CoE's Winning Team in Sports Medicine

Tennis elbow, a pulled hamstring, shin splints or an ankle sprain. We've all dealt with common sports injuries in an attempt to get in shape. Faculty at Georgia Tech's College of Engineering are laser-focused on providing sports medicine for even the most common injury. Past that, extracellular matrix therapies, regenerative medicine and wearable joint sensory technology are just a few of their more advanced focus areas. Sports medicine today has become a specialized field with many facets. No longer just a study of orthopedics, sports medicine now encompasses new therapies and technologies that tackle all sorts of sports-related injuries and diseases, leveraging predictive analytics and wearables to keep athletes performing at their best.

BY GEORGIA PARMELEE

Robert Guldberg

ROB FELT

Tech's sports medicine research program continues to grow, led by faculty such as Robert Guldberg, Omer Inan, Michelle LaPlaca and Johnna Temenoff, all leaders at the top of the field.

Each of these engineers has made impactful contributions to sports medicine research, and their work is already seeing real-world application today. Each one of them is driven by a common desire to enhance the quality of life of athletes, both on and off the field. And even the occasional exerciser can reap the benefits.

Robert Guldberg // Executive Director, Parker H. Petit Institute for Bioengineering and Bioscience and Mechanical Engineering Professor

Baseball players today may soon benefit from Robert Guldberg's work on treatments for rotator cuff injuries, ligament tears and osteoarthritis. Guldberg has recently worked with the likes of Dr. Gary Lourie, head physician for the Atlanta Braves, whose focus is to keep athletes safe and healthy. Lourie will deliver a keynote talk on regenerative medicine at the Major League Baseball annual meeting in December. This close collaboration with Tech brings cutting edge sports medicine therapies to baseball players across the nation, keeping athletes performing at their peak.

Much of Guldberg's research can be applied to athletes, like baseball or football players, who have early onset osteoarthritis from trauma to their bones and joints. Guldberg has recently focused on extracellular matrix (ECM) therapies for sports injuries and using stem cells to reduce inflammation and stimulate healing. More than 200 prohealing proteins make it one of the latest treatment options to help manage sports injuries.

"Injured athletes just want to get back to the playing field faster, as well as prolong their career," said Guldberg. "In collaboration with MiMedx, Inc. in Marietta, GA, we have shown that an injectable form of micronized ECM can slow down and partially reverse post-traumatic arthritis in preclinical studies. We believe this will have a positive impact on athletes in the near future."

Guldberg is also interested in biomaterials and bio-printing for injuries to cartilage like the meniscus. Bio-printing involves 3D printing but with living tissues. Currently, there is no real solution for a damaged meniscus. But in the future, a living meniscus could feasibly be printed. In the meantime, biomaterial hydrogels are used to replace cartilage tissue and speed recovery.

Working with biomaterials leverages Guldberg's work in both BME and ME at Georgia Tech, and he's interested in understanding how the mechanical environment in the body relates to the healing process. Guldberg sees a natural interface between mechanical engineering and the biosciences. His research helps answer questions such as, 'if an athlete has a back injury, what is the optimal rehabilitation protocol for them to be up and moving again?'

