Gray Matter Matters in Mild Traumatic Brain Injury

Erin D. Bigler, PhD

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Related Article

Prospective Study of Gray Matter Atrophy Following Pediatric Mild Traumatic Brain Injury

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By the Centers for Disease Control (CDC) surveillance methods, approximately 1.5 million children each year sustain a mild traumatic brain injury (TBI), also referred to as concussion. The numbers are likely even higher because a substantial number of pediatric cases with mild TBI are not seen or evaluated in a medical setting. Until recently, mild TBI was mostly considered a relatively minor condition, especially in the context of sports-related concussion and mild TBIs that occurred in recreational and related activities. However, given mild TBI's high prevalence, it became clear that some children had lingering symptoms and changes that did not resolve over time.[1] This inspired the CDC and the NIH to fund large-scale studies to more fully examine brain changes in children who experience a mild TBI. Neuroimaging methods are the most direct way to study the potential effects of a mild TBI. In their study published in this issue, Mayer and coworkers[2] used advanced brain imaging methods to show regional changes in brain gray matter that lasted at least 4 months in children who sustained a mild TBI. Gray matter refers to the part of the brain that contains brain cells.

The researchers in this study compared study participants' brain MRI images taken shortly after the participants' injuries and then again at 4 months after injury. As a group, these images showed changes in gray matter size in those with mild TBI but not in healthy, noninjured control participants. Specifically, it showed changes in 2 important brain regions: part of the frontal lobe and an important part of the temporal lobe called the hippocampus. These findings are significant because these regions of the brain are important for a wide range of cognitive (that is, related to thinking), emotional, and physical functions. Changes in these functions relate to the symptoms that are seen after mild TBI.

From the Department of Psychology and Neuroscience Center, Brigham Young University, Provo, UT and Departments of Neurology and Psychiatry, University of Utah, Salt Lake City, UT.

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Gray Matter vs White Matter in Mild TBI

As mentioned earlier, gray matter refers to the parts of the brain that contain most of its neurons or brain cells. Some other parts of the brain are referred to as white matter. These contain the connections, or "wiring," between brain regions that enable them to work together. Gray matter has a distinct appearance on an MR image. This allows researchers to measure its size.[3,4]

The Importance of Potential Effects of Mild TBI on Brain Structure

Until recently, mild TBI was generally considered a brief neurologic event with no lasting effects. However, the 21st century view of mild TBI is quite different than that of the past. Advanced brain imaging methods have helped researchers better understand the changes that can happen with mild TBI. When standard MRI is performed on people with mild TBI, abnormalities are rarely seen. However, advanced computer methods that analyze brain images have changed our thinking. Changes in specific brain regions that are identified using these methods are likely to point to important changes in brain cells and their connections, potentially injured when a child sustains a mild TBI.

Brain Injury and the Developing Brain

Changes in both gray and white matter are expected as part of normal brain development during childhood, adolescence, and even into early adulthood. A very important issue regarding pediatric mild TBI is the potential for an injury to interfere with this process at key time points, depending on when an injury occurs. These interruptions could affect long-term brain development. Such effects have been well established in moderate-to-severe TBI,[5] but in this work, Mayer and colleagues have shown that these effects can also happen as a result of mild TBI.

How Was the Study Conducted?

Children who received care for mild TBI in emergency department and urgent care centers were enrolled in this study. The baseline MRI was obtained within 11 days postinjury. The MRI was then repeated at 4 months. For comparison, a "healthy" sample group of children of the same age and sex as those who had had mild TBI also had similar MRI scans. Both groups filled out surveys about their symptoms and underwent cognitive testing. The average age of the children in this study was approximately 14 years, and there were approximately 200 children studied in each group.

How Was Mild TBI Defined?

The researchers used established clinical rules to determine who had mild TBI. In general, mild TBI was defined as an injury to the brain resulting from an external force from an event such as a blast, fall, direct impact, or motor vehicle accident.[6] To be eligible for the study, each participant from the group with mild TBI had an injury that had caused an alteration in brain function and had to have produced symptoms such as headache, nausea, vomiting, dizziness/balance problems, fatigue, insomnia/sleep disturbances, drowsiness, sensitivity to light and/or noise, blurred vision, difficulty remembering things, and/or difficulty concentrating.

