

# INSIDE VIEW

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A Quarterly Magazine Dedicated to the Field of Acquired Brain Injury

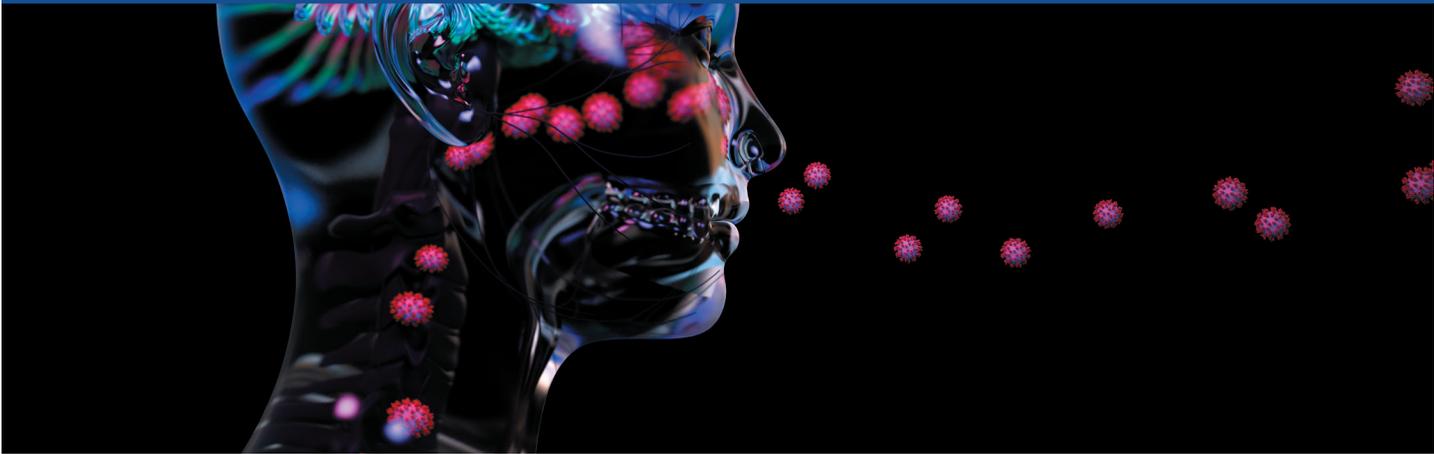


## BLOOD

Test Set to Transform  
Detection of Brain Damage

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# Nervous System Manifestations of COVID-19

*SARS-CoV-2 can infect nerve cells and cause a range of neurological and psychiatric symptoms*

COVID-19 can result in a prolonged effect on brain wave patterns for at least four months.

The cluster of neurological symptoms associated with SARS-CoV-2 infection, the virus that causes COVID-19, suggests the virus can enter the brain and affect neural function. New findings were presented at Neuroscience 2021, the annual meeting of the Society for Neuroscience and the world's largest source of emerging news about brain science and health.

Although much of the attention on COVID-19 centers on its respiratory effects, the virus has significant neurological manifestations as well. Many people infected with SARS-CoV-2 report neurological and psychiatric symptoms, including headache, loss of sense of smell and taste, hallucinations, vivid dreams, depression, fatigue, "brain fog," and even seizures or stroke. These symptoms suggest the virus is capable of reaching the brain and may also affect other areas

of the nervous system. Even for those who initially recover, many will experience lingering cognitive or neurological problems for months post-infection.

Today's new findings show:

- An analysis of human brain tissue identified two proteins, NRP1 and furin, that may mediate SARS-CoV-2 entry into human brain cells (Ashutosh Kumar, All India Institute of Medical Sciences-Patna).
- Studies of rhesus monkeys reveal how SARS-CoV-2 invades and spreads through the brain (John H. Morrison, University of California, Davis).
- In mice, peripheral nerve cells that transmit touch and pain information to the central nervous system are susceptible to SARS-CoV-2 infection, offering a possible route to

infect the brain (Jonathan D. Joyce, Virginia Tech).

- COVID-19 can result in a prolonged effect on brain wave patterns for at least four months, but these differences may resolve by seven months post-infection (Allison B. Sekuler, Rotman Research Institute, McMaster University, and University of Toronto).