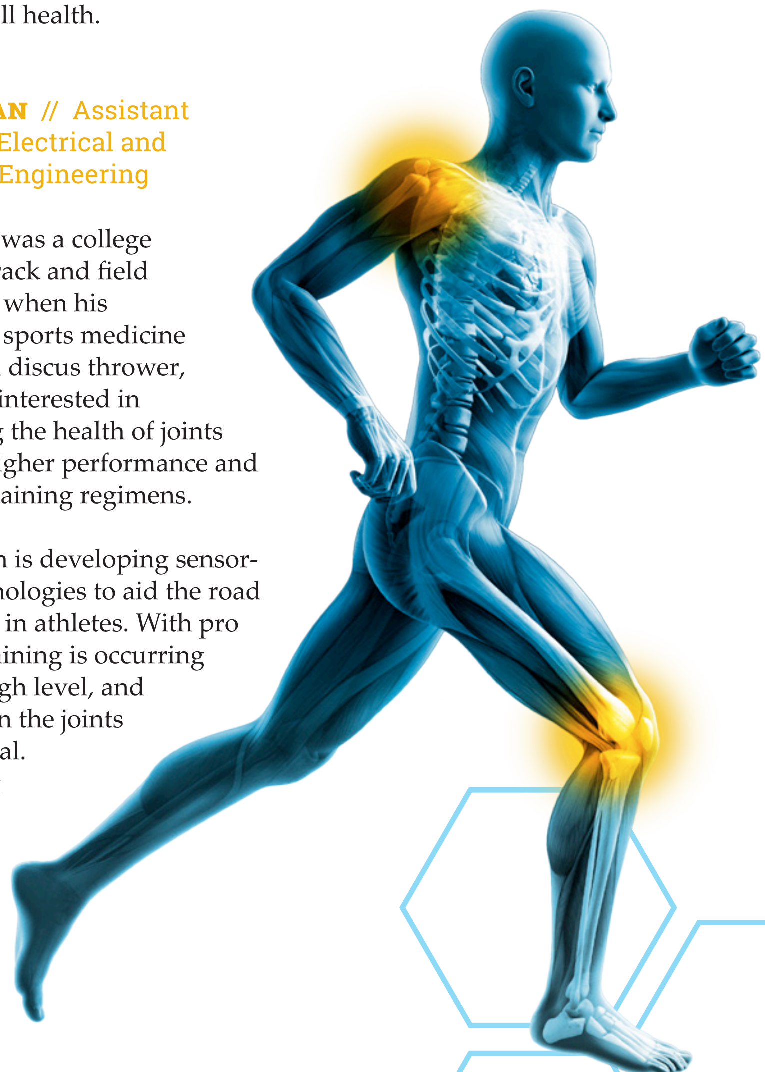
In research published in the prestigious *Proceedings of the National Academies of Science*, Guldberg's lab recently showed that stressing an injury site too early can disrupt revascularization and healing, while a delayed mechanical loading protocol stimulates more robust tissue repair. "We want to wait until the right moment to encourage blood vessels to grow and for tissue to start reforming, so timing is everything," said Guldberg. "Mechanical loading in the healing process is crucial for a speedy recovery of functional performance."

When asked about the future of biomedical engineering, Guldberg points to predictive modeling and data analytics.

"I think the next frontier will involve working with health data analytics," said Guldberg. "The future for healthcare is understanding all the data and using it to predict injuries and identify the optimal personalized medicine approaches to quickly return patients to full health."

Soon, there will be predictive models for diseases like arthritis, creating the opportunity for doctors to intervene early and stop the damage. Guldberg hopes to be on the front lines of returning athletes and others to full health.

Omer Inan // Assistant Professor, Electrical and Computer Engineering



Omer Inan was a college athlete in track and field at Stanford when his passion for sports medicine began. As a discus thrower, he became interested in quantifying the health of joints to enable higher performance and influence training regimens.

Today, Inan is developing sensor-based technologies to aid the road to recovery in athletes. With pro athletes, training is occurring at a very high level, and the stress on the joints is substantial. Monitoring athletes' bodies, "Healthy and damaged joints sound very different. This wearable knee joint sensor helps evaluate joint injuries and create healing regimens."

– OMER INAN

particularly the joints and ligaments, can help coaches make better training decisions. Objectively-driven decisions guided by data reduce the chance of re-injury and optimize recovery.

Inan has developed a Wearable Knee Health System (WKHS) that listens to the sounds a joint makes to determine its health. The WKHS can be used during rehab to monitor swelling and structural stability improvements. It's creating a much more objective level of monitoring. And it's not just for knees.

"Healthy and damaged joints sound very different," said Inan. "This wearable knee joint sensor helps evaluate joint injuries and create healing regimens. It also has preventative applications. Pitchers for example can potentially listen to their rotator cuff and decide how much pitching they should do based on the sounds."

When Inan was throwing discus in college with his sights set on the Olympic trials, he over extended himself, cutting his career short. If his coaches had possessed technology like this, it is likely he could have competed much longer and at a higher level.

Inan's work also takes him to College of Sciences Professor Mindy Millard-Stafford's lab at Georgia Tech, where he measures heart function in a high heat environment, like a summer ball field or football stadium. Many athletes suffer from dehydration in these conditions, and Inan is looking for a way to measure the body's reaction based on cardiac response.

"If an athlete is performing when it's hot, and the coach is worried about loss of fluids, we can potentially monitor changes in cardiovascular performance and decide when to rehydrate and rest," said Inan. "We are measuring cardiovascular performance with wearable sensors, and the overall solution may be a great way to prevent heat exhaustion in athletes."

In the future, Inan is interested in looking at overuse injuries, which he predicts to be the next big thing for joint health monitoring in sports medicine. Inan believes data analytics will help researchers study overuse injuries by quantifying injury risk with wearable sensors. Analytics are helping Inan build better sensors to gather more accurate data.

