

Measurement of acute changes in choroid thickness in healthy eyes during posture change using optical coherence tomography

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Introduction

The Visual Impairment and Intracranial Pressure (VIIP) syndrome affects 60% of astronauts returning from long-duration missions and is characterized by structural and functional changes of the eye (3). Upon entry into weightlessness, approximately two liters of fluid translocates from the lower body to the thorax and cephalad regions, potentially contributing to elevated intracranial and intraocular pressures. The choroid is the vasculature that supplies blood flow to the posterior part of the retina and has limited autoregulation. As a consequence these vessels may engorge during a cephalad fluid shift, contributing to structural changes in the retina. The purpose of this experiment was to quantify changes in choroid thickness during a fluid shift. In order to fulfill this objective, it was also necessary to improve the measurement technique for assessing choroid thickness.

Methods

We induced a fluid shift by positioning subjects at 15° head-up-tilt (HUT), supine (SUP), and 15° head-down-tilt (HDT) for 30 minutes each. Spectral-domain optical coherence tomography with enhanced depth imaging (SD-OCT, Heidelberg Spectralis®) was used to generate a line scan (30°, ART of 100) centered through the optic nerve head and macula in both eyes of 10 healthy subjects (age 30 ± 8 years, 6 male) following 10 minutes of HUT, SUP and HDT. A second set of images were taken in both eyes at the end of 30 minutes HDT (HDTE). Heidelberg TruTrack™ Active Eye Tracking and AutoRescan™ technology were used to ensure reproducibility in the placement of the line scan across the retina during each tilt angle. During post processing, Bruch's membrane delineation was objectively and automatically determined using Heidelberg Eye Explorer software and the external boundary of the choroid was manually drawn in triplicate by a single observer. The external boundary of the choroid could not be detected in both eyes of one subject and data from this subject were excluded from analysis. We developed a MATLAB program to allow for analysis of choroid thickness in any region of the retina. Average choroid thickness reported in this document was calculated over a 5 mm section centered on the fovea.

Results

Figure 1 shows the mean choroid thickness for each eye across all tilt angles. Choroid thickness in the right eye was 287 ± 23 μm (mean \pm SEM) during HUT and 294 ± 23 μm during SUP. After 25 min of HDT, choroid thickness was similar to that measured after 10 minutes HDT (301 ± 22 μm and 306 ± 23 μm respectively). Choroid thickness in the left eye was 288 ± 20 μm during HUT, 296 ± 17 μm during SUP, 304 ± 19 μm following 10 minutes of HDT, and 303 ± 19 μm following 25 minutes of HDT.

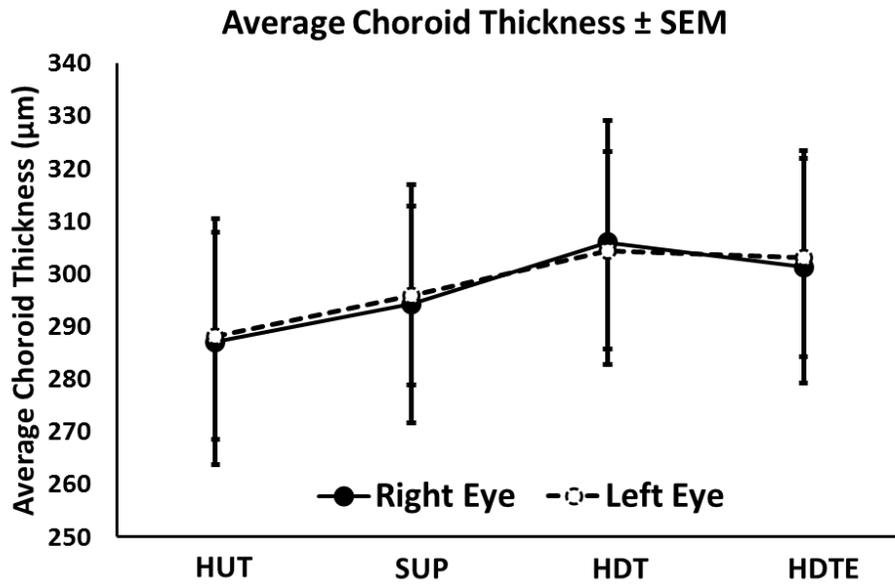


Figure 1 Average choroid thickness in the right and left eye during HUT, SUP, HDT and HDT end, N=9

