The Effects of Hypergravity and Microgravity on Biomedical Experiments
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SYNTHESIS LECTURES ON BIOMEDICAL ENGINEERING #18
ABSTRACT
Take one elephant and one man to the top of a tower and simultaneously drop. Which will hit the ground first?

You are a pilot of a jet fighter performing a high-speed loop. Will you pass out during the maneuver?

How can you simulate being an astronaut with your feet still firmly placed on planet Earth?

In the aerospace environment, human, animal, and plant physiology differs significantly from that on Earth, and this book provides reasons for some of these changes. The challenges encountered by pilots in their missions can have implications on the health and safety of not only themselves but others. Knowing the effects of hypergravity on the human body during high-speed flight led to the development of human centrifuges. We also need to better understand the physiological responses of living organisms in space. It is therefore necessary to simulate weightlessness through the use of specially adapted equipment, such as clinostats, tilt tables, and body suspension devices.

Each of these ideas, and more, is addressed in this review of the physical concepts related to space flights, microgravity, and hypergravity simulations. Basic theories, such as Newton's law and Einstein’s principle are explained, followed by a look at the biomedical effects of experiments performed in space life sciences institutes, universities, and space agencies.

KEYWORDS
microgravity, weightlessness, hypergravity, clinostats, ground-based simulations, space physiology, centrifuge.
Contents

1. General Concepts in Physics—Definition of Physical Terms ......................... 1
   1.1 Gravity and Related Concepts ................................................................. 1
   1.2 Weight Versus Mass and Inertial Mass ..................................................... 4
   1.3 Apparent Weight and Normal Force ......................................................... 5
   1.4 The Einstein Principle ............................................................................. 7
   1.5 Microgravity ........................................................................................... 8
   1.6 Hypogravity ............................................................................................ 13
   1.7 Partial-Gravity Environments on Earth .................................................... 13
      1.7.1 Underwater Immersion ...................................................................... 14
      1.7.2 Parabolic Flights ............................................................................. 14
      1.7.3 Body Suspension Devices ................................................................. 14
   1.8 Hypergravity .......................................................................................... 15

2. The Effects of Hypergravity on Biomedical Experiments ............................... 17
   2.1 Hypergravity and Human Physiology ....................................................... 17
      2.1.1 Positive Gz Effects .......................................................................... 18
      2.1.2 Negative Gz Effects ........................................................................ 20
   2.2 G Impact in Space Missions ..................................................................... 21
   2.3 Human Centrifuges ................................................................................ 24
   2.4 The Microgravity Centre Hypergravity Experiments ............................... 28
   2.5 Test Models ........................................................................................... 30
      2.5.1 System of Tubes Simulating the Column of Blood ......................... 30
      2.5.2 Magnetic Rings Representing Intervertebral Disks ......................... 31
      2.5.3 Spring and Rubber Band With an Attached Mass Modeling
          Muscle Function ..................................................................................... 33
      2.5.4 *Eruca sativa* Mill (Rocket Plant) .................................................... 34
3. The Effects of Microgravity on Biomedical Experiments

3.1 Ground-Based Microgravity Simulation
3.1.1 Bed Rest and Bed Rest-Associated HDT
3.1.2 Tilt Tables
3.1.3 Water Immersion (Neutral Buoyancy)
3.1.4 Immobilization
3.1.5 Body Suspension Devices
3.1.6 Barany’s Chair
3.1.7 3D Clinostat

3.2 Collection of Peripheral Blood and Isolation of Mononuclear Cells
3.2.1 Microgravity Test With PBMCs

3.3 Cell Proliferation/Viability Assay
3.3.1 Statistical Analysis
3.3.2 Proliferation and Cellular Viability With PBMCs in Microgravity Simulation
3.3.3 Proliferation and Viability Assay

References
1.1 GRAVITY AND RELATED CONCEPTS

Konstantin Tsiolkovsky, a pioneering Russian rocket scientist, once said that “The Earth is the cradle of Humanity, but we can not [sic] live in a cradle forever.” Mankind, in its process of evolution, will eventually leave their home planet searching for new places to inhabit, just like our primitive ancestors did when they left their caves. Living organisms on Earth share at least one thing in common: all of them live under the influence of the gravitational force of the Earth, which produces an acceleration of approximately 9.81 m/s² at mean sea level. Earth’s acceleration is represented by the small letter “g.” Therefore, any variation in this force will result in physiological changes in any given organism. To better understand topics related to the effects of hypergravity and microgravity on living organisms, it is important to be familiar with some definitions of physical terms, theories, and laws that will be presented and discussed in this chapter (Chandler; Cutnell and Johnson, 2006; Dobson et al, 2006; Halliday et al, 1993).

Gravitation (or gravity) is the tendency of objects with mass to accelerate toward each other. The terms gravity and gravitation are often used to explain the same thing, but for many authors there is a definite difference between the two:

Gravitation is the attractive force existing between any two objects that have mass. Gravitation is the reason for the very existence of the Earth, the Sun, and other celestial bodies. Without it, matter would not have coalesced into these bodies and life as we know it would not exist.

Gravitation is also responsible for keeping the Earth and the other planets in their orbits around the sun, the Moon in its orbit around the Earth, the formation of tides, and various other natural phenomena that are commonly observed (Figure 1.1).

Gravity, however, is the gravitation related to Earth. It is then the gravitational force that occurs between the Earth and other bodies, the force acting to pull objects toward the Earth. It is expressed as 1G (capital “G,” as opposed to the acceleration g). Bodies with less mass than the Earth will have values lower than 1G (the Moon has 1/6G), and bodies with mass bigger than the Earth will have values higher than 1G (planet Jupiter has 3.5G).