"We are just beginning to understand the central nervous system manifestations of COVID-19," said Rita Balice-Gordon, the chief executive officer of Muna Therapeutics, an early-stage company working on novel therapeutics for neurodegenerative diseases. "The research presented today adds important new information about the neurobiological mechanisms underlying COVID's effects on cognition and behavior." ■

# 2022 Calendar of Events

## Mar

**11-12**

11th International Conference on Stroke and Cerebrovascular Diseases  
London, UK  
[strokecongress.neurologyconference.com](http://strokecongress.neurologyconference.com)

**30-31**

BIA of Massachusetts Annual Conference  
Marlborough, MA  
[biama.org](http://biama.org)

**30-1**

American Society for Neuroscience Conference  
St. Louis, MO  
[asnr.com/i4a/pages/index.cfm?pageid=3851](http://asnr.com/i4a/pages/index.cfm?pageid=3851)

## May

**13-19**

ASNR 2022 Symposium and Annual Meeting  
New York, NY  
[asnr.org/events/upcoming-meetings/asnr/](http://asnr.org/events/upcoming-meetings/asnr/)

**15-18**

2022 IRSG Annual Conference  
Baltimore, MD  
[irsghome.org/](http://irsghome.org/)

## Jun

**6-7**

12th Annual Traumatic Brain Injury Conference  
Washington, D.C.  
[tbiconference.com/home/](http://tbiconference.com/home/)

**26-28**

BIA of Pennsylvania Annual Conference  
Lancaster, PA  
[biapa.org/annualconference/](http://biapa.org/annualconference/)

**26-29**

Neurotrauma 2022  
Atlanta, GA  
[neurotrauma.org/symposium/2022-atlanta/general-info-2022](http://neurotrauma.org/symposium/2022-atlanta/general-info-2022)

## Sep

**21-24**

Fourth International Conference on Pediatric Acquired Brain Injury  
New York, NY  
[internationalbrain.org/meetings-and-events/virtual-conference-2021](http://internationalbrain.org/meetings-and-events/virtual-conference-2021)

**21-24**

34th Annual Conference on Medical and Legal Issues in Brain Injury  
New York, NY  
[internationalbrain.org/meetings-and-events/2022-legal-and-medical-issue-in-brain-injury](http://internationalbrain.org/meetings-and-events/2022-legal-and-medical-issue-in-brain-injury)

