# Japanese Aerospace Literature This month: *Gravitational Physiology*

**A93-49179 Effect of chronic centrifugation on in vitro fertilization and early development in mice ova.** MASAO ITO, RURIKO MARU, TAKASHI MAEDA, ESTER SANADA, TAKAICHI MANO, SHINICHI HORIGOME, KENICHI IWASAKI, YUICHI KAMEYAMA, YOSHIRO ISHIJIMA, and KAZUYOSHI YAJIMA, *Japanese Journal of Aerospace and Environmental Medicine* (ISSN 0387-0723), Vol. 30, No. 1, March 1993, pp. 19–25.

It is reported that fertilization rate was over for mice ova subjected to 0.6 and 1.2 G of acceleration in centrifuges and in those receiving 1.8 G and over. In the former group ova ceased to grow mostly at metaphase II and sperm penetration was prevented. In the latter group, while sperms penetrated the ovular cytoplasm and the nuclei reached anaphase or telophase, polyspermy and abnormalities were frequent. Centrifugation at 2 G or less had no effect on in vitro growth of two-cell ova into blastocysts, but the cell number of embryos thus produced was significantly smaller than in controls. In ova receiving 3.6 or 4.0 G, most failed to grow to blastocysts and those that did were smaller than 60 cells.

**A93-45322 The effect of G-experience on heart rate during +Gz loading.** CHIEKO MIZUMOTO, TADAO YANAKA, and HIDEO TARUI, *Japan Air Self Defence Force, Aeromedical Laboratory, Reports* (ISSN 0023-2858), Vol. 33, No. 3, Sept. 1992, pp. 67–74.

The effects of the subject's age and experience to +Gz loading on the heart rate (HR) and the saliva cortisol concentration as well as on the subjective feeling of discomfort of humans subjected to +G loading were investigated in subjects of one of three groups of subjects: (1) nonexperienced, (2) those who have experienced +Gz loading 3 to 20 times in the past, and (3) those who have experienced +Gz more than 100 times. The G profile in the experiments was as follows: Max +5 Gz, head movement at +2 Gz, on-off set rate 0.1 G/sec. The results of measurements and the surveys of discomfort complaints showed that, at a given +Gz, HR and the HR increase due to G loading were lower in the most experienced subjects and that the HR of older subjects was lower than HR in young ones. The saliva cortosol concentration rose markedly after +Gz loading in all subjects, with no statistically significant difference between the groups, and the amount of subjective complaints was lowest among most experienced subjects.

**A93-49178 Arterial oxygen saturation during +Gz acceleration by short-radius centrifuge.** KENICHI IWASAKI, HAJIME SUZUKI, MASAO ITO, TAKAICHI MANO, CHIKAKO SAEKI, and KAZUYOSHI YAJIMA, *Japanese Journal of Aerospace and Environmental Medicine* (ISSN 0387-0723), Vol. 30, No. 1, March 1993, pp. 11–17.

Artificial gravity has been proposed to prevent the problems of physiological deconditioning in space. From ground-based studies to make an artificial gravity with a short radius centrifuge, it was reported that decreases of the arterial oxygen saturation (SaO2) caused by a ventilation/perfusion mismatch in the human lung and a decrease in central blood volume were observed at +3Gz or above it. However the duration of centrifuge was only a few minutes. We measured SaO2 during 60 min +Gz acceleration by a pulse oximeter. Seven men were studied at 1.4 G, 1.7 G, and 2.0 G. Significant decreases of SaO2 occurred at 1.7 G from 10 min to 30 min and at 2.0 G from 10 min to 40 min. SaO2 were improved after 35 min (1.7 G) and 45 min (2.0 G). Increase in heart rate, blood pressure, and tidal volume improved the decreases of SaO2 during +Gz acceleration.

**N93-28018 Artificial gravity experiment satellites Jinkou Juuryoku Jikken Eisei.** TADASHI HARADA, *NASDA, Future Space Activity Workshop: Lunar Base Workshop 1992 21 p* (SEE N93-28014 10-12).

