103

Rod sensitivity recovery in the older eye

Laura Patryas[1], Neil RA Parry[2], Dave Carden[1], Tariq Aslam[2] & Ian J Murray[1]

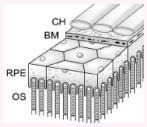
[1]Faculty of Life Sciences, University of Manchester, UK

[2]Manchester Royal Eye Hospital, UK

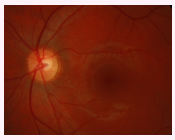
Email: laura.patryas@manchester.ac.uk

1. Introduction

Dark adaptation becomes slower with age [1]. The underlying cause for this is not well understood but may be related to structural changes in the Bruch' s membrane-Retinal Pigment Epithelium (RPE) complex.



The potential of nutritional intervention to slow down the effects of ageing on dark adaptation kinetics has not been explored.



The macular pigment (composed of lutein and zeaxanthin) has recently been studied in the context of scotopic vision. Research shows that higher levels of the pigment preserve scotopic sensitivity in older, retinally normal adults [2] and improve the rate of S2 rod recovery in early stage age-related macular degeneration patients [3].

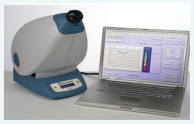
Our aims were, first, to characterise the rate of scotopic sensitivity decline with age using CRT-based dark adaptometry and, second, to compare dark adaptation data with the macular pigment optical density (MPOD).

2. Methods

Subjects

33 subjects were recruited and divided into 2 groups: older group (≥ 45 years old, n = 16, mean age 57.44 ±7.98) and younger group (<45 years old, n = 17 mean age 25.12 ±6.08).

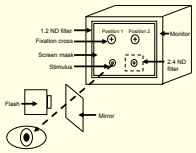
Macular pigment measurement



MPODs were determined using the principle of heterochromatic flicker photometry. Subjects responded to the appearance of flicker as the temporal frequency of blue-green flickering lights was reduced. The luminance ratio of these lights was plotted against temporal frequency for a series of blue-green ratios. A minimum is obtained when the blue and green lights are isoluminant. The MPOD was calculated from the difference between the minima of central (0°) and peripheral (8°) curves.

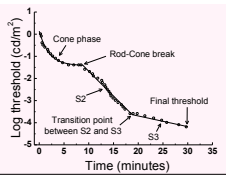
Dark adaptation

Dark adaptation was measured using a Sony CRT monitor and VSG 2/5 card. A 1° circular test spot (1931 CIE x = 0.31, y = 0.316) temporally modulated at 1 Hz was presented at 11° in the inferior field and viewed from 90 cm. The subject's head was positioned in a chin/head rest. Subjects fixated a red cross (0.3°) throughout the entire test duration. The CRT's luminance output was extended using neutral density filters which were placed in front of the monitor and calibrated to expose 5 log units of recovery. An electronic 0.9 ms flash of white light was used to produce an estimated 30-98% bleach in the area to be tested. Thresholds were measured immediately after bleaching and were set at approximately twice per minute using the method of adjustment for 30 minutes. Viewing was monocular with a natural pupil and the unstimulated eye wore a patch.



3. Analysis

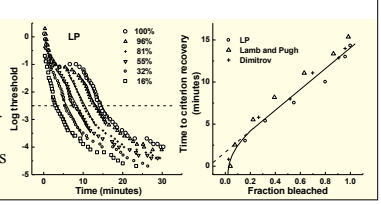
MPOD and dark adaptation were measured twice therefore data points are the means of two sessions. Dark adaptation curves were plotted as $\log_{10}$ threshold (cd/m²) versus time in minutes. These were fitted with an exponential-bilinear model as described by McGwin [4] using Matlab.



4. Results

Dark adaptation

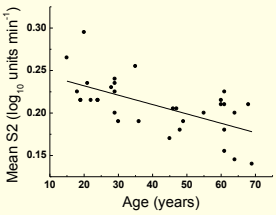
The S2 region showed a linear relationship with the size of bleach for fractions above 20%. Our data (LP) were in good agreement with previous studies [5,6].



