

The NASA Light-Emitting Diode Medical Program



– Progress in Space Flight and Terrestrial Application

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Abstract. This work is supported and managed through the NASA Marshall Space Flight Center – SBIR Program. Studies on cells exposed to microgravity and hypergravity indicate that human cells need gravity to stimulate cell growth. As the gravitational force increases or decreases, the cell function responds in a linear fashion. This poses significant health risks for astronauts in long term space flight. LED-technology developed for NASA plant grown experiments in space shows promise for delivering light deep into tissues of the body to promote wound healing and human tissue growth. This LED-technology is also biologically optimal for photodynamic therapy of cancer.

LED-ENHANCEMENT OF CELL GROWTH

The application of light therapy with the use of NASA LED's will significantly improve the medical care that is available to astronauts on long-term space missions. NASA LED's stimulate the basic energy processes in the mitochondria (energy compartments) of each cell, particularly when near-infrared light is used to activate the color sensitive chemicals (chromophores, cytochrome systems) inside. **Optimal LED wavelengths include 680, 730 and 880 nm.** The depth of near-infrared light penetration into human tissue has been measured spectroscopically (Chance, et al 1988). Spectra taken from the wrist flexor muscles in the forearm and muscles in the calf of the leg demonstrate that most of the light photons at wavelengths between 630-800 nm travel 23 cm through the surface tissue and muscle between input and exit at the photon detector. Our laboratory has improved the healing of wounds in laboratory animals by using NASA LED light and hyperbaric oxygen. **Furthermore, DNA synthesis in fibroblasts and muscle cells has been quintupled using NASA LED light alone, in a single application combining 680, 730, and 880 nm each at 4 Joules per centimeter squared.**

Muscle and bone atrophy are well documented in astronauts, and various minor injuries occurring in space have been reported not to heal until landing on Earth. Long term space flight, with its many inherent risks, also raises the possibility of astronauts being injured performing their required tasks. The fact that the normal healing process is negatively

affected by microgravity requires novel approaches to improve wound healing and tissue growth in space. NASA LED arrays have already flown on Space Shuttle missions for studies of plant growth. The U.S. Food and Drug Administration (FDA) has approved human trials. The use of light therapy with LED's is an approach to help increase the rate of wound healing in the microgravity environment, reducing the risk of treatable injuries becoming mission catastrophes.

Wounds heal less effectively in space than here on Earth. Improved wound healing may have multiple applications which benefit civilian medical care, military situations and long-term space flight. Laser light and hyperbaric oxygen have been widely acclaimed to speed wound healing in ischemic, hypoxic wounds. An excellent review of recent human experience with near-infrared light therapy for wound healing was published by Conlan, et al in 1996. Lasers provide low energy stimulation of tissues which results in increased cellular activity during wound healing (Beauvoit, 1989, 1995; Eggert, 1993; Karu, 1989; Lubart, 1992, 1997; Salansky, 1998; Whelan, 1999; Yu, 1997). **Some of these activities include increased fibroblast proliferation, growth factor syntheses, collagen production and angiogenesis.**

Lasers, however, have some inherent characteristics, which make their use in a clinical setting problematic, including limitations in wavelengths and beam width. The combined wavelengths of light optimal for wound healing cannot be efficiently produced, and the size of wounds which may be treated by lasers is limited. **Light-emitting diodes (LED's) offer an effective alternative to lasers.** These diodes can be made to produce multiple wavelengths, and can be arranged in large, flat arrays allowing treatment of large wounds. Our experiments suggest potential for using LED light therapy at 680, 730 and 880 nm simultaneously, alone and in combination with hyperbaric oxygen therapy, both alone and in combination, to accelerate the healing process in Space Station Missions, where prolonged exposure to microgravity may otherwise retard healing. NASA LED's have proven to stimulate wound healing at near-infrared wavelengths of 680, 730 and 880 nm in laboratory animals, and have been approved by the U.S. Food and Drug Administration (FDA) for human trials. Furthermore, near-infrared LED light has quintupled the growth of fibroblasts and muscle cells in tissue culture. The NASA LED arrays are light enough and mobile enough to have already flown on the Space Shuttle numerous times. LED arrays may prove to be useful for improving wound healing and treating problem wounds, as well as speeding the return of deconditioned personnel to full duty performance. Potential benefits to NASA, military, and civilian populations include treatment of serious burns, crush injuries, non-healing fractures, muscle and bone atrophy, traumatic ischemic wounds, radiation tissue damage, compromised skin grafts, and tissue regeneration.