An overview of the conceptual study of an artificial gravity experiment satellite based on the assumption of a launch by the H-2 launch vehicle with a target launch date in the Year 2000 is presented. While many satellites provided with artificial gravity have been reported in relation to a manned Mars exploration spacecraft mission, the review has been conducted on missions and test subjects only for experimental purposes. Mission requirements were determined based on the results of reviews on the mission, test subjects, and model missions. The system baseline and development plan were based on the results of a study on conceptual structure and scale of the system, including measures to generate artificial gravity. Approximate scale of the system and arm length, mission orbit, visibility of the operation orbit from ground stations in Japan, and satellite attitude on the mission orbit are outlined.

**A92-38212 Human exploration and the voyage to Mars.** LAURENCE R. YOUNG, *Proceedings of the International Aerospace Symposium 90,* Nagoya, Japan, Nov. 26, 27, 1990, (A92-38201 15-01). Nagoya, Japan, Nagoya Chamber of Commerce and Industry, 1990, pp. 93–96.

An evaluation is made of potential problems associated with manned mission to Mars. Foremost among the health hazards is calcium loss due to the microgravity environment, resulting in bone demineralization. Muscles, as well as bone, atropy in the absence of regular use in the counteracting of body weight. The cardiovascular system will adapt to the long period of weightlessness through a change in pressure regulation and a shrinking of heart size. The immune and endocrine systems are also influenced by weightlessness.

**A93-49177 Image technology and information analysis of bone change with gravitational exposure.** KOUSUKE NISHIMURA, *Japanese Journal of Aerospace and Environmental Medicine* (ISSN 0387-0723), Vol. 30, No. 1, March 1993, pp. 1–10.

The influences of gravitational changes on bone were analyzed from the point of view of imaging technology using a microfocus tube and a highly sensitive X-ray image sensor with the photostimulable phosphor. Gravitational changes markedly affected the spongy bone of the posterior vertebral joint, with bone resorption occurring at about 0 G and enhancement of bone formation at 2 G. Such changes were larger in the posterior vertebral joints that bear more weight. In the seventh posterior vertebral joint, which showed the largest bone changes, the photostimulated luminescence level increased by about 19 percent and decreased by about 46 at about 0 G and 2 G, respectively, compared with 1 G. These bone changes resemble those occurring during the aging process of mandibular bone trabeculae on earth.

**A93-31531 Effects of visually induced self-motion perception (vection) on upright standing posture.** MASUMI ICHIKAWA and SATORU WATANABE, *Japanese Journal of Aerospace and Environmental Medicine* (ISSN 0387-0723), Vol. 29, No. 4, Dec. 1992, pp. 107–116.

Research supported by Special Coordination Fund for Science and Technology of Japan. The relationship between the magnitude of visually induced perception of self-motion (vection) and the forward body tilt induced by optokinetic stimulation (OKS) was investigated in 12 healthy human subjects who were presented with a large hemispherical dome screen which had a pattern on it which was moved downward. Each subject stood on a force-measuring platform in Romberg's position and gazed at a red fixation point in the center of the screen. The analysis of data indicated that there was a close relationship between the magnitude of vection and the forward displacement of the center of gravity caused by OKS.

**N93-20450 Space environment model construction technology Uchuu kankyou moderu no seibi gijutsu.** HIRONOBU NISHIMOTO and HARUHISA MATSUMOTO, *In its Research and Development Activities of the Tsukuba Space Center* (SEE N93-20410 07-12) pp. 183–186.

A space environment model was constructed based on the results of the review on space environment model conducted in Fiscal Year 1986 and 1987. The space environment model was constructed to collect theories and data required for grasping various physical entities such as radiation, plasma, and spacecraft fragments and so forth, and to enable quantitative prediction of their time wise, spacial distribution and their effects such as electrification and material deterioration, and its system structure and functions were shown. The Technical Data Acquisition Equipment (TEDA) installed onboard the Engineering Test Satellite-5 (ETS-5) consist of various satellite environment monitors and component and material deterioration monitors for the purpose of acquiring technical data required for design and evaluation for satellite development. Review was conducted to clarify the correlation between each TEDA data and to apply the result in constructing the satellite environment model. Correlation between each TEDA data was made clear.

