Bones In Space Essay, Research Paper

Bones in SpaceHypogravitational Osteoporosis: A review of literature.By Lambert Titus Parker. May 19 1987. (GEnie Spaceport)Osteoporosis: a condition characterized by an absolute decrease in theamount of bone present to a level below which it is capable of maintainingthe structural integrity of the skeleton. To state the obvious, Human beings have evolved under Earth’s gravity”1G”. Our musculoskeleton system have developed to help us navigate inthis gravitational field, endowed with ability to adapt as needed undervarious stress, strains and available energy requirement. The systemconsists of Bone a highly specialized and dynamic supporting tissue whichprovides the vertebrates its rigid infrastructure. It consists of specializedconnective tissue cells called osteocytes and a matrix consisting oforganic fibers held together by an organic cement which gives bone itstenacity, elasticity and its resilience. It also has an inorganic componentlocated in the cement between the fibers consisting of calcium phosphate[85%]; Calcium carbonate [10%] ; others [5%] which give it the hardnessand rigidity. Other than providing the rigid infrastructure, it protectsvital organs like the brain], serves as a complex lever system, acts as astorage area for calcium which is vital for human metabolism, houses thebone marrow within its mid cavity and to top it all it is capable of changingits architecture and mass in response to outside and inner stress. Itis this dynamic remodeling of bone which is of primary interest in microgravity. To feel the impact of this dynamicity it should be noted that a boneremodeling unit [a coupled phenomena of bone reabsorption and bone formation]is initiated and another finished about every ten seconds in a healthyadult. This dynamic system responds to mechanical stress or lack of itby increasing the bone mass/density or decreasing it as per the demandon the system. -eg; a person dealing with increased mechanical stresswill respond with increased mass / density of the bone and a person wholeads a sedentary life will have decreased mass/density of bone but the rightamount to support his structure against the mechanical stresses she/sheexists in. Hormones also play a major role as seen in postmenopausalfemales osteoporosis (lack of estrogens) in which the rate of bone reformationis usually normal with the rate of bone re-absorption increased. In Skeletal system whose mass represent a dynamic homeostasis in 1g weight-bearing,when placed in microgravity for any extended period of time requiringpractically no weight bearing, the regulatory system of bone/calciumreacts by decreasing its mass. After all, why carry all that extra massand use all that energy to maintain what is not needed? Logically thegreatest loss -demineralization- occurs in the weight bearing bones ofthe leg [Os Calcis] and spine. Bone loss has been estimated by calcium-balancestudies and excretion studies. An increased urinary excretion of calcium, hydroxyproline & phosphorus has been noted in the first 8 to 10 daysof microgravity suggestive of increased bone re-absorption. Rapid increaseof urinary calcium has been noted after takeoff with a plateau reachedby day 30. In contrast, there was a steady increase off mean fecal calciumthroughout the stay in microgravity and was not reduced until day 20 ofreturn to 1 G while urinary calcium content usually returned to preflightlevel by day 10 of return to 1G.There is also significant evidence derived primarily from rodent studies thatseem to suggest decreased bone formation as a factor in hypogravitationalosteoporosis. Boy Frame,M.D a member of NASA’s LifeScience Advisory Committee[LSAC] postulated that “the initial pathologic event after the astronautsenter zero gravity occurs in the bone itself, and that changes in mineralhomeostasis and the calcitropic hormones are secondary to this. It appearsthat zero gravity in some ways stimulate bone re-absorption, possibly throughaltered bioelectrical fields or altered distribution of tension and pressureon bone cells themselves. It is possible that gravitational and muscularstrains on the skeletal system cause friction between bone crystalswhich creates bioelectrical fields. This bioelectrical effect in someway may stimulate bone cells and affect bone remodeling.” In the early

missions, X-ray densitometry was used to measure the weight-bearing bonespre & post flight. In the later Apollo, Skylab and Spacelab missions Photonabsorptiometry (a more sensitive indicator of bone mineral content) wasutilized. The results of these studies indicated that bone mass [mineralcontent] was in the range of 3.2% to 8% on flight longer than two weeksand varying directly with the length of the stay in microgravity. Theaccuracy of these measurements have been questioned since the marginof error for these measurements is 3 to 7% a range being close to theestimated bone loss.Whatever the mechanism of Hypogravitational Osteoporosis, it is one ofthe more serious biomedical hazard of prolonged stay in microgravity. Many forms of weight loading exercises have been tried by the astronauts& cosmonauts to reduce the space related osteoporosis. Although isometricexercises have not been effective, use of Bungee space suit have shownsome results. However use of Bungee space suit [made in such a way thateverybody motion is resisted by springs and elastic bands inducing stressand strain on muscles and skeletal system] for 6 to 8 hrs a day necessaryto achieve the desired effect are cumbersome and require significant workload andreduces efficiency thereby impractical for long term use other than provinga theoretical principle in preventing hypogravitational osteoporosis. Skylab experience has shown us that in spite of space related osteoporosishumans can function in microgravity for six to nine months and returnto earth’s gravity. However since adults may rebuild only two-third ofthe skeletal mass lost, even 0.3 % of calcium loss per month though smallin relation to the total skeletal mass becomes significant when Mars missionof 18 months is contemplated. Since adults may rebuild only two-thirdsof the skeletal mass lost in microgravity, even short durations can causeadditive effects. This problem becomes even greater in females who arealready prone to hormonal osteoporosis on Earth.So far several studies are under way with no significant results. Muchstudy has yet to be done and multiple experiments were scheduled on theSpacelab Life Science [SLS] shuttle missions prior to the Challengertragedy. Members of LSAC had recommended that bone biopsies need to beperformed for essential studies of bone histomorphometric changes tounderstand hypogravitational osteoporosis. In the past, astronauts withthe Right Stuff had been resistant and distrustful of medical experimentsbut with scientific personnel with life science training we should beable to obtain valid hard data. [It is of interest that in the SLS mission,two of the mission specialists were to have been physicians, one physiologistand one veterinarian.]After all is said, the problem is easily resolved by creation of artificialgravity in rotating structures. However if the structure is not largeenough the problem of Coriolis effect must be faced. To put the problemof space related osteoporosis in perspective we should review our definitionof Osteoporosis: a condition characterized by an absolute decrease in theamount of bone present to a level below which it is capable of maintaining thestructural integrity of the skeleton. In microgravity where locomotionconsists mostly of swimming actions with stress being exerted on upperextremities than lower limbs resulting in reduction of weight bearingbones of lower extremities and spine which are NOT needed for maintainingthe structural integrity of the skeleton. So in microgravity the skeletalsystem adapts in a marvelous manner and problem arises only when thismicrogravity adapted person need to return to higher gravitational field. So the problem is really a problem of re-adaptation to Earth’s gravity. To the groups wanting to justify space related research: Medical expensedue to osteoporosis in elderly women is close to 4 billion dollars ayear and significant work in this field alone could justify all space lifescience work. It is the opinion of many the problem of osteoporosis on earthand hypogravity will be solved or contained, and once large rotatingstructures are built the problem will become academic. For completenesssake: Dr. Graveline, at the School of Aerospace Medicine, raised a litterof mice on a animal centrifuge simulating 2G and compared them with alitter mates raised in 1G. “They were Herculean in their build, and unusuallystrong….” reported Dr.Graveline. Also X-ray studies showed the 2G miceto have a skeletal density to be far greater than their 1G litter mates.