Investigating the Pathogenesis of Spaceflight Associated Neuro-ocular Syndrome with Head-mounted Visualization Engineering of Pupil Reactivity

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Introduction: Spaceflight associated neuro-ocular syndrome (SANS) refers to a collection of neuro-ophthalmic imaging and clinical findings observed in astronauts during and after long-duration spaceflight (LDSF)[1]. These findings include optic disc edema (ODE), posterior globe flattening, hyperopic refractive error shifts, and chorioretinal folds. Given its risk and consequence on vision and the neuro-ophthalmic system, NASA has deemed that mitigation of SANS is a top priority for a planetary mission to Mars[2]. While a physiological barrier to deep-space exploration, the pathogenesis of SANS is not well understood. Initially termed "Vision Impairment and Intracranial Pressure", it was initially thought that cephalad fluid shifts during spaceflight led to increased intracranial pressure (ICP) and subsequent SANS findings such as ODE. However, there are several discrepancies between terrestrial elevations of ICP and SANS including lumbar puncture opening pressure values in SANS astronauts post-flight which have been normal or only mildly elevated. However, given its invasive nature, lumbar punctures are not available during spaceflight[1].

Description: Hand-held pupillometry has emerged as a promising non-invasive, quantitative indicator of ICP for terrestrial pathologies of elevated ICP[3]. Head-mounted technology may further optimize pupil testing efficiency as well as potential helmet implementation for non-oxygenated space environments. To further investigate the role of ICP in SANS pathogenesis, we report the technical development of NASA-funded non-invasive, head-mounted, extended reality-based quantification of pupil reactivity as an indirect measure of ICP. We discuss our technical design and deployment of stimulating and analyzing pupil parameters in XR. The pupil variables such as maximum and minimum pupil diameter, percentage change in pupil constriction amplitude, constriction velocity, dilation velocity etc. are computed for each pupil.

Conclusion: Further understanding SANS is critical for countermeasure development for future spaceflight. This head-mounted, pupil analytic technology described may further elucidate the role of ICP in SANS development.

References

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