REVIEW ARTICLE

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Exploring Astronautical Dentistry: A Review

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ABSTRACT

The Human body reacts differently in different environment(s). With development in the field of astronomy, long distance trip to another planet is now possible. These trips require humans to stay in zero gravity conditions for a long time. Simulated microgravity is the best way to assess the physiologic changes in near zero gravity conditions, as it is not always possible to conduct scientific experiments in space. The purpose of this review is to determine the effects of zero gravity on oral cavity.

KEYWORDS: Astronautical, Zero gravity, Microgravity, Dentistry

INTRODUCTION

Each year billions are spent in space programs. One of the most important part of space programs is sending humans in space for exploration. A round trip to Mars requires 18 months just for transit.[1] For many years, the prevailing concept in space human factors research has been that microgravity has an impact on human physiology and astronauts are faced with several health risks during both short- and long-duration spaceflights.[2] Various health problems reported include cardiovascular and fluid-related problems of orthostatic hypotension immediately after spaceflight; altered cardiac susceptibility to ventricular arrhythmias; reduced cardiac muscle mass and diminished cardiac function; muscle related problems of atrophy involving loss of muscle mass, strength, and endurance; decreased bone mineral density; circadian rhythm-related problems involving sleep and performance; and immune-related problems involving infections and immunodeficiency.[3] Brown et al. in their simulated skylab mission found that composition of saliva changes in zero gravity conditions.[4] Numerous counter measures have been developed and tested to moderate these physiologic changes. Human physiologic adaptation hence becomes a major challenge faced in the development of human spaceflight.[5]

Simulated microgravity is the best way to assess the physiologic changes in near zero gravity conditions. One of the best ways to create microgravity conditions on earth is head down tilt (HDT) bed rest condition. HDT bed rest condition is a simulated microgravity condition in which subject lies on bed inclined –6 degree feet up. Very few studies have been done on this aspect of space flight. Although there are case reports presenting prevalence of periodontitis, dental caries, bone loss, pain and numbness of teeth and oral tissues, salivary duct calculi and cancer in simulated microgravity conditions. This paper discusses various changes seen in human physiology in simulated microgravity.

HISTORY

During World War II, when aircrafts began to fly at altitudes of more than 25,000 feet, it was realised that a new field of dentistry which deals with dental problems at high altitudes is needed. But not much changed in the field of dentistry till 1957 when guidelines for dentistry in space medicine were developed by US air force General office. In 1960 astronautical dental training program was started. In 1966 US air force appointed Colonel William Forme to full time duty at NASA to look after the dental health of astronauts. In 1970 the term barodontalgia was introduced to dentistry. In 1980 Colonel Johan Young was given the duty for developing dental instruments and guidelines for preventive and emergency procedures in zero gravity conditions. In 2000, a discussion was held by The National Academy of Science, Institute of Medicine Committee on Space Medicine on how to maintain oral health of astronauts on long missions. In 2009, Dr. Balwant Rai was appointed dental health and safety officer for the Mars desert research station.

EFFECT ON BONES

Increased bone loss is seen in flight. The rate of bone loss is about 1% to 2% of bone mass per month.[6] Osteoporosis of both Maxilla as well as mandible is seen in space flights. Bone loss pattern is different for different bones which varies from location of the bone and mechanical load received by it.[5] Microgravity causes uncoupling of the processes of bone formation and bone resorption reducing skeletal loading and osteoblast function resulting in bone resorption and a decrease in bone density.[7] Prostaglandin E2 and Interlukin-6 play a key role in bone resorption. Kumei Y et al. did a study on rat osteoblasts.[8] Specimen were cultured for 5 days during a Shuttle-Spacelab flight(STS 65) After collection of the culture medium, the cellular DNA and RNA were fixed on board. Results showed upto 136 fold increase in PGE2 and IL-6 levels. Rai et al. in another study reported a decrease in bone mineral content and density. The levels of MMP-8 and MMP-9 were also found to be increased in microgravity conditions.[9]