## Nov

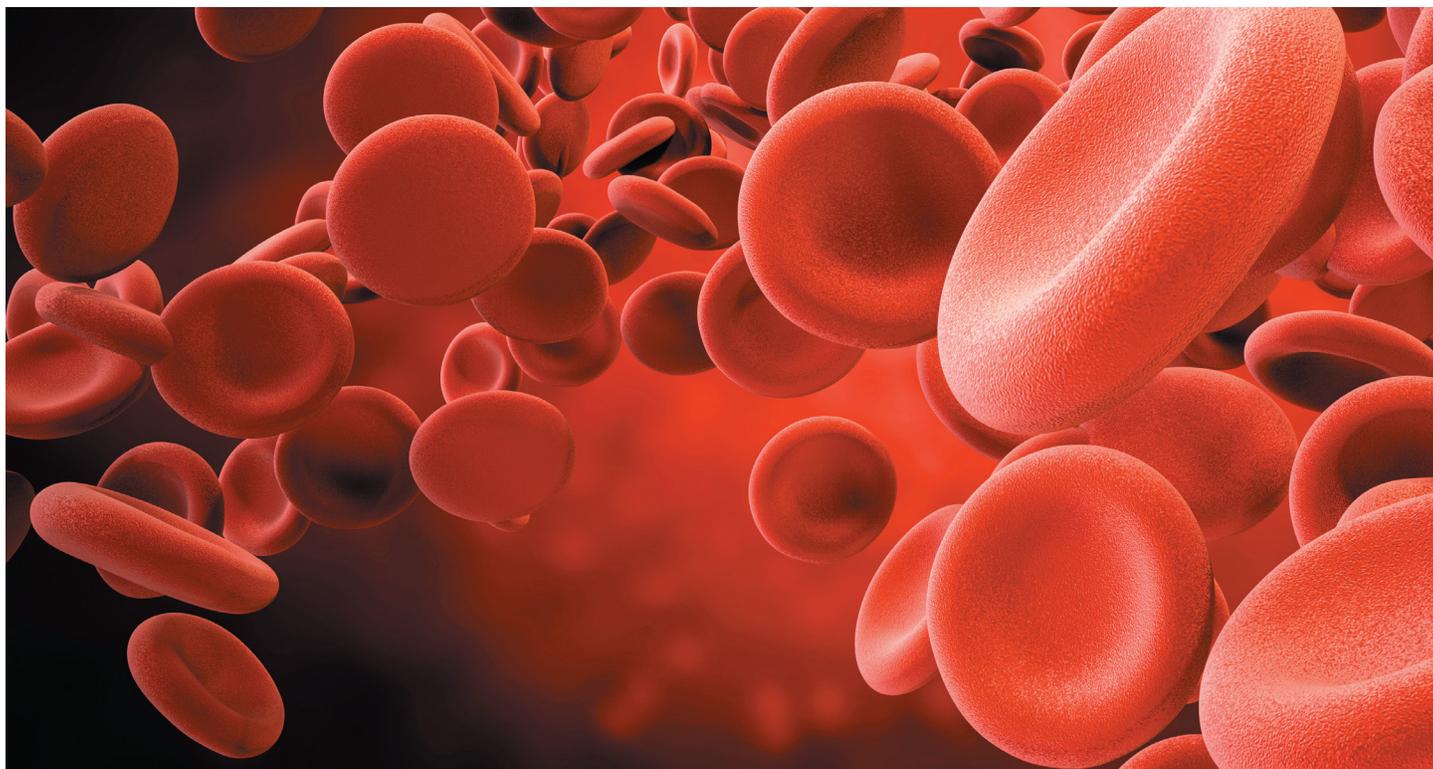
**8-11**

ACRM Annual Conference  
Chicago, IL  
[acrm.org/meetings/](http://acrm.org/meetings/)

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Articles are sourced from scientific journals, universities and publications that contribute to the ongoing research of brain injury.

## COVER STORY



# Ultrasensitive Blood Test Set to Transform Detection of Brain Damage After Head Injury

Measuring blood levels of neurofilament light, a protein important for axonal structure, provided a remarkably accurate long-term prognosis for the patient.

A new study has used a state-of-the-art blood test to track damage to the brain in people who have sustained traumatic brain injury (TBI). Measuring the protein biomarker in the blood will provide a simpler, more accurate way to predict clinical outcomes and may help to identify those at higher risk of developing dementia. The study is published in *Science Translational Medicine*.

Around 50 million people each year worldwide experience TBI as a result of head injury. In the brains of these individuals, the nerve cells encounter severe stretching and sheering forces which cause damage to their axons, the part which transmits electrical signals. Axonal damage is the best predictor of clinical outcomes and recovery but has been difficult to measure in patients.

The team from the UK Dementia Research Institute's (UK DRI) Care Research and Technology Centre, based at Imperial College London,

set out to identify a chemical that could be easily detected in the blood—a biomarker—that would accurately reflect this axonal damage in the brain after TBI. To do this they harnessed cutting-edge technology called single molecule array (SiMoA) that can measure sub-femtomolar (10<sup>-16</sup>) levels of chemicals in the blood.

In this multicenter study, the researchers began by detecting proteins that are important to the structure of the nerve cell axons. They found that measuring blood levels of neurofilament light, a protein important for axonal structure provided a remarkably accurate long-term prognosis for the patient.

The team also used advanced types of brain imaging to validate blood test findings. Blood levels of neurofilament light were found to be closely related to measures from diffusion MRI, an advanced type of imaging which also provides measures related to damage to axons. The team also compared blood levels of neurofilament light with a special type of brain imaging that measures shrinkage (atrophy) of the brain, indicating the loss of nerve cells. They found that blood levels of neurofilament light tracked extremely well to brain atrophy and importantly predicted further nerve cell degeneration up to one year after the injury. These findings mean future blood tests could provide similar information to MRIs, but in a more cost-effective and accessible manner.

Dr. Neil Graham, joint first author and Alzheimer’s Research UK Clinical Research Fellow based at the UK DRI’s Care Research and Technology Centre, based at Imperial College London, said that he’s “extremely excited by the ultrasensitive blood test technology we used here as it has opened up a whole new world of possibilities when it comes to precise injury diagnosis and prediction of outcomes after head injury. This is particularly useful in the area of dementia risk assessment after TBI, which is very challenging at present. If we could roll the neurofilament light test out across the country, it would be hugely impactful. We’re gearing up to offer it to patients in the near future.”

Dr. Karl Zimmerman, joint first author and postdoctoral researcher based at the UK DRI’s Care Research and Technology Centre, based at Imperial College London, said that “these results are exciting as they pave the way for the use of these advanced biomarkers in the assessment of head injuries in other contexts. We have studied and shown that there may be similar changes occurring in professional athletes exposed to head injuries. We’re setting up more research to look at this in detail to improve care of sportspeople concerned with later life risk of dementia.”