"Leveraging data and technology helps us sense and modulate," said Inan. "It's not just the physical hardware, but also the processing and interpretation of the data that comes from the sensors. Data analytics is a big component of our lab and helps us extract information from the data that we sense."

Inan hopes to use analytics for overuse injury detection to help athletes avoid further damage and create a healing regimen to get them back to playing, and fast.

Michelle LaPlaca // Associate Professor, Coulter Department of Biomedical Engineering

Michelle LaPlaca recently gave a TEDx talk on concussions, bringing her research and viewpoints to center stage for a large, engaged audience. In her talk, she makes the case for personalized health to transform the way doctors treat concussion injuries. For each athlete that suffers a concussion, LaPlaca argues you have to take into account any number of personal health factors, such as medication and preexisting conditions. Doctors can then make more objective decisions about concussion treatment and more accurately predict outcomes.

"Each of us has a brain fingerprint based on how many times you've hit your head in the past, what medications you're on, your medical history, diet, etc.," said LaPlaca during her TEDx talk. "We can take all these data points and use algorithms to create personalized finger prints that allow us to tailor

Right: Omer Inan and student.

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Michelle LaPlaca and athlete.

diagnosis and treatment plans just for you and your brain. So this is a data-driven approach, and we can create individual plans for each athlete."

LaPlaca advocates for personalized healthcare to diagnose and treat concussions. She's leveraging technology and systems thinking from her engineering background to uncover the simplest solutions to address concussion issues. LaPlaca developed DETECT (integrated Display Enhanced TEsting for Cognitive Impairment and mTBI) alongside David Wright at Emory University as a rapid concussion assessment tool for sideline evaluation of concussions. It's an immersive tool that uses virtual reality to objectively detect deficits from several different neurological domains in just 20 minutes, taking the guesswork out of diagnosing a concussion during a game. So no more 'how many fingers am I holding up?'

"Every concussion is different, and we are really trying to understand the complexity of the data coming out of DETECT," said LaPlaca. "The device allows us to test balance, motor function, reaction time, neurocognitive function and oculomotor function. After you test across all these different domains, you can then make the call whether the player should go back in the game."

LaPlaca believes the next phase for DETECT is to leverage the data analysis to make concussion therapy even more personalized and predictive. Ideally, she would also like athletes to have access to the tools on a personal device, like a smartphone.

"We want people to have more control over their health and diagnoses," said LaPlaca. "We want to empower them with information so they can be aware of their health. It would be great if we could turn DETECT into a point-of-care device that is convenient for athletes, as well as inexpensive."

LaPlaca finds the brain intriguing and challenging, and every day she leverages her bioengineering background to problem solve for the most efficient, yet complex, machine on earth: the human brain.

JOHNNA TEMENOFF // Co-Director, Regenerative Engineering and Medicine Center and Biomedical Engineering Professor

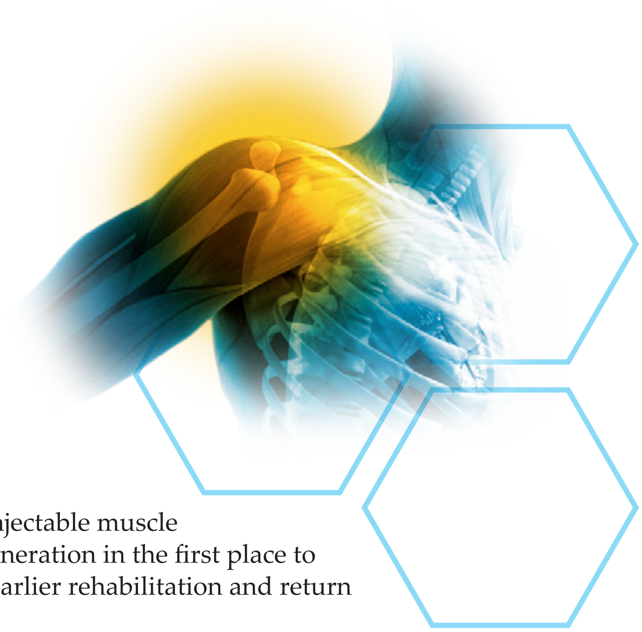
Johnna Temenoff is passionate about making people's lives better. And she does that with her research into regenerative therapies, which involves injecting cells or proteins into tissue to aid healing and stimulate repair. As athletes age and put more stress on their bones, joints and ligaments, degeneration occurs, which leads to tears to the tendons and ligaments. Temenoff is hoping to identify degeneration and stop it in its tracks, before a tear occurs.

