2022 ANNUAL REPORT

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ROBERT H. BROOKS SPORTS SCIENCE INSTUTUT

DIRECTOR'S CORNER

Dear Friends, Family and Associates of the Robert H. Brooks Sports Science Institute,

Once again, I am very pleased to share with you the work and accomplishments achieved this year under the banner of the Robert H. Brooks Sports Science Institute. As you will see, the reach and impact of the work of faculty and students associated with RHBSSI continues to grow.

As Director of RHBSSI, I often tell people I work at the intersection of Academic Street and Athletic Avenue. In this report, among varied other accomplishments, you will see three major illustrations of that geography.

First, our 2022 seed grant recipients show how their studies of subjects important to athletic safety and injury prevention can translate into higher levels of knowledge that can benefit citizens throughout their lifetime. Together, the academic and athletic sides of the university work to protect our student-athletes, both physically and mentally. Moreover, these studies have the potential to illuminate the path to better long-term health for all citizens.

Second, the Institute and Department of Athletics partnered to pilot a program that develops stronger ties between academic research and athletic performance. Dr. Jason Avedisian joined the staff of CUAD and the Department of Bioengineering earlier this year and is tasked with working with faculty and students to prevent injuries and improve performance of student-athletes in the Olympic Sports.

Finally, one of our faculty fellows is at the forefront of modern television communications technology. Her work will be noticed by millions, though she will remain behind the scenes. Have you ever turned on a Clemson game and wondered why we are wearing jerseys from the University of Georgia? Dr. Erica Black Walker, assistant professor of graphic communications, has developed a color correction computer application, called ColorNet, that automatically adjusts the color of jerseys as seen on television using machine learning and artificial intelligence to the correct color – Pantone 165, aka, Clemson Orange!

In sum, it has been a great year for sports sciences at Clemson and I look forward to bigger years to come.

Go Tigers!

Brett Wright, Ph.D. Director, Robert H. Brooks Sports Science Institute

Cover image: ColorNet (featured on page 6) is alpha tested during a live broadcast Clemson basketball game and is deemed successful. Learn more about ColorNet on the following pages of this report.



2022-23 SEED GRANT AWARDEES



Em V. Adams Assistant Professor Parks, Recreation & Tourism Management

"Identifying Facilitators" and Barriers to Ensuring Psychological Safety for Collegiate Athletes."



Zhaoxu Meng Assistant Professor Mechanical Engineering

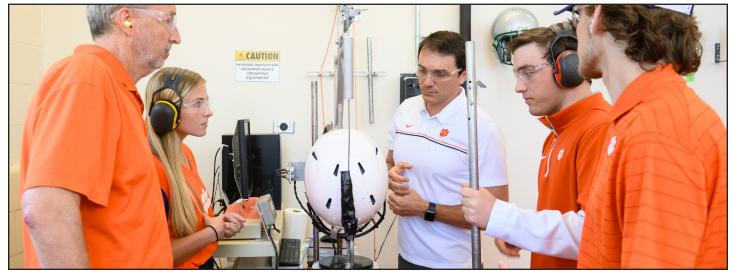
"Investigating Structure-Property Relationship of Rotator Cuff Tendon-Bone Enthesis."



John DesJardins Professor Bioengineering

"Comparison of Head Impact Mechanics between Cadaveric Specimens and a Synthetic Hvbrid III Model."

Competitive seed grants are awarded each academic year to Clemson University faculty and researchers to engage in multidisciplinary sports research. The purpose of these seed grants is to stimulate and expand faculty and graduate student research in the academic study of sport. Congratulations to this year's awardees! Proposals are accepted each spring in mid-March. Visit Clemson.edu/ brooks-sports to see the RFP.



