Prospective Observational Study of Ocular Health of International Space Station Astronauts

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2 University of Michigan, Ann Arbor, MI
3 Coastal Eye Associates, Webster, TX
4 NASA Johnson Space Center, Houston, TX
5 KBRwyle, Houston, TX
6 The University of Texas Medical School at Houston, Houston, TX
7 The University of Houston, College of Optometry, Houston, TX
8 University of Alabama at Birmingham, AL

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~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
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

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<th>Pre-flight Exams</th>
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<th>Post-flight Exams</th>
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<tr>
<td>L-21/18 mo</td>
<td>L+10 L+30 L+60 L+90 L+120 R-30</td>
<td>R+1-3 R+30 R+90 R+180 R+365</td>
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<td>• Vision Testing* • Fundoscopy • Refraction • Pupil Reflexes • Extra-Ocular Muscle Bal. • IOP (Tonometry)</td>
<td>• Vision Testing* • Fundoscopy • IOP (Tonometry) • Ocular Ultrasound • OCT • Cardiac Ultrasound • Blood Pressure • Transcranial Doppler</td>
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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)

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

Left Eye

Axial Length (cm)

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

Non-Cases

Case
Intraocular Pressure

Intraocular Pressure (mmHg)

Right Eye

Non-Cases Tonopen
Case Tonopen
Non-Cases Applanation
Case Applanation

Left Eye

Preliminary Data
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
Choroid Thickness
Preliminary Data

Choroid Thickness (um)

Right Eye

- Non-Cases
- Case

Left Eye

Choroid Thickness (um)
Near Visual Acuity

Preliminary Data

Right Eye

Near Visual Acuity

Left Eye

Near Visual Acuity

Non-Cases

Case

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

Pre  FD10  FD30  FD60  FD90  FD120  R-30  R+1/3  R+30  R+90  R+180  R+365
Far Visual Acuity

Preliminary Data

Right Eye

Far Visual Acuity

Left Eye

Far Visual Acuity

Non-Cases

Case
Visual Field Mean Defect

Preliminary Data

Mean Defect (dB)

Right Eye

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

Left Eye

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

Non-Cases

Case
Central Retinal Artery Mean Blood Flow Velocity

**Preliminary Data**

### Right Eye

- Mean Blood Flow Velocity (cm/s)
- **Non-Cases**
- **Case**

### Left Eye

- Mean Blood Flow Velocity (cm/s)
- **Non-Cases**
- **Case**

Central Retinal Artery

Hayreh et al 1977
Vascular Compliance
Preliminary Data

**Seated**

![Graph showing vascular compliance in seated position]

**Supine**

![Graph showing vascular compliance in supine position]
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


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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)
Acknowledgments

International Space Station Medical Projects

Medical Operations

Remote Guiders
  Ultrasound
  OCT
  Tonometry
  Vision Testing