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WEARABLE MECHANOTRANSDUCTION COUNTERMEASURE FOR MUSCULOSKELETAL RESILIENCE IN LONG-DURATION SPACEFLIGHT

Abstract

Musculoskeletal deconditioning remains a central barrier to long-duration human spaceflight, particularly for orbital, lunar, and Mars missions where exercise-based countermeasures impose substantial time, mass, volume, and compliance demands. This work introduces an original wearable mechanotransduction framework intended to provide low-burden mechanical stimulation during unloading. The proposed approach uses controlled surface-level mechanical cues to engage pathways relevant to bone remodeling, while preserving a compact form factor suitable for future crewed missions. FAK, encoded by PTK2, is considered a candidate upstream response node linking external mechanical input to cellular adaptation under reduced loading. The planned validation strategy includes osteocyte-like cell models and hindlimb unloading studies, with readouts including pFAK response, YAP-related activity, sclerostin output, DEXA-derived bone mineral density, and microcomputed tomography bone architecture. This framework positions wearable mechanotransduction as a biomarker-guided countermeasure direction for maintaining musculoskeletal resilience during future exploration-class spaceflight.