BIOGRAPHICAL SKETCH

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NAME: Sung Eun Kim

eRA COMMONS USER NAME (credential, e.g., agency login): S.EUNKIM

POSITION TITLE: Postdoctoral Scholar

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable. Add/delete rows as necessary.)*

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	Start Date MM/YYYY	Completion Date MM/YYYY	FIELD OF STUDY
University of Florida, Gainesville, FL	BS	08/2004	05/2008	Finance
Yonsei University, Seoul, Korea	PHD	03/2014	02/2018	Sports Biomechanics
Stanford University, Stanford, CA	Postdoctoral Scholar	08/2022	Present	Biomedical Engineering

A. Personal Statement

I played golf competitively in NCAA Division 1 at the University of Florida and earned a PhD from Yonsei University, Korea, majoring in Sports Biomechanics. The goal of pursuing the PhD was to understand the biomechanics of the golf swing because I was curious about my golf swing when I was an athlete. For instance, am I using all my capability to my golf swing, where am I losing energy on my golf swing, and what is the next step to improve that gap; however, it was largely uncovered to answer those questions.

After graduation, I worked as a Research Engineer at the Descente Shoes R&D Center (DISC Busan), Asia's biggest shoe R&D center. I developed a spikeless golf shoe called ‘Descente Golf R90’ with supervised by Mario Lafortune, who was the director of Nike Sport Research Laboratory (Beaverton, OR). The shoe is patented in Korea and has had great success in the industry since 2020. Soon after, I came back to Yonsei University and was awarded a grant of National Research Foundation of Korea as a Principal Investigator to investigate the risk factors of knee injuries in golf swing.

As a Postdoctoral Scholar at Stanford University, I have an opportunity to pursue research on understanding the biomechanics of the golf swing. Currently, I am developing a biomechanics model to prescribe personalized movement modification to maximize capability performance and collaborating with the Department of Bioengineering to combine it with computer vision technology to make them accessible to the public (mentioned in the Advanced technology applications under C. Contributions to Science below). Next, I plan to develop biomechanics models that prescribe personalized movement modification to prevent musculoskeletal injuries.

Developing personalized intervention is a difficult question, which is central to understanding how different people have different strategies to perform golf swings. Experienced golf coaches are aware of the existence of various swing mechanics. They carefully scan each individual’s swing mechanics and provide personalized instructions to help the golfer achieve their best performance. Here, the major part of the modeling is to convert the experienced coaches’ process, classifying movement types, into a computational framework with a mixture of biomechanics and artificial intelligence for personalized diagnosis and automated diagnosis. My experience in golf over 25 years will most likely make the modeling framework the right way.

Golf swing is a good experimental tool to uncover the biomechanics of human movement because it consists of a complex whole-body coordinated system at a static foot position. I plan to start the investigation with the golf swing and eventually for gait, as there are some similarities in using the lower limb.

B. Positions, Scientific Appointments, and Honors

Positions

2022 – Present	Postdoctoral Researcher, Stanford University
2021 – 2022	Researcher, Frontier Research Institute of Convergence Sports Science, Yonsei University, Seoul, Korea
2019 – 2020	Research Engineer, Human Performance Lab, Descente Innovative Sports Complex (DISC), Busan, Korea
2018 – 2019	Consultant, Descente Korea, Seoul, Korea
2018 – 2019	Director, Descente Sports Foundation, Seoul, Korea
2015 – 2019	Lecturer, Yonsei University, Seoul, Korea

Scientific Appointments

2023 – Present	Committee, the Nominate Women, International Women in Biomechanics

Honors

2021 – 2022	Principal Investigator, National Research Foundation of Korea
2017 – 2018	Internal Scholarships, Yonsei University, Seoul, Korea
2006	Dean's List, Warrington College of Business, University of Florida
2004 – 2008	Full Athletic Scholarships, University of Florida Athletic Association
2004 – 2008	SEC Academic Honor Roll, Southeastern Conference, USA

C. Contributions to Science

My study has *investigated* human movement, *developed* assistive gear and interventions for injury prevention, and *utilized* advanced technologies for applications.

Understanding human movement

a) The patterns of movement behaviors: Twenty professional golfers participated, and their swings at nine different ball positions, as small as the length of one golf ball, were captured using a 3D motion capture system. Statistical Parametric Mapping was used to investigate the changes of golf swing in a continuous time domain (1D), not at one discrete time (i.e. peak). The results showed that small changes in ball position were significantly and systematically associated with swing variables throughout the golf swing across the participants: the ground reaction forces, trunk rotation angles, trunk and leg angles, whole-body center of mass, and clubhead movements. This result is very fascinating because so many degrees of freedom in the 14-linked body segments play a role during a golf swing, providing the possibility of formulating a theory of human movement.
   - **Kim, S. E.**, Lee, J. Y., Lee, S. Y., Lee, H. D., & Lee, S. C., Shim, J. K. (2023). Golf Swing in Response to Anteroposterior Ball Position. International Journal of Sports Science & Coaching, 18(5), 1639-1648
   - **Kim, S. E.**, Lee, J. Y., Lee, S. Y., Lee, H. D., & Shim, J. K., Lee, S. C. (2021). Small changes in ball position at address cause a chain effect in golf swing. Scientific Reports, 11(2694).
   - **Kim, S. E.**, Koh, Y. C., Cho, J. H., Lee, S. Y., Lee, H. D., & Lee, S. C. (2018). Biomechanical Effects of Ball Position on Address Position Variables of Elite Golfers. Journal of Sports Science & Medicine, 17(4), 589-598.

b) Human-ground interaction: The methodology of measuring horizontal ground reaction force moment should be carefully selected. The study suggests that human movement may ban physics.
   - **Kim, S. E.** & Ladd, A. (2023) Measurement of horizontal ground reaction force moment in the golf swing. ISB Congress XXIX. Fukuoka, Japan.