**A93-20899 Effects of head down tilt on hepatic circulation and metabolism in conscious dogs.** NOBUYUKI TERADA, JOUJI HORIUCHI, MITUSHIRO NAGAO, and TORU TAKEUCHI, *Japanese Journal of Aerospace and Environmental Medicine* (ISSN 0387-0723), Vol. 29, No. 3, Sept. 1992, pp. 73–80.

The effects of head down tilt at 20 deg on hepatic circulation and of feeding in a horizontal position with head down tilt on hepatic circulation and metabolism were studied. The head down tilt caused a significant decrease in portal blood flow and an immediate increase in right atrium and portal venous pressures. At the horizontal position, portal venous pressure, hepatic arterial blood flow, and portal blood flow increased significantly after feeding. During head down tilt, portal pressures and hepatic blood arterial blood flow also increased significantly with feeding, but the increase in portal blood flow was inhibited. Plasma triglyceride and glucose in the portal blood increased significantly with feeding, and these postprandial increases were also inhibited during head down tilt. These effects may be induced by changes in the autonomic nervous system, and have implications for hepatic hemodynamics and function as well as digestion and absorption of food in a microgravitational environment.

**A92-53740 Change of skin blood flow by body tilting.** KENJI KAWAKAMI, MASAMICHI SUDOH, TAKAO SHIMADA, YUTAKA MORI, MASATOSHI SHIOTA, SACHIO IKAWA, *Proceedings of the 17th International Symposium on Space Technology and Science,* Tokyo, Japan, May 20–25, 1990, Vol. 2 (A92-53451 23-12). Tokyo, AGNE Publishing, Inc., 1990, pp. 2053–2058.

Radionuclide methods were used to study the effect of body tilt on the hemodynamics of the human body's lower limbs. While decreased skin blood flow in the head-up position was associated with a decrease of total limb flow, skin blood flow in the head-down position decreased despite the enhancement of total limb flow. The peripheral-perfusion resistance was also increased in the head-up position; regulation in the cutaneous hemodynamics may be different from that in the systemic circulation.

**A93-15530 The cardiovascular system.** AKIRA MIYAMOTO, *Japanese Journal of Aerospace and Environmental Medicine* (ISSN 0387-0723), Vol. 29, No. 2, June 1992, pp. 62–64. 5 Refs.

Cardiovascular deconditioning changes during space flight and after return to the ground are presented. A ground simulation test is described, and the load reaction of lower body negative pressure (LBNP) is addressed. Preventive measures in connection with cardiovascular deconditioning are discussed.

**A93-15527 Adaptation of skeletal muscles and physical work capacity in a weightless environment.** YOSHINOBU OHIRA, NAOTAKE INOUE, and TOHRU WAKATSUKI, *Japanese Journal of Aerospace and Environmental Medicine* (ISSN 0387-0723), Vol. 29, No. 2, June 1992, pp. 51–54. 18 Refs.

Research on skeletal muscle atrophy due to limited exercise during a long-duration space flight is presented. The characteristics of muscular contraction are discussed, and muscle fiber types and physical work capacity in a weightless environment are studied.

**N92-33863 Result of aircraft experiments.** SATORU WATANABE, *Science and Technology Agency,* The 14th Space Station Utilization Workshop in Japan pp. 141–146 (SEE N92-33854 24-12)

Airborne experiments were conducted on biological system phenomena under microgravity conditions. The effect of gravity change on the vestibular apparatus in goldfish was examined. Negative reaction to light, in microgravity conditions, was also examined. One fish had its vestibular apparatus removed and the other did not. The latter always swam with its back directed upward (0 deg) when illuminated from above, but it swam with its back directed at an angle (20 to 30 deg) when illuminated from the side (90 deg). The former laid down with its back directed toward the light. Normal goldfish took an attitude called diving response (head down) in microgravity, but diving response was not observed in the fish that had undergone removal of the vestibular apparatus. Fish which returned to normal swimming after the operation showed diving response, though they had no vestibular apparatus, making it clear that diving response is not caused by said organ.

