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CERIUM OXIDE NANOPARTICLES FOR SKELETAL MUSCLE CELL PROTECTION AGAINST OXIDATIVE STRESS IN SPACE

Abstract

Characterized by low gravity conditions and high energy radiations, space environment is known to exert deleterious effects on the astronauts' musculoskeletal system, inducing/accelerating loss of skeletal muscle mass and force that are typical of aging or certain pathological conditions on Earth. In astronauts, these effects are reversible upon return on Earth, yet they hinder long-term permanence in space and interplanetary exploration. Oxidative stress is among the causes of the observed effects, and its onset both on Earth and in space is related to the unbalanced production/removal of highly reactive species such as hydroxyl radical, superoxide and singlet oxygen, collectively termed as reactive oxygen species (ROS). These species are typically scavenged by endogenous antioxidant defenses (provided for instance by superoxide dismutase –SOD- and catalase -CAT), in synergy with dietary intakes of natural antioxidants (like vitamins and polyphenols). Traditional antioxidant require constant supply due to their short biological activity, whereas novel materials such as cerium oxide nanoparticles (nanoceria, NC) exhibit a self-regenerative antioxidant property mimicking SOD/CAT activity which was demonstrated in a number of cellular models and even in some disease animal models. Selected by the Italian Space Agency for implementation onboard the International Space Station with increment 51/52, our experiment entitled "Nanotechnology Solutions against Oxidative Stress in Muscle Tissue during Long-Term Microgravity Exposure" (NANOROS) aims at assessing the protective role of nanoceria as antioxidant agents with differentiating H9c2 myoblasts in space. To date, preliminary on-ground simulations of the whole experimental timeline (performed in hardware qualified to flight) enabled the identification of suitable cell density (30,000 cells/cm2), nanoceria size (30 nm) and coating (with fetal bovine serum) to obtaining high RNA concentrations (ca. 100 ng/ul) for transcriptional analyses. The minimum concentration of nanoceria (100 ug/ml) suitable to oxidative stress alleviation was also identified by administering increasing concentrations of NC (0-200 ug/ml) to differentiating cells, and then by providing oxidative insult with 1 mM H2O2. The amount of ROS generated by this insult was assessed with 2',7'-dichlorodihydrofluorescein diacetate (H2DCF-DA), which undergoes fluorescence emission after interaction with intracellular ROS.
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