Microgravity and Vision: Investigating Intraocular Pressure Variations and Potential Consequences for Astronauts

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Introduction: Spaceflight-Associated Neuro-ocular Syndrome (SANS) is a newly identified eye and optic nerve pathology with an unclear cause, posing risks to astronauts' health and long-duration space missions. Although microgravity impacts intraocular pressure (IOP), which could significantly influence SANS, its changes have not been thoroughly explored in this context. A longitudinal study using NASA's hindlimb unloading (HU) model, an affordable and accessible mouse analog for microgravity, was conducted to examine microgravity's effects on IOP dynamics. This approach aims to better understand microgravity's role in SANS and potentially guide future astronaut health strategies.

Methods: A HU protocol was developed, suspending mice by their tails at an approximate 30-degree angle for 21 days, followed by a 14-day recovery period. Twenty male B6(Cg)-Tyrc-2J/J albino mice were randomly assigned to either the control (n=10) or HU (n=10) group. Serial in vivo tonometry was conducted on both eyes at baseline (day 0), during suspension (days 8, 14, and 21), and post-recovery (days 22, 28, and 35) to assess IOP. Concurrent body weight measurements were taken. The control group was not subjected to suspension but followed an identical assessment schedule. Linear mixed-effects models were employed to analyze longitudinal changes in IOP between the HU and control groups comprehensively.

Results: Significant increases in IOP were observed in the HU group on day 14 compared to baseline (day 0) in both the right and left eyes ($p < 0.05$ for each). Consequently, a splined mixed-effects model was utilized to further examine the IOP changes before and after day 14 in both groups. In the HU group, IOP significantly rose from day 0 to day 14 in the right eye ($p < 0.05$), followed by a notable decrease from day 14 to day 35 in both eyes ($p < 0.05$ for each). Conversely, the control group exhibited no significant IOP changes at any time point (all $p > 0.05$).

Conclusions: The study demonstrated that IOP increases from baseline to day 14, then decreases to near baseline levels, underlining the potential of HU as a valuable model for investigating the ocular changes experienced by astronauts. This finding suggests that HU could be an effective method for studying the mechanisms behind astronaut eye changes, offering insights into preventive and therapeutic strategies for SANS.