.6 in controls. There was no difference in spherical equivalent.

## 3.2 | Contrast sensitivity

In the HeSVA cohort, the contrast sensitivity in the VLBW group was lower compared with the control group in the spatial frequencies of 3, 6 and 12 cycles per degree (cpd, $p \leq 0.03$). In the NTNU LBW Life cohort, contrast sensitivity was lower in the 6 cpd spatial frequency ($p < 0.01$). In both cohorts mean contrast sensitivity was lower across all spatial frequencies although not statistically significant for all (Figure 2).

## 3.3 | Intraocular pressure and visual fields

Mean IOP was 14.4 (3.5) mmHg in the VLBW group and 13.9 (3.2) mmHg in controls ($p = 0.31$). There were no differences between the VLBW and control group in any of the visual field parameters (MD, PSD and sLV).

## 3.4 | Self-reported vision-targeted health status

The VLBW group had significantly lower scores in self-reported vision-targeted health status measured by NEI VFQ-25 compared with the control group in most subscales, namely general health, general vision, ocular pain, near activities distance activities social functioning, role difficulties and peripheral vision (Figure 3).

**TABLE 2** Best-corrected visual acuity and refraction in the very low birth weight (VLBW) and control group in the Helsinki Study of Very Low Birth Weight Adults and the NTNU Low Birth Weight in a Lifetime Perspective study.

| | VLBW | | Control | | Mean difference | |
|---|---|---|---|---|---|---|
| | *n* (%) | Mean (SD) | *n* (%) | Mean (SD) | (95% CI)[a] | *p* |
| Better eye | | | | | | |
| Spherical equivalent (D) | 113 | −1.33 (2.39) | 143 | −1.08 (2.11) | 0.23 (−0.79 to 0.35) | 0.42 |
| Refraction | | | | | | |
| Emmetropia (−1.0 to +1.0D) | 61 (54.0) | | 92 (64.3) | | | |
| Mild hyperopia (1.0D–3.0D) | 3 (2.7) | | 4 (2.8) | | | |
| Moderate to strong hyperopia (>3.0D) | 3 (2.7) | | 1 (0.7) | | | |
| Mild myopia (−1.0D to −3.0D) | 25 (22.1) | | 30 (21.0) | | | |
| Moderate myopia (−3.0D to −6.0D) | 17 (15.0) | | 9 (6.3) | | | |
| high myopia (>−6.0D) | 4 (3.5) | | 7 (4.9) | | | |
| Astigmatism | | | | | | |
| Mild (0–0.75D) | 81 (71.7) | | 113 (79.0) | | | |
| Moderate (1.0–2.25D) | 27 (23.9) | | 28 (19.6) | | | |
| Strong (>2.5D) | 5 (4.4) | | 2 (1.4) | | | |
| BCVA | | | | | | |
| ETDRS letter score | 124 | 86.7 (13.4) | 149 | 90.2 (4.4) | −3.8 (−6.6 to −1.5) | 0.02 |
| LogMAR | 124 | 0.001 (0.41) | 149 | −0.09 (0.10) | 0.1 (0.04 to 0.17) | 0.08 |
| Worse eye | | | | | | |
| Spherical equivalent (D) | 113 | −1.42 (2.91) | 143 | −1.25 (2.11) | 0.12 (−0.76 to 0.48) | 0.72 |
| Refraction | | | | | | |
| Emmetropia (−1.0 to +1.0D) | 60 (53.1) | | 91 (63.6) | | | |
| Mild hyperopia (1.0D-3.0D) | 4 (3.5) | | 3 (2.1) | | | |
| Moderate to strong hyperopia (>3.0D) | 4 (3.5) | | 0 (0.0) | | | |
| Mild myopia (−1.0D to −3.0D) | 21 (18.6) | | 31 (21.7) | | | |
| Moderate myopia (−3.0D to-6.0D) | 16 (14.2) | | 11 (7.7) | | | |
| High myopia (>−6.0D) | 8 (7.1) | | 7 (4.9) | | | |
| Astigmatism | | | | | | |
| Mild (0–0.75D) | 79 (69.9) | | 119 (83.2) | | | |
| Moderate (1.0–2.25D) | 26 (23.0) | | 23 (16.1) | | | |
| Strong (>2.5D) | 8 (7.1) | | 1 (0.7) | | | |
| BCVA | | | | | | |
| ETDRS letter score | 124 | 82.3 (14.9) | 149 | 87.6 (4.6) | −5.58 (−8.6 to −2.9) | 0.003 |
| LogMAR | 124 | 0.10 (0.56) | 149 | −0.05 (0.09) | 0.15 (0.08 to 0.23) | 0.02 |

