Prospective Observational Study of Ocular Health of International Space Station Astronauts

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Ocular Clinical Findings

~35-50% U.S. operating segment astronauts have developed some or all of the following findings during or after long-duration spaceflight:

- Optic disc edema
- Hyperopic shift
- Choroidal folds
- Optic nerve sheath distention
- Optic nerve kinking
- Globe flattening

Kramer et al 2012
Mader et al 2011
Kramer et al 2012
Ocular Health Study

**Purpose:** Characterize the time course of ocular, cerebral, and cardiovascular changes that occur during ISS missions and their recovery post-flight.

**Methods:**

- Medical ocular data (MedB) collected pre-, in-, and post-flight
  - Flight Medicine Clinic
  - UTMB Victory Lakes
  - Coastal Eye Associates
  - ISS
- MedB and complementary data collected at additional time points
- 11/13 crewmembers have completed pre-, in- and post-flight testing
  - Optic disc edema: 2/13 crewmembers (15.4%)
- Preliminary data for 6 subjects (1 case) will be presented
### Timeline

#### Pre-flight Exams
- **L-21/18 mo**
  - Flt Med. Clinic
    - Vision Testing*
    - Fundoscopy
    - Refraction
    - Pupil Reflexes
    - Extra-Ocular Muscle Bal.
    - IOP (Tonometry)
  - Coastal Eye Associates
    - OCT
    - Biomicroscopy/ Hi Res Photogr.
  - UTMB Victory Lakes
    - MRI

#### In-flight Exams
- **L+10**
  - Flt Med. Clinic
    - Vision Testing*
    - Fundoscopy
    - Refraction
    - Pupil Reflexes
    - Extra-Ocular Muscle Bal.
    - IOP (Tonometry)
    - Ocular Ultrasound
  - Cardiovascular & Vision Laboratory
    - Cardiac Ultrasound
    - Blood Pressure
    - Transcranial Doppler Ultrasound
- **L+30**
  - ISS
    - Vision Testing*
    - Fundoscopy
    - IOP (Tonometry)
    - Ocular Ultrasound
    - OCT
    - Cardiac Ultrasound
    - Blood Pressure
    - Transcranial Doppler
  - MedB Sessions
  - Added Research Sessions

#### Post-flight Exams
- **R+1-3**
  - Flt Med. Clinic
    - Vision Testing*
    - Fundoscopy
    - Refraction
    - Pupil Reflexes
    - Extra-Ocular Muscle Bal.
    - IOP (Tonometry)
    - Ocular Ultrasound
    - Blood Pressure
  - Coastal Eye Associates
    - OCT
    - Biomicroscopy/ Hi Res Photogr.
  - UTMB Victory Lakes
    - MRI
    - Cardiovascular & Vision Laboratory
      - Cardiac Ultrasound
      - Blood Pressure
      - Transcranial Doppler Ultrasound

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*Vision Testing includes Visual Acuity, Amsler Grid, Contrast Sensitivity, & Threshold Visual Fields. The latter is measured at Coastal Eye for ground testing.*
Inflight Vision Testing

Fundoscopy

Optical Coherence Tomography (OCT)

Images from www.nasa.gov
OCT Scan Patterns

Scans taken in both eyes:

- Centered over optic nerve head
- Centered over macula
Case: Right Eye

Pre-flight

FD90

R-30
Axial Length
Preliminary Data

Right Eye

Axial Length (cm)

Left Eye

Axial Length (cm)
Optic Nerve Sheath Diameter

Preliminary Data

Right Eye

Optic Nerve Sheath Diameter (cm)

Non-Cases

Case

Left Eye

Optic Nerve Sheath Diameter (cm)

Non-Cases

Case
Retinal Nerve Fiber Layer Thickness

Preliminary Data

Right Eye

Left Eye

RNFL Thickness (um)

Non-Cases
Case

L-3 Mo FD10 FD30 FD60 FD90 FD120 R-30 R+1/3 R+30 R+90 R+180 R+365

L-3 Mo FD10 FD30 FD60 FD90 FD120 R-30 R+1/3 R+30 R+90 R+180 R+365
Choroid Thickness

Preliminary Data

Choroid Thickness (um)

Right Eye

Non-Cases

Case

Left Eye
Cycloplegic Refraction

Preliminary Data

Right Eye

<table>
<thead>
<tr>
<th>Time</th>
<th>Cycloplegic Refraction</th>
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<tbody>
<tr>
<td>Pre</td>
<td>-2.5</td>
</tr>
<tr>
<td>R+1/3</td>
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<tr>
<td>R+30</td>
<td>-2.5</td>
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<tr>
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Left Eye

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<tr>
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</table>
Far Visual Acuity

Preliminary Data

Right Eye

Far Visual Acuity

Non-Cases
Case

Left Eye

Far Visual Acuity

Non-Cases
Case
Visual Field Mean Defect

Preliminary Data

Right Eye

Mean Defect (dB)

L-3 Mo  R+1/3  R+30  R+90  R+180  R+365

Non-Cases
Case

Left Eye

Mean Defect (dB)

L-3 Mo  R+1/3  R+30  R+90  R+180  R+365
Central Retinal Artery Mean Blood Flow Velocity

Preliminary Data

Mean Blood Flow Velocity (cm/s)

Right Eye

Left Eye

Hayreh et al 1977
Vascular Compliance
Preliminary Data

Vascular Compliance (ml / mmHg)

Seated

Supine

Non-Cases
Case
Optical Coherence Tomography

- Orange lines are approximate location of clinical circle scan.
- Note thickening and upward movement of optic disc.
Hydrodynamics of Cerebral Spinal Fluid Flow

CINE phase-contrast MRI flow quantification used to assess cerebral spinal fluid flow hydrodynamics through the cerebral aqueduct.

**Key outcome measures:**
- Cerebral spinal fluid pulsatility
- Cerebral spinal fluid production rate

![Cerebral Aqueduct](image)

**Image Description:**
- Diagram showing cerebral aqueduct and surrounding structures.

**Graph:**
- Total CSF Flow versus Time
- Graph showing CSF flow over time with key areas labeled A<sub>1</sub>, A<sub>2</sub>, and B.

**References:**

**Author:**
- Larry A. Kramer, M.D.
- Professor of Diagnostic Imaging and Intervention
- UTHSC, Houston, TX
Future Work

- Cerebral blood flow regulation during tilt
- Total body vascular compliance
- Ocular structural (OCT) and functional (visual fields) relationships
- Clinical impression and grading of ocular and brain MRI
- Globe flattening quantification (MRI)
International Space Station Medical Projects

Medical Operations

Remote Guiders

Ultrasound
OCT
Tonometry
Vision Testing