HEALTH & HUMAN SCIENCES

The Effects of Environmental Copper Exposure on the Behavior and Morphology of Developing Zebrafish

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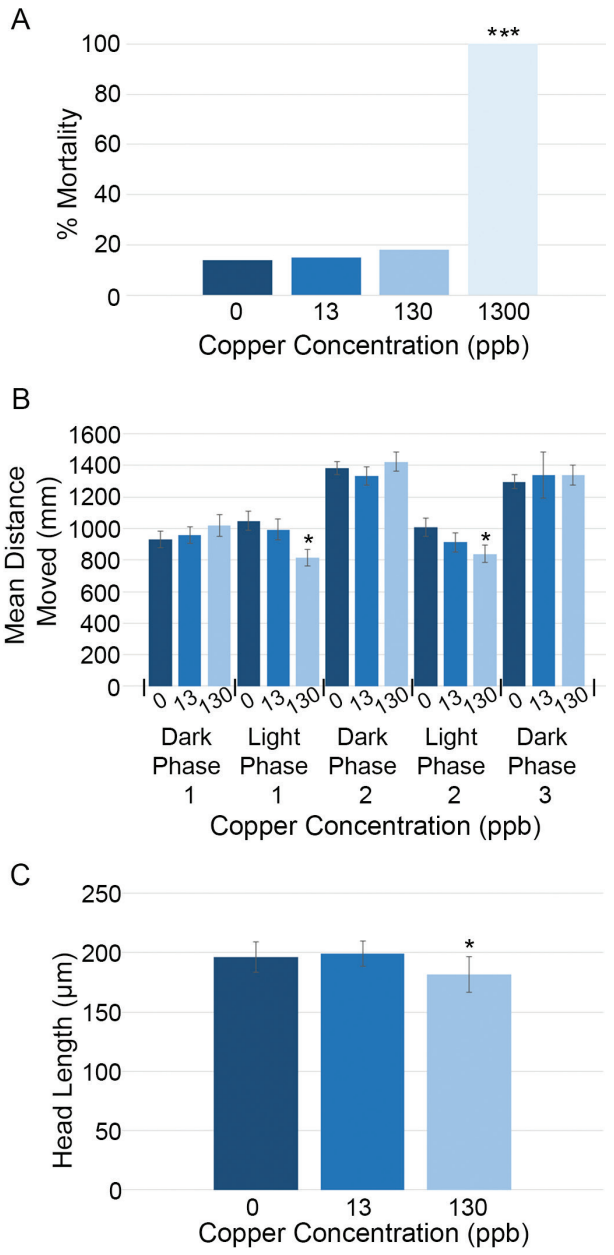
Copper is an essential metal that is key in many metabolic functions and is a cofactor in many enzymes. Excess copper exposure has been associated with fatigue, weakness, and neurologic dysfunction in humans. Zebrafish have a high degree of genome sequence homology to humans and were used as the animal model for copper toxicity studies. Survival and then behavioral and morphological changes at sublethal concentrations were assessed in developing zebrafish with exposure from 1 to 120 hours postfertilization. Exposure concentrations included 0, 13, 130, and 1,300 parts per billion (ppb) to span the current U.S. Environmental Protection Agency regulatory level in drinking water for the survival analyses and were revised to sublethal concentrations of 0, 13, and 130 ppb for the behavior and morphology assessments. It was hypothesized that zebrafish exposed to higher concentrations of copper during embryogenesis and early larval development would show signs of increased physiological and behavioral stress as well as abnormalities in morphology. Copper caused mortality at 1,300 ppb and was excluded from further studies. Behavioral studies using the visual motor response test revealed decreased total distance moved, velocity, and time spent moving at 130 ppb in light phases (p <less than> 0.05). In addition, larvae exhibited significantly decreased head width, head length, total length, brain length, and eye diameter in the 130 ppb treatment (p <less than> 0.05). Overall, developmental copper exposure resulted in dysfunctional locomotor behavior and morphological abnormalities in zebrafish at concentrations lower than the regulatory concentration in U.S. drinking water, indicating species sensitivity.

Research advisor Jennifer L. Freeman writes: "Recent studies indicate risks of increased adverse neurological outcomes related to environmental copper exposure. Christina's study used the zebrafish model system to better understand influences of a developmental copper exposure on physiological development and behavioral outcomes."



*Developmental toxicity of copper following exposure from 1 to 120 hours post fertilization in zebrafish. (A) Complete mortality was observed at 1,300 ppb (***p <less than> 0.0001), while no significant changes in mortality were observed in larvae exposed to 13 or 130 ppb compared to zebrafish not exposed to copper (n = 4, with 50 subsamples per biological replicate). (B) Hypoactivity was observed in larval behavior in the 130 ppb treatment group in both light phases (*p <less than> 0.05), while no significant changes were observed in the dark phases (p <more than> 0.05) (n = 4, with 32 subsamples per biological replicate to total 128 larvae per treatment group). (C) A decrease in head length was observed in the 130 ppb treatment group (*p <less than> 0.05) (n = 8, with 8–10 subsamples per biological replicates to total 64–80 total larvae per treatment group). Error bars represent standard deviation.*

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