



Artificial gravity improves blood-pressure control
After simulated gravity

ESA's artificial gravity expert group (AGEG) :
Gilles Clément, Dag Linnarsson, Bill Paloski, Jörn Rittweger,
Floris Wuyts, Jochen Zange
Lars Karlsson, Edwin Mulder

Dag Linnarsson MD PhD
Dept of Physiologi and Pharmacology
Karolinska Institutet
Stockholm Sweden

SRS, Uppsala 2014-03-12

Gravity and size (1)

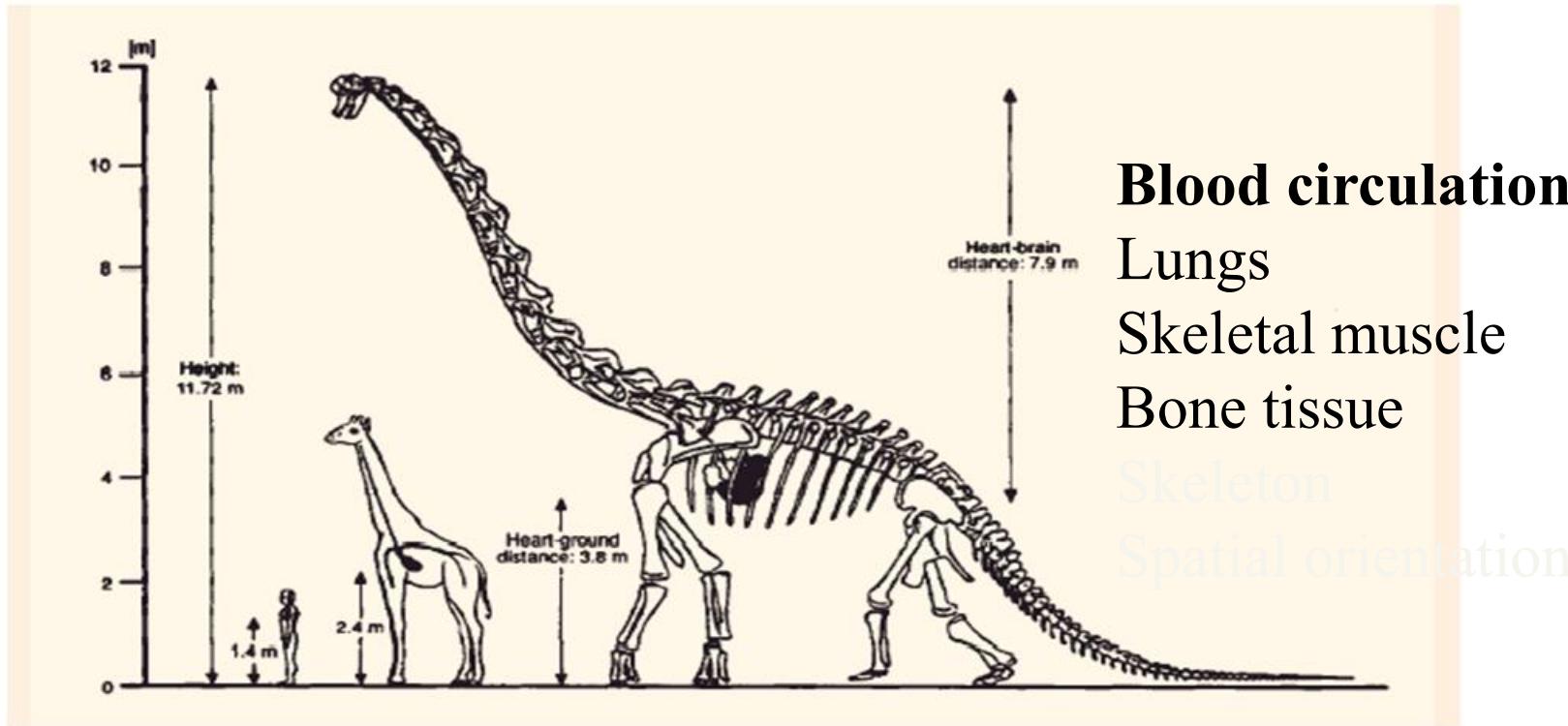
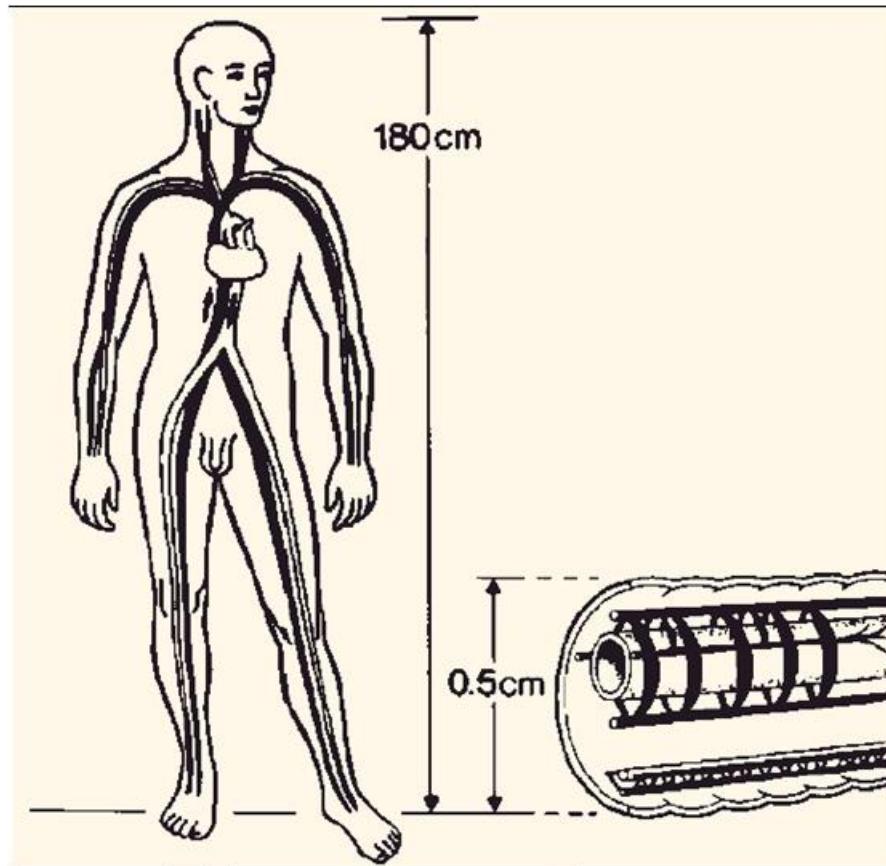