Greg Batt, Ph.D., and his research team test the efficacy of bullriders' helmets to prevent head trauma, 2021

PAST SEED GRANT AWARDEES

2021-22

- Greg Batt, Food, Nutrition and Packaging Sciences; "Efficacy of bullriders' helmets to prevent head trauma." Kristen Okamoto, Communication; "Understanding the role of instructor in online group fitness programs." • Erica Walker, Graphic Communications; "ColorNet: Developing artificial intelligence-based color correction tools for sports
- media applications."

university/non-profit collaboration."

2020-21

- Andrew Duchowski, School of Computing; "Sideline Concussion Screening in Eye-Tracked Augmented Reality." • Casey Hopkins, School of Nursing; "A Mixed Methods Study of Adolescent Girls' Experiences with Sport Participation and Their
- Intentions for Future Physical Activity."
- Jeremy Mercuri, Bio-Engineering; "Comparing the Regenerative and Anti-Fibrotic Effects of Biologic Therapies for Muscle Iniuries."

Novel Match Simulation Techniques."

2019-20

partnership in movement science."

• Pingshan Wang, Electrical and Computer Engineering; "Cellular rectification of electrical stimulation fields."

2018-19

- Rvan Gagnon, Parks, Recreation and Tourism Management; "Promoting Positive and Healthy Development in African American Youth Through the Sport of Climbing."
- Jeremy Mercuri, Bio-Engineering; "Early Detection and Prophylactic Treatment for Post Traumatic Osteoarthritis" • Thompson Mefford, Materials Science and Engineering; "Advanced imaging agents to diagnose the state of confused brain." Heidi Zinzow, Psychology; "Sexual violence prevention program."

2017-18

• Gregory Batt, Department of Food, Nutrition and Packaging Sciences; "Quantifying the impact performance of football helmet facemasks."

symptomology: An application of the health disclosure decisionmaking model."

- Sabarish Babu, School of Computing; "Investigating perceptual-motor synchrony and coordination on cybersickness, skills training, and spatial perception in a VR rowing simulator."
- Adam HooverDepa rtment of Electrical and Computer Engineering; "Pedometer evaluation during structured. semi-structured and unstructured gaits."
- Greg Ramshaw, Department of Parks, Recreation and Tourism Management; "Reminiscing Howard's Rock: Harnessing the power of Clemson Football memories to improve cognitive functioning of South Carolinians with dementia."
- Mary Anne Raymond, Department of Marketing; "Collaborative marketing and vehicle engineering for the Deep Orange 9 motorsports project."
- Travers Scott, Department of Communication; "What comes after coming out? Effective integration strategies for LGBTQ persons and college athletics."

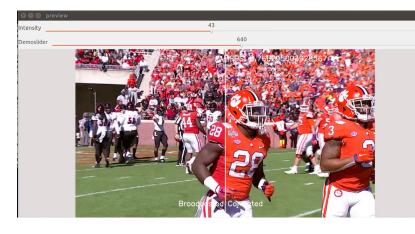
Joel Williams, Public Health Sciences; "Improving injury surveillance to promote adolescent athlete health and safety: A

- Jasmine Townsend, Parks, Recreation and Tourism Management; "3D Modeling and Kinematics of Wheel chair Tennis Within
- John Desjardins, Department of Bioengineering; "The effect of balance on internal swing consistency: An athletic/academic

• Gregory Cranmer, Department of Communication; "Factors affecting high school football players' intent to report concussion

RESEARCH HIGHLIGHT: COLORNET

Protecting Clemson's Brand at Athletic Events



When watching sports on screen, fans recognize inconsistencies in their team colors. ColorNet is an artificial intelligence (AI) technology that ingests live video, adjusts each frame pixel-by-pixel, and outputs color corrected video in real-time ensuring accurate brand colors. In this study, ColorNet is demonstrated using Clemson University orange, Pantone 165. The patent-pending technology developed for this study uses machine learning techniques to identify regions of an image with incorrect color and adjust only those specified pixels to maintain consistent brand specifications. Unlike alternative approaches,

ColorNet performs color correction on-the-fly and pixel-by-pixel, automatically adjusting to scene changes that impact how color is perceived. With the creation of two prototype devices, ColorNet has demonstrated the ability to perform real-time color correction for displays. The resulting color adjustments focus only on regions in the image that should match brand color specifications without negatively impacting surrounding colors.