Abbreviations: BCVA, best-corrected visual acuity; D, dioptre; ETDRS, Early Treatment of Diabetic Retinopathy Study; logMAR, logarithm of the Minimal Angle of Resolution; VLBW, very low birth weight.

[a]Adjusted for cohort, age and sex. *p*-Values based on bias-corrected and accelerated bootstrap (BCa).

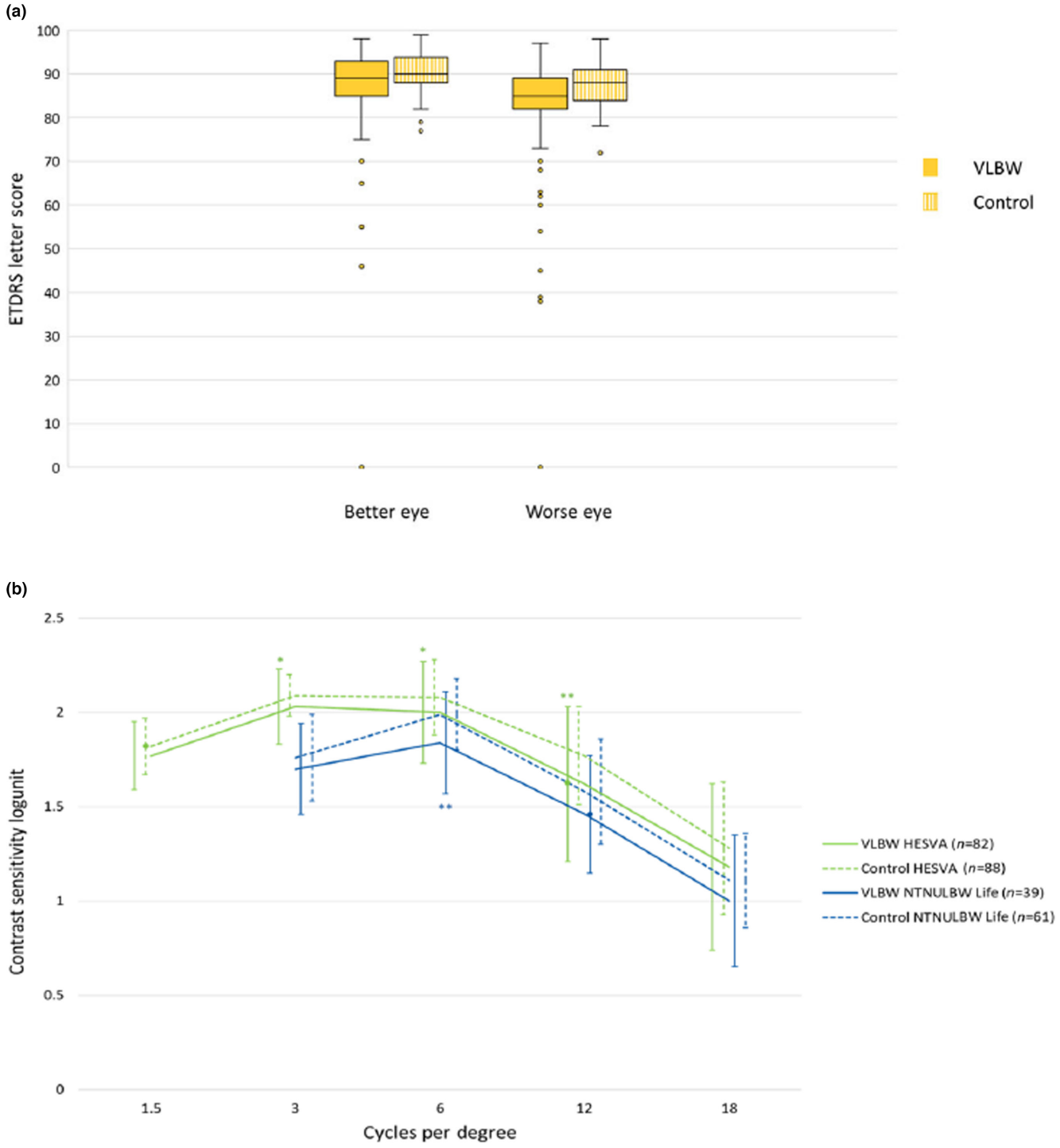


**FIGURE 2** Best-corrected visual acuity and contrast sensitivity in the Helsinki Study of Very Low Birth Weight Adults and the NTNU Low Birth Weight in a Lifetime Perspective study. (a) Best-corrected visual acuity group in the better and worse eye of the VLBW and Control in the Helsinki Study of Very Low Birth Weight Adults and the NTNU Low Birth Weight in a Lifetime Perspective study. Data are presented as median and interquartile range. (b) Contrast sensitivity in the better eye of the VLBW and Control group in the Helsinki Study of Very Low Birth Weight Adults and in the NTNU Low Birth Weight in a Lifetime Perspective study. Data are presented as mean and standard deviations. *$p<0.05$, **$p<0.01$. ETDRS, Early Treatment Diabetic Retinopathy Study; HeSVA, Helsinki Study of Very Low Birth Weight Adults; NTNU LBW Life, NTNU Low Birth Weight in a Lifetime Perspective study; VLBW, very low birth weight.

### 3.5 | Sensitivity analyses

Sensitivity analyses were performed without participants that had a neurosensory impairment. Following sensitivity analyses differences in contrast sensitivity in the spatial frequency of 6 cpd in the HeSVA cohort and three out of eight domains of the NEI VFQ-25 questionnaire (general vision, near activities and social functioning) were no longer statistically significant.

## 4 | DISCUSSION

We found that 31–43-year-old adults born preterm with VLBW in the late 1970s and 1980s had lower visual function and self-reported vision-targeted health status than their peers born at term. These results confirm that lower visual function is not only confined to the few individuals born preterm with VLBW that suffer from sequelae from ROP and that