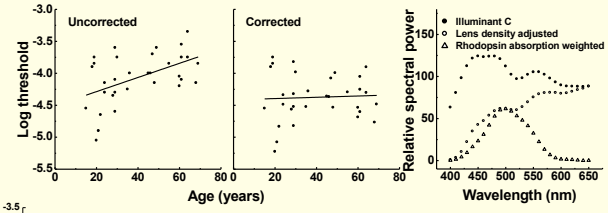
4. Results

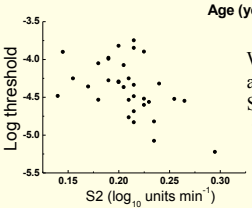
Dark adaptation

The mean rate of S2 for the younger group was 0.23 ±0.03 $\log_{10}$ units min^{-1} (time constant [tc] = 1.9 minutes). The older group was significantly slower than the younger group (r = 0.62, F[1,32] = 18.77, p < 0.0002) with an average S2 of 0.19 ±0.03 $\log_{10}$ units min^{-1} (tc = 2.3 minutes). The rate of S2 recovery decreased 0.01 log units/min per decade.



Before correction for the pupil and the lens, the mean threshold was elevated in the older group by 0.4 log units (t = 3.14, p < 0.004) compared with the younger group and declined at a rate of 0.1 log units per decade. After correction the older group sustained an average threshold elevation of 0.1 log units compared with the younger group (t = -0.48, p = 0.63).





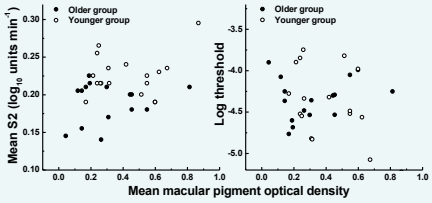
We also found significantly lower (corrected) dark adapted thresholds (improved sensitivity) with faster S2 recovery for the whole group (r = 0.49, F[1,32] = 9.57, p < 0.005).

Macular pigment

The average MPOD for our cohort was 0.37 ±0.21. There were no significant correlations between gender or age and MPOD. Subjects with dark iris pigmentation had significantly higher (0.5 ±0.19) MPOD than those with light iris pigmentation (0.3 ±0.20) (t = -2.35, p = 0.03).

Macular pigment and dark adaptation

We found a weak relation between MPOD and S2 (r = 0.32, F[1,32] = 3.5, p = 0.07) and MPOD and thresholds (r = 0.24, F[1,32] =1.85, p = 0.18). The rate of S2 for the lower 10% of MPOD was significantly slower compared with the upper 10% (p = 0.037).



5. Conclusions

- Our CRT-based dark adaptometry method produced results that agree with previous studies using alternative techniques.
- Slowing down of S2 with increasing age found in this study is indicative of delayed rhodopsin regeneration which may be related to structural changes in the Bruch's membrane/RPE complex subsequent to oxidative stress.
- Macular pigment is a powerful antioxidant therefore augmentation of MPOD could have beneficial effects on scotopic vision in the elderly. Longitudinal, placebo-controlled intervention studies are needed to explore this possibility.

6. References

1. Jackson et al. Aging and dark adaptation. *Vision research*. 1999;39(23):3975-3982.
2. Hammond et al. Preservation of visual sensitivity of older subjects: association with macular pigment density. *IOVS*. 1998;39(2):397-406.
3. Berendschot et al. The CLEAR (Combination (of) Lutein Effects (on) Aging Retina) study; lutein supplementation improves visual acuity and night vision in early AMD; a two-centre, placebo-controlled study. *IOVS*. 2011;52(6):3631.
4. McGwin et al. Using nonlinear regression to estimate parameters of dark adaptation. *Behavior Research Methods, Instruments & Computers: A Journal of the Psychonomic Society, Inc*. 1999;31(4):712-717.
5. Lamb TD, Pugh EN. Dark adaptation and the retinoid cycle of vision. *Progress in Retinal and Eye Research*. 2004;23(3):307-380.
6. Dimitrov et al. Measuring rod and cone dynamics in age-related maculopathy. *IOVS*. 2008;49(1):55.

7. Acknowledgements

The authors would like to thank BBSRC and Vitabiotics for funding this project and Dr D.H. Baker for writing the Matlab code used to analyse dark adaptation curves.