CALIFORNIA SCIENCE & ENGINEERING FAIR
2019 PROJECT SUMMARY

Name(s)

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Project Number

S2201

Project Title

Use of Pulsed Photobiomodulation in Nerve Regeneration after Injury-Induced Peripheral Neuropathy in Danio rerio

Abstract

Objectives

The objective of my study is to examine if photobiomodulation (PBM) treatment can result in improved stress response and peripheral nerve regeneration, particularly of A delta and C nerve fiber, after caudal fin injury in wild type and mutant (Casper) Danio rerio.

Methods

24 Danio rerio, 2 Ten-gallon tanks, 2 5-gallon tanks with gridlines, Tricaine Solution, PBM/Cold Laser Light Therapy Device, Cell culture clusters, Micropipettes, 0.1M PBS = Phosphate Buffer (pH 7.4), 0.1M PBS+ = Phosphate Buffer with 0.3 % Triton-X 100, rabbit anti-peripherin polyclonal antibody, fluorescein-conjugated donkey anti-rabbit IgG, fluorescent microscope (Nikon, E400, Melville, NY).
Both wild type and Casper (a mutant for mitochondrial protein mpv 17) Danio rerio were randomized to control or PBM treatment when caudal fin was clipped and were placed in the novel tanks with grids and video was acquired. Caudal fins were clipped again after 14 days of daily or every other day PBM treatment of different durations. The fins were stained with peripherin antibody and fluorescence microscope was used to detect A delta and C nerve fiber regrowth. Video was analyzed for stress response and swimming distance.

Results

Experimental groups with PBM treatment had more growth than the control group. The group with PBM dose of 10 sec every other day had the most growth (266% more than control). Giving PBM treatment every day did not result in greater growth ($p<.0002$). Experiment group wild type showed much greater A delta and C nerve fiber regrowth than experiment Casper, which lacks the mpv 17 mitochondrial protein (536% more growth in wild type vs. mutant) ($p<.003$). PBM treatment prior to fin clip decreased stress response in both wild type and mutant D. rerio by approximately 4-fold ($p<.01$), as well as greater fin function as assessed by swimming distance (160% greater in experimental vs control, $p<.001$).

Conclusions

PBM after nerve injury results in faster recovery of fin function and faster peripheral nerve growth, with a possible mitochrondrial pathway mechanism, involving the mpv17 protein. A delta and C nerve fibers are damaged in many conditions including diabetes, post-chemotherapy and autoimmune disorders, like Guillain-Barre. PBM therapy could be helpful in these conditions, affecting 20 million individuals in the US, thereby lessening dependence on pain medications and possibly improving sensory nerve regrowth and function.

Summary Statement

I showed that photobiomodulation can significantly improve peripheral nerve regeneration, possibly through a mitochondrial protein mechanism.

Help Received

I received help from Dr. Guo at UCI for caudal fin clip and caudal fin staining. I independently came up with the research question, proposed to use zebrafish as the animal model for my experiment, and found published papers with various protocols, including that for staining zebrafish peripheral nerve fibers.