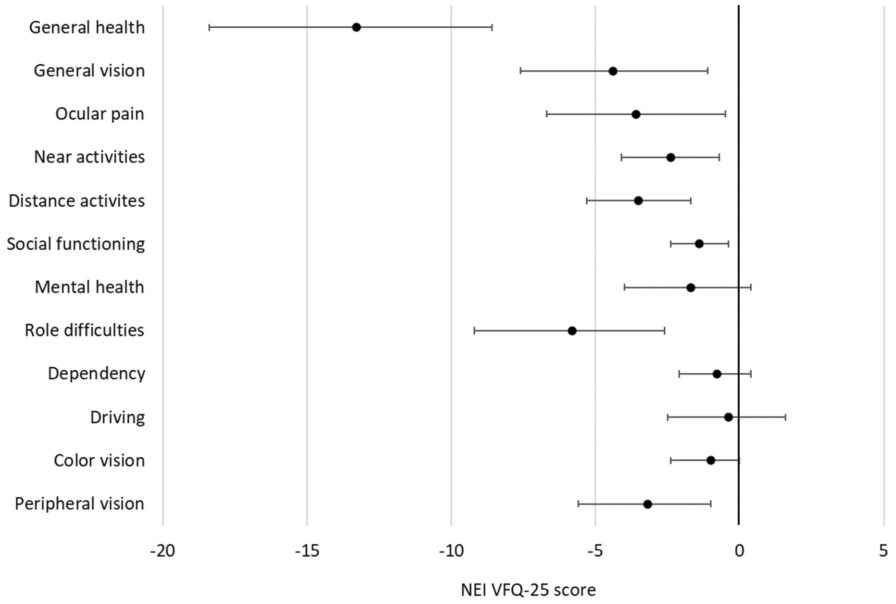


**FIGURE 3** Self-reported vision-targeted health status mean difference (95% CI), adjusted for cohort, age and sex in adults born very low birth weight ($n=136$) compared with controls ($n=156$) in the Helsinki Study of Very Low Birth Weight Adults and the NTNU Low Birth Weight in a Lifetime Perspective study. Abbreviations: NEI VFQ-25, National Eye Institute Visual Function Questionnaire- 25.

visual impairments are examples of the life-long consequences of prematurity.

The strength of this study is that a joint data collection with rigorous and extensive ophthalmological examinations as well as vision-targeted health status examination has been performed in two adult follow-up studies from a Nordic population. Methods were harmonised and examiners followed a common study protocol. Furthermore, all participants were examined by a single ophthalmologist at each site, and the examiner was masked to group status. Weaknesses include the loss to follow-up of 43%, which although to be expected in long-term studies, represent a considerable proportion of the cohorts. Furthermore, the NEI VFQ-25, although being the most recognised patient-related outcome measure of visual function, has not been validated in Norwegian and Finnish populations other than one study on Norwegian patients with age-related macular degeneration (Jelin et al., 2019).

Previous studies have reported lower BCVA in VLBW individuals at the age of 14–15 years, at the age of 19 years in extremely preterm (<25 gestational weeks) born individuals (Jain et al., 2022) and at the age of 25–29 years in VLBW individuals (Darlow et al., 2018; Pétursdóttir et al., 2020). However, we show for the first time that reduced visual acuity extends to adults in their 30s–40s and that it is accompanied by lowered contrast vision and self-perceived, vision-related health and well-being.

At the time, the HeSVA and NTNU LBW Life participants were born, there was not any screening programme for ROP. The first screening programme guidelines for ROP in the Nordic countries were published in 1993 (Holmström et al., 1993). The fact that two participants received a diagnosis of retrolental fibroplasia in early childhood is testimony to the lack of an ROP screening programme in Finland and Norway at the time of study recruitment in the 1970–80s. Even though participants were born in the early era of neonatal intensive care, a lack of a ROP screening programme is distinctly different from the treatment today, and this is also true for other aspects of modern neonatal intensive care with for instance only few receiving currently standard medication with surfactant, antenatal glucocorticoids and protein fortifications.

VLBW participants of these large cohorts reported lower vision-targeted health compared with term-born controls, indicating that vision has a significant impact on daily living. The number of VLBWs without a driver's licence was higher (21%) than in the control group (8%). Interestingly, these numbers are consistent with numbers from a younger VLBW cohort in New Zealand where 23% in the VLBW and 5% in the control group did not hold a driver's licence at age of 25–29 years (Darlow et al., 2018). Good vision is a prerequisite for being able to drive. It is conceivable that a self-perceived problem with vision may prevent individuals born preterm from obtaining a driver's licence.

The cause of visual impairments in this large group of preterm-born survivors is thus far undescribed but may conceivably be a consequence of injury to either the central macula or the visual axis that extend from the retina via the optic nerve through the optic radiation to the visual cortex or a combination. Indeed, it has been proposed that lower visual function in preterm-born individuals has a common underlying mechanism with injury to neurovascular tissue in both the retina and the brain, in a syndrome that has been coined Visuopathy of Prematurity (VOP) (Ingvaldsen et al., 2021). The present study supports this hypothesis. VOP may have substantial consequences on life chances by contributing to other components of the adult preterm phenotype such as poorer motor skills, lower levels of physical activity or difficulties in establishing social relationships, which may in part underlie the finding that VLBW adults are less likely to partner and reproduce (Kajantie et al., 2021).

## 5 | CONCLUSION

Adults who were born preterm with VLBW had lower visual function and self-reported vision-targeted health than term-born controls. The precise mechanisms for this remain to be determined. These results show that lower visual function is one of the life-long consequences of being preterm.

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