

Human physiology during exposure to cave environment: a systematic review and potential future implications for aerospace medicine

Lucrezia Zuccarelli, L. Bessone, E. Coffey, R. Turner, G. Strapazzon

ICASM 2017, Roma, Italy

Long term goals of space agencies

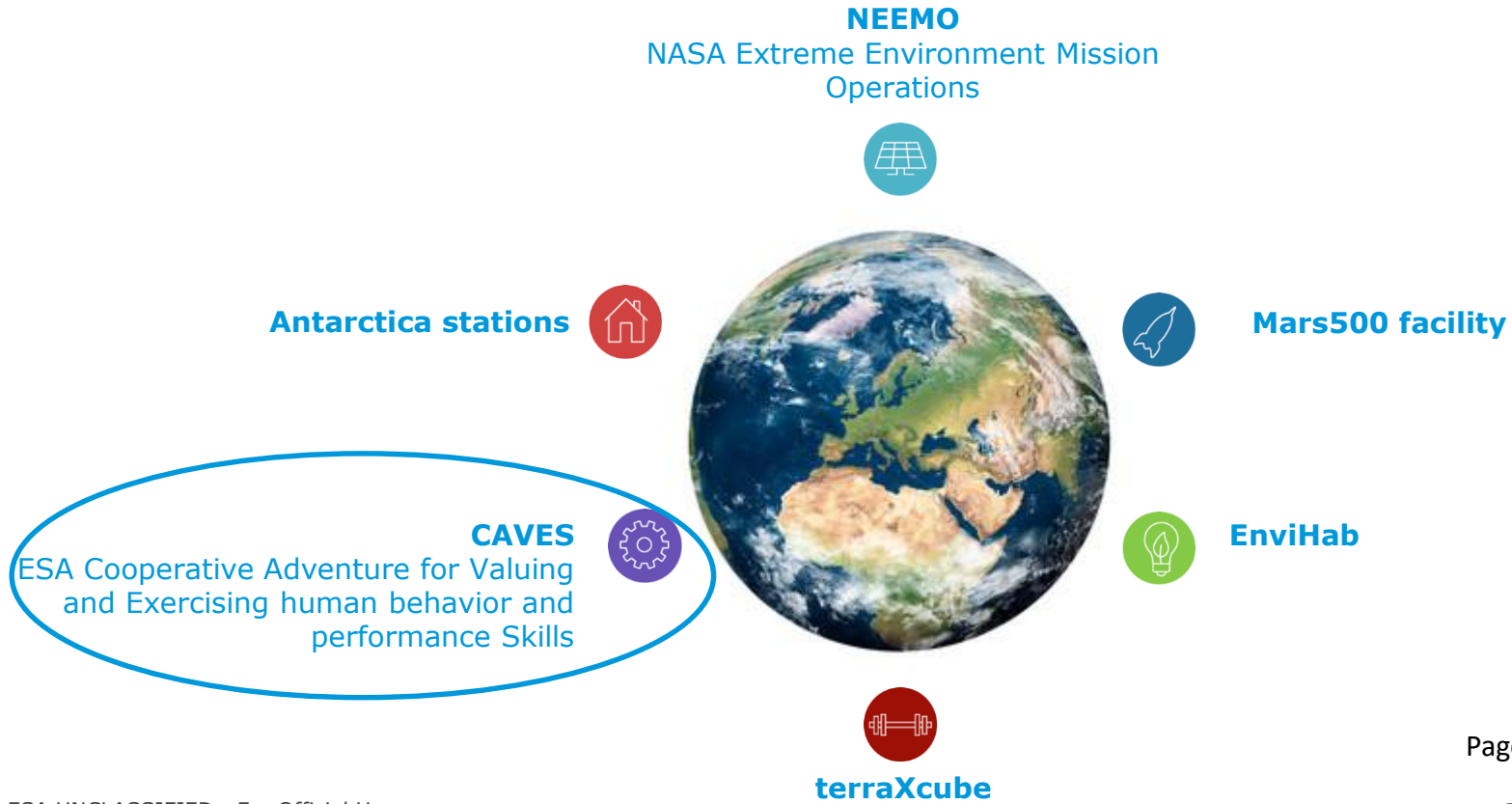


Terrestrial space analogues



Pagel et Choukèr JAP 2016

Terrestrial space analogues



Pagel et Choukèr JAP 2016



The ESA CAVES program:

- What is it?
- What do the astronauts do?
 - Cave environment
- Relevance for the space

Strapazzon et al. WEM 2014

CAVES: training for the space



CAVES: training for the space



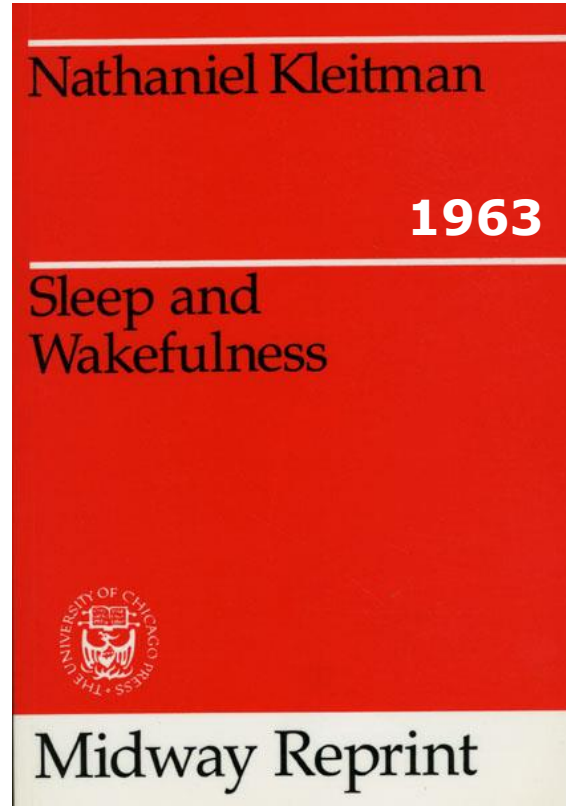
CAVES: training for the space



CAVES: training for the space



From the past ... to the present ...



Some problems of desynchronisation of sleep-wakefulness and circadian rhythms for long duration spaceflights,

Michel SIFFRE

Proceedings of the Space & Sea Colloquium, Paris, 24–26 September 1990, ESA SP-312

Effects of Isolation on Interferon Production and Hematological and Immunological Parameters

GERALD SONNENFELD,¹ JOHN MEASEL,² MICHAEL R. LOKEN,³ JOSEPH DEGIOANNI,⁴
STEFANIA FOLLINI,⁵ ANDREA GALVAGNO,⁵ and MAURIZIO MONTALBINI⁵

JOURNAL OF INTERFERON RESEARCH 2:75–81 (1992)
Mary Ann Liebert, Inc., Publishers

to systematically review the human studies associated with cave environment,
and thereby to facilitate to understand the results of studies
and to extend the results to implications
for human planetary exploration missions and space medicine

PRISMA (Preferred Reporting Items for Systematic reviews and Meta-Analyses) guidelines: specific research question, eligibility criteria, explicit and systematic method

Moher et al. PloS Med 2009

Studies on acute effect were define if the permanence in the cave was up to 72 h,
whereas studies on chronic effect if the permanence was more than 72 h

- Atmospheric Science
- Emergency Medicine
 - Human Factor
- Human Physiology
- Psychological Aspects
 - Radiation

NASA JSC - Medical Sciences Division. Medical Aspects of Exploration Missions
Hansen et al. Human anatomy and physiology for the European Astronaut Team

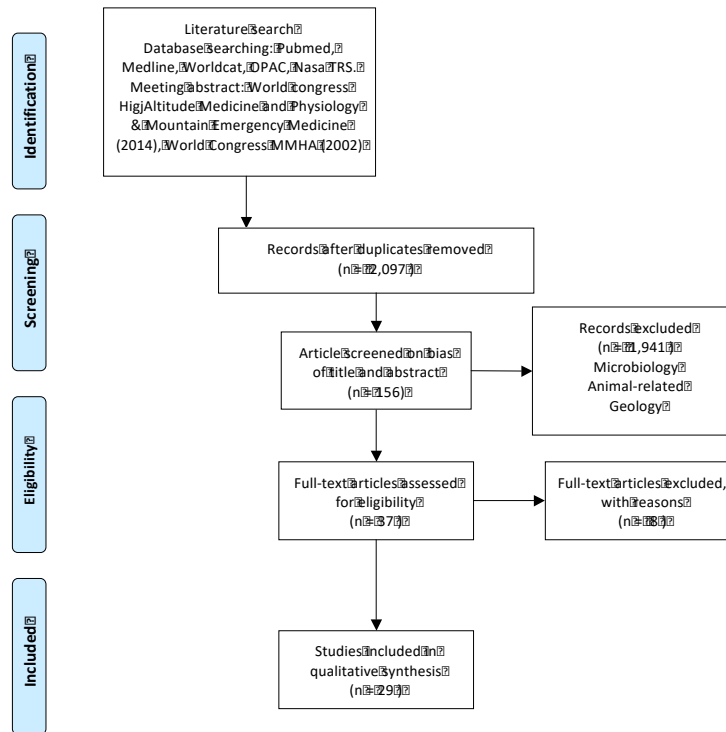
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 - Radiation