"We are trying to better understand what causes the pathology that leads to tears, so we can develop a biomarker or imaging technique to monitor and intervene before the damage occurs," said Temenoff. "We have a National Institutes of Health (NIH) grant to fund the degeneration research, which is really well suited to athletes who are monitored closely anyways."

Starting this fall, a new NIH grant will enable Temenoff to focus on the idea of intrinsic healing. She's proposing an injectable material that would recruit the body's own stem cells to injured muscle to stimulate regeneration. The cells would then prevent further degeneration and potentially promote future regeneration. Temenoff suspects this research will be very useful for sports injuries like rotator cuff tears, a common condition among athletes derived from overuse.

Temenoff's rotator cuff research has also detected early changes to the cartilage, so she's looking to target cartilage, as well as tendons for those who may be susceptible to injury. Baseball and football players, swimmers and throwing sport competitors in track and field can benefit from cartilage monitoring. The regenerative therapies being developed would treat the cartilage with an injection, preventing negative changes to the joint.

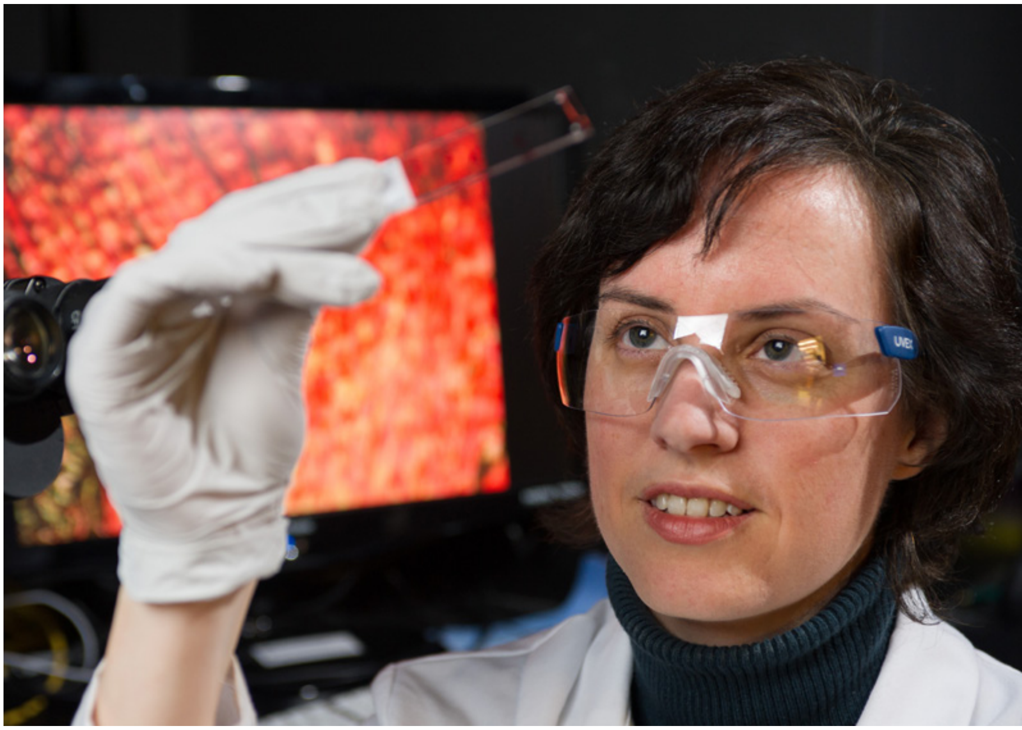
If a tendon tear does occur, the next question is how best to treat it. Standard procedure is to suture the tendon back to the bone. The biggest issue for athletes in this situation is the inability to return to full function because the muscle is too weak. It is also very easy for re-injury to occur because of the tightness of the tendon. Temenoff has a solution in mind: to completely regenerate the tendon and avoid surgery all together.



"Ideally, we will develop regenerative therapies that mitigate the need for suturing," said Temenoff. "And our injectable muscle therapy could reduce degeneration in the first place to improve the potential for earlier rehabilitation and return to function."

Temenoff's hope is that eventually the regenerative therapies will completely prevent the need for tendon reconstructive surgeries or at least provide alternatives to allow the body to regenerate if a tear does occur.

Temenoff is collaborating with Emory Orthopedics and their physician team to validate her studies. The doctors at Emory lend a unique perspective to the research by providing patient tissue samples. Emory also gains an engineering team who is focused on regeneration that they can eventually use to treat their patients. Temenoff expects this synergy to grow as her research continues. ▪



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Johnna Temenoff