Professor David Sharp, senior author of the paper and Director of the UK DRI’s Care Research and Technology Centre based at Imperial College London, said that “outcomes after TBI are very difficult to predict. This is a major challenge for doctors trying to care for patients recov-

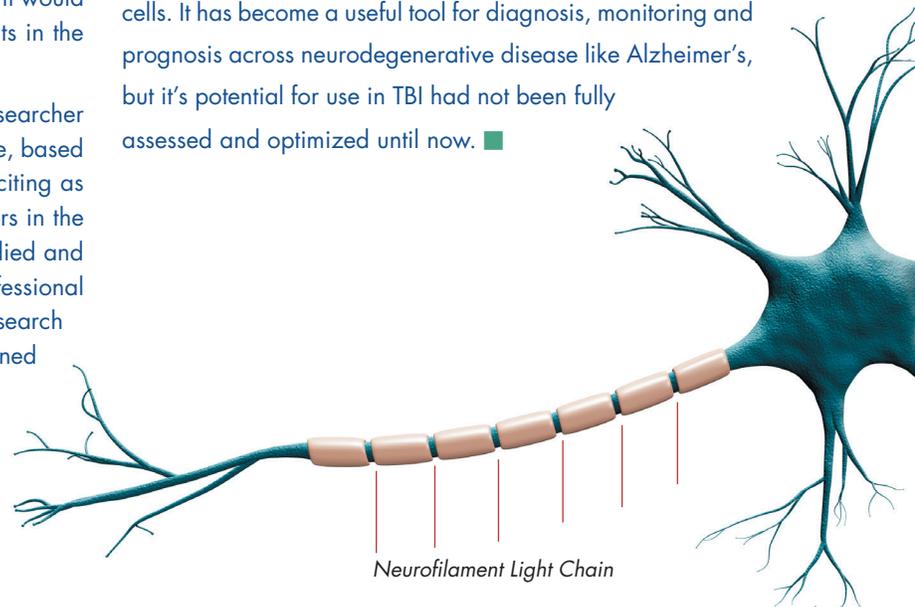
ering from head injuries of all severities. What we need are more accurate diagnostic tests that can be used in our major trauma units and clinics. Our work shows that measuring neurofilament light soon after head injury helps predict who will develop long-term problems. We are applying this in various contexts, including for the investigation of sporting TBI, and will be investigating whether this blood test can be used to predict those at high risk of developing dementia”

Dr. Rosa Sancho, Head of Research at Alzheimer’s Research UK, said that “traumatic brain injury is a risk factor for dementia, and identifying the long-term impact of individual head injuries remains an important goal for research. This work gets us closer to a blood test able to predict how brain changes develop up to one year after injury. Dementia develops over many years and we need to build on these findings to help improve longer-term prognosis and to reliably determine an individual’s risk of dementia following a head injury.”

“As the UK’s leading dementia research charity, we’re pleased to have funded both Dr. Graham’s clinical work and the UK DRI. We couldn’t do either without the continued dedication of our supporters.”

The study involved over 200 patients who had experienced moderate to severe TBI, recruited from eight major trauma centers across Europe. In 56% of cases the injuries were classed as ‘high energy’, involving falls from over 3 meters or collisions at more than 30km/hour, with the majority of these caused by road traffic accidents.

The biomarker identified in the study, neurofilament light, is a protein found in neurons, important for the overall structural stability of these cells. It has become a useful tool for diagnosis, monitoring and prognosis across neurodegenerative disease like Alzheimer’s, but it’s potential for use in TBI had not been fully assessed and optimized until now. ■



# Aerobic Exercise After a Sport-Related Concussion Speeds Recovery in Adolescent Athletes

“Our findings show that to accelerate recovery and reduce the risk of delayed recovery, physicians should not only permit, but they should consider prescribing sub-symptom threshold physical activity early after sport-related concussion.”

Adolescents can speed their recovery after a sport-related concussion and reduce their risk of experiencing protracted recovery if they engage in aerobic exercise within 10 days of getting injured, according to a new University at Buffalo study.

Recently published in *The Lancet Child & Adolescent Health*, the randomized controlled trial conducted by researchers at UB’s Concussion Management Clinic reproduces and expands on the team’s 2019 study published in *JAMA Pediatrics*.

The new study shows for the first time that sub-symptom threshold aerobic exercise — meaning exercise that doesn’t exacerbate symptoms — when initiated within 10 days reduced a participant’s risk of persistent post-concussion symptoms by 48%.

