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EXPLORATION OF THE BIOMECHANICAL STRESS ON THE BODY WHILE PERFORMING FUNCTIONAL AND OPERATIONALLY RELEVANT MOVEMENT PATTERNS UNDER VARIABLE GRAVITATIONAL STRESS

Abstract

Long-term exposure to microgravity has proven to cause biomechanical side effects to our human physiology. With the onset of commercial spaceflight and space tourism following the drive of multiple national space agencies and corporations around the world, the importance to avoid and mitigate these effects is more prevalent than ever. It is necessary to 1) identify all internal-external factors causing the side effects; 2) identify existing counter-interventions; and 3) develop new countermeasure strategies studied to be effective.

There is still much to be elucidated regarding the physiological effects from being exposed to various gravitational stresses across the scale (μg < partial gravity < 1 g). In this review, we describe these fundamental physiological changes that occur in the human skeleton and highlight the unique importance of exercise in space. We discuss the interplay between the musculoskeletal, neuromuscular, and the cardiovascular system, noting how each system responds to changing gravitational environments. While investigating the effect of microgravity on bone density, muscle atrophy, and joint stability, simulations of hypogravity and reduced gravity provided insight into the potential effects of acceleration and deceleration forces on the body. Also discussed are the clinical and preclinical interventions that have been used to investigate biomechanical stress during movement. Compared to 1G, studies in microgravity and in particular, partial gravity showcase significant reduction in several aspects including mechanical work and ground reaction forces, resulting in a need for sufficient exercise and countermeasures in order to compensate for this inadequate in mechanical stimuli.

This review presents an in-depth discussion of the biomechanical stress on the human body during functional movement under varying gravity conditions, and summarizes findings and data collected from existing studies in the last 10 years. The insights from this review not only remain important, but also hold promise for improving human performance, reducing injury risks, and optimizing physical training regimens in both space exploration and terrestrial applications. Overall, it summarizes our knowledge of the effects of biomechanical stress in space, and will help provide more constructive understanding on how to best conduct exercise programmes that will be critical to overall health, ensuring the safety of our future astronauts and future missions.