The change in choroid thickness relative to SUP is shown in Figure 2. In the right eye, choroid thickness decreased from SUP to HUT ($-7 \pm 2 \mu\text{m}$, mean \pm SEM), and increased from SUP to both HDT and the end of HDT (HDT: 12 ± 2 , HDTE: $7 \pm 2 \mu\text{m}$). In the left eye, choroid thickness decreased from SUP to HUT ($8 \pm 4 \mu\text{m}$), while choroid thickness increased from SUP to both HDT and end of HDT (HDT: 9 ± 3 , HDTE: $7 \pm 2 \mu\text{m}$).

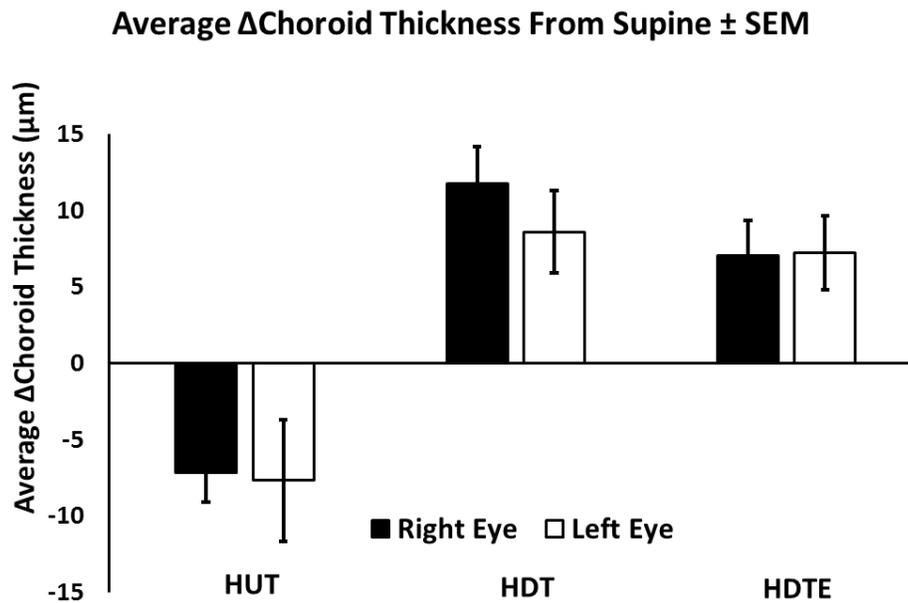


Figure 2 Difference in choroid thickness during HUT, HDT, and HDTE relative to SUP posture, N=9

Discussion

Data from this study were used to develop a novel analysis tool to quantify choroid thickness spanning any location across the width of the retina. This technique was then applied to data collected across three tilt angles which indicated choroid thickness increases when acutely moving a subject from HUT to HDT. There were no differences in choroid thickness measurements between 10 minutes and 25 minutes HDT. While VIIP has developed asymmetrically in some crew members, there was no observable difference in choroid thickness between the left and right eye of subjects in this study. Identifying asymmetries in physiological measures is an important step toward understanding and preventing the development of VIIP. Limitations of this study included subjective choroid boundary delineation, single non-blinded observer, and small sample size. Future work should focus on development of reliable technology to automatically detect the choroid boundary using data collected with SD-OCT. Accurate and repeatable measures of choroid thickness will help NASA determine if changes in choroid blood flow regulation, and thus engorgement, represent a factor contributing to VIIP. Future studies in this area will need a larger subject pool to better quantify changes in choroid thickness during various perturbations in ocular blood flow.

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