NASA JSC - Medical Sciences Division. Medical Aspects of Exploration Missions
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Summary of Bibliographic Research



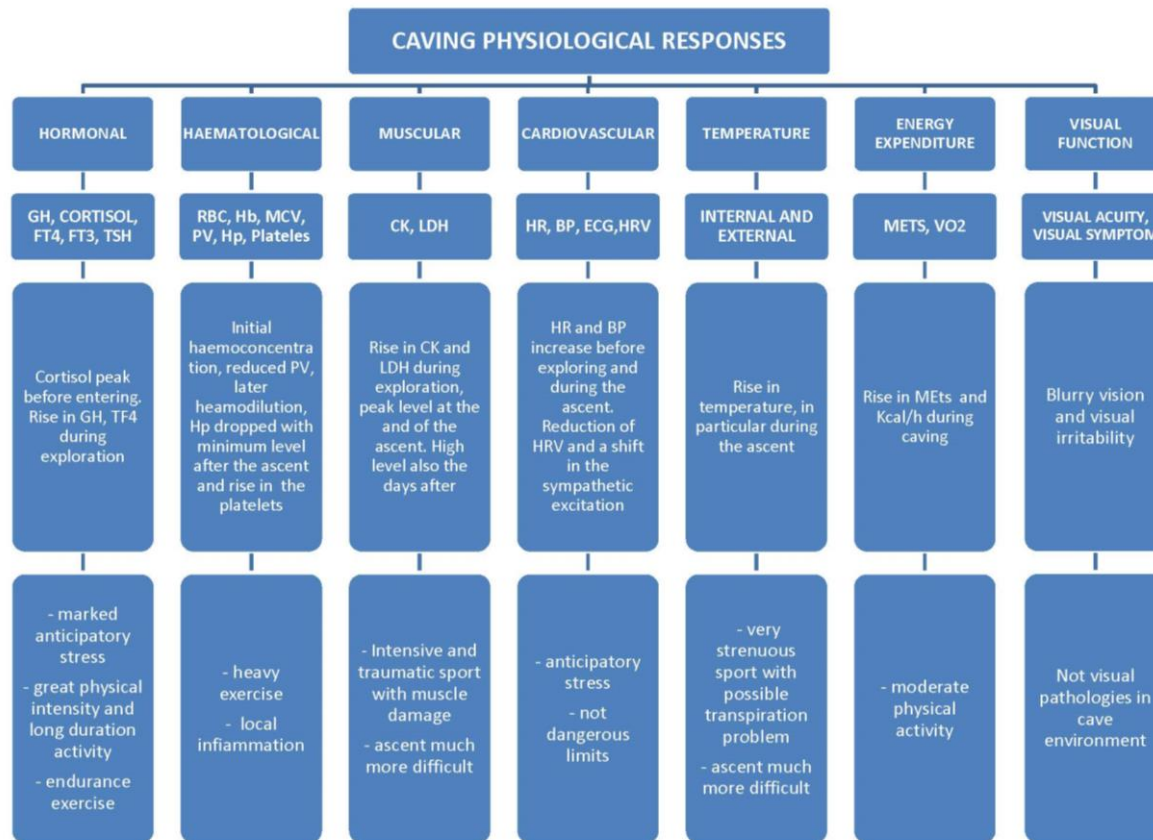