The system uses Machine Learning (ML) which focuses on learning patterns from data. In this case, the "pattern" is the relationship between the color incorrect and color correct images and the "data" is a large set of manually produced, paired examples of the incorrect and correct images. By exposing an appropriate ML model to a sufficient number of such paired examples, the model learns to predict the correct from the incorrect.

Segmentation is the next step in the ColorNet evolution. For more information, contact Erica Walker at eblack4@clemson.edu.





Erica Black Walker Assistant Professor Graphic Communications

Dr. Erica Walker has a diverse background in visual communications which includes feature film production, web design & development, print buying, marketing, and graphic design. As a faculty member in the Department of Graphic Communications at Clemson University, Dr. Walker has taught courses in Photography, Video, Visual Storytelling, Web Design and Development, and Entrepreneurship. Outside the classroom, Dr. Walker speaks at conferences across the country on topics including classroom and industry implementation of Adobe applications, curriculum development, mixed methods classroom research, the entrepreneurial mindset, game-based learning, color management, branding, and social marketing. Her current research focuses on the use of Al and machine learning to ensure the consistency of brand colors in live video, Dye Sub and Inkjet printing of fine arts photography on non-paper substrates, and classroom research where she works as an instructional designer in partnership with industry expert adjunct (IEAs) lecturers.

2022-23 MARK V. BELLAMY UNDERGRAD SCHOLARS



Margaret Neal Parks, Recreation, and Tourism Management

"After working with the Clemson Adaptive Sports and Recreation Lab in the Summer of 2021, I found a passion in working in sports and making them accessible to people of all abilities.

I am honored to be recognized for my work and to be receiving the Mark V. Bellamy Brooks Endowed Scholarship this year. I am looking forward to finishing my time at Clemson and continuing to work with the Adaptive Sports and Recreation Lab to continue to make sports accessible to all."

Brian Smith Sports Marketing

"Working in Sports Business was my career goal well before I went to college. Both my parents have been with pro franchises, and the industry slowly became a passion of mine.

I'm excited to be the recipient of the Mark V. Bellamy Brooks Endowed Scholarship, and proud to be recognized for the work I've done thus far. I look forward to a great senior year at Clemson and can't wait to see what the sports business world has in store post-graduation!"

Delaney O'Tuel Sports Communication

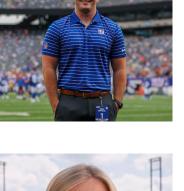
"There's something special about sports. The feeling it gives you cannot be matched. The environment, the people and the energy it brings aren't found anywhere else. Being the youngest sibling, I was constantly dragged to random fields or gyms, but it never bothered me. I knew I wanted to be surrounded by sports for the rest of my life.

I am so thankful for being chosen as a recipient of the Mark V. Bellamy Brooks Endowed Scholarship and for the encouragement I receive from Clemson University and the Robert H. Brooks Sports Science Institute. Graduating college and starting a new chapter may be scary, but it is reassuring to know that so many great people are supporting me! Go tigers!"

Michael Cloer Mechanical Engineering

"I have been living and breathing motorsports as much as possible since arriving at Clemson. My dream job is to be a design engineer on a Formula One (F1) team. I think I would be happy in any motorsports engineering role, whether it be in an American series, like NASCAR or IndyCar, or in a European series – but the end goal, for me, is Formula One."









OLYMPIC SPORTS SCIENCE PROGRAM

Did you know that Clemson University has an Olympic Sports Science program? The Robert H. Brooks Sports Science Institute was proud to support the hire of a new Sports Science Director, Jason Avedesian, Ph.D., roughly a year ago. The program boasts uniformity across applied sports sciences, high-level analytics, and a strong connection with sports coaches, performance staff and to sports medicine on campus. They continue to develop cross-campus partnerships and venture into more published research and development, and internal technology validation.

