ENDOCRINE AND METABOLIC CHANGES IN PAYLOAD SPECIALIST L-1

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Background

The endocrine system plays an important role in the adaptation to unusual environments by secreting hormones to control metabolism. Since human beings have long evolved on the surface of the Earth under a gravity environment, the weightless environment must be quite unusual for them. The purpose of this experiment is to study the mechanisms of human adaptation to a weightless environment from endocrine and metabolic changes.

Our study plan is focused on four major physiological changes which have been reported during past space flights or which may be expected to occur under that condition.

1. Hormone and metabolic changes associated with fluid shift. It is well-established that exposure to weightlessness results in significant redistribution of body fluids. As shown in Figure 1, on arrival at zero gravity, body fluid shifts from the lower part of the body to the upper part, resulting in overhydration of the upper body. The change can be partly ameliorated by hormonal adjustment of fluid metabolism such as increased urine flow. This change causes a decrease in plasma volume. Therefore, on return to Earth, gravity-induced downward fluid shift may elicit cardiac deconditioning. Thus, investigation of body fluid metabolism and its regulating mechanism has been thought to be one of the most important subjects in space medicine.

2. Bone demineralization and muscle atrophy. On the Earth, bone and muscle function to sustain body weight and to exercise against gravitational force. Under the weightless condition, the load on them is greatly reduced. Thus, bone and muscle atrophy are commonly observed in the astronauts after space flight. These changes are accompanied by increased urinary calcium excretion and loss of muscle proteins. Since loss of calcium continues for the entire stay in space, bone demineralization has been thought to be one of the major limiting factors of long-term space flight. Up to now, these changes in bone and muscle have been attributed to gravitational unloading, but the involvement of the endocrine system also should be considered. It is widely known that increased secretion of glucocorticoids such as occurs in Cushing's syndrome or their administration for a variety of diseased states causes bone and muscle atrophy, while various kinds of anabolic steroids are used by athletes to strengthen bone and muscle. Thus, changes in catabolic glucocorticoids and anabolic testicular steroids during space flight should be examined.

3. Altered circadian rhythm. Various physiological functions of living organisms on the Earth show remarkable rhythmical changes which are concordant with the Earth's rotation. Among these physiological functions, circadian rhythmicity of some hormone secretion is prominent ensuing circadian variation of metabolic parameters. It has been suggested that alteration of circadian rhythm may cause disease. The alteration of the circadian rhythm of adrenocortical hormone secretion is known in patients with depression. On the other hand, eastward or westward air travel causes so-called jet lag. This well-experienced phenomenon is a result of discordance between the acquired rhythm at the original location and rhythm of the new

location. Therefore, the effect of space flight free from influence of Earth's rotation on ciradian rhythm of endocrine and metabolic function is interesting.

4. Stress reaction during space flight. When living organisms are exposed to unusual environments, stress reaction which accompanies increased secretion of adrenocortical hormones occurs. Since stress reaction modifies the regulation of water and electrolyte metabolism as well as gonadotropic hormone secretion, evaluation of the stress reaction is indispensable. The elucidation of the interrelationship between stress reaction and above the three subjects is most interesting.

Procedures of the Experiment

Timed urine samples will be consecutively collected from the seventh pre-flight day to the third post-flight day, with a 2- day interruption during the in-flight period. Blood samples will be obtained at pre- and post-flight periods. Body weight will be measured every morning before breakfast. Fluid intake of all kinds will be recorded. Various parameters will be measured, for example, water- and electrolyte-regulating hormones, adrenal and testicular hormones, catecholamines and metabolic parameters such as Na, K, Cl, Mg, Ca, P, hematocrit, osmolality, etc. Simultaneous determination of various hormones and metabolic indices and consecutive collection of urine characterize this experiment.

Influential Effects of this Experiment on Biomedical Science

In spite of wide variations of environment that surround living organisms, composition of body fluid is maintained within relatively narrow ranges. Thus, cells which are fundamental

components of organisms, are bathed by stable body fluid and keep their function. The maintenance of constant internal milieu, homeostasis, is essential for life. The endocrine system plays an important role in homeostasis. Thus, investigations of the endocrine system under unusual environments offer fundamental knowledge to biomedical science. The weightless environment is a novel unusual environment which has been experienced by few human beings. Therefore, the proposed experiment may offer new results on the mechanism of human adaptation to various environments.

