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WEARABLES IN SPACEFLIGHT: MOTION TRACKING OF ASTRONAUTS ON LONG DURATION MISSIONS FOR PHYSICAL AND MENTAL HEALTH MONITORING. AN ISS AND GATEWAY FUTURE PROJECT PROPOSAL

Abstract

Humankind aspires to transition towards a multiplanetary species and to achieve this goal, it is of vital importance to understand the impact of long term effects of altered states of gravity on astronaut health. Future exploration missions to Mars (led by NASA and SpaceX) will involve a long period of microgravity (in the order of months), followed by a period of hipogravity (in the order of years) and a return to normal gravity levels. There is a research gap in our understanding of these effects, in devising effective countermeasures and in establishing the best methods to promote long term post-mission behavioral health (NASA's BMed9 Gap in the Human Research Roadmap [1].

This project addresses these challenges through minimally invasive, continuous monitoring of astronaut body dynamics within the space habitat and on extravehicular activities through the use of wearable devices. The field of musculoskeletal biomechanics has undergone a paradigm shift in the way data is being captured, with a shift from lab-scale optical motion capture experiments with a duration of minutes to 'in the wild' motion capture using Inertial Measurement Units (IMUs) combined with Machine Learning algorithms to carry out observations with a duration of hours or days, capturing the natural behavior of the subject [2, 3]. Now, IMUs can be embedded in smart watches and flexible pads applicable to the skin. Furthermore, they can be combined with cortisol and pulse measurement flexible sensors to collect additional biometric data [4]. The resulting sensor suite is non-intrusive and easy to wear, allowing a longitudinal study on astronaut body dynamics and stress levels during exercise and normal activities.

This work constitutes a future project proposal for implementing of novel wearable sensors on Earth-based analog astronaut missions followed by trials on the International Space Station including testing on the COLBERT T2 treadmill and subsequent implementation on missions to the Gateway and the Mars Research Stations. Opportunities offered by the technology in monitoring both musculoskeletal and mental health are identified alongside the methods that would be used in processing the sensor data. Furthermore, technology limitations and their future evolution are detailed. The project will allow for unprecedented levels of insight into the evolution of astronaut mental and musculoskeletal health in long-term exploration missions. Furthermore, insight into gait adaptations in a hipogravity regime has now been previously studied, this project would inform future astronaut-machine interaction design appropriate to the Moon and Mars.