Binocular co-ordination of saccades in children born preterm

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Abstract
Introduction:
Binocular co-ordination of saccades is impaired in subjects with strabismus, where intrasaccadic disconjugacy can be in the region of $1.8^\circ$. Preterm children are at increased risk from a number of cerebral lesions resulting in visual and oculomotor deficits. We have extended our investigation of monocular oculomotor control to examine the conjugacy of binocular saccades in children born preterm.

Methods:
We compared 8 preterm children (aged 9-10 years) with normal IQ (>85) who were free from major neurological deficit and 7 full term age matched controls. Subjects viewed a monitor binocularly from 57cm with their head stabilized. Eye movements were recorded using infrared oculography. Intra-saccadic disconjugacy and post-saccadic vergence drift 75ms and 150ms after the peak disconjugacy were measured.

Results:
The amplitude of saccade disconjugacy was larger for preterms (convergent: $1.6\pm0.9^\circ$; divergent: $1.9\pm0.9^\circ$; mean±sd) compared to full term controls (convergent: $1.4\pm0.5^\circ$; divergent: $1.2\pm0.5^\circ$); these differences did not reach statistical significance ($p=0.7/0.2$). Post-saccadic drift at both 75ms and 150ms was also larger for the preterm group compared to the controls, but again did not reach statistical significance.

Conclusion:
The preterm group showed small, statistically insignificant, deficits of binocular co-ordination of saccades in comparison to age-matched full term controls. The lack of statistical significance may be due to the small sample size and variability in the preterm group. The findings are however consistent with other oculomotor deficits that we have found in preterm children.

Keywords
Preterm, saccade, binocular, saccade disconjugacy, post-saccadic drift

Introduction
Advances in medical technology over the past 20 years have meant that the chance of survival of preterm (< 32 weeks) infants has dramatically increased (1; 2). The survivors however, are at increased risk of suffering from a number of cerebral lesions resulting from haemorrhage or ischaemia due to difficulty with the auto-regulation of cerebral blood flow. These include periventricular leucomalacia (3), intraventricular haemorrhage (4), reduction in the volume of the caudate nucleus (5), pulvinar lesions (6) and cerebellar haemorrhages (7; 8). Not surprisingly there is an increased incidence of visual dysfunction (9; 10), general cognitive dysfunction (11) and potential for specific reading difficulties (12). In previous work
experiments, we have examined monocular oculomotor control in preterm children and found significantly increased anti-saccade error rates and more subtle increases in smooth pursuit latency, compared to full term age matched controls (13). Given the increased incidence of strabismus in preterms, and that binocular co-ordination of saccades is impaired in subjects with strabismus (14) we have extended our investigation of monocular oculomotor control to examine the conjugacy of binocular saccades in children born preterm.

Material and Methods
We compared 8 preterm children (aged 9-10 years) with normal IQ (>85) who were free from major neurological deficit and strabismus (LogMar acuity 0.5 or better) with 7 full term age matched controls. Subjects viewed a monitor binocularly from 57cm with their head stabilized. Eye movements were recorded using infrared oculography (IRIS, Skalar Medical, Delft, Netherlands; spatial resolution <0.1°). Visual stimuli were generated by a Visual Stimulus Generator 2/5 (Cambridge Research Systems, Rochester, UK). The target consisted of a small dark square (0.3° x 0.3°) presented on a light background (contrast 90%) and each trial commenced with a fixation target appearing in the centre of the display for a random period of 0.5-1.5s. A saccade target then appeared randomly 5° to the left or right of fixation. Subjects were exposed to 52 trials in each experimental run, followed by 24 calibration trials. The output from the eye-tracker was digitised with 16-bit precision at 1kHz using a CED Power 1401 interface (Cambridge Electronic Design, Cambridge, UK), and data written to hard disk for off-line analysis. Intra-saccadic disconjugacy and post-saccadic vergence drift were measured 75ms and 150ms after the peak disconjugacy.

Results
The amplitude of saccade disconjugacy was larger for preterms (convergent: 1.6±0.9°; divergent: 1.9±0.9°; mean±sd) compared to full term controls (convergent: 1.4±0.5°; divergent: 1.2±0.5°; Fig 1); these differences did not reach statistical significance (p=0.7/0.2).

Fig 1
Distribution of saccade disconjugacy
Post-saccadic drift was also larger for the preterm group at both 75ms and 150ms (at 75ms: convergent: $1.5\pm0.8^\circ$; divergent: $1.7\pm1.0^\circ$; at 150ms: convergent: $1.8\pm0.7^\circ$; divergent: $1.7\pm0.6^\circ$; mean±sd) compared to the controls, (at 75ms: convergent: $1.2\pm0.7^\circ$; divergent: $1.1\pm0.6^\circ$; at 150ms: convergent: $1.4\pm0.9^\circ$; divergent: $1.1\pm0.6^\circ$; mean±sd) but again did not reach statistical significance (75ms convergent/divergent p=0.5/0.2; 150ms convergent/divergent p=0.4/0.1).

**Discussion**
This investigation aimed to determine if the group of preterms could maintain binocular co-ordination during saccades in comparison to full terms. Whilst static binocular control has been shown to be impaired in preterm children (who were free from major neurological impairment) (10), to our knowledge dynamic binocular control during saccades has not been previously investigated. Binocular co-ordination of this nature is necessary in order to prevent misalignment when changing fixation from one point to another.

We found the preterm group to have small, statistically insignificant, deficits of binocular co-ordination of saccades in comparison to age-matched full term controls. This is surprising given the increased risk of lesions affecting the oculomotor system in this group and the increased incidence of strabismus. The lack of statistical significance may be due to the small sample size and variability in the preterm group or because the preterm children in our sample were a selected sub-group who were free from major neurological insults with normal IQ. The tendency towards greater disconjugacy and post-saccadic drift is however consistent with other oculomotor deficits that we have found in this group (13). We are currently recruiting more subjects and controls that will enable us to draw a firmer conclusion.
References