“The study clearly demonstrates that strict physical rest until symptoms spontaneously resolve is no longer an acceptable way to treat sport-related concussion in adolescents,” said John J. Leddy, MD, first author, clinical professor of orthopedics in the Jacobs School of Medicine and Biomedical Sciences at UB, and director of the UB Concussion Management Clinic at UBMD Orthopedics and Sports Medicine.

## Prescribing physical activity

“Our findings show that to accelerate recovery and reduce the risk of delayed recovery, phy-

sicians should not only permit, but they should consider prescribing sub-symptom threshold physical activity early after sport-related concussion,” he said.

Adolescents are the most vulnerable age group for concussions, and they take the longest time to recover.

The new findings are the result of a large body of work by Leddy and colleague Barry S. Willer, PhD, professor of psychiatry in UB’s Jacobs School, research director in the Concussion Management Clinic and senior author on the paper. Leddy and Willer have spent years investigating how concussions impact young athletes.

Their research, which is internationally known, has played a key role in the evolution of guidelines that no longer state that athletes recovering from concussions should be prescribed complete rest.

They began this line of research in 2000 after working together to develop guidelines for return to play after concussion for the International Olympics. They were interested in developing a safe and systematic assessment of exercise tolerance, since this was a known problem after concussion.

“We based our approach on how patients with heart disease are prescribed exercise by, identifying a safe threshold below which the patient can exercise,” said Leddy. “We



developed our Buffalo Concussion Treadmill Test by adapting a cardiac treadmill test to stress the brain instead of the heart. Since we know that regular aerobic exercise is good for brain health, the goal was to use sub-symptom threshold exercise to see if it could help the concussed brain recover.”

#### **Non-pharmacological, safe and effective**

“As the current study shows, this approach is non-pharmacological, safe and effective,” said Leddy, adding that no adverse events were reported.

Study participants were adolescents between the ages of 13 and 18 who had sustained a concussion while playing a sport. A total of 118 adolescents were included, with 61 receiving the aerobic exercise treatment and 57 receiving the placebo treatment of stretching exercises that did not elevate their heart rate.

Those who participated in the aerobic exercise group took a median of 14 days to

recover from concussion versus 19 days for those in the stretching exercise group.

The use of heart rate monitors, in particular, revealed to the UB researchers a more robust picture of the aerobic exercise sessions the participants were pursuing at home.

“What we discovered is that participants were quite diligent in following their prescription and further, that those who followed the prescription or may even have exceeded the exercise prescription of 20 minutes per day recovered much faster than those that did not follow the prescription,” Willer said. “This finding is important because delayed recovery comes with substantial cost to adolescents, including academic difficulties, risk for depression and reduced quality of life.”

Leddy and Willer said there are a number of possible reasons why this approach is effective, related to the physiological and neurological benefits that stem from aerobic

exercise, including enhancements to neuroplasticity (i.e. neuron repair).

“We are very pleased that the results of this second study provide much stronger evidence that the Buffalo Protocol is not only effective, but it is effective whoever provides the treatment and with all adolescent athletes who experience a concussion,” said Willer. “Importantly, the benefits of prescribed aerobic exercise were experienced by both genders equally.”

The UB research focused exclusively on adolescents recovering from sport-related concussion. Other investigations, focused on adults who have sustained a concussion in a non-sport setting, have found that such an approach can be effective, but it doesn’t work as rapidly or effectively as it does for athletes. In adults, the aerobic exercise approach can work but, Leddy said, it usually has to be combined with other therapies.

“By contrast, this kind of sub-symptom aerobic exercise approach is often the only treatment that adolescent athletes need,” he noted. ■

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# Study Links Amateur Boxing to Increased Risk of Brain Impairment and Early Onset of Dementia

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Research found that men who had boxed in their youth were twice as likely to have Alzheimer's-like impairment as those who had not boxed.

Amateur boxing is associated with an increased risk of cognitive impairment and earlier onset of dementia, according to a study carried out by Cardiff University.

The research team found that men who had boxed in their youth were twice as likely to have Alzheimer's-like impairment as those who had not boxed. It was also linked to an earlier onset of dementia by about five years.