Let us introduce you to the program and the team's goals for the future.

SIX GUIDING PRINCIPLES

The Clemson Olympic Sports Science team functions to meet six principles to offer support across the Athletic Department.

- 1. Athlete Readiness and Load Monitoring
- 2. Athlete Evaluation and Return-to-Performance
- 3. Performance Team Collaboration
- 4. Data Integration and Analytics
- 5. Systems and Principles
- 6. Experimental Frontiers

HIGH-END TECHNOLOGY



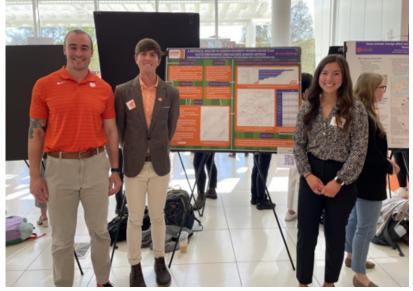
The Blast system compares softball hitting metrics to team and normative values

Clemson Olympic sports has access to many different technologies for athlete evaluations, workload monitoring, performance team collaborations and return-to-performance interventions. From devices that utilize GPS to track various forms of athletic workload in field-based sports to 3D Doppler radar systems that precisely measure the location, trajectory and spin rate of hit and pitched baseballs and softballs, each technology may offer a unique insight into athlete behavior and performance. The team boasts nearly

twenty different high-end devices that provide insights to athletes on and off the field.

STUDENT ENGAGEMENT

The backbone of the Olympic Sports Science program at Clemson is its students. They boast a robust internship program with three levels where students do everything from set up technology and collect data to direct sports science support for designated teams and analyze advanced data. In Spring 2022, seven students, the majority of which were from STEM programs on campus, participated in the program and developed final posters for a semester's-end research forum. Interns have gone on to work for such teams as the Tampa Bay Rays, Utah Athletics and more.



Jason Avedesian (left) pictured with students at the Spring 2022 researh forum

OLYMPIC SPORTS SCIENCE PROGRAM

EXPERIMENTAL FRONTIERS

Technology vetting, academic partnerships and continued research are all a part of the team's 'experimental frontiers.' as they call them. Moving forward, they hope to offer a Sports Science and Engineering Certificate that will provide students core competencies in the analysis and optimization of human performance, and both retain and progress students in the Olympic Sports Science program. Coursework would include sports engineering, sports equipment design, theoretical coursework, quantitative coursework and applied experience.



Students, staff and faculty gather in the Clemson Weight Room for an open house hosted by the Olympic Sports Science Program in Fall 2022



For more information or to partner with Clemson University's Olympic Sports Science Program, contact Jason Avedesian, Ph.D., Director of Sports Science – Olympic Sports, at javedes@clemson.edu.

RHBSSI ANNUAL LECTURE SERIES

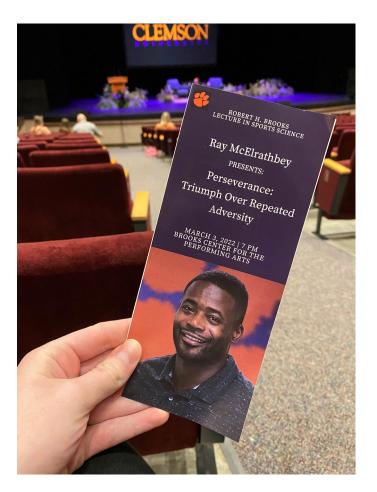
Featuring Disney+ 'Safety' film inspiration "Ray Ray" McElrathbey

Ray McElrathbey, former Clemson Football player and inspiration for the Disney+ film "Safety," was the featured speaker at the Robert H. Brooks Lecture in Sports Science at Clemson University on Thursday, March 3.

