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Editorial

Space Physiology: A Promising field of Research for Physiologists

Our country is moving ahead with steady speed in the field of space exploration. Sequential success of Chandrayaan 1 (2008) and 2 (2019) has given confidence that Indian manned space flights are possible in near future. Our space station is a dream possible in coming years. The ambitions have already started building up. To fulfill the aspirations and ambitions of Indians in space, our scientists, technologists and policy regulators need to gear up for the new horizon.

We as physiologists need to shoulder the responsibilities for our space mission programs. There is huge opportunity in waiting. Let us focus on the following two dimensions for the success of human space program.

Physiology for application in space

The shape of biological research and human physiological research requires intense collaborative and concerted efforts. To achieve it, a multipronged approach is required. We need to initiate thoughtfully planned and well-conceived endeavors in space biology and space physiology for humans. These efforts should focus on the long term goals.

To develop space physiology, we as physiologists specifically should initiate education and research in simulated environment and real environment. The simulated microgravity, human isolation and radiation environment can be created on earth. Similarly respective countermeasures can also be set up or developed on Earth laboratories.

In the Department of Physiology at AIIMS, New Delhi, we set up Space and Environmental Physiology lab about 3 years ago. Although, the work on Lower Body Negative Pressure (LBNP), a counter measure to microgravity for fluid shift started in 2013. We have completed the following studies addressing several issues related to space physiology:

i. The effect of lower body negative pressure (LBNP) on baroreflex response.

ii. The effect of LBNP on dynamic cerebral auto-regulation.

iii. The effect of slow breathing on frequency dependent baroreflex sensitivity assessed by oscillatory LBNP.

iv. Acute effects of slow breathing on cardiovascular variability during head up tilt, head down tilt and lower body negative pressure in yoga practitioners.

v. Cardio-respiratory and hormonal responses to oscillatory LBNP in healthy subjects.

vi. The effect of graded lower body positive pressure on dynamic cerebral autoregulation.

vii. Assessment of peripheral arterial compliance during graded LBNP.

viii. The effect of isometric handgrip exercise on baroreflex sensitivity during varying lower body negative pressure at different oscillatory frequencies.

The current work is going on in the following directions; i. Effect of 6° head down microgravity simulation on sleep. ii. Hemodynamic correlates of retrograde shear augmentation in brachial artery by LBNP. iii. Acute cardio-autonomic responses to graded head down tilt in long term Shirsasana yoga (head-down pose) practitioners. iv. The effect of gravitational loading on autonomic function, muscle function and oxygen consumption. v. The effect of simulated microgravity on baroreflex in rodents.

We have made headway in developing a countermeasure of microgravity in terms of developing a gravity producing suit to be used in space for performing Yoga. We are using gravitational loading and unloading as model to manipulate gravitational load on human body on earth. Our efforts are miniscule in the field of space physiology. The extent of space physiology work that can be carried out is enormous and it opens new avenues for physiologists and other medical scientists in the country.

Earth application of space physiology

The earth application of the findings of space research and technologies is an important dimension which needs special consideration for emerging and developing country like India. The justification lies in the fact that the space research is cost-intensive and the cost can be justified by having larger application back on earth. It means that all space science and technologies must be translated into the terrestrial applications. It makes more sense to our country where our investment in space exploration and research needs to give us better returns.

In technological world, there are several examples where space technologies have resulted in their extensive application on Earth such as communication, agricultural sciences, education, defense & mass media etc. With reference to Biology, Physiology and Medicine, the space research offers the advantages in the following fields :

1. Deciphering complex physiological mechanisms as we get a new physiological challenge/scenario to manage gravitational paradigm: This opens up the field of hypo-gravitational and hyper-gravitational physiology. This will include research and its application to almost all systems from molecular biology to systemic physiology to biomedical engineering. The same argument will be applicable to other challenges in space such as radiation exposure, psychological and nutritional.

2. Understanding human aging and ways to alleviate ageing and ageing effects: It is known that during microgravity exposure, a human being ages faster. The countermeasure used in space may be used to reduce the aging effects on earth.

3. Understanding of physiology of un-loaded bones muscles and their interaction with un-loaded skeletal system: The findings of space physiology will be applicable to improve the condition of prolonged recumbency.

4. Understanding capillary fluid dynamics, intramural and interstitial pressures: Such research will have useful implications to engineering such as micro-fluidics and other domains where capillary system forms the integral part of system.

5. Understanding fetal physiology, fluid and hemo - dynamics and developmental biology: The space physiology research will help in understanding and managing the issues in developmental biology and fluid dynamics.

6. Implication to Sports physiology: Space physiology essentially works around physiological reserves and physiological capacities. The process involves to identify the characteristic capacities needed for adaptability. It also involves countermeasures that enhance physiological capacities of human performance. Therefore , the space technologies have promising role in developing better human , better athlete and better sports person.

The pursuance of space physiology is essential to support and sustain life in space for astronauts. It also provides directions for devising interventions for space tourists with compromised physiological limits.

Microgravity experiments should be performed both in a task-force mode and in a “free-choice experimental paradigm”. The Indian Space Research Organization (ISRO) and other scientific bodies are encouraging the researchers in the field. As a quick starter, already existing research organizations should start research in the field of their interest with available resources. The time has come to set up more dedicated institutions for this purpose in addition to programs run by ISRO. Institute of Aerospace Medicine (IAM) is already pursuing service, education and research in the field. In order to involve intelligentsia of large number of scientific institutions and universities a new policy needs to be set up. It will be worthwhile to create more institutes/centers of excellence to cater to the research in space biology, space physiology and space medicine. Such program should provide opportunity for experimentation in real and simulation microgravity environment. India should start parabolic and low earth orbit flights where microgravity experiments can be performed. Such programs will provide a platform for research in Space Physiology.

Undoubtedly, Space Physiology is one of the emerging needs for India in the field of space sciences and technology development. Therefore, a research policy involving all contributors and stake holders needs to be established for this purpose. I am sure, with advances in this field, we will explore much more in space to bring fruitful results for mankind. Our Indian dream of “Basudhaiv Kutumbkum” (One world family) will surely be realized in much larger context. We hope that our research will kindle the thinking process and boost confidence in minds to exercise their choices to explore the ‘Bhramand’ (The Universe).

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