Visual function with optical filters in speleologists exposed to cave environments

Efeito de filtros ópticos na função visual de espeleologistas

Nádia Fernandes BSc, Carla Lança PhD, Ana Monteiro MSc, Ana Almeida MD

There is no actual or potential conflict of interest in relation to this presentation.
Introduction

- Speleologist’s perform their activity in **demanding visual conditions of very low luminance** - many visual tasks involve resolution of detail under conditions of low contrast.

- Work related conditions in a cave as exposure to heat, chemicals, dust and poor lighting conditions could influence the integrity of the visual system and predispose the eye to diseases that eventually affect vision.

Ovenseri-Ogbomo, Ocansey, Abu, Kyei, & Boadi-Kusi (2012)
Introduction

- Poor lighting conditions cause a variety of symptoms of visual discomfort and may increase the risk of accidents.

- Good visual acuity is crucial for several and has an important role for safety purposes.

**The aim** of this study was to evaluate lighting conditions and optical filters effects on visual performance in speleologists exposed to cave environments.

A cross-sectional study was conducted.

An examination of visual acuity, contrast sensitivity, stereoacuity and headlamps illuminance levels was performed in 16 speleologists at two caves deprived of natural lightning.
The illuminance measurements (headlamp on the helmet or head) were made using a luximeter.

Two organic filters (450nm and 550nm) were used to compare visual function with and without filters (ML filters optical solutions).

Graphic 1 – 450 nm optical filters transmittance.  
Graphic 2 – 550 nm optical filters transmittance.
Results

Subjects

Mean age of the workers: 40.65(±10.93) years (The majority were males - 65.2%).

Optical correction was found in 14 subjects with 4 subjects using glasses just for near due to presbyopia.

6 participants had decreased visual acuity of which refractive error (17.4%) was the major cause.

2 subjects had a visual pathology (retinal detachment and keratoconus).
Results

Visual symptoms

- During the cave activity blur vision was the most referred visual symptom (n=10) - 5 had decreased visual acuity.

Visual function

- There were no signs and symptoms of visual pathologies related to the exposition to the cave in this workers.

- **Binocular visual acuity** (BVA) in the cave environment was -0.05±0.15 LogMAR (20/18) and all subjects had visual acuities LogMAR of 0.3 or higher (20/40).
Results

<table>
<thead>
<tr>
<th></th>
<th>Mean ± Std. Deviation</th>
<th>Median</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visual acuity without filter</td>
<td>- 0.05± 0.15 (20/18)</td>
<td>- 0.10 (20/16)</td>
<td></td>
</tr>
<tr>
<td>Visual acuity with 550 filter</td>
<td>- 0.04± 0.16 (20/18)</td>
<td>- 0.10 (20/16)</td>
<td>0.093</td>
</tr>
<tr>
<td>Visual acuity with 450 filter</td>
<td>- 0.07± 0.15 (20/17)</td>
<td>- 0.10 (20/16)</td>
<td></td>
</tr>
<tr>
<td>Contrast sensitivity (3cpd)</td>
<td>1.73±0.17</td>
<td>1.63</td>
<td></td>
</tr>
<tr>
<td>Contrast sensitivity (3cpd)</td>
<td>1.76±0.17</td>
<td>1.78</td>
<td>0.104</td>
</tr>
<tr>
<td>Contrast sensitivity (3cpd)</td>
<td>1.84±0.12</td>
<td>1.78</td>
<td></td>
</tr>
<tr>
<td>Contrast sensitivity (6cpd)</td>
<td>1.99±0.24</td>
<td>1.92</td>
<td></td>
</tr>
<tr>
<td>Contrast sensitivity (6cpd)</td>
<td>1.92±0.16</td>
<td>1.84</td>
<td>0.034*</td>
</tr>
<tr>
<td>Contrast sensitivity (6cpd)</td>
<td>2.04±0.16</td>
<td>2.07</td>
<td></td>
</tr>
<tr>
<td>Contrast sensitivity (12cpd)</td>
<td>1.56±0.33</td>
<td>1.54</td>
<td></td>
</tr>
<tr>
<td>Contrast sensitivity (12cpd)</td>
<td>1.58±0.37</td>
<td>1.62</td>
<td>0.368</td>
</tr>
<tr>
<td>Contrast sensitivity (12cpd)</td>
<td>1.64±0.39</td>
<td>1.69</td>
<td></td>
</tr>
<tr>
<td>Contrast sensitivity (18cpd)</td>
<td>1.05±0.34</td>
<td>1.03</td>
<td></td>
</tr>
<tr>
<td>Contrast sensitivity (18cpd)</td>
<td>0.97±0.25</td>
<td>0.96</td>
<td>0.026*</td>
</tr>
<tr>
<td>Contrast sensitivity (18cpd)</td>
<td>1.18±0.39</td>
<td>1.25</td>
<td></td>
</tr>
</tbody>
</table>

