

Screening Activities and Metrics That Predict ACL Injury Risk

Insights from the Wu Tsai Human Performance Alliance



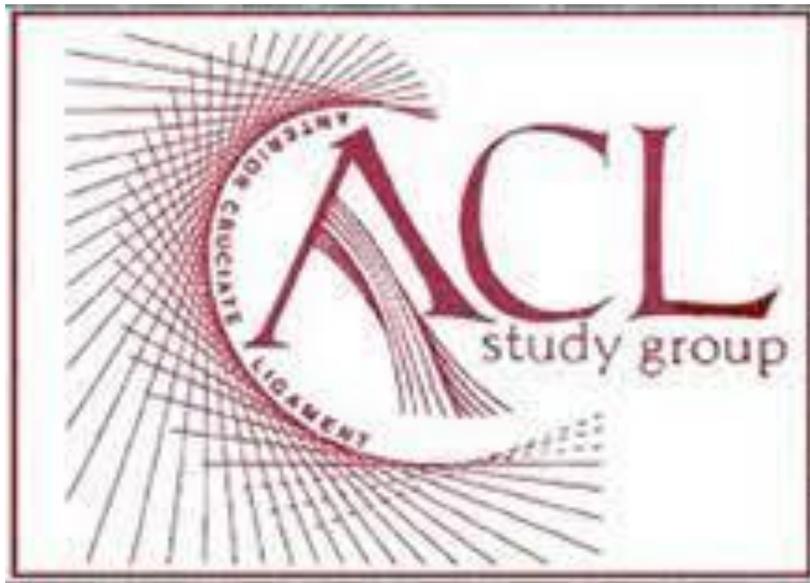
Seth L. Sherman, M.D.
Associate Professor of Orthopedic Surgery
Fellowship Director, Stanford Sports Medicine
Head Team Physician, Stanford Cardinal Football



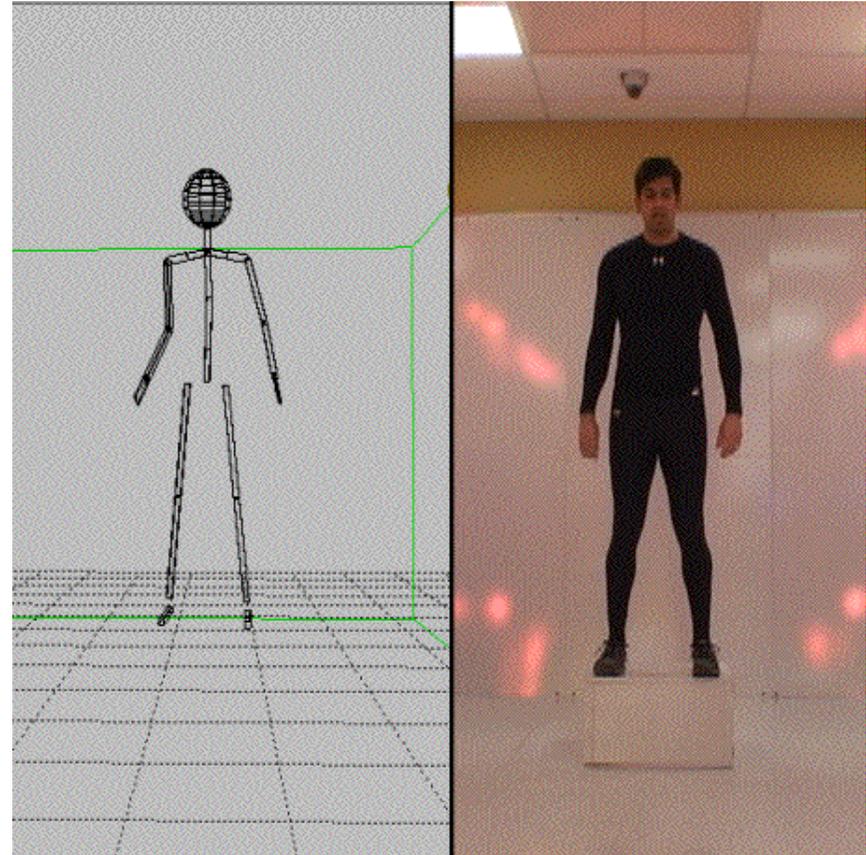
Wu Tsai Human
Performance Alliance

Stanford University

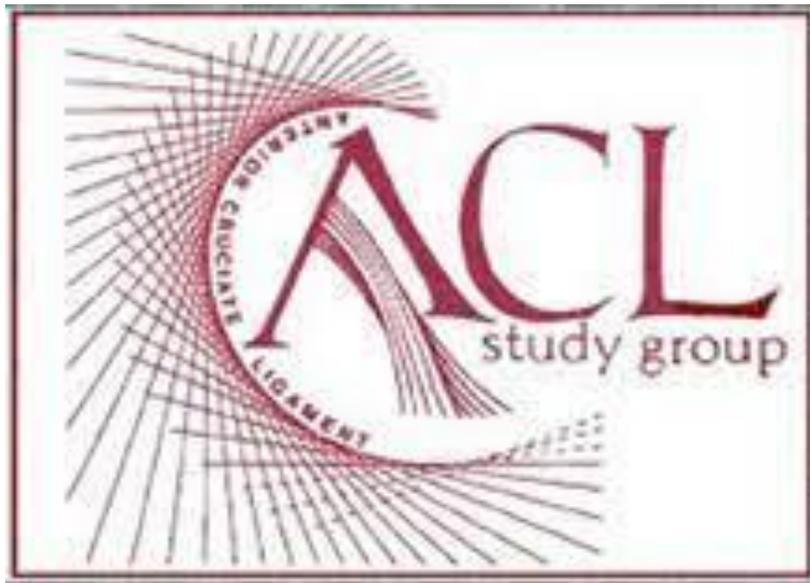
We introduced X-box Kinect as “portable and inexpensive” option



Capetown 2014



