NASA SBIR 2008 Phase I Solicitation

X9 Exploration Crew Health Capabilities

Human space flight is associated with losses in muscle strength, bone mineral density and aerobic capacity. Crewmembers returning from the International Space Station (ISS) can lose as much as 10-20% of their strength in weight bearing and postural muscles. Likewise; bone mineral density is decreased at a rate of ~1% per month. Although aerobic capacity has not been formally measured in returning ISS crew, short duration Space Shuttle crewmembers have been shown to undergo a 22% reduction in VO2max in response to space flight. During future exploration missions such physiological decrements represent the potential for a significant loss of human performance which could lead to mission failure and/or a threat to crewmember health and safety. The ability to estimate the physical cost of exploration tasks, monitor crew health and fitness, and to provide effective hardware for exercise countermeasures use will be valuable in supporting safe and successful space exploration. Exercise systems is seeking technologies or devices to provide resistive and aerobic exercise in flight, monitor a crewmember inflight fitness state or simulate an Extra Vehicular Activity (EVA) suit on the ground.

Subtopics

X9.01 Crew Exercise System

Lead Center: GRC

Participating Center(s): JSC

Compact, reliable, multi-function exercise devices/systems are required to protect bone, muscle, and cardiovascular health during lunar outpost missions (missions with total duration less than 6 months). This device should be easily configured and stowed, require minimal power to operate, include instrumentation to document exercise session parameters including portable electronic media, and require minimum periodic calibration (no more than 2 times per year). The device must be capable of providing whole body axial loading and individual joint resistive loading that ideally simulates free weights. If unable to match the inertial properties of free weights, then the device must provide near constant loading at any given load setting and achieve an eccentric to concentric load ratio greater than 90%. The load must be adjustable in increments no greater than 2.5 kgs and provide adequate loading to protect muscle strength and bone health such that post-mission muscle strength is maintained at or above 80% of baseline values; bone mass DEXA T score must not exceed â€“ 2.0 S.D. below the mean bone mineral density at missionâ€™s end. The same device must be capable of providing whole-body aerobic exercise levels necessary to maintain aerobic capacity at or above 75% of baseline VO2max. Finally, the ideal device should also stimulate the sensory-motor system which controls balance and coordination.

A small, lightweight, sensor-based fitness monitoring system that can be used to assess periodic fitness during lunar outpost missions and transit to Mars is also desired. Devices should be small, employ re-usable elements (versus requiring consumables), and be minimally invasive to measure heart rate and rhythm, oxygen consumption and lactic acid threshold. The ideal system would also include other medical monitoring capabilities such that it

could be utilized to assess other crew health variables (e.g., imaging capabilities, respiration rate, blood parameters, etc.).

The Exercise Systems subtopic is also seeking a wearable suit or system that simulates the mechanical properties of the current extravehicular space suit. System should be lightweight (less than 30 pounds), easy to don/doff (especially in the supine position), replicate the mechanical properties of a space suit (in terms of resistance to motion and mass and inertia), and able to be worn during conduct of simulated lunar tasks that last up to 4 hours. Suit system must be adjustable to accommodate individuals of different height and weight. Joints of primary interest to simulate in this system are the shoulder, elbow, trunk, hip, and knee.

Phase 1 Requirements: Phase 1 expectations would be a fully developed concept, complete with feasibility analyses and top-level drawings. A breadboard or prototype is highly desired.

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