

Altitude Decompression In Simulated Microgravity

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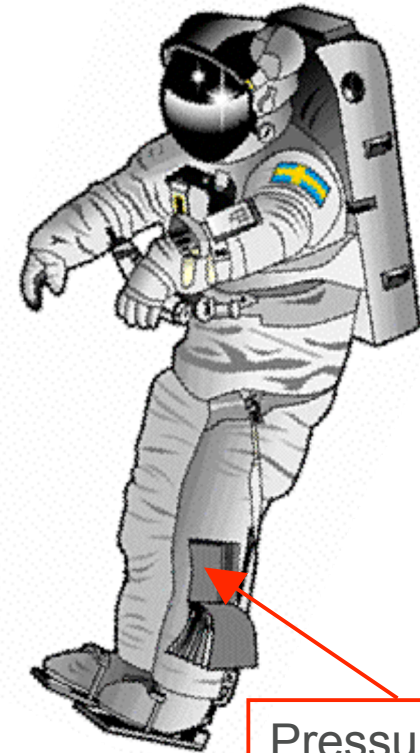
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Extravehicular activity (EVA)

- Decompression before EVA
 - EMU suit: 1 bar \rightarrow 0.3 bar
 - Orlan suit: 1 bar \rightarrow 0.4 bar
- Prebreathe to prevent venous gas embolism (VGE) and decompression illness (DCI)
- Studies on earth (ambulatory) with 1 h prebreathe and decompression to 0.4 bar show up to:
 - 65%** VGE after 2h / **84%** after 6 h
 - 35%** DCS after 2h / **78%** after 6 h

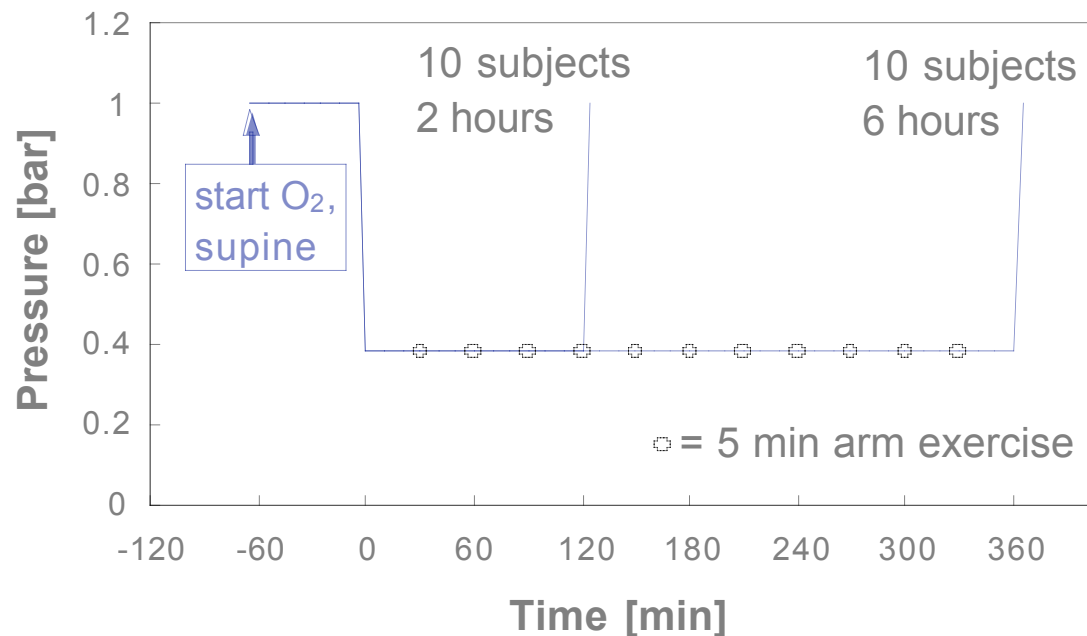
[Webb and Pilmanis, 2005]
- In space - **no reports** of VGE / DCI



Pressure =
0.3 / 0.4 bar

Methods

- The Russian pre-EVA/EVA decompression regimen with 1 hour prebreathe period was simulated in altitude chamber
- Twenty subjects were decompressed to 0.38 bar (285 mmHg / 7500 m / 25 000 ft) after 1 h of oxygen breathing, and continued to breathe oxygen for 2 hours (n=10) or 6 hours (n=10)



Methods (continued)

- Subjects strictly supine
- Intermittent biceps curls with weights of 2 x 1_ or 2 x 2_ kg
- Intermittent pre-cordial Doppler ultrasound detection of venous gas embolies (VGE)
- Monitoring symptoms of DCI
- Subjects were studied in pairs with 1-2 attendants present



Protocol	BMI (kg*m ⁻²)	AGE (yrs)	Gender
2h 0.38bar	23 ± 3	28 ± 7	4_, 6_
6h 0.38bar	26 ± 6	40 ± 10	4_, 6_
Total	25 ± 6	36 ± 15	8_, 12_

Results

Subject with VGE

rest / flex - KM Doppler score

0 / 3- @ 56 min

3 / 3+ @ 1h 26 min → recompression 

0 / 0 @ 55 min after start recompression

Group	Total	No VGE for		EVA aborted due to	
		2 h	6 h	VGE	Other
2 h	10	8	-	1	1
6 h	10	10	6	0	4

Operator with DCI

rest / flex - KM Doppler score

- @ 2h 50 min - fullness knee

3 / 4 @ 3h 01 min - fullness knees

0 / 0 @ 28 min after start recompression

Results (continued)

- Out of the 20 subjects, only **one** showed large numbers of detectable VGE (KM Doppler scores of grade III or above). This subject reported no DCI symptoms.



Discussion

- Lower occurrence of VGE and DCI than expected from the literature
- In contrast to most previous studies our subjects were **strictly supine** and performed **mild exercise**
- The horizontal posture and the complete lower-extremity unloading appeared to have prevented substantial formation of VGE. This lends support to the notion that Russian cosmonauts have a very low, if any, risk of DCI
- The operator that experienced both VGE and DCI had performed a **heavy physical effort** [*Henry, 1956*]



**Fracture in the Scaphoid Bone
(Hand Navicular Bone)**



**Fracture in the Radial Head
(Caput Radii)**

Discussion (continued)

- Unintentionally we decompressed a subject with a relatively recent fracture, and most likely with an associated soft tissue damage
- Local inflammatory processes and / or local endothelial damage in the fractured area → increase formation of, or entry of, decompression gas bubbles into the blood
- To our knowledge there are no previous reports on humans with muscular / skeletal injury exposed to altitude decompression
- However, reports of cats exposed to hypobaric pressures after trauma show increased levels of VGE and DCI [*Harvey, 1951*]

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