**N92-33758 Fundamental experiments of shower development for space use Uchuu you shawa no kaihatsu ni kansuru kiso jikken.** NORIYUKI TAKAHASHI, KENICHI UNNO, KAORU OOTSUJI, and TAKESHI MIYAMOTO, *NASDA, Future Space Activities,* Lunar Base Workshop 1991 8 p (SEE N92-33753 24-91)

The problems associated with humans living in space have been investigated during past manned flights. The problems fall into two categories: (1) the effects of microgravity on human physiology; and (2) the problem of closed system substance circulation. The specialized equipment that is necessary for closed system substance circulation (equipment for air and water processing, air conditioning, water supply and drainage, and sanitation) is discussed. Data concerning the behavior of water drops in microgravity conditions were obtained utilizing parabolic flight. There are also problems of physical phenomena which relate to gravity (sedimentation) and convection. These problems are primarily concerned with equipment related to water. Possible solutions to these problems may make use of centrifugal force or air flow systems.

**A92-53746 Behavioral responses of Paramecium to gravity.** AKIRA MURAKAMI and KEIICHI TAKAHASHI, *Proceedings of the 17th International Symposium on Space Technology and Science,* Tokyo, Japan, May 20-25, 1990, Vol. 2 (A92-53451 23-12). Tokyo, AGNE Publishing, Inc., 1990, pp. 2087–2089. 6 Refs.

The swimming behavior of Paramecium was recorded and analyzed under various gravitational conditions. The responses to hypergravity were investigated using a centrifuge microscope. When centrifuged, the paramecia were gradually oriented parallel or antiparallel to the direction of the centrifugal force. Paramecia that had been centrifuged shortly before were more rapidly oriented than those without the precentrifugation, as long as the centrifugal force was above 70 g. A gravitational acceleration of 1 g is not enough to induce gravitactic orientation by the mechanism suggested by the 'physical hypothesis' of geotaxis. Analyses of the swimming tracks of paramecia under 1 g indicated that the negative gravitactic behavior was caused by upward orientation of the swimming organisms. The swimming behavior of paramecia during a free fall was recorded using the 18 m drop facility in Bremen. The results suggest that a physiological mechanism is involved in the response of Paramecium to microgravity.

**A92-53739 Relations between cardiac function and body tilting angle.** MASAMICHI SUDOH, SACHIO IKAWA, KENJI KAWAKAMI, MASATOSHI SHIOTA, KUNINOBU YOKOTA, and YOSHIO HONDA, *Proceedings of the 17th International Symposium on Space Technology and Science,* Tokyo, Japan, May 20–25, 1990, Vol. 2 (A92-53451 23-12). Tokyo, AGNE Publishing, Inc., 1990, pp. 2047–2052. 6 Refs.

The head-up and head-down position of 28 healthy males were changed while changes were conducted in stroke volume, heart rate, transthoracic impedance, and systolic and diastolic blood pressure (DBP). Mean arterial pressure (MAP), pulse pressure, and total peripheral resistance were also calculated. While there were almost no changes in blood pressure in the head-down tilt, head-up tilting led to changes in DBP, heart rate, and MAP. Stroke volume and cardiac output increased with downtilt and decreased with uptilt.

**A92-53747 Observation of behavior of treefrogs in space.** AKEMI IZUMI-KUROTANI, MASAMICHI YAMASHITA, and ATSUSHI OKETA, *Proceedings of the 17th International Symposium on Space Technology and Science,* Tokyo, Japan, May 20–25, 1990, Vol. 2 (A92-53451 23-12). Tokyo, AGNE Publishing, Inc., 1990, pp. 2091–2095.

The Russian space station Mir will use Japanese treefrogs for experimental observations of microgravity effects on their behavior under various stimuli. Experimental system verification trials will give attention to the mechanical and gaseous media environment, materials selection, and biological contamination for the experiment's life-support box, frog observation system, and frog recovery box.

**A92-53742 Characteristic change of muscular synergy during isometric contraction under weightlessness simulated by water immersion.** YASUHIRO SUGAJIMA and GENYO MITARAI, *Proceedings of the 17th International Symposium on Space Technology and Science,* Tokyo, Japan, May 20–25, 1990, Vol. 2 (A92-53451 23-12). Tokyo, AGNE Publishing, Inc., 1990, pp. 2065–2069.