McElrathbey spoke on "Perseverance: Triumph Over Repeated Adversity" at the event, held at the Brooks Center for the Performing Arts. The free, public event was presented by the Robert H. Brooks Sports Science Institute, in partnership with the Wilbur O. and Ann Powers College of Business and the College of Behavioral, Social and Health Sciences at Clemson.

Featuring notable speakers from the intersection of sports, society and academics, the Robert H. Brooks Lecture in Sports Science highlights leading-edge work in sports and provides a mechanism for engaging the entire Clemson community in the field. The lecture series began in 2018 with NFL coach and NASCAR owner Joe Gibbs serving as the inaugural speaker.

Stay tuned for details on the 2023 lecture, to be held again at the performing arts center. Visit Clemson.edu/brooks-sports for more.





NEW MEMBER, BOARD OF DIRECTORS Welcome, Clemson Athletic Director, Graham Neff

Graham Neff was named Clemson's 14th Director of Athletics on December 23, 2021 in the midst of his ninth year at Clemson.

The 38-year-old has been in senior leadership positions within Clemson Athletics since 2013, including as chief financial officer and director of capital projects prior to his most recent role as deputy director of athletics. Neff has helped oversee the build and financing of more than \$200 million in facility improvements, aided in the continued development of IPTAY, and served as a sport administrator for football and men's basketball.

Neff works consistently with key university stakeholders, including the university Executive Leadership Team, The Board of Trustees, IPTAY Board of Directors, Athletics Council, as well as several university committees and appointments.

During his time as a sport supervisor, the football program won two national championships, the men's basketball program made a pair of NCAA Tournament appearances, including a Sweet 16 run in 2018. Academically, Clemson's graduation success rate has been above 91 percent for seven consecutive years, and student-athlete total GPA has been above 3.0 for nine straight semesters.

Neff has helped develop several key areas of the department, including the financial philosophy, fundraising, student-athlete welfare, and external operations management, and in 2019 was named one of Sports Business Daily's Power Players.

Prior to his role as Deputy AD, he joined Clemson in 2013 as Associate AD of Finance and Facilities. Before Clemson, Neff served two-plus years in several senior administrative roles at Middle Tennessee State Athletics, with emphasis in finance, facilities and external operations.

A civil engineering graduate of Georgia Tech, he served as a student manager for Coach Paul Hewitt and the men's basketball program, advancing to a Final Four in 2004. Neff worked in the Financial Advisory Services group at Deloitte and Touche from 2006 to 2008, prior to returning to a finance and ticketing role at the Georgia Tech Athletic Association. He earned an MBA from Georgia Tech in 2010.

Neff and his wife Kristin have three sons, Grady and twins Emmett and Nolan.

Neff joins Leslie Hossfeld, dean of CBSHS, Anand Gramopadhye, dean of CECAS, and Wendy York, dean of COB, on the Robert H. Brooks Sports Science Institute Board of Directors (pictured below in that order).





DEEP ORANGE 12 UPDATE

Last year, we reported on Deep Orange 12, the high-speed driveerless car engineered by Clemson Automotive, of which the Robert H. Brooks Sports Science Institute was a sponsor. After its debut, the vehicle's design was duplicated 10 times and given to teams around the world to modify the systems and algorithms for continued improvement and use. The cars then ran solo laps at the Indianapolis Motor Speedway in October 2021 to prove the technology, followed by a head-to-head competition at the Las Vegas Motor Speedway. The competition saw record-breaking passes at over 160 MPH. Since then, the record has been set at over 180 MPH for the driverless car engineered by Clemson University.

Recently, National Defense Magazine published an article in which they interviewed Dr. Rob Prucka, Clemson professor of automotive engineering and Brooks Institute fellow, about how the U.S. Army could utilize autonomous vehicles. The Combat Capabilities Development Command's Ground Vehicle Systems Center, or GVSC, was a collaborator on Deep Orange 12.

