Potential role of macular pigment in preserving rod-dominated dark adaptation in the older eye

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Introduction

Dark adaptation becomes slower with age. The cause for this is unknown but may be related to ageing of the RPE/Bruch’s membrane complex.

Macular pigment (MP) is a powerful antioxidant and may protect the retina from photochemical damage.

MP is composed of lutein and zeaxanthin.
Introduction

Recent evidence suggests that:

1. Higher MP levels preserve scotopic sensitivity in older adults (Hammond et al., 1998)

2. Higher MP levels improve rod recovery in age-related macular degeneration (AMD) (Berendschot et al., 2011)
Objectives

(i) To characterise the rate of scotopic sensitivity decline with age using CRT-based dark adaptometry

(ii) To see whether the rate of rod recovery is correlated with macular pigment optical density (MPOD)
**Methods**

**Subjects**

33 subjects, divided into 2 groups:

- **Older group**
  
  ≥ 45 years old, n=16, mean age 57.44 ±7.98

- **Younger group**
  
  <45 years old, n=17, mean age 25.12 ±6.08
**Methods**

**Macular pigment optical density**

MPOD was measured psychophysically using MPS 9000 based on heterochromatic flicker photometry.
**Methods**

**Dark adaptation**

Dark adaptation was measured using a CRT monitor.

- The CRT's luminance range was extended using ND filters
- Test area was bleached using an electronic flash
- Thresholds were measured for 30 mins using MOA
- Viewing was monocular with a natural pupil and the unstimulated eye wore a patch
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/m$^2$) vs time (mins) and fitted with an exponential-bilinear model using Matlab.
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.
Results

Dark adaptation

Mean rate of S2 for the younger group was $0.23 \pm 0.03 \log_{10} \text{ units min}^{-1}$ (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 $0.19 \pm 0.03 \log_{10} \text{ units min}^{-1}$ (tc = 2.3 minutes). The rate of S2 recovery decreased 0.01 log units/min per decade.
Rod photoreceptor

Rhodopsin
(opsin + 11-cis retinal)

Light

Association

Bathorhodopsin

Lumirhodopsin

Metarhodopsin I

Metarhodopsin II

Dissociation

all-trans retinal

opsin

11-cis retinal

11-cis retinal

11-cis retinal

11-cis retinol

all-trans retinal

all-trans retinol

RPE cell

RETINOID CYCLE
**Results**

*Dark adaptation*

Before pre-retinal correction the mean threshold was significantly higher (0.4 log units) in the older group ($p < 0.004$) 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 ($p = 0.63$).

![Graph of dark adaptation showing significant differences between corrected and uncorrected age groups](image)
Results

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

Macular pigment

The average MPOD for our group was 0.37 ±0.21. There were no significant correlations between gender or age and MPOD. Subjects with light iris pigmentation had significantly lower MPOD than those with dark iris pigmentation ($p = 0.03$).

MPOD: 0.3 ±0.20  
MPOD: 0.5 ±0.19
Results

Dark adaptation & MPOD
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% ($p = 0.037$).
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.
Thanks!

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