PRISMA 2009 Flow Diagram



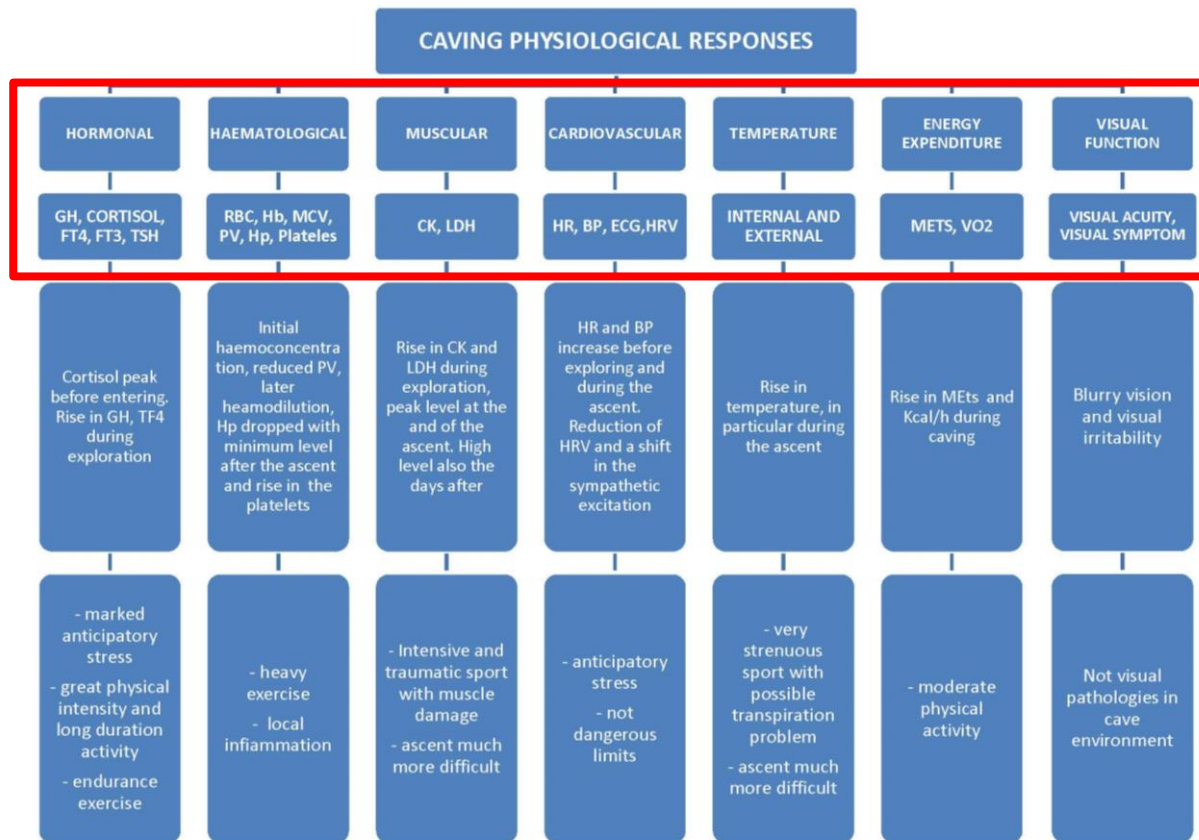
Acute effects (<72 h): 12 published between 1994 and 2017 and included a total of 130 subjects, all performing exercise in different cave/lab study setting

