Knowledge transfer to and from clinical research

Igor B. MEKJAVIC*
Automation, Biocybenetics & Robotics
Jozef Stefan Institute
Slovenia

* igor.mekjavic@ijs.si
Space travel simulations and operational analogues

- Bed rest
- Hypoxia confinement
- Lunar habitat simulations
Problems associated with Lunar and Mars habitats

Reduced gravity & hypobaric hypoxia
Problems associated with exposure to microgravity

- Muscle atrophy
- Bone demineralisation
- Cardiovascular deconditioning
- etc.

"Commander, how does it feel to be back on earth after six months of weightlessness?"
Research designs

Subject confinement (wks, months)

- Ambulatory (1G) vs. bed rest (µG)
- Normoxic (ISS) vs. hypoxic (Lunar habitat)
- Bed rest: horizontal, head-down tilt, head-up tilt
Muscle atrophy and bone demineralisation

Time courses of bone loss and muscle atrophy

![Graph showing the time courses of bone loss and muscle atrophy.](image)

Organized by European Commission Enterprise and Industry and eesa
Hip, knee and calf muscle atrophy

*Berg et al. 2007*

- effect of aging on locomotion and gait
- rehabilitation post injury
Cardiovascular deconditioning

Tibial artery diameter in response to 5 wk of bedrest

(Eiken et al. 2009)

Implications: understanding the pathophysiology of essential hypertension

Organized by European Commission Enterprise and Industry eesa
Metabolism

- **Decreased muscle protein synthesis** through impaired anabolic effects of exogenous amino acids
- **Muscle oxidative stress** with compensatory activation of glutathione synthesis and increases of antioxidant defenses
- Activation of low-grade **systemic inflammatory response**
- **Impaired insulin action** at the level of skeletal muscle

*Biolo, 2009*
Rehabilitation

Ritweger et al., Bone (2009)
Potential clinical implications of hypoxic bed rest studies

• Chronic obstructive pulmonary disease (COPD)
• Congestive heart failure
• Obesity
• Hematology
CHALLENGES

• The combined effect of reduced gravity and hypobaric hypoxia (Lunar habitat environment) on physiological systems.
• Countermeasures
• Biomarkers
RECOMMENDATIONS
Hypoxic bed rest research programme

- ESA TT (Nov. 2009) “Lunar habitat simulation”
- ESA meeting (June 2010) “Hypoxic bedrest studies” NASA, JAXA, DLR
“Space exploration can be considered as the combination of robotic and human activities for the discovery of extra-terrestrial environments - that will open up new frontiers for the acquisition of knowledge and peaceful expansion of humankind”
Olympic Sport Centre
Owned and operated by the Ministry of Education

• Development of educational modules

Provide ..

“inspirational and educational potential that space exploration carries for motivating youth for science, technology, engineering and mathematics (STEMS) curricula at large”
Space life sciences are essential for human space exploration

James Lind
1747-1795

First controlled prospective experiment
Technology transfer - examples
b-CAT (The Netherlands)

VPSA technology

• Hypoxic and hyperoxic gas generators
• Altitude acclimatisation
• Weight loss
EC-ESA WORKSHOP ON SCIENCE AND EDUCATION WITHIN SPACE EXPLORATION

ISKRATEL (Slovenia) & AVAYA (USA)

Prime Care+ platform

Organized by

European Commission
Enterprise and Industry

eesa
EC-ESA WORKSHOP ON SCIENCE AND EDUCATION WITHIN SPACE EXPLORATION

COSMED (Italy)

Cardiopulmonary equipment

- Hypoxic function
ISKRAMEDICAL (Slovenia)

Vibration platform

• Countermeasure
• Rehabilitation
Prototype space suit made by W.L. Gore & Associates for NASA
YOYO Technology (Sweden)

Flywheel exercise device

- Countermeasure
- Rehabilitation
- Training
EMONA (Slovenia), MARS (UK) & NESTLE (CH)

Food supplements as countermeasures

• Muscle atrophy
• Osteoporosis
Revolving space station by Herman Potočnik Noordung

Revolving space station by Arthur C. Clarke in “2001: A Space Odyssey”

Short arm centrifuge developed by ESA

EC-ESA WORKSHOP ON SCIENCE AND EDUCATION WITHIN SPACE EXPLORATION
EC-ESA WORKSHOP ON SCIENCE AND EDUCATION WITHIN SPACE EXPLORATION

Principle of operation

- CO2 scrubber
- Oxygen scrubber
- (de)humidifier
- heater/AC

Central control unit
Measurement and control of:
- Oxygen (O2)
- Carbon Dioxide (CO2)
- Temperature
- Humidity

Air-tight room with reduced oxygen level
Blower for internal circulation

Organized by
European Commission
Enterprise and Industry
eesa
SMART HOUSE

Controllable House
- House with one integrated remote control
- House with interconnected devices
- Houses controlled by voice, gestures or movement

Programmable House
- House programmed to react to time or single sensor input
- House programmed to recognize predefined scenarios

Intelligent House
- House reacts to time or simple sensor input
- House recognizes and reacts to behavioural patterns (scenarios)
EC-ESA WORKSHOP ON SCIENCE AND EDUCATION WITHIN SPACE EXPLORATION

- Human-robot teaming
- Intelligent habitats

Organized by European Commission Enterprise and Industry