Visual acuities are reported in LogMAR units with the Snellen equivalent of the mean in parenthesis. Contrast sensitivity values are reported in log units.

*Significant difference (p<0.05).

- **BVA for distance without filter was not statistically different from BVA with 550nm or 450nm filters (p=0.093).**

- **Significant improved contrast sensitivity was observed with 450nm filters for 6cpd (p=0.034) and 18cpd (p=0.026) spatial frequencies.**
Results

Illuminance measurements

- In the cave environment the majority of the workers used a headlamp on the helmet or head, especially at a medium position or position 2 without diffuser.

- Is this position the mean illuminance values were 451.0±305.7 lux

<table>
<thead>
<tr>
<th></th>
<th>headlamp in position 1 without diffuser (n=15)</th>
<th>headlamp in position 2 without diffuser (n=14)</th>
<th>headlamp in position 3 without diffuser (n=11)</th>
<th>headlamp in position 4 without diffuser (n=7)</th>
<th>headlamp in position 1 with diffuser (n=3)</th>
<th>headlamp in position 2 with diffuser (n=2)</th>
<th>hand lantern (n=1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean ± Std. Deviation</td>
<td>250.2±414.3</td>
<td><strong>451.0±305.7</strong></td>
<td>1551.3±1165.9</td>
<td>1670.2±1275.4</td>
<td>134.0±108.6</td>
<td>210.0±127.3</td>
<td>28</td>
</tr>
<tr>
<td>Median</td>
<td>100</td>
<td>400</td>
<td>840</td>
<td>2000</td>
<td>170.</td>
<td>210</td>
<td>28</td>
</tr>
<tr>
<td>Minimum</td>
<td>16.8</td>
<td>50</td>
<td>365</td>
<td>92</td>
<td>12</td>
<td>120</td>
<td>28</td>
</tr>
<tr>
<td>Maximum</td>
<td>1600</td>
<td>1300</td>
<td>3000</td>
<td>4000.0</td>
<td>220</td>
<td>300</td>
<td>28</td>
</tr>
</tbody>
</table>
Discussion

- **Mine workers** environments have an enormous impact on their health (Ovenseri-Ogbomo et al., 2012).

- None of the workers had previous history of acute or chronic conjunctivitis, which leads the authors to conclude that occupationally associated eye diseases/disorders were not obvious among the speleologist workers.

- It has been found that under **scotopic conditions**, sensitivity functions are dramatically lowered across the entire spectrum from the normal contrast sensitivity function (Sekuler & Blake, 1994).

- In this environment the binocular visual performance was not impaired by the light conditions of the cave.
Discussion

- A night security guard to recognize faces from a distance of 6m under low illumination need to have a visual acuity of 0.5 LogMAR (20/60) (Johnson & Casson, 1995).

- The improvement in contrast sensitivity with the 450 nm filters could be beneficial to the cave operational environments.

- It is important that eye care practitioners are able to provide accurate advice on whether filters will provide a long-term benefit, prior to their recommendation to workers.

- According to the Artificial Light norm (DIN 5035-2, 1990) the level of illuminance that should be used for normal visual tasks with medium details is 500-750 lux.
Conclusions

- There were no signs and symptoms of visual pathologies related to cave exposure.
- Illuminance levels were adequate to the majority of the activities performed.
- The enhancement in contrast sensitivity with filters could potentially improve tasks related to bats observation.
- More investigation is therefore needed to better understand the influence of cave lighting conditions in the visual symptoms referred by the workers.
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Thank you for your attention!

carla.costa@estesl.ipl.pt