HEALTH AND HUMAN SCIENCES

Synergistic Toxicity of the Heavy Metal Lead and Radiation

Student researcher: Boghos Taslakjian, Junior

Lead (Pb) is used in many industrial products, causing widespread exposure. Pb is known to cause cancer, neurodevelopmental alterations, and cardiovascular diseases. Today, about 500,000 U.S. children ages 1–5 have high lead levels, exhibiting symptoms like headaches and decreased IQ. Radiation is increasingly used in the medical field, doubling the annual radiation exposure since the 1980s. Radiation is known to cause cancer, and neurological and cardiovascular diseases. Children are more susceptible to radiation and Pb damage than adults given early stages of development.

In this study, zebrafish were used to evaluate the synergistic toxicity effects of Pb and radiation on development. Zebrafish embryos were dosed immediately after fertilization with 0, 10, or 100 parts per billion (ppb; $\mu\text{g/L}$) of Pb, and, at 24 hours post-fertilization (hpf), were exposed to 0, 0.11, or 1 Gray of photon radiation, to result in 9 different treatment groups. At 120 hpf, morphological assessments (body length, head length, head width, and brain length) and behavioral assessments (distance moved, velocity, movement to center point, and no movement to center point) were measured.

Morphological assessments indicated that exposure to 100 ppb Pb alone or in mixture with 0.11 and 1 Gray photon radiation led to significantly shorter body lengths and head lengths compared to control ($p < 0.05$). Interaction between Pb and radiation (100 ppb Pb/0.11 Gray and 100 ppb Pb/1 Gray) led to significantly shorter head widths and brain lengths compared to control ($p < 0.05$). Furthermore, the ratio of head length to body length was significantly less for the zebrafish exposed to 10 ppb Pb/1 Gray, 100 ppb Pb/0.11 Gray, and 100 ppb Pb/1 Gray, indicating head lengths were smaller than expected for the decreased body length in the top treatment interaction groups ($p < 0.05$). Brain length to head length ratio was not significantly different ($p > 0.05$), showing decreases in brain length were representative of the shorter heads. Behavior assessments indicated that an interaction between Pb and radiation (100 ppb Pb/1 Gray) led to significantly less distance moved and velocity ($p < 0.05$). In summary, the results of this project shows that there is a synergistic toxicity effect for Pb and radiation and that the toxicity of this mixture should be investigated further.

Research advisor Jennifer Freeman writes: “Boghos’s project is a collaboration with the laboratory of Linda Nie and is the initial step in investigating the potential for a synergistic toxic interaction with exposure to the heavy metal lead and radiation, which is a likely combined exposure for children in today’s society that needs further investigation.”

A

B

C

D

E

F

Significant alterations following exposure to Pb and radiation. (A) At 120 hpf body length (a), head length (b), head width (c), and brain length (d) were measured. A significant decrease in all 100 ppb Pb treatment groups was observed for body length (B) and head length (C), but a significant decrease in the ratio of head length to body length indicated heads were even smaller than expected in the top Pb and radiation combined treatment groups (D). Brain length was decreased in the 100 ppb Pb and radiation combined treatment groups (E), while a decrease in distance moved was only observed at the top Pb and radiation combined treatment (F). * $p < 0.05$, Error bars represent standard error.