EFFECT ON SALIVA

Rai et al.[10] did a study on 10 human male subjects in HDT rest condition assessing the flow and chemical composition of saliva. They observed a decrease in flow rate, Sodium and potassium levels. Increase in the levels of Calcium and Phosphate were also observed. This finding was probably due to bone catabolism. Same results were found in urine excretion also. Increased levels of free radicals, malonaldehyde, Vitamin E and C are also reported.[10] The threshold for capsaicin increases while that of sodium chloride decreases in microgravity.[11]

EFFECT ON MUSCLES

Muscular atrophy is generally observed in microgravity conditions. There is very little data available regarding the effect of microgravity on muscles of mastication. It has been proposed that change in stomatognathic apparatus due to muscular atrophy may lead to difficulty in maintaining body's balance.[12]

EFFECT ON IMPLANTS

Haigneré C et al. did a study on a French astronaut with oral implant who stayed in Russia's Mir Space Station for 6 months.[13] Measurements were performed by 2 examiners before the flight, after the flight and following a recovery period. Standardised periapical radiographs were taken and it was found that peri-implant bone levels remained stable after 6 months in microgravity.

EFFECTS ON BACTERIA

Various studies have reported rapid growth of bacteria in microgravity conditions. Efficacy of antibiotics is decreased against these pathogens in microgravity conditions. Humans suffer from immune suppression after prolonged space time. All these conditions combined can lead to a dental emergency while an astronaut is in space. So the role of dentist in long space missions such as the Mars mission becomes crucial.

DENTIST IN SPACE

A dental problem in space can cause huge financial loss and jeopardise the safety of the mission if it is not attended appropriately. A dentist will be required on any manned mission to mars or other planets which requires extended duration travel in microgravity. Luxuries of RCTs, radiographs or other comprehensive treatments are not available in space. On top of that in-flight equipment carried into space is very limited due to weight and storage space limitations.

NASA has established strict standards for the selection, retention, and pre-flight dental examination of astronauts chosen for a specific space flight, and a strict clinical schedule is followed. At 6 months before launch, crew members undergo an examination. If dental treatment is deemed necessary, all such treatment is completed by 3 months before launch, so as to minimize the potential for problems during flight.[3] Standard equipment and emergency treatment guidelines have also been setup. The dental equipment includes tooth removal forceps, elevator, local anesthetic with syringe, periodontal curette, restorative material applicator, file, battery powered light source with mirror, selvage gauze, Gigli saw, and temporary restorative material. Much effort came from the US Air Force corps as they developed a special formula for the restorative material provided to the space travellers.[14] The formulation allowed it to be mixed even with zero gravity. After much success from the equipment testing process the flight crews were subjected to two days of intensive training for them to have the ability to use the equipment after the launch. The duties of an aeronautic dentist besides attending to dental problems would include:

1. To design and conduct ground-based studies in aeronautic dentistry with the purpose of determining the effects of acceleration (weight) on the system under investigation
2. Preparing for real microgravity experiments on orbiting spacecraft, sounding rockets, and parabolic flight aircraft
3. Identifying the parameters that might be changed under real microweight conditions
4. Examining the interaction of a system under study in relation to the hardware being used in a real microweight experiment
5. Investigating the effect of launch accelerations and vibrations on the system under study or in combination with the utilized hardware.

Rai et al.[3] in 2009 proposed 2 types of training programs for aeronautical dentistry: A Fellowship of Aeronautic Dentistry of duration of 18 weeks and Post Graduate Diploma in Aeronautic Dentistry of a duration of 36 weeks.

CONCLUSION

In the end we would like to conclude that the role of a dentist is very crucial in further space research. Dental emergencies are very painful and can jeopardize million dollar missions. This area of dentistry is not well researched and there is a lot of scope for new developments.

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