Figure 2.1.1.2. Schematic of the major hydrostatic distances acting on the heart and from circulatory systems in man, in the giraffe, and in the dinosaur *Brachiosaurus branickii* (Gunga et al. 1999, Mitt. Mus. Natl. Berl. Geowiss., p. 97)

Gravity and size (2)

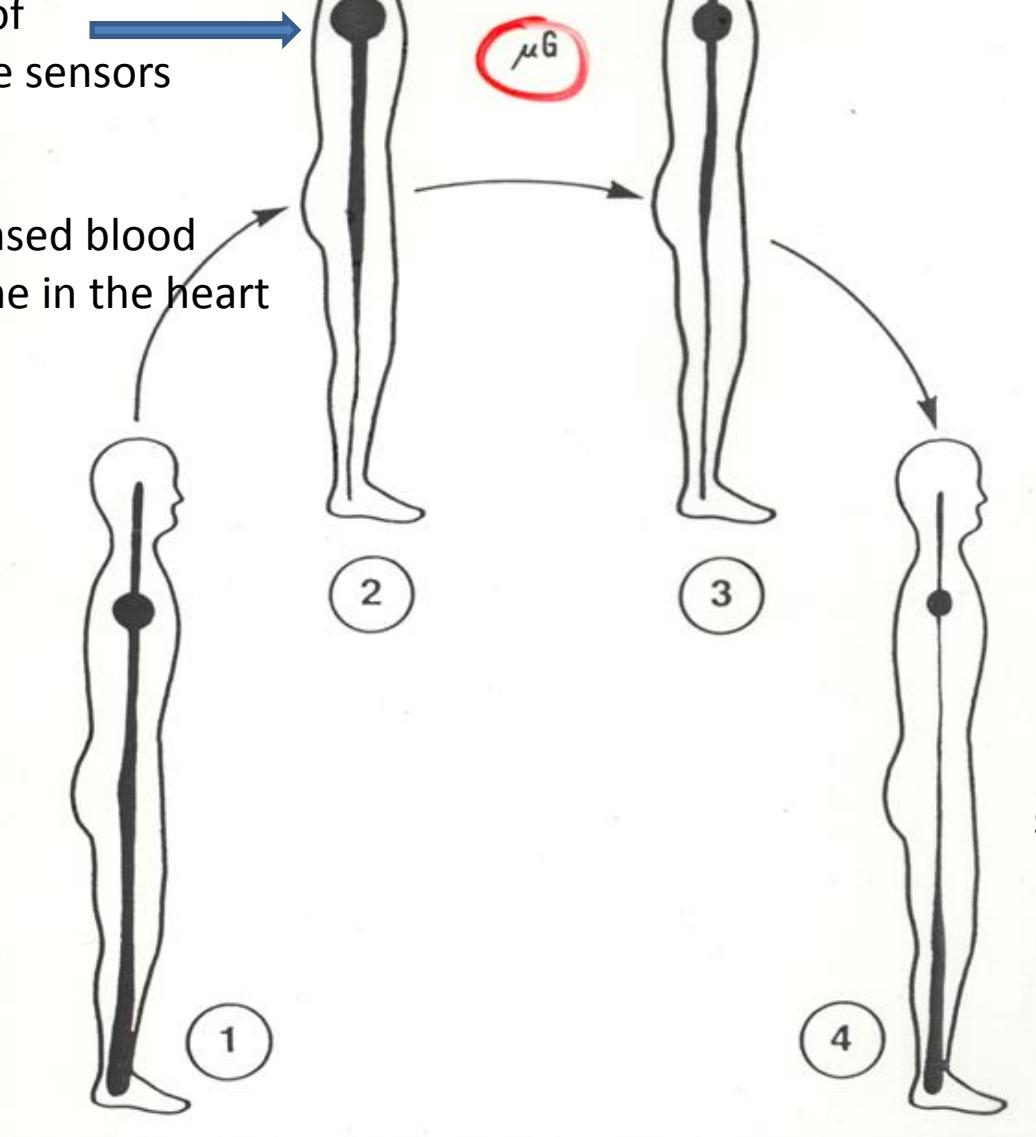


Localization of
Blood volume sensors

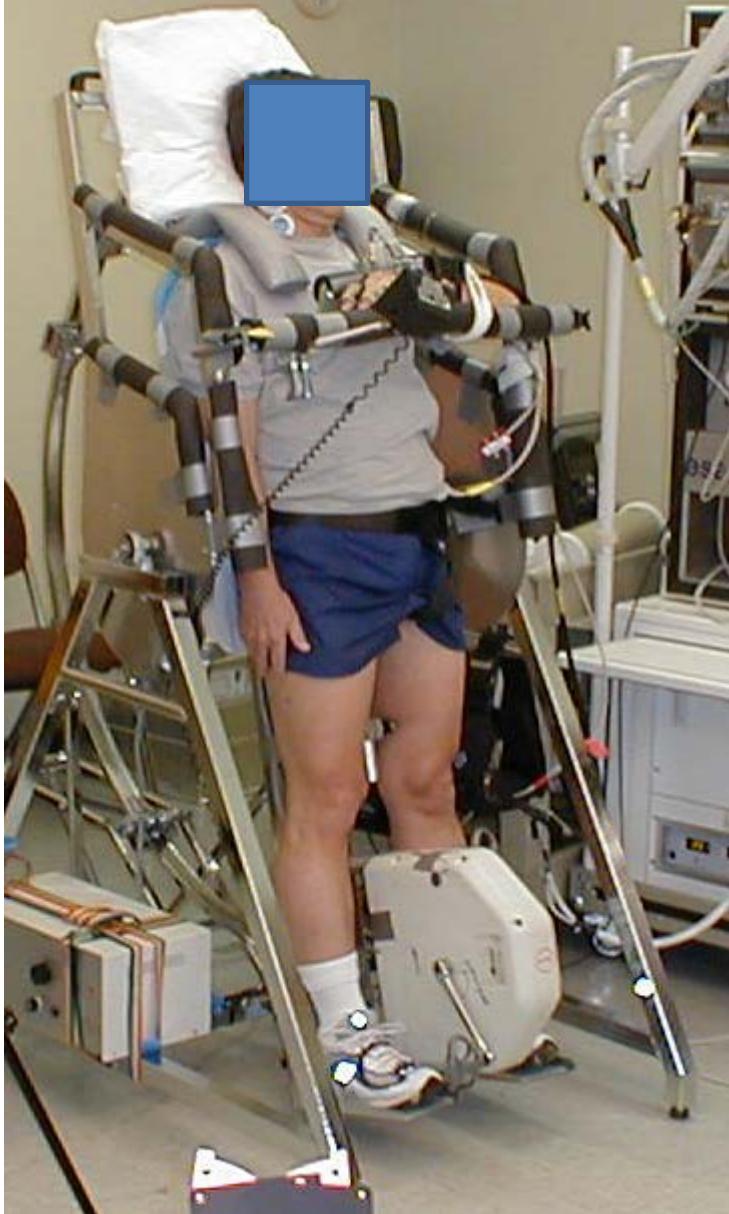
Down-regulation of
blood volume

Increased blood
volume in the heart

Inability to maintain
blood pressure during
standing



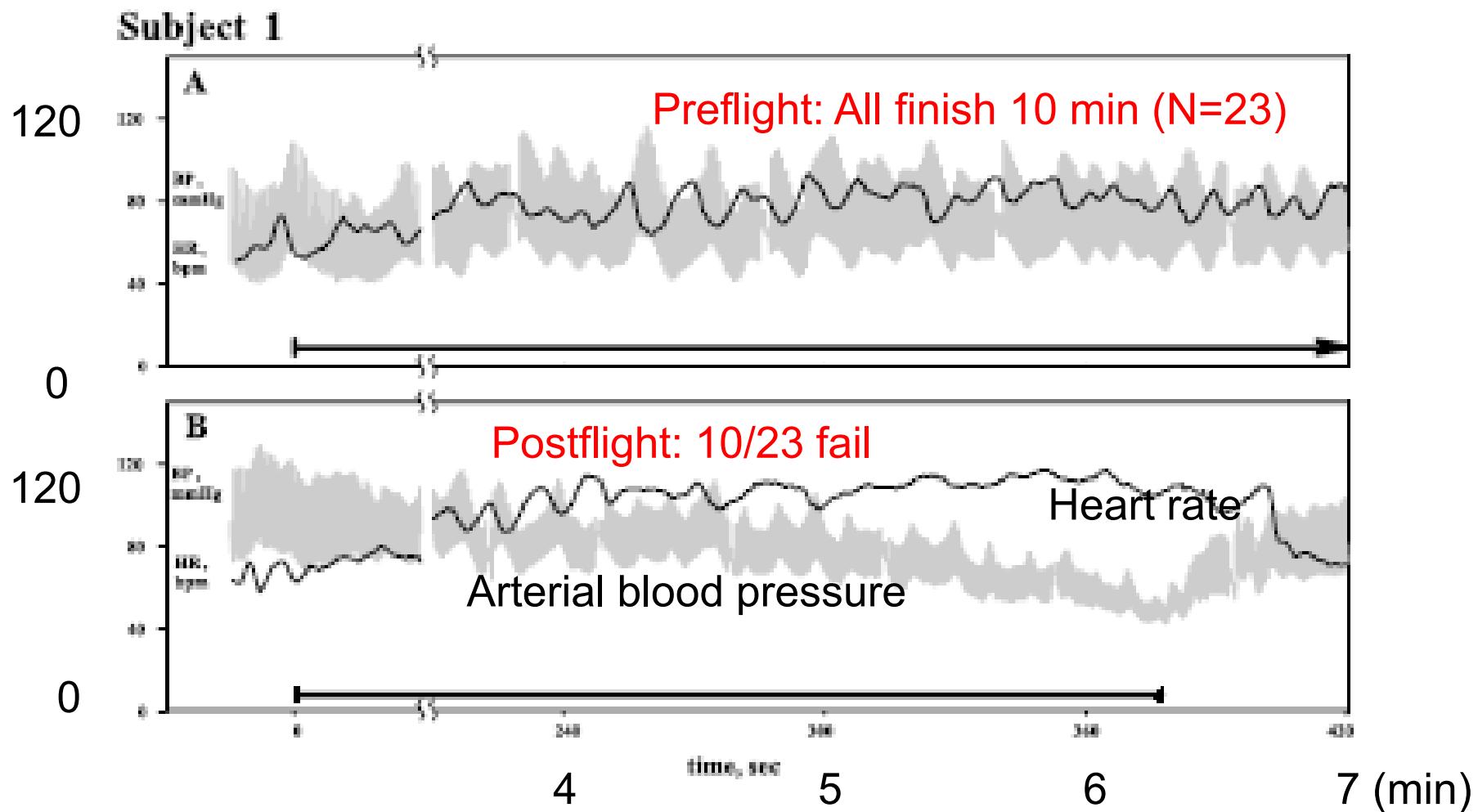
Orthostatic intolerance after space Flight: Theories



- Reduced blood volume
- Reduced heart muscle mass
- Impaired blood pressure reflexes:
 - Pressure sensor sensitivity?
 - Central processing?
 - Command signal suppression?
 - Impaired actuator response?

Stand test 10 min

MECHANISMS OF POSTFLIGHT HYPOTENSION IN ASTRONAUTS



Meck et al 2004



Dynamic exercise: Cycle ergometer

- Daily 1-2 hours
- Limited impact on orthostatic intolerance, muscle, and bone?
- Technically easy to implement
- Generally accepted as the standard

Dynamic exercise: Threadmill

- Optional
- Favourable effects on muscle and bone
- Comfort problems
- Disturbs the micro-g environment
- Technically more complex than ergometer