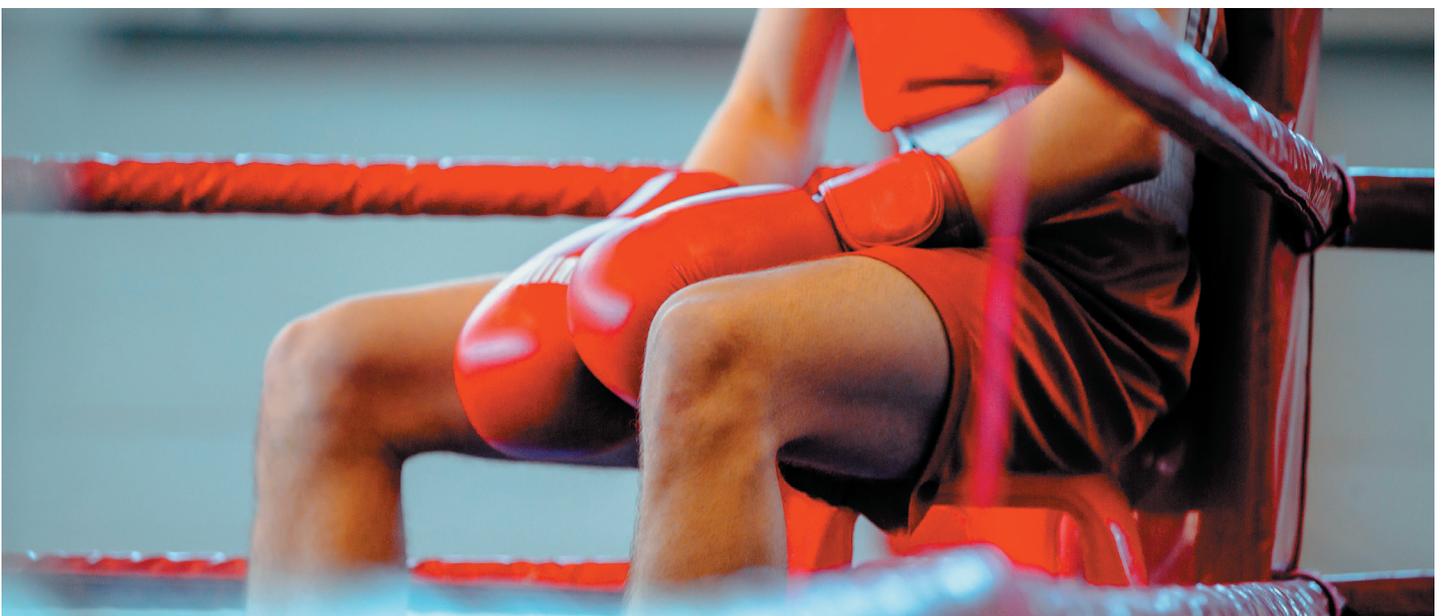
They said their findings suggest a ban on blows to the head should be considered in the amateur sport.

The study, the first to look at the long-term effects of amateur boxing on the brain, is

published in the *Clinical Journal of Sport Medicine*. The researchers say it adds to the growing evidence on links between dementia and sport and the ongoing debate around safety measures.

Lead author Professor Peter Elwood, Honorary Professor at Cardiff University's School of Medicine, said: "Professional boxing is known to cause chronic traumatic brain injury—but there has been little to no long-term research on this issue in amateur boxing.

"Our study therefore provides some of the best available evidence suggesting that amateur boxing is associated with clinically



“Banning blows to the head would seem to be an acceptable preventive measure, as this need not reduce the competitive aspect of the sport but would preserve its undoubted considerable physical and social benefits.”

measurable long-term brain injury, manifested as earlier onset Alzheimer’s-like impairment.

“Over the years the introduction of increasingly tight controls in the amateur sport, with shorter bouts and mandatory headgear, means that the chances of serious brain injury are much reduced—but there is still a true long-term impact of boxing.

“Banning blows to the head would seem to be an acceptable preventive measure, as this need not reduce the competitive aspect of the sport but would preserve its undoubted considerable physical and social benefits.”

The research team used the Caerphilly Cohort Study to collect evidence on predictors of cognitive decline and dementia.

The study is based on a representative sample of 2,500 men resident in Caerphilly, South Wales, who were aged 45–59 years when enlisted to the study in 1979.

Subjects were followed for 35 years, and every five years their lifestyle and behavior, health and activities, and the diseases they experienced, were recorded by interview, clinical examination, and inspection of their GP and hospital records, along with repeated tests of cognitive function. At the conclusion

of the study in 2014, evidence of dementia was collected from medical records.

This study found that, of a sample of 1,123 of men, 73 said they had boxed “seriously” when they were younger.

When they were aged 75–89 years, a third of those who had boxed showed evidence of cognitive impairment, compared with about a fifth of the men who had not boxed. This represents a “significant” two-fold increase in cognitive impairment, said the study, rising to almost three-fold for Alzheimer’s-like impairment.

The onset of dementia was almost five years earlier in the men who had boxed, compared with those who had not participated in the sport, the study found.