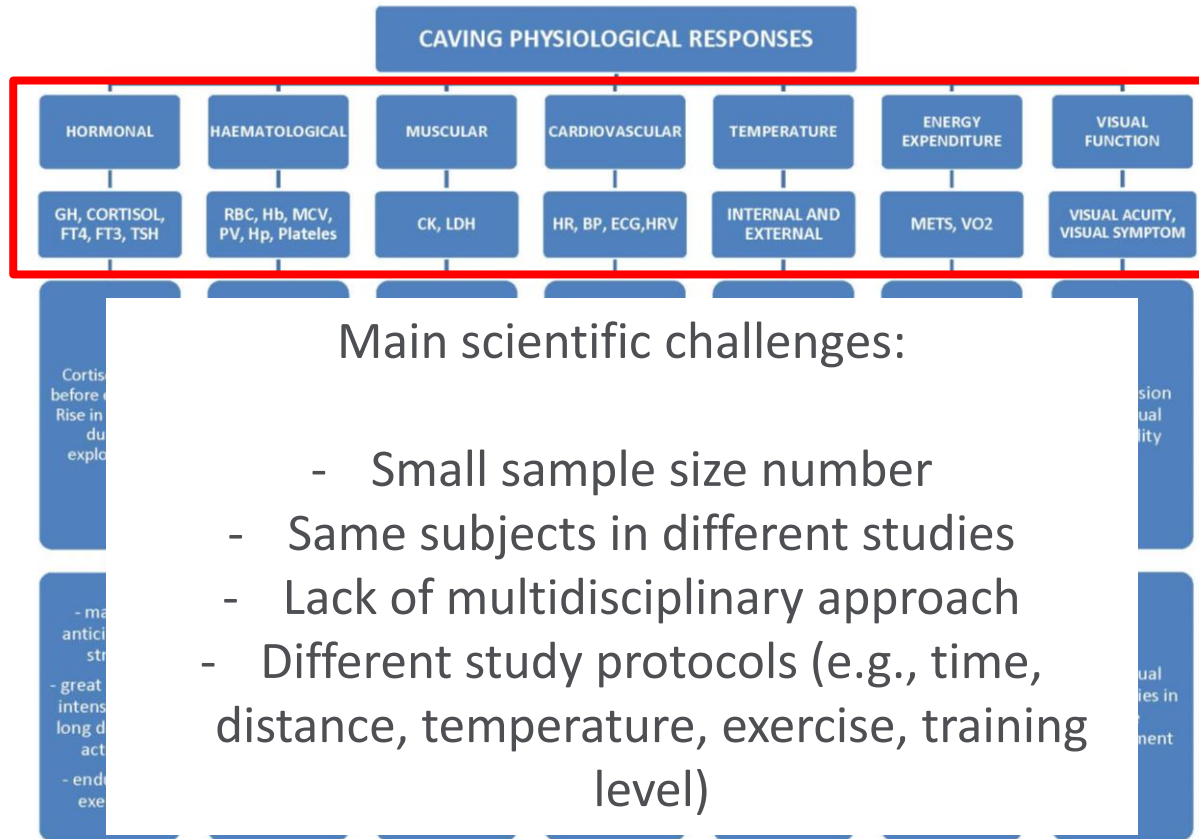
Chronic effects (>72 h): 17 published between 1963 and 2010 and included a total of 29 subjects, all except one exposed to cave environment for more than 30 days

