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MAGNETIC RESONANCE IMAGING AFTER EXPOSURE TO MICROGRAVITY

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A number of physiological changes have been demonstrated in bone, muscle, and blood from exposure of humans and animals to microgravity. Determining mechanisms and the development of effective countermeasures for long-duration space missions is an important NASA goal. Historically, NASA has had to rely on tape measures, x-ray, and metabolic balance studies with collection of excreta and blood specimens to obtain this information. The development of magnetic resonance imaging (MRI) offers the possibility of greatly extending these early studies in ways not previously possible; MRI is also non-invasive and safe; i.e., no radiation exposure. MRI provides both superb anatomical images for volume measurements of individual structures and quantification of chemical/physical changes induced in the examined tissues. This investigation will apply MRI technology to measure muscle, intervertebral disc, and bone marrow changes resulting from exposure to microgravity.

Limb volume changes associated with exposure to microgravity probably involves two factors: (1) changes in fluid amount and distribution and (2) muscle atrophy. Both processes involve fluid shifts, the first mostly extracellular, the second intracellular. MRI techniques are ideal for measuring changes in water content of tissues and are both non-invasive and quantitative. Muscle wasting would be expected to produce muscles less able to perform work. Muscular deconditioning was documented during Apollo and Skylab missions and in ground-based simulation bed rest studies. The loss in muscle mass and strength produced by weightless

exposure affects some muscles more than it does others, i.e., differential muscle atrophy. In Skylab, this was suggested by the observed differences between the leg flexors and extensors. Animals flown in space or subjected to simulated weightlessness have demonstrated differential muscle atrophy. MRI will be used to measure volume changes of individual muscle groups of the calf, thigh, and back of Spacelab crewmen.

Marrow fat increases in immobilized patients (bone biopsy of paraplegics) and animals. Rats flown aboard Cosmos also had dramatic changes in marrow fat. The exact function of marrow adipose cells and their relation to bone metabolism and hematopoiesis is unknown; however, the metabolic activity of the marrow adipose cells appear to be coupled to the hematropoietic activity of the marrow. Therefore, the study of marrow fat as it relates to hematological changes in weightlessness could provide new information concerning the loss of red cell mass during space flight. The possible association of changes in marrow fat and trabecular bone loss is also of scientific interest. We will measure the relaxation times of the lumbar spine bone marrow before and after space flight to determine if changes in marrow composition are occurring.

Research studies indicate that normal ambulation is necessary for intervertebral disc health. Unloading the discs in weightlessness may adversely affect disc physiology. Our bed rest studies indicate changes in the lumbar discs during bed rest and reambulation. Our studies suggest an expansion of the disc during bed rest followed by relatively rapid changes following reambulation. The exact nature and significance of these changes is under investigation.

MRI imaging of the crew members of the Spacelab mission, SL-J, will be performed prior to flight on days F-90, F-60, F-30 and post-flight on days R+1 and R+30. The equipment will be the Siemens 1.5 Tesla magnet located at the Methodist Hospital, Department of Radiology. Multi-slice images, using a spin echo technique, will be obtained to measure muscle volume changes in the calf, thigh, and back. A single, 1 cm sagittal slice through the center of the lumbar spine will be obtained with a spin echo sequence for calculating T2 of the lumbar spine bone marrow and intervertebral discs. Changes in disc shape will also be quantitated from these images. In addition, a series of thin sagittal slices through the lumbar disc will be obtained to document disc volume changes.