Professor Elwood said that while a sample of 73 is a relatively small number to study, long-term analysis of amateur boxers is rare, so it provides valuable evidence in the ongoing debate around head injury and contact sport.

“Millions of people are affected by dementia and the links between this devastating disease and certain types of contact sport are only now starting to come to light,” said Professor Elwood.

“Further research in this area is vital so that we can bring in simple measures now to protect the health of generations to come.” ■





# Stroke May be Triggered by Anger, Emotional Upset and Heavy Physical Exertion

The suspected triggers have been identified as part of the global INTERSTROKE study which analyzed 13,462 cases of acute stroke.

A global study co-led by NUI Galway into causes of stroke has found that one in 11 survivors experienced a period of anger or upset in the one hour leading up to it. One in 20 patients had engaged in heavy physical exertion.

The suspected triggers have been identified as part of the global INTERSTROKE study – the largest research project of its kind, which analyzed 13,462 cases of acute stroke, involving patients with a

range of ethnic backgrounds in 32 countries, including Ireland. The research has been published in the European Heart Journal.

Stroke is a leading global cause of death or disability. Each year, approximately 7,500 Irish people have a stroke and around 2,000 of these people die. An estimated 30,000 people are living in Ireland with disabilities as a result of a stroke.

Professor Andrew Smyth, Professor of Clinical Epidemiology at NUI Galway, Director of the HRB-Clinical Research Facility

Galway and a Consultant Nephrologist at Galway University Hospitals, was one of the lead researchers.

He said: “Stroke prevention is a priority for physicians, and despite advances it remains difficult to predict when a stroke will occur. Many studies have focused on medium to long-term exposures, such as hypertension, obesity or smoking. Our study aimed to look at acute exposures that may act as triggers.”

The research analyzed patterns in patients who suffered ischemic stroke – the most common type of stroke, which occurs when a blood clot blocks or narrows an artery leading to the brain, and also intracerebral hemorrhage – which is less common and involves bleeding within the brain tissue itself.

Professor Smyth added: “We looked at two separate triggers. Our research found that anger or emotional upset was linked to an approximately 30% increase in risk of stroke during one hour

after an episode – with a greater increase if the patient did not have a history of depression. The odds were also greater for those with a lower level of education.

“We also found that heavy physical exertion was linked to an approximately 60% increase in risk of intracerebral hemorrhage during the one hour after the episode of heavy exertion. There was a greater increase for women and less risk for those with a normal BMI.

“The study also concluded that there was no increase with exposure to both triggers of anger and heavy physical exertion.”

Co-author of the paper, Dr Michelle Canavan, Consultant Stroke Physician at Galway University Hospitals, said “Our message is for people to practice mental and physical wellness at all ages. But it is also important for some people to avoid heavy physical exertion, particularly if they are high-risk of cardiovascu-

lar, while also adopting a healthy lifestyle of regular exercise.”

The global INTERSTROKE study was co-led by Professor Martin O’Donnell, Professor of Neurovascular Medicine at NUI Galway, and Consultant Stroke Physician at Galway University Hospitals, in collaboration with Prof Salim Yusuf of the Population Health Research Institute of McMaster University and Hamilton Health Sciences, Canada.

“Some of the best ways to prevent stroke are to maintain a healthy lifestyle, treat high blood pressure and not to smoke, but our research also shows other events such as an episode of anger or upset or a period of heavy physical exertion independently increase the short-term risk.” Prof O’Donnell said.

“We would emphasize that a brief episode of heavy physical exertion is different to getting regular physical activity, which reduces the long-term risk of stroke.” ■

“Some of the best ways to prevent stroke are to maintain a healthy lifestyle, treat high blood pressure and not to smoke.”



# Nearly 7% of U.S. Kids Have Had a Head Injury or Concussion



Blows to the head are common among America's kids, with close to 7% showing signs of a brain injury at some time in childhood, U.S. health officials report. Sports, falls and abuse are likely causes, experts say.

Concussions and other head injuries are more common among white kids than Black or Hispanic kids. And prevalence increases with age—from 2% in children up to 5 years old to 12% in 12- to 17-year-olds, officials from the U.S. Centers for Disease Control and Prevention reported.

The researchers also found that boys are more likely than girls to suffer head trauma.

"It will be important to continue to monitor these disparities in the hopes of better understanding the pathways that lead to both having a brain injury or

concussion and seeking medical care," said researcher Benjamin Zablotsky. He is a statistician at the CDC's National Center for Health Statistics (NCHS), in Hyattsville, Md.