The present study examines whether muscle relaxation under weightlessness results in changes of synergetic activities in the joint muscle groups of lower limbs during voluntary contraction. The subjects were healthy male volunteers. During water immersion (WI), electromyogram discharges became less and it was specially noticed that the rate of increase following increase of contraction force changed in each muscle compared with those without WI. It was found that large transient spikes appeared under WI. The results suggested that the synergy of muscle groups was changed by weightlessness.

**A92-53741 Effects of passive angular body movement on soleus H-Reflex in humans.** CENYO MITARAI and MITSUHIRO KOEDA, *Proceedings of the 17th International Symposium on Space Technology and Science,* Tokyo, Japan, May 20–25, 1990, Vol. 2 (A92-53451 23-12). Tokyo, AGNE Publishing, Inc., 1990, pp. 2059–2063. 6 Refs.

The purpose of this experiment was to investigate influence of semicircular canal inputs on the activity of the lumbo-sacral motoneuron pool in humans. The rotating chair was used for preferred stimulation of the lateral semicircular canal, and the amplitude modification of the soleus H-reflex by rotation was observed. The results obtained from eighteen healthy young male subjects showed that the H-reflex was suppressed, without any exception, by exposing to both acceleration and deceleration. The suppression was a function of the exposure time as well as of the intensity of acceleration. From these results, it was suggested that sensory inputs from the semicircular canal exert inhibitory effect on the spinal motoneuron of lower limb; these effects are mediated through the vestibulo-reticulo-spinal tracts.

**A92-33883 GRAPE-1A—Special-purpose computer for N-body simulation with a tree code.** TOSHIYUKI FUKUSHIGE, TOMOYOSHI ITO, JUNICHIRO MAKINO, TOSHIKAZU EBISUZAKI, DAIICHIRO SUGIMOTO, and MASAYUKI UMEMURA, *Astronomical Society of Japan, Publications* (ISSN 0004-6264), Vol. 43, No. 6, 1991, pp. 841–858. 11 Refs.

GRAPE (GRAvity PipE)-1A, a special-purpose computer for N-body simulations, has been developed using the O(N log N) tree code. GRAPE-1A calculates the gravitational force between particles. The peak speed of GRAPE-1A is equivalent to 240 Mflops. The effective speed is over 200 Mflops for the direct summation, and around 80 Mflops for the tree algorithm. Using GRAPE-1A and the modified tree algorithm code, one time step takes 2 s for N = 4096 and 20 s for N = 32768. GRAPE-1A can complete either a simulation of interacting galaxies or a cosmological simulation within one week. GRAPE-1A can be also applied to particle-based hydrodynamical simulations such as smoothed-particle hydrodynamics (SPH). The performance of GRAPE-1A is comparable to that of a supercomputer with a peak-speed of 500 Mflops for any type of the direct summation, the modified tree algorithm, and SPH.

**A92-29550 Automatic blood sampling system (useful during Gz and/or other aviation stresses).** YOSHINORI MIYAMOTO, HIDEAKI SHIMAZU, ATSUSHI KAWARADA, HIDEO TARUI, and HIROSHI ITO, *Japan Air Self Defence Force, Aeromedical Laboratory, Reports* (ISSN 0023-2858), Vol. 32, June 1991, pp. 23–27.

An automatic blood sampling system for use in collecting blood consecutively during Gz stress in a subject has been developed. The system consists of a catheter unit, microtube pump, main control, and manifold unit which contains eight collecting tubes. Blood is automatically pumped out and fed into the manifold. The volume of blood collected by the device is controlled by the length of time the main control switch is used. The system would be useful in sampling blood during Gz stress and/or other aviation stress.

**A90-43457 Responses of rats to 3-week centrifugal accelerations.** MASAMICHI SUDOH and SACHIO IKAWA, *Japanese Journal of Aerospace and Environmental Medicine* (ISSN 0387-0723), Vol. 25, Sept. 1988, pp. 69–74.

The effects of gravity on physiological changes in rats exposed to three-week centrifugal accelerations are studied. Twelve female rats are exposed to 1 G, 1.6 G or 3 G. Body weight, urine volume, food and water intake, and water balance are measured and analyzed. The data reveal that body weight and daily food and water intake decrease due to acute exposure to hypergravity, and that gravity intensity affects the rate of the decrease.