Expectations on each topic: (1) Disturbances of water and electrolyte metabolism comprise not only edematous disorders but also hypertensive disorders which are the most common adult diseases. Since changes in water- and electrolyte-regulating hormones during space flight differed from what was expected by simulated weightless experiments on the Earth, the control of these hormones may be modulated by other factors so far not fully realized. This experiment may elucidate them. (2) Atrophy of bone and muscle is an important problem in geriatric medicine. Elucidation of the mechanism of atrophy during space flight should greatly contribute to the understanding of pathogenesis of bone and muscle atrophy in aged people. (3) Recent development of aircraft and popularization of world travel has made jet lag common. The mechanism of circadian rhythmicity of physiological functions, however, has not been clarified yet. Investigation on the rhythmicity of hormone secretion in space where the influence of the Earth's rotation is absent may contribute to understanding the basic mechanism of the rhythm and may offer countermeasures against jet lag. (4) Stress reaction affects various endocrine systems. Studies on the influence of stress reaction induced by space flight upon endocrine and metabolic systems are important to understand the control mechanisms of living organisms.

Thus, this experiment may be important not only for maintenance of good health of astronauts but also for basic and clinical medicine on the Earth, and it may contribute to understanding of the basic phenomena of life.

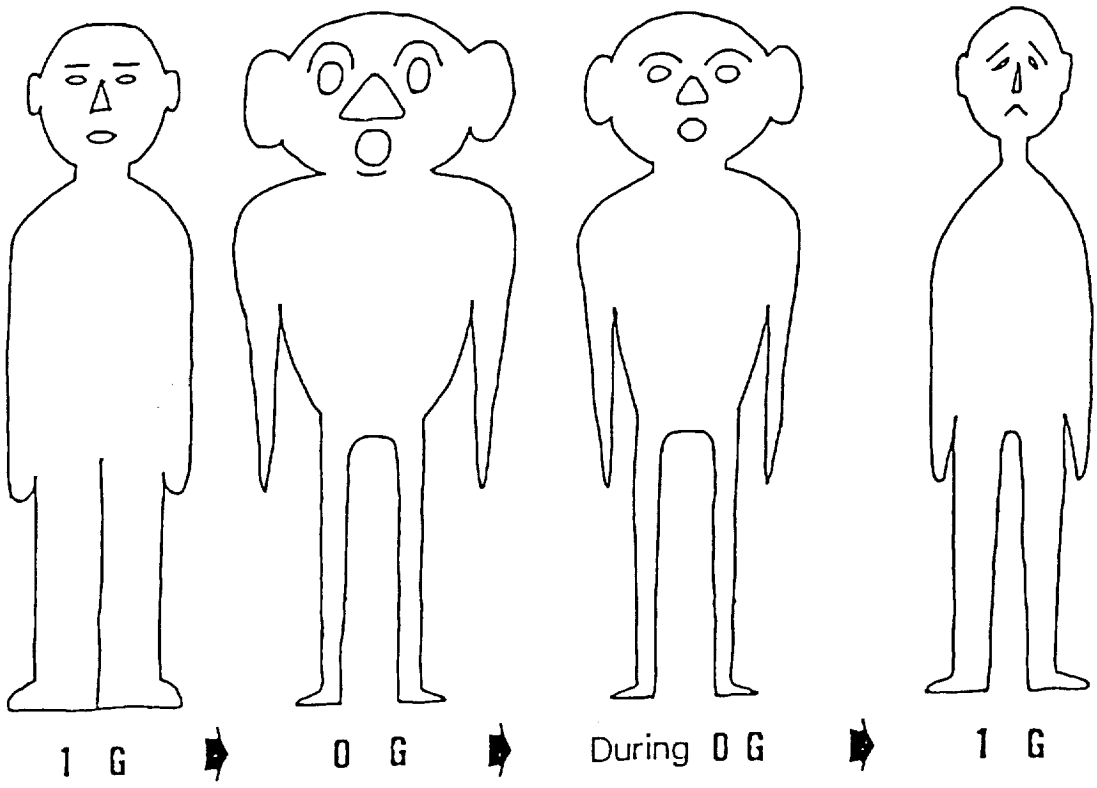

Figure 1. Body fluid shift caused by space flight.