Artificial Gravity (AG) as a counter-measure during short-term microgravity

Short Arm Human Centrifuge

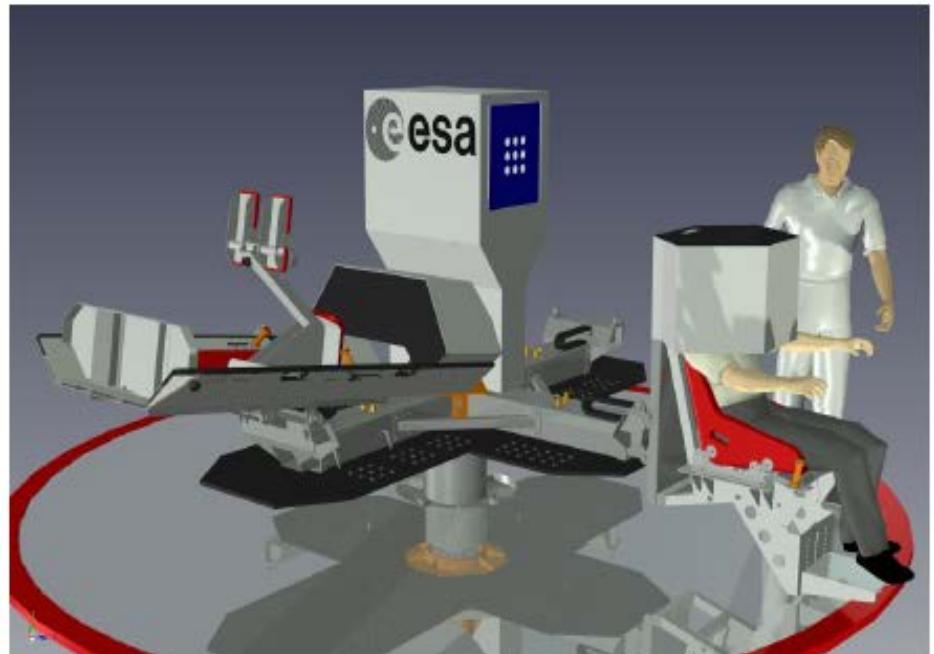
SYSTEM PROPERTIES

Max. rotor radius (adjustable)

r_{\max} 2.82 m

Max. radial acceleration at outer radius of rotor

$a_{n\max}$ 6,40 g



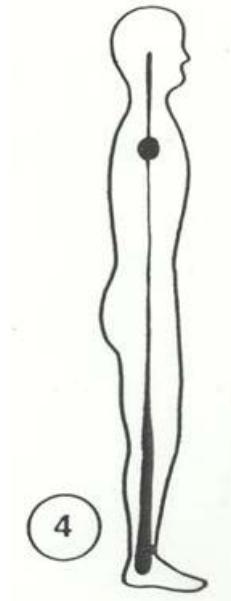
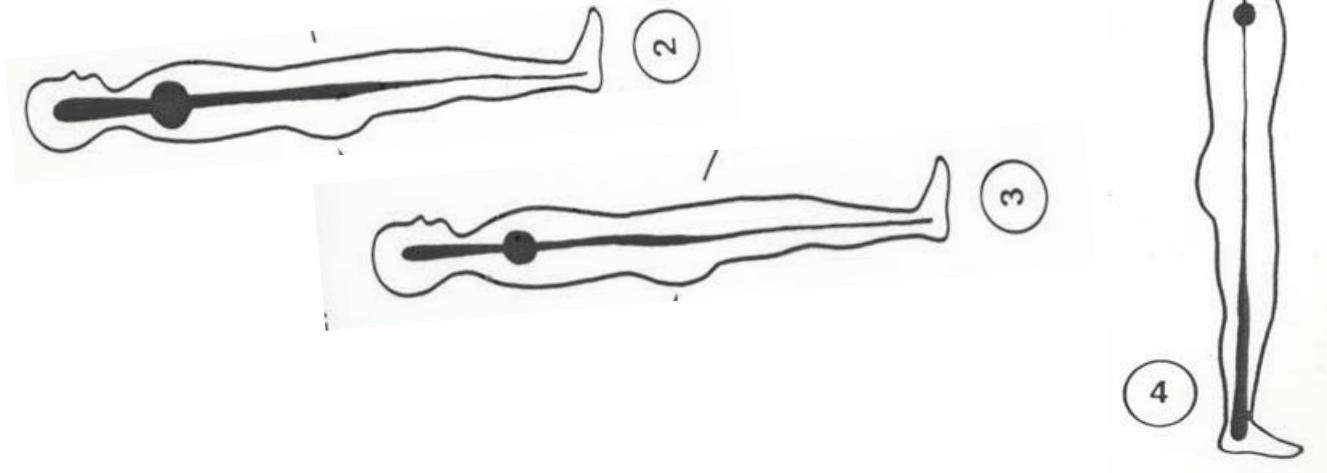
Test
before



6 degree head-
down tilt bed-
rest for 5 days:

- No AG
- AG 30 min/day
- AG 6*5 min/day

Test
after



Head-up tilt (HUT) procedure:

Baseline data collection for 5 min with subject in supine horizontal position

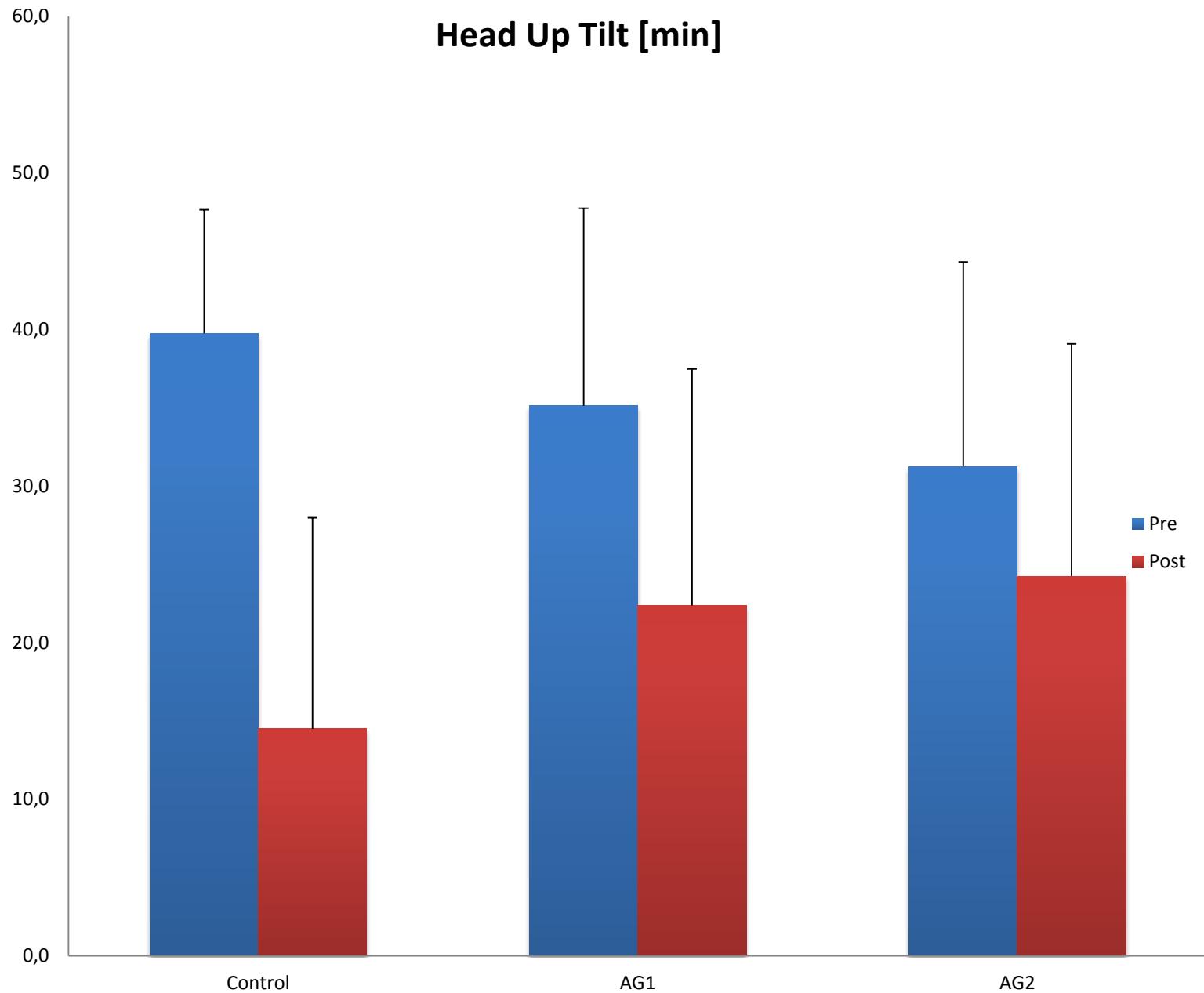
Tilt to 80° head up position for 30 minutes, followed by LBNP at -10 mmHg for 3 min, then decrements of -10 mmHg in 3 min stages until stop criteria are reached

Orthostatic tolerance:

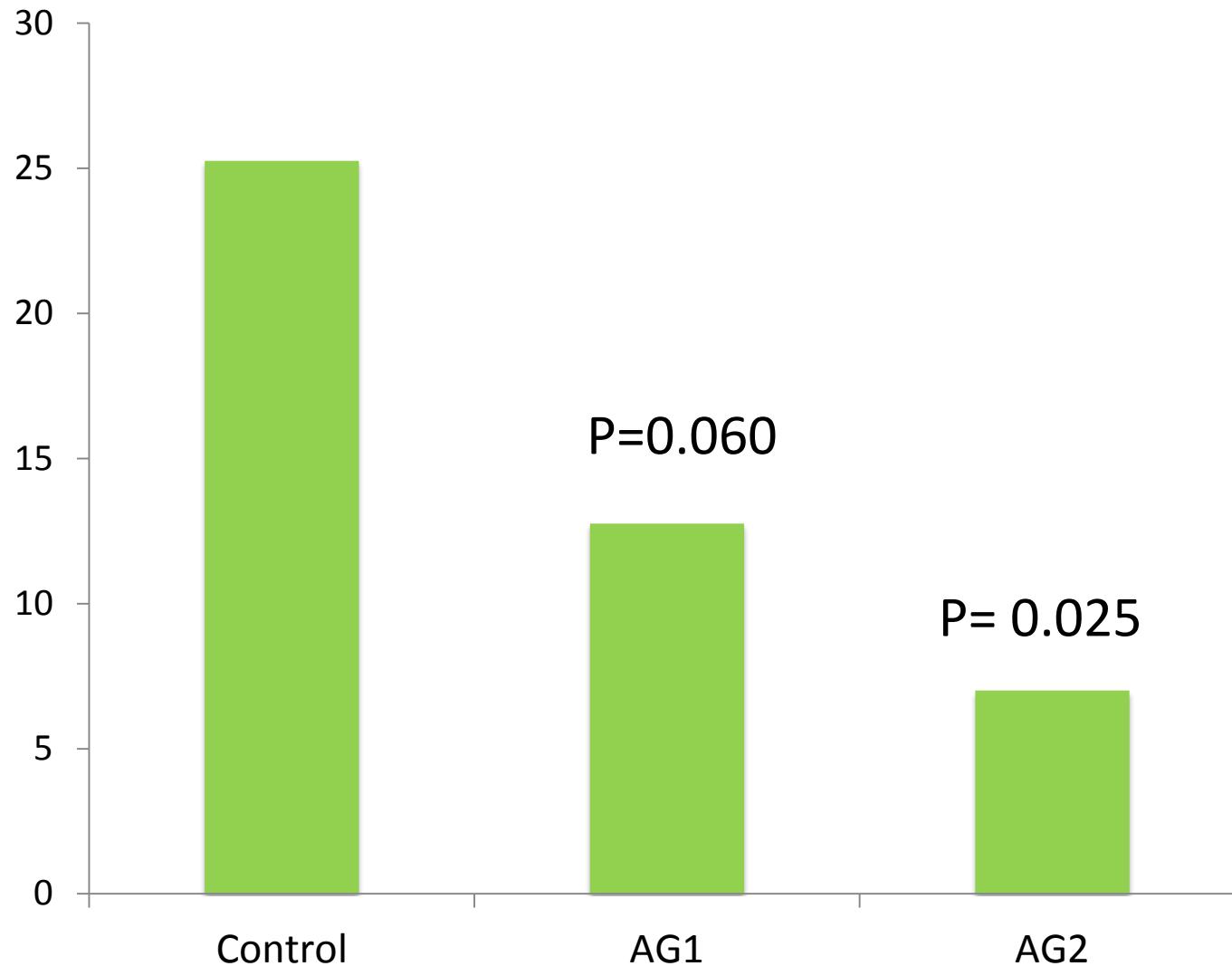
Time until presyncope

Maximal oxygen uptake

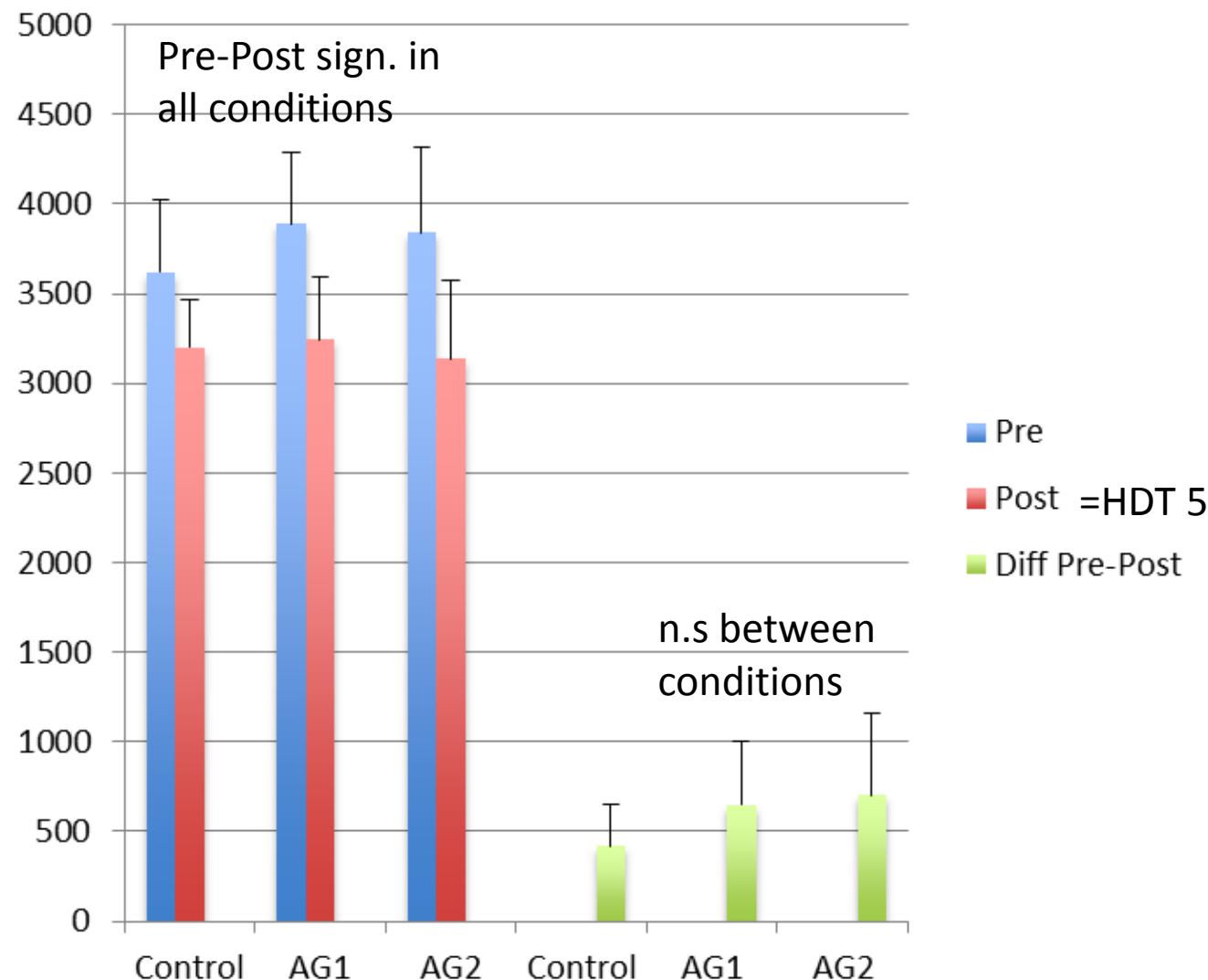
Blood plasma volume



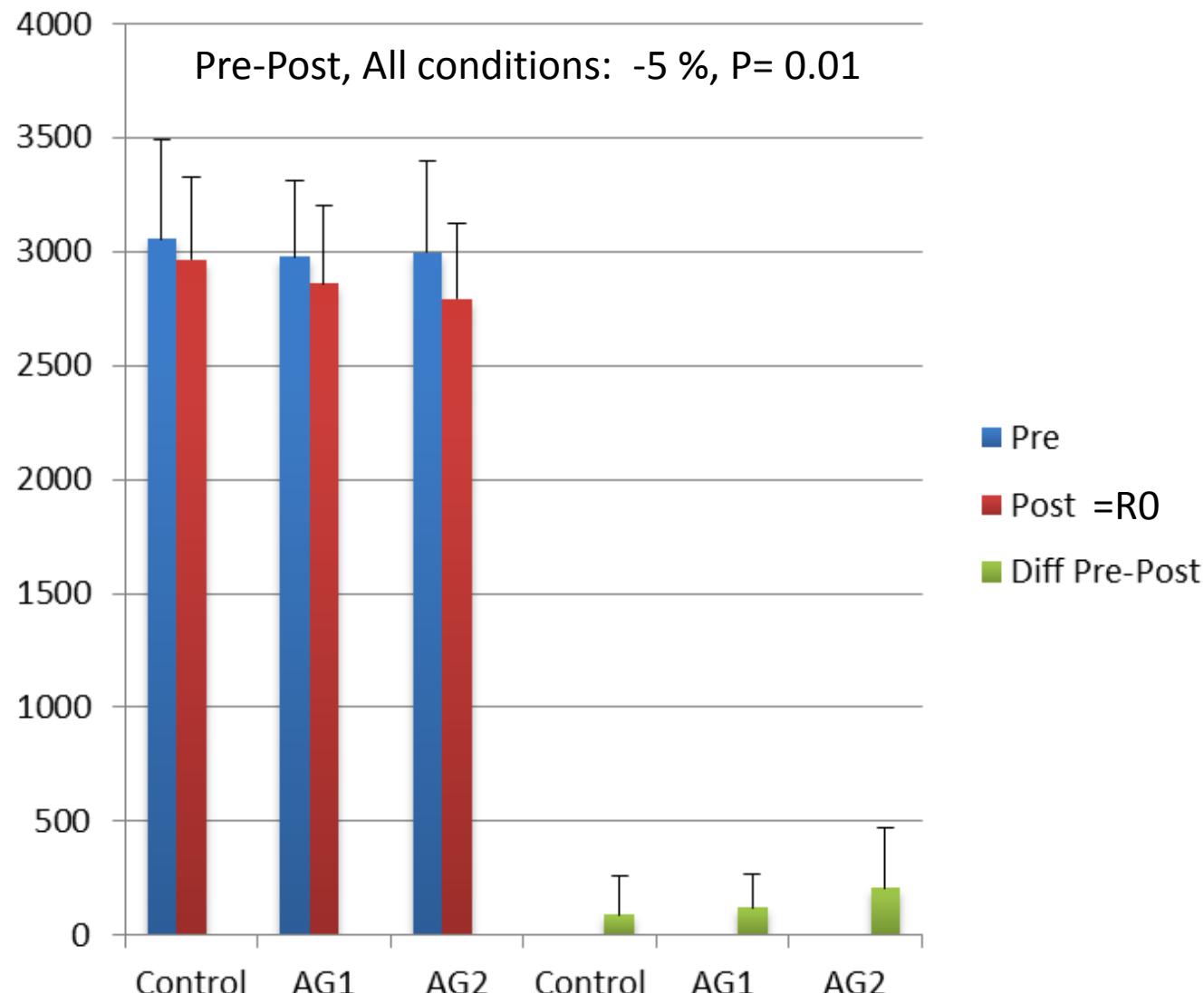
HUT tolerance Δ pre - post [min]



Plasma vol (ml)



VO₂max (ml/min)



Conclusions :

- 5 days of HDTBR results in significant reductions of plasma volume and orthostatic tolerance
- 30 min AG per day improves orthostatic tolerance, especially the 6 x 5 min protocol
- Plasma volume cannot explain the improved orthostatic tolerance during AG2 compared to control

..