"'The U.S. Army, what they're trying to work on is, obviously, to speed up these driverless vehicles,' [Prucka] said [in the article]. 'So, we think that there are a lot of learnings that we can utilize from programs like Indy Autonomous Challenge to help maybe speed up the vehicles that they work on.'"

The project was formed by 40 students, seven or more Clemson faculty and staff members, and 38 industry partners who all collaborated to set records and change the industry's expectations for autonomous driving. Through this project, many students have earned prestigous roles with leading automotive companies.

To learn more about the complete project, visit cuicardeeporange.com/project/deep-orange-12.



NEWLY APPOINTED FACULTY FELLOWS

Faculty who conduct research, teach sports-related courses or provide service to the sports industry are invited to formerly affiliate with the Institute as Brooks Faculty Fellows. Along with the four Legacy Professors, these faculty constitute the Institute's Board of Faculty. Fellows are appointed for three-year terms, renewable if faculty members remain actively engaged in the mission of the Institute. Welcome our three new faculty fellows for the 2023-25 term!





Rikishi Rey, Assistant Professor Department of Communication

Greg Batt Associate Professor Department of Food, Nutrition, and Packaging Sciences

Rikishi played Division I soccer at Cal State Fullerton. She studies injury reporting, concussion management, mental health and well being, and coach-athlete communication. Dr. Rey has published in Communication and Sport and the International Journal of Sport Communication. Greg serves as Director of the Clemson Packaging Dynamics Laboratory and serve as Co-Director of the Clemson Headgear Impact Performance (CHIP) laboratory. He has partnered in mentoring a team of students conducting research and providing service to industry in the area of protective equipment testing and design for impact sports since 2013.



Virginia Harrison, Assistant Professor Department of Communication

Virginia's work in strategic communication and nonprofits has appeared in journals such as Public Relations Review, Communication and Sport, and the Journal of Sports Media. She holds a Ph.D. in Mass Communications from Penn State University.

ENDOWMENT FINANCIALS

Endowments 80191 and 90038 provide operating funds for the Robert H. Brooks Sports Science Institute, which was created by Mr. Brooks in October 1994.

80191	2018	2019	2020	2021	2022
Corpus	\$5,555,463	\$5,555,463	\$5,555,463	\$5,555,463	\$5,555,463
Appreciation	\$2,028,351	\$2,161,947	\$1,950,743	\$4,141,194	\$3,641,067
Market Value	\$7,583,814	\$7,717,410	\$7,506,206	\$9,696,657	\$9,196,530
Carryover Balance	\$612,320	\$591,653	\$554,733	\$564,587	\$535,566
Endowment Value	\$8,196,134	\$8,309,063	\$8,060,939	\$10,261,243	\$9,732,095

90038	2018	2019	2020	2021	2022
Corpus	\$2,231,375	\$2,235,773	\$2,235,773	\$2,235,773	\$2,235,773
Appreciation	\$717,610	\$802,515	\$715,921	\$1,526,165	\$1,309,124
Market Value	\$2,948,986	\$3,038,288	\$2,951,694	\$3,761,938	\$3,544,897
Carryover Balance	\$138,421	\$31,755	\$38,093	\$-2,239	\$5,311
Endowment Value	\$3,087,406	\$3,070,043	\$2,989,787	\$3,759,699	\$3,550,208

Endowment 90037 provides scholarships to undergraduate students majoring in curricula related to the Robert H. Brooks Institute for Sports Science.

90037	2018	2019	2020	2021	2022
Corpus	\$41,764	\$41,764	\$41,764	\$41,764	\$41,764
Appreciation	\$30,550	\$32,184	\$29,719	\$49,070	\$43,732
Market Value	\$72,314	\$73,948	\$71,483	\$90,834	\$85,495
Carryover Balance	\$14,808	\$3,439	\$0	\$0	\$0
Endowment Value	\$87,122	\$77,387	\$71,483	\$90,834	\$85,495

For more information, contact: Dr. Brett Wright 864-653-1049 wright@clemson.edu



Clemson.edu/Brooks-Sports