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AI/ML POWERED COMMERCIAL GRADE HUMAN PERFORMANCE SYSTEM ENABLING STANDARDIZED SPACE BIOTECH RESEARCH AND DEVELOPMENT

Abstract

Tissue-on-chip (TOC) platforms, which simulate human biology on a microscale, are transforming drug discovery by offering novel ways to model diseases, particularly those associated with aging. Leveraging the microgravity of space, these devices can mimic disease states more accurately, with the space environment acting as a unique stressor. Micr-gRx developed a human muscle-on-chip, utilizing biopsy cells from adult volunteers formed into three-dimensional myobundles within a microfluidic chip, has been a significant advancement. This chip, integrated into an autonomous CubeLab^{TM}, was sent to the International Space Station (ISS) where the muscle TOCs underwent electrical stimulation and real-time imaging to assess skeletal muscle biomechanics in microgravity. Analysis of flight images and video using digital image correlation provided data on contractile function both prior to and during electrical stimulation, which was then compared with ground controls. This research helps identify microstructural features contributing to local tissue oscillations, informing our understanding of muscle degradation—key in conditions like atrophy and aging muscle. Applying computer vision analytics to interpret muscle properties aids in grasping muscle degradation over time, indicating accelerated aging in space and validating the platform for developing treatments for muscle-wasting diseases. In collaboration with G-SPACE, an automated software feature is being developed that monitors real-time biomechanical changes in the muscle MPS unit and their environmental dependencies. This innovation is crucial for meeting FDA certification requirements, offering a standardized approach to evaluating muscle degradation and the efficacy of drugs and treatments. As the data from the muscle MPS system expands, the integration of physics-based models with Machine Learning techniques will transition this process into a platform with powerful predictive capabilities, democratizing access to this cutting-edge technology. The outcomes of this work will underpin the creation of a commercial grade human performance system enabling standardized space biotech Research and Development. This platform will meet the operational, scientific, and technical specifications set by NIH-NCATS TOC and OOAC, provide a first-of-its-kind standardized platform to evaluate muscle MPS degradation, contribute to the FDA approval process for new drug therapies, and offer real-time analysis for experimental tests.