Assistive gear

a) Golf footwear: To design the outsole stud of a golf shoe, the direction of horizontal ground reaction force (for the shape of the stud) and the foot pressure (for the placement of the stud) when the maximum linear and rotational coefficient of friction occur in golf swing were examined. As a result, both ball distance and direction were significantly improved by regulating the ground reaction force. Therefore, there is an impactful value in utilizing biomechanics for developing footwear, and the developed golf shoe has great success in the industry. Furthermore, this study showed that the specific timing is vital in evaluating the

coefficient of friction. We chose the timing at its maximum, whereas the traditional calculation averaged it during the downswing, and the calculation showed better friction in the developed golf shoes compared with the competitors', whereas the traditional calculation didn't have differences between the spike and spikeless golf shoes. Lastly, the golf swing pattern largely varies among recreational golfers - Determining the exact timing (possible to select the second maximum value for some) across all golfers, which required checking the data one by one, was tricky, partially subjective, and critical.

- **Kim, S. E.** & Lee, J. I. (2021) Golf footwear prevented rotary and horizontal slippage. Descente Korea. 10-2344447, KR patent

b) Golf apparel: The study suggests that apparel may improve movement, but gear that regulates ground reaction force (i.e., footwear) has a greater impact. In this project, to evaluate the apparel, we developed a simplified marker set using four markers on the trunk to minimize the number of markers and calculate the swing variables.

- **Kim, S. E.**, Hyun, S. C., & Bang, J. S. (2021). Balancing golf apparel. Descente Korea. 10-2300002, KR patent

Injury prevention

a) Risk factors of knee injuries in golf swing: Prevention of anterior cruciate ligament (ACL) injuries and knee osteoarthritis (OA) progression is important. In golf swing, the knee loadings related to ACL injuries, internal rotation moment and tibial anterior shear force, and related to knee OA progression, adduction and abduction moments, occur greater than in gait. The preventative interventions that reduce the knee loading not only for gait but also during a golf swing will maximize the lifespan of natural joints. Investigating the risk factors in the complex coordinated movement over period of time is a difficult question, which is central to utilize an advanced analytical method that can examine 1D data, not only at a discrete event. This study utilized a novel approach, named Statistical Parametric Mapping, referred as SPM. The study suggests potential modifications, such as rapid knee extension during the downswing for golfers with an ACL injury, wider stance width and restricted shoulder sway towards the target during the downswing for golfers with a risk of medial compartment knee OA, and less tibial medial tilt at address for golfers with that of the lateral compartment. In addition, we found that the ball position modification reduces those joint loadings.

- **Kim, S. E.**, & Ladd, A. (2023). Greater knee flexion is associated with higher loading of anterior cruciate ligament during the golf swing. Proceedings of the 1st Wu Tsai Human Performance Alliance Research Symposium. Stanford University
- **Kim, S. E.**, Pham, N. S., Park, J. H., Ladd, A., & Lee, J. (2022). Potential biomechanical risk factors on developing lead knee osteoarthritis in the golf swing. Scientific Reports, 12(22653).
- **Kim, S. E.** (2022). Reducing Knee Joint Load during a Golf Swing: The Effects of Ball Position Modification at Address. Journal of Sports Science & Medicine, 21(3), 393-400.

Advanced technology applications

a) Inertial Measurement Unit (IMU) validation: A prior study has validated IMU data compared to data derived from 3D motion capture during the golf swing. However, the participants in that previous study only included novices and had a small number of participants (N = 10). Our study validated the IMU compared to 3D motion capture in a larger and broader population (N = 36) of evenly distributed female, male, professional, and amateur golfers (N = 9 each). We found that IMU can accurately measure trunk rotational kinematic variables. This study will advance the use of IMU sensors for practical application, particularly for the measurement of rotational movements.

- **Kim, S.E.**, Koltsov, J. C. B., Richards, Zhou, J., Schadl, K., Ladd, L. A., Rose, J. (2023). Validation of inertial measurement units for analyzing golf swing rotational biomechanics. Sensors, 23(20), 8433.

b) Computer vision (OpenCap): We conducted a study to examine how stability affects wrist consistency in golf putting. We used 3 iPhones with the OpenCap platform (computer-vision technology) to collect 3D motion data. It was a pilot study (N = 4) aimed at validating our hypothesis before collecting the data at a larger scale. The results showed that improving stability is associated with improved wrist consistency. OpenCap was also able to detect changes in postural angles associated with improved stability. In the future, we plan to develop an artificial intelligence (AI) model that can diagnose personalized posture and

simulate its performance outcomes. The integration of the AI model with OpenCap technology holds potential for commercialization.

- **Kim, S. E.,** Heigold, H., & Ladd, A. (2023). Stability retraining to improve the address posture and wrist consistency in golf putting. *The Innovation and Discovery Expo*. Stanford Bio-X and Wu Tsai Human Performance Alliance, Stanford University.

D. Scholastic Performance

YEAR	COURSE TITLE	GRADE
	YONSEI UNIVERSITY	
2014	Research in Motor Learning	A+
2014	Application of Computer in Physical Education	A+
2014	Dynamics	B+
2014	Pathological Motion Analysis	A+
2014	Statistical Methods I	B+
2014	Linear Algebra and its Application	P
2015	The Understanding of LabVIEW Programming	A+
2015	Instrumentation of Sports Biomechanics	A
2015	Research Method in Kinesiology	A
2015	Evidence-Based Sports Medicine	A+

At Yonsei University, the grade of P indicates a pass in certain required courses.