An *in silico-in vivo* framework for the acute ocular and cardiovascular response to 6° head-down tilt

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1. Introduction

- Spaceflight associated **neuro-ocular syndrome** (SANS) has been acknowledged to cause severe ocular disorders in astronauts returning from long permanence in space [1].
- Head-down tilt (HDT) has gained large popularity to resemble the cardiovascular response to microgravity, as well as to study SANS [2].
- A novel multiscale **cardiovascular model** is presented to simulate the acute response to 6° HDBR to help shed light on SANS onset.
- The numerical framework has been validated *in vivo* through **HDT experiments** conducted at TAMU Bioastronautics and Human Performance (BHP) lab.

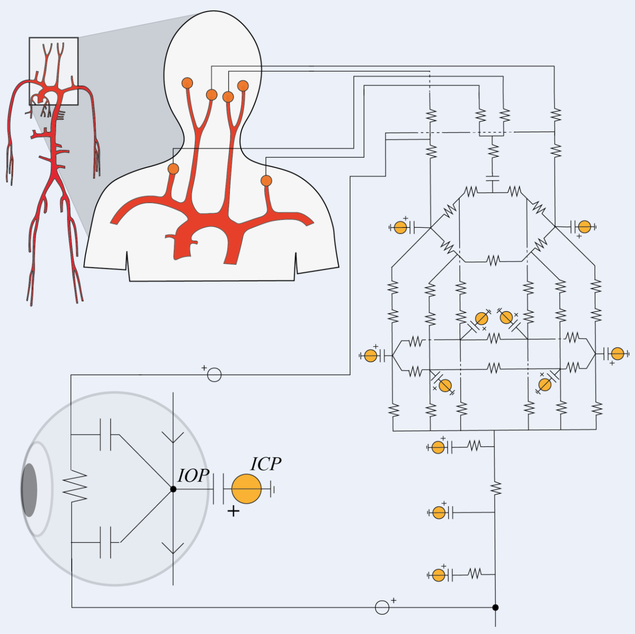


Fig. 1

Fig. 2

2. Methods

2.1 The cardiovascular model

- The cardiovascular model (Fig. 1) integrates our previously validated 1D-0D framework [3] with a lumped model of the **eye** [4] and of the **cerebrovascular circulation** [5].
- The global model presents a 1D description of the arterial tree combined with 0D analogues of the remaining vasculature, accounting for short-term homeostatic control and for the action of gravity during posture changes.
- Using the model, we simulated a tilt maneuver between 80° head-up tilt (HUT) and 6° HDT.

2.2 The *in vivo* experiments

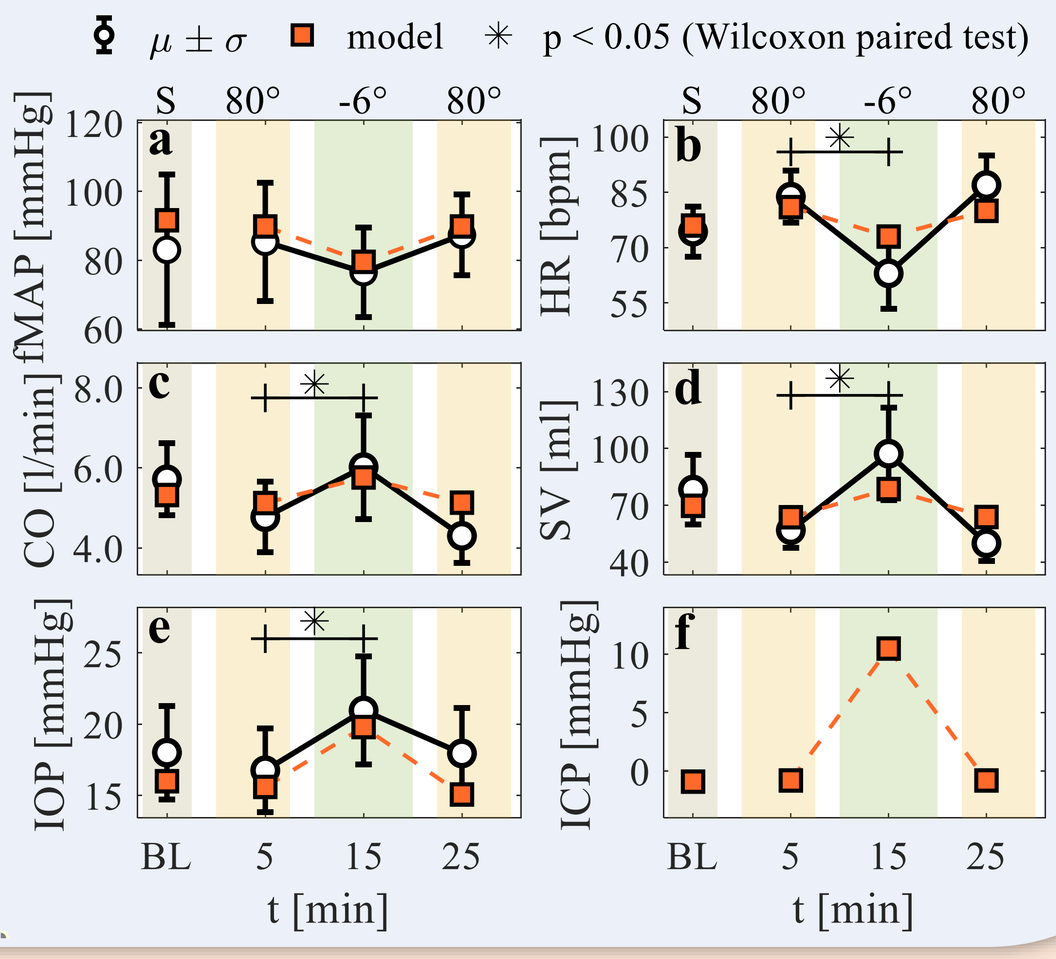
- Six healthy male subjects were positioned upright (80°) on the inversion table (Fig. 2), tilted down to 6° HDT for approximately 10 minutes and eventually tilted back upright to 80°.
- Subjects' arterial pressure, heart rate, cardiac output, stroke volume, and intraocular pressure measures were collected at each position. Seated baseline measures of the same parameters were also acquired

Fig. 1 (left): cardiovascular model architecture (IOP: intraocular pressure, ICP: intracranial pressure).

Fig. 2 (right): inversion table.

3. Results & Conclusions

Fig. 3: model results vs. *in vivo* measures (fMAP: finger mean arterial pressure at heart level, HR: heart rate, CO: cardiac output, SV: stroke volume, IOP: intraocular pressure, ICP: intracranial pressure).



- As observed in microgravity, the initial **fluid shift** elicited by 6° HDT leads to an increase in SV and CO accompanied by a drop in HR.
- IOP rises by 4.2 mmHg (model) compared to 80° upright.
- The simulated ICP increase in response to 6° HDT [6-7] is much larger than the observed IOP increase. As a result, the model predicts that the **translaminar pressure** IOP-ICP is markedly reduced during acute HDT (– 43%) [6-8].
- These results may contribute to the understanding of SANS among astronauts experiencing analog ocular and vascular responses upon **long-term space missions**.

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