New research opens a window on eye health

April 14 2017

Kathleen Hill, a professor in the Department of Biology at Western, is working on research that appears to indicate deteriorating vision could be a precursor of neurodegenerative ailments later in life. Credit: Paul Mayne//Western News

Poets see the eyes as a window to the soul. Scientists increasingly view the eyes as a window to the inner workings of the body.

And early vision loss, according to Western researchers, could be a predictor, and precursor, of other ailments that may appear later in life. For an aging population facing vision-related diseases, like macular degeneration and glaucoma, that's good news.

"If retinal cells are lost, you can't treat them," said Kathleen Hill, a professor in the Department of Biology at Western. "But we've learned eye function in mice starts to deteriorate before the structure does. That means there may be a therapeutic window of opportunity where we can treat cells to compensate for their inability to function properly."

And while early detection of vision loss improves potential for treatment, research indicates it can also provide insight into the brain and potential development of age-associated neurodegenerative diseases, like Parkinson's and Alzheimer's. With these diseases, the progressive death of nerve cells causes problems with movement or mental functioning.

"Our research is an important first step in understanding neurodegenerative diseases and developing a framework for diagnostic and intervention strategies," Hill said.

Electroretinography reveals functional deficits before neurons in the retina are lost.

When mitochondria – tiny packages of enzymes that make the energy to power cells in every part of the body – fail due to genetic or environmental factors, less energy is generated within the cell, which can lead to cell death, and even organ failure.

"Retinal cells require lots of energy, for both their basic function and to constantly rebuild the underlying structure," explained Hill. "The cells are like a factory going all out, all the time."

What happens when there's not enough energy to power both types of production? Hill has been looking to answer this question with research on the harlequin mouse, a species that has a mutation which helps it mimic signs of aging in the human eye.

Her research team looked at the role mitochondrial dysfunction plays in the function and structure of the retina. The mice did not show any one specific human disease; they simply reached a point where they couldn't produce enough energy for the retinal cells to function properly. Instead of going full out, the cell 'factory' faltered, contributing to premature aging and progressive neuron loss, leading to blindness.

"What's new about our approach was figuring out how the different cells of the retina were making and using energy," Hill said. "Do they have fewer cells, or do they fire less often? Which cells are lost first? How do the cells try to compensate? When does an inflammatory response start, and how does treatment affect it? Those were some of our questions."

Answering these questions is a first step in looking at the connections between deteriorating vision and neurodegenerative conditions.

A geneticist by training, Hill worked with a team that included scientists and students, specialists in ophthalmology, physiology, applied math, physics, metabolism and structural engineering, with support from Cindy Hutnik, a professor in the Departments of Ophthalmology and Pathology.

Whole eye imaging provides a noninvasive window into structural integrity or structural losses, she explained.

State-of-the-art equipment helped the team use non-invasive imaging tests over the lifespan of the mice. A human eye model, created with 3-D printing, also helped test drug flow through the eye.

"The retina is like a multi-layered cake," Hill noted. "All the layers have to be a particular shape, size and thickness for it to function properly. The imaging equipment is so sophisticated, we can measure the layers and see if they are thinning or not developing properly over time.

"That helps us figure out the first event that takes the eyeball down the path to degeneration. Once we know that, we know what to target and change, rather than always dealing with symptoms."

The features of the electroretinogram map to specific cells in the retina.

As a child, Hill worked alongside her father at a complex in Windsor designed for blind and senior citizens, which has encouraged her research path.

"I learned a lot from the people who were adapting to change in their eyesight in this supportive community, and that has stayed with me," she said.

The potential of monitoring retinal cells to make sure other treatments, such as chemotherapy, don't compromise a healthy eye fascinates Hill. People with inherited genetic deficiencies and other disorders could also benefit from her research.

"Doctors are getting good at diagnosing problems, and there's greater awareness of treating the whole person in both drug development and treatment," Hill added. "Pharmaceutical companies will be key in translating research to the patient."

Provided by University of Western Ontario