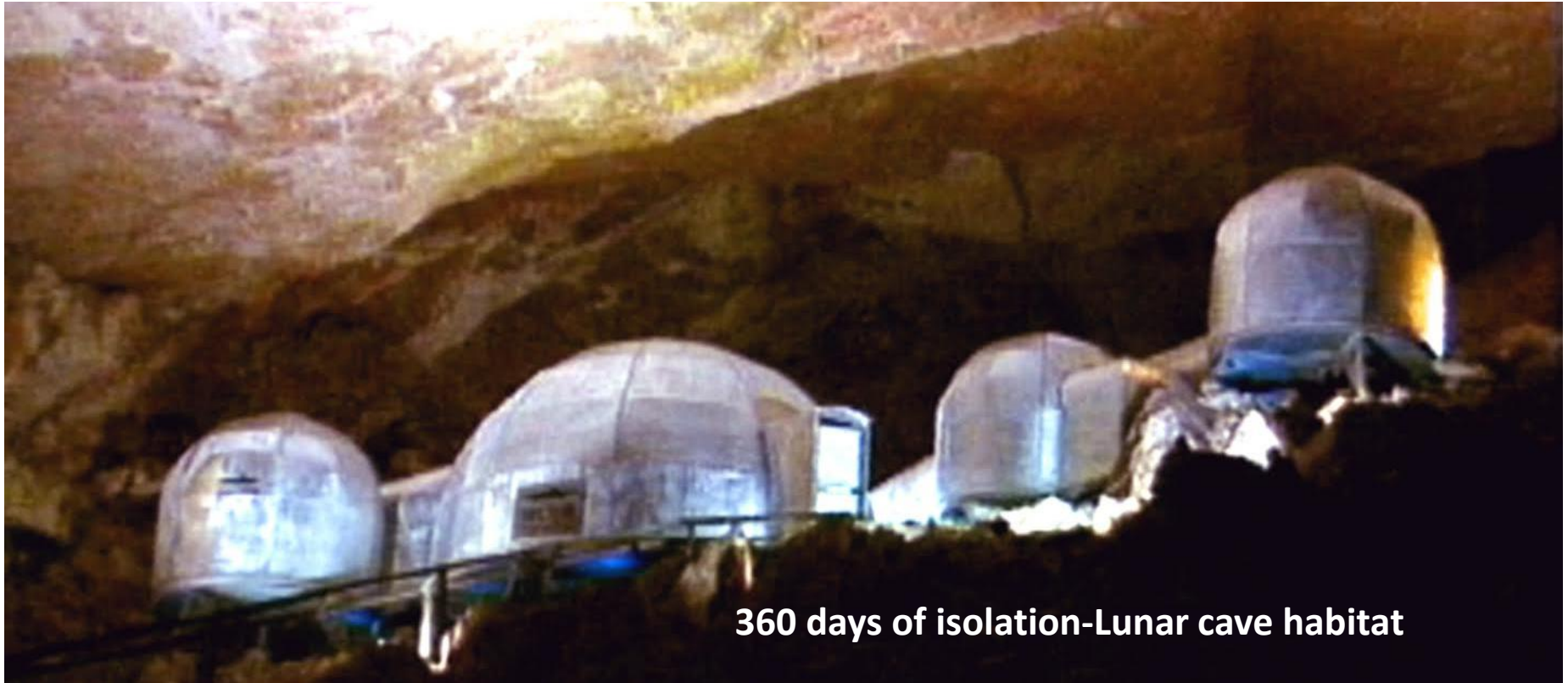




Results – Acute studies



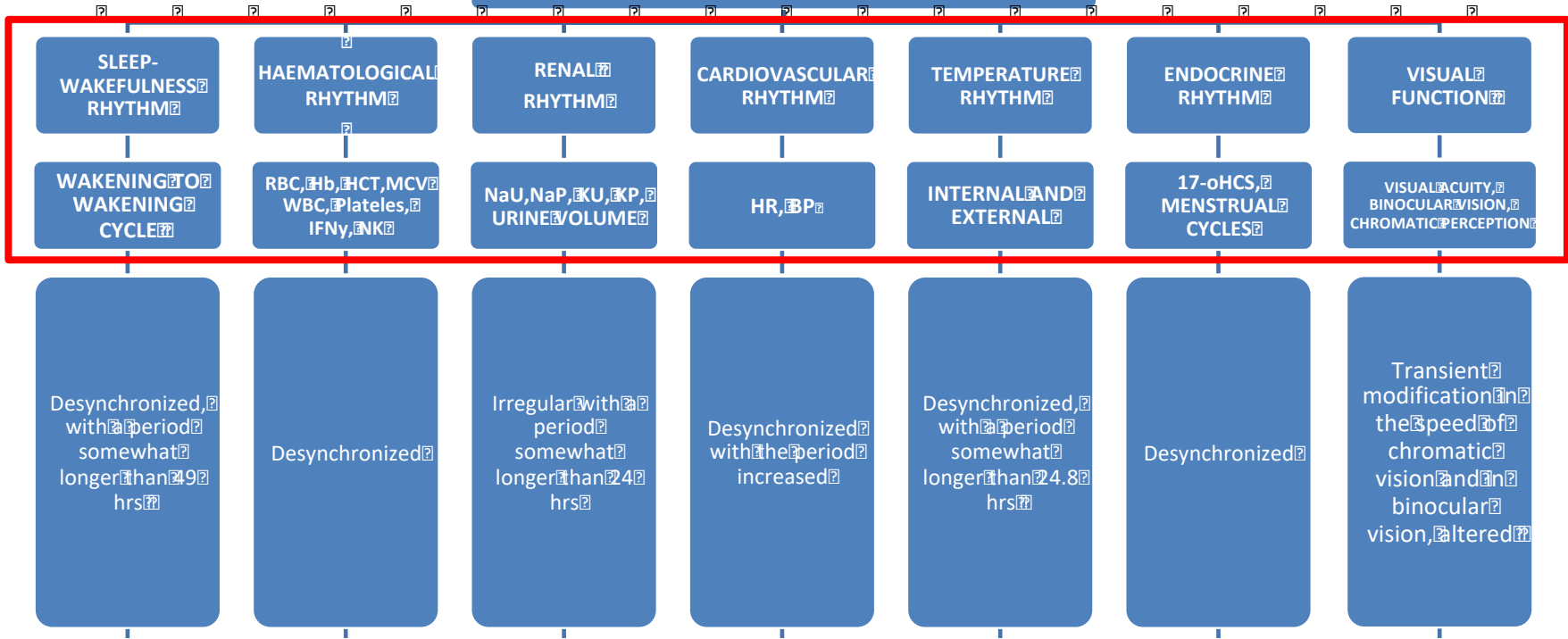




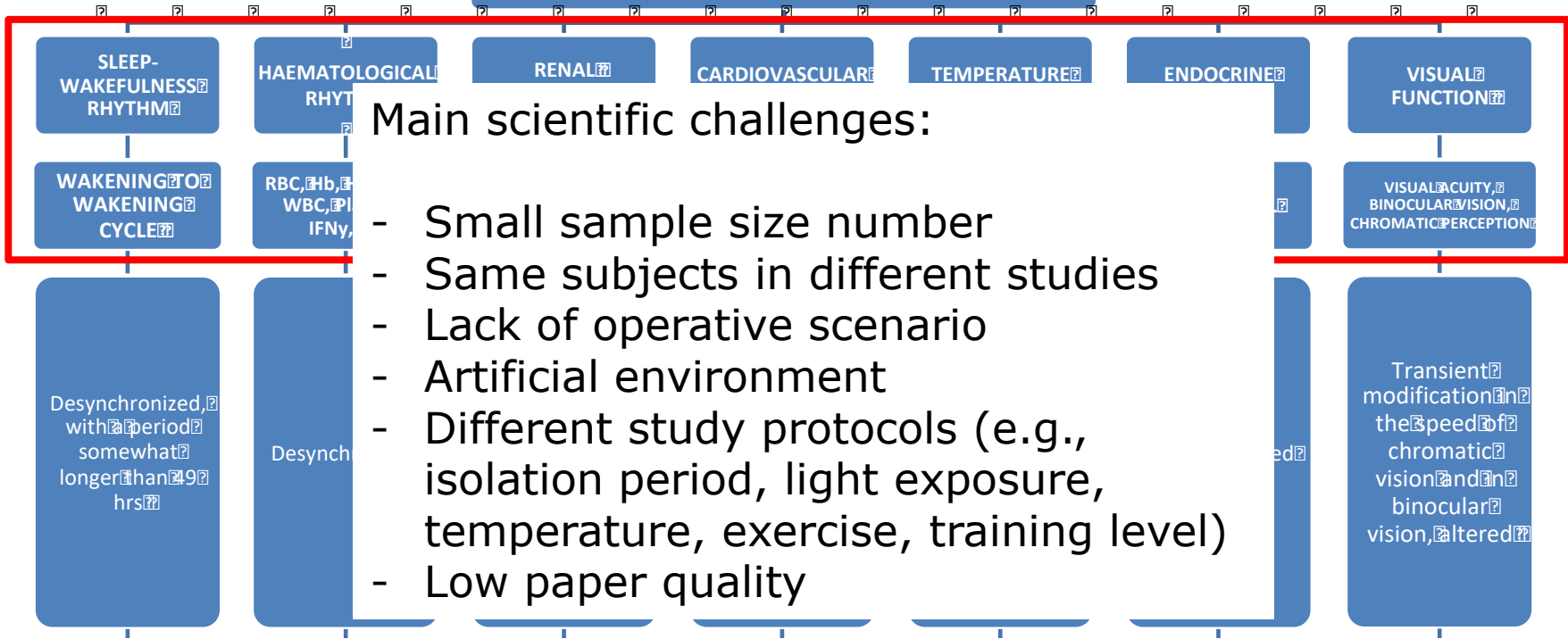
Results – Chronic studies



CAVING PHYSIOLOGICAL RESPONSES



CAVING PHYSIOLOGICAL RESPONSES



Main scientific challenges:

- Small sample size number
- Same subjects in different studies
- Lack of operative scenario
- Artificial environment
- Different study protocols (e.g., isolation period, light exposure, temperature, exercise, training level)
- Low paper quality

- Acute exposure to cave environment could offer a real operative scenario with atypical, strenuous and three dimensional human movements
- Alterations of circadian rhythms have important and practical consequences in organizing and understanding implications of astronaut expeditionary training courses in space analogue environment taking place in underground environments
- Future studies with new technologies are needed to better understand the physiological responses and adaptations to the cave environment

Thanks for the attention



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European Space Agency

Future Space Analogues: Perspective research

Extend terrestrial space analogue models with dynamic environmental simulation facilities

Take lessons learned from existing programs and delve deeper into physiological mechanisms and risk reduction in potential mission scenarios

Cluster expertise regarding optimisation of physiological performance for human planetary exploration missions and space medicine