Because the study relied on parent reports, Zablotsky noted the number of reported head injuries may be underestimated.

The best medicine is to not suffer a brain injury, said Dr. Jose Prince, a pediatric surgeon at Northwell Health in New Hyde Park, N.Y.

"Preventing head injuries with seat belts, helmets, fall prevention and appropriate supervision can make a world of difference," said Prince, who was not involved with the study.

Using data from the 2020 U.S. National Health Interview

Within the field of pediatrics, adolescent males appear to be at the highest risk of head trauma overall, often related to risky behaviors"

Survey, the NCHS researchers found that:

- Among all children, nearly 9% of white kids had suffered a concussion or brain injury versus less than 6% of Hispanics and less than 3% of Black kids.
- While roughly 7% showed signs of concussion or brain injury, only 4% had a doctor's diagnosis.
- Nearly 8% of boys had symptoms of a concussion or brain injury versus 6% of girls.

It's not known if cases are on the rise. "Since this is the first year, we asked these specific questions," Zablotsky said, "we can't really comment on if the rate has risen or remained about the same."

The researchers also didn't ask about how children are being injured. "But there is certainly a need to understand the role sports- and physical activity-related injuries may be playing among older children," Zablotsky added.

Dr. Michael Grosso, chief medical officer and chair of pediatrics at Huntington Hospital in Huntington, N.Y., said there are many causes of head injury in children. The most common: falls, car crashes, abuse and sports.

"The range of severity for head injury is very broad," he noted.

"Abusive injury is especially concerning. Infant shaking can cause bleeding and swelling

of the brain that results in permanent damage or even death. Within the field of pediatrics, adolescent males appear to be at the highest risk of head trauma overall, often related to risky behaviors that include substance use," Grosso said.

Milder head injury can sometimes cause more serious symptoms than one would think, he added. So-called "post-concussive syndrome" can include prolonged periods of headache, visual disturbances, problems with sleep, coordination, mood and school performance.

"As pediatricians, we are especially concerned about return to activity for children with concussion, since doing so too rapidly can place the child at risk for a second injury, which carries its own risks," Grosso explained.

Prince said causes and effects tend to vary by age.

"For babies, falls and abuse can lead to death or devastating lifelong brain injury," Prince said.

For older children, car crashes can result in a severe brain injury that leads to cognitive problems, difficulty communicating, and behavioral and emotional struggles. In addition, sports injuries that cause a concussion can affect learning and return to play, he said. ■

## Young Veterans with Mild TBI Show Premature Cognitive Aging

Subtle, subclinical cognitive problems observed in specific cognitive domains in young veterans with mild traumatic brain injury (mTBI) are similar to those seen in patients with early-stage Parkinson disease (PD) who are decades older, according to a study published online in PLOS ONE.

Vicki A. Nejtek, Ph.D., from University of North Texas Health Science Center in Fort Worth, and colleagues compared age- and IQ-matched veterans with and without mTBI, nonveteran healthy controls, and IQ-matched nondemented early-stage PD patients to assess specific cognitive domains most involved with mTBI-related

PD onset. The analysis included 114 individuals.

The researchers found that groups differed on cognitive tests. Veterans with mTBI performed worse than matched-control groups on four out of eight cognitive tests according to post hoc tests; they also more often than not performed comparably to patients with early-stage PD.

"We found subtle, premature cognitive decline occurring in very specific cognitive domains in veterans [with] mTBI that would typically be overlooked in a clinic setting," the authors write. "This result potentially puts them at risk for continual cognitive decline that may portend to the eventual onset of PD or some other neurodegenerative disease." ■

Veterans with mTBI often performed comparably to patients with early-stage Parkinson disease.

# INSIDE VIEW

A Quarterly Magazine Dedicated to the Field of Acquired Brain Injury



## Our Mission

Centre for Neuro Skills is committed to helping those who have sustained a brain injury achieve the maximum possible quality of life and has served clients from around the world since 1980. CNS offers cost-effective, outcome-driven, community-based rehabilitation programs that focus on environmental validity, a normal rhythm of living, and obtaining the highest level of functioning for each client.

## Locations

CNS California programs are located in Bakersfield, Los Angeles and San Francisco. Texas programs are located in Austin, Dallas, Fort Worth, and Houston. For more information about our services please email us at [cns@neuroskills.com](mailto:cns@neuroskills.com) or call our toll free number 800.922.4994 or from outside the US at 661.872.3408.



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Our mission is to advance awareness, research, treatment, and education and to improve the quality of life for all people affected by brain injury.