Importance of Studying Gray Matter in Mild TBI

Much of previous TBI research using brain imaging has focused on white matter. A common finding in that research has been subtle injuries to the "wiring" of the white matter, often referred to as "diffuse axonal injury" (DAI). There are mechanical reasons why the white matter can be injured in TBI, and this has been an important area of research to help understand the effects of TBI. However, brain gray matter is also vulnerable to injury. It lies closer to the skull and can be injured or "bruised" when TBI occurs. What this research from Mayer and coworkers has emphasized is that researchers should not ignore what is also happening in the gray matter regions of the brain after mild TBI.[2]

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About Mild TBI

The Significance of MRI-Detected Changes in Pediatric Mild TBI

Websites for the American Academy of Neurology, Center for Disease Control, American Academy of Pediatrics, and others provide detailed clinical information on pediatric mild TBI. As stated earlier, they estimate that each year, more than 1.5 million children sustain such injuries. Accordingly, even if disrupted gray matter occurs only in a minority of children who sustain mild TBI, the clinical importance may be significant because TBI is so widespread. As shown in the study by Mayer and coworkers, even with mild TBI, there can be a range of injury severity. More severe concussion has been associated with greater likelihood for gray matter damage. This would also suggest that children with the mildest level of TBI, who are likely those who follow a more typical recovery trajectory, may not experience more persistent gray matter disruption. As the researchers suggested, by establishing a very early postinjury baseline, this type of imaging research has the potential to identify and follow-up children who may not experience a complete recovery from their TBI.[4]

Not All Mild TBI Is the Same: Why Frontal and Temporal Lobe Effects Are Most Likely

The most common forms of pediatric mild TBI occur with concussions that happen during sports and other recreational activities. Often, the injuries are captured by video. We have all likely seen some of the different forms of head impact that can result in pediatric concussion. But the differences go beyond the different types of concussion. There are genetic factors that not only relate to who gets injured but also to how well they recover. Age, sex, and other factors also enter into the injury-and-recovery equation. This tells us that there is no single type of injury that occurs with every head injury resulting in a mild TBI. Despite these individual differences, research has clearly shown that the frontal and temporal lobe brain regions are most vulnerable in mild TBI. This was also demonstrated in this study, in which the most significant mild TBI–related gray matter changes in their participants occurred in frontal and temporal (hippocampus) areas.

Public Awareness

Studies such as this also add to greater public awareness about the potential seriousness of mild TBI in children. Because mild TBI treatment is often just supportive while waiting for spontaneous improvement, the best prevention is to avoid sustaining a TBI. If there are detectable brain changes after pediatric mild TBI, this emphasizes greater need for public awareness about the importance of avoiding injury whenever possible and in cases where injury does occur, to seek proper care as quickly as possible.

The Future of Mild TBI Research

This research used the approach of establishing a baseline and assessing changes over time. This was important to detect gray matter changes in mild TBI. However, MRI is an expensive technology. It also cannot be conducted on some children—for example, those wearing braces, because the metal in the braces distorts the MRI signals. Children who move in the scanner may also have unusable MR images. These factors limit the practicality of MRI for assessing the chronic effects of pediatric mild TBI. However, if a less expensive but still reliable mild TBI biomarker could be developed[3], such a tool could identify which patients with pediatric mild TBI should go on to receive MRI. More research is needed, but undergoing the kinds of MRI analyses as performed in this study may be especially important for children who experience significant, prolonged postinjury symptoms and problems from mild TBI. These results add to research that hopefully will lead to improved identification of what the long-term effects of mild TBI may be.

For More Information

Brain & Life
brainandlife.org

American Academy of Neurology
AAN.com/practice/sports-concussion

Centers for Disease Control and Prevention
cdc.gov/traumaticbraininjury

American Academy of Pediatrics
AAP.org

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