



COMPARISON OF OCULAR OUTCOMES IN TWO 14-DAY BED REST STUDIES



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INTRODUCTION

Reports of astronauts' visual changes have raised concern about ocular health during long-duration spaceflight. Some of these findings include globe flattening with hyperopic shifts, choroidal folds, optic disc edema, retinal nerve fiber layer (RNFL) thickening, and cotton wool spots. While the etiology remains unknown, it is hypothesized that, in predisposed individuals, hypertension in the brain may follow cephalad fluid shifts during spaceflight. This possible mechanism of ocular changes may also apply to analogous cases of idiopathic intracranial hypertension (IIH) or pseudotumor cerebri on Earth patients.

Head-down tilt (HDT) bed rest is a spaceflight analog that induces cephalad fluid shifts. Previous studies of the HDT position demonstrated body fluid shifts associated with changes in intraocular pressure (IOP) but the conditions of bed rest varied among experiments, making it difficult to compare data and draw conclusions. For these reasons, vision evaluation of bed rest subjects was implemented for NASA bed rest studies since 2010, in an attempt to monitor vision health in subjects subjected to bed rest. Vision monitoring is thus currently performed in all NASA-conducted bed rest campaigns.

BED REST PLATFORM

Bed rest studies were performed at the Flight Analogs Research Unit at the University of Texas Medical Branch (UTMB) in Galveston, TX. Standard conditions for bed rest in NASA-conducted studies include:

- Room Temperature: 70-74°
- Study duration: 13-15 days pre-bed rest, bed rest phase (duration depends on the particular study); 7-14 days recovery
- Sleep/Wake cycle: Wake at 0600 hrs, lights out at 2200 hrs
- Monitored 24 hrs/day by subject monitors and cameras
- Daily Vital signs:
 - Blood pressure
 - Heart rate
 - Body temperature
 - Respiratory rate
 - Body weight (bed scale)
- Fluid intake and output is measured
- Psychological support provided
- Stretching and physiotherapy provided according to schedule
- Diet based on NASA spaceflight nutritional requirements: caloric intake 35.7 kcal/kg body weight (2500 calories/70 kg subject), adjusted to maintain weight within 3%; carbohydrate: fat: protein ratio 55:30:15; no caffeine, cocoa, chocolate, tea or herbal beverages. All food must be consumed.
- Fluid intake 28.5 ml/kg body weight (2000 ml/70 kg subject)

For this study, two 14-day bed rest platforms were used on Campaigns 15 (C15) and 17 (C17), respectively:

C15	C17
Supine (horizontal)	Head-down tilt (-6 degrees)
Exercise routine (aerobic and resistance)	No exercise
Vision outcomes pre and post bed rest	Vision outcomes assessed weekly

In this work, we report the findings for the common outcomes determined for each of these bed rest campaigns, which correspond to measurements pre and post bed rest. For the statistical analysis, the Kolmogorov-Smirnov (KS) test is provided as a method for evaluating whether the distributions of the Pre- and Post-BR data are different. A significant KS test suggests that the distributions of the Pre-BR data differ from that of the Post-BR data. This test is a *conservative* estimate because it does not recognize the within-subject correlation (repeated measures design) of data. In our case, the KS was never significant, suggesting conservatively that the two distributions are not different.

INSTRUMENTATION



CIRRUS HD-OCT



SPECTRALIS SD-OCT

Pre and post bed rest eye examinations were conducted at the UTMB Eye Center. OCT measurements were done using both a Cirrus HD-OCT (Zeiss) and a Spectralis Spectral Domain OCT (Heidelberg Engineering).

	0° Bed Rest (n = 9)			-6° Bed Rest (n = 10)		
	Pre-BR *	Post-BR *	p [§]	Pre-BR *	Post-BR *	p [§]
BCVA (logMAR)	.00 (-.12, .00)	.00 (.00, .00)	.99	-.14 (.06)	-.18 (.07)	.33
Spherical Equivalent (D)	-.27 (1.62)	-.66 (1.75)	1.00	-0.66 (1.59)	-1.05 (1.67)	.56
IOP (mmHg)	14.00 (12.75, 18.00)	13.00 (13.00, 16.25)	.96	15.30 (2.92)	14.85 (4.32)	.33
CIRRUS HD-OCT:						
Rim Area (mm ²)	1.34 (.19)	1.37 (.19)	.77	1.37 (.22)	1.28 (1.18, 1.67)	.98
Disc Area (mm ²)	1.67 (.31)	1.49 (1.33, 1.93)	.96	1.80 (.33)	1.73 (1.52, 2.00)	1.00
Average C/D	.27 (.16, .60)	.25 (.08, .51)	1.00	.49 (.43, .55)	.49 (.41, .54)	1.00
Vertical C/D	.27 (.14, .53)	.19 (.06, .44)	.96	.46 (.41, .52)	.46 (.40, .53)	.98
Cup Volume (mm ³)	.02 (.00, .26)	.02 (.00, .10)	1.00	.08 (.06, .14)	.09 (.06, .14)	.98
Average RNFL Thickness (µm)	93.56 (10.79)	91.69 (8.03)	1.00	94.90 (7.13)	95.95 (7.43)	.56
Macular Cube Average Thickness (µm)	275.00 (269.00, 289.75)	276.63 (11.20)	1.00	286.65 (11.84)	287.90 (12.32)	1.00
Macular Cube Volume (mm ³)	9.90 (9.70, 10.45)	9.98 (.39)	1.00	10.32 (.44)	10.36 (.44)	1.00
SPECTRALIS OCT:						
Average Macular Thickness (µm)	332.10 (312.55, 348.25)	326.50 (316.20, 344.35)	.27	334.70 (12.02)	334.06 (11.57)	1.00
Average Macular Volume (mm ³)	.48 (.03)	.48 (.02)	.77	.48 (.02)	.48 (.02)	1.00
Average Peripapillary Retinal Thickness (µm)	355.52 (33.39)	364.50 (37.24)	.77	336.71 (25.02)	339.68 (27.91)	.82
Average Peripapillary Retinal Volume (mm ³)	.47 (.44, .54)	.47 (.45, .56)	.97	.47 (.04)	.48 (.04)	1.00
Average RNFLT (µm)	97.33 (9.47)	96.44 (8.35)	1.00	99.40 (8.35)	100.85 (7.49)	.98

* Mean (standard deviation) values for normally distributed variables; Median (first quartile, third quartile) values for non-normally distributed variables.

§ Kolmogorov-Smirnov test for equality of distribution functions.

BCVA, Best Corrected Visual Acuity; BR, Bed Rest; C/D, Cup-to-Disc ratio; D, Dioptres; IOP, Intraocular Pressure (Goldmann applanation tonometry); MAR, Minimum Angle of Resolution; RNFL, Retinal Nerve Fiber Layer.

CONCLUSIONS

For all measures, there was no significant difference between subject groups for pre-bed rest testing. Post bed rest values also remained similar between groups. Comparison of pre- to post bed rest testing within each group did not demonstrate any statistical differences.

These preliminary results from 14-day bed rest studies suggest that the combination of exercise and horizontal bed rest as compared to 6° HDT bed rest did not produce differences in the ocular response with regard to IOP and optic disc parameters. The ocular measures reported here only included pre- and post bed rest time points. Further investigation is needed to examine both the acute response and long term adaptation of structural and functional ocular parameters in the bed rest platform and determine its usefulness for studying spaceflight phenomena. From a clinical perspective, the ability to study ocular responses in the controlled environment of the bed rest platform can provide valuable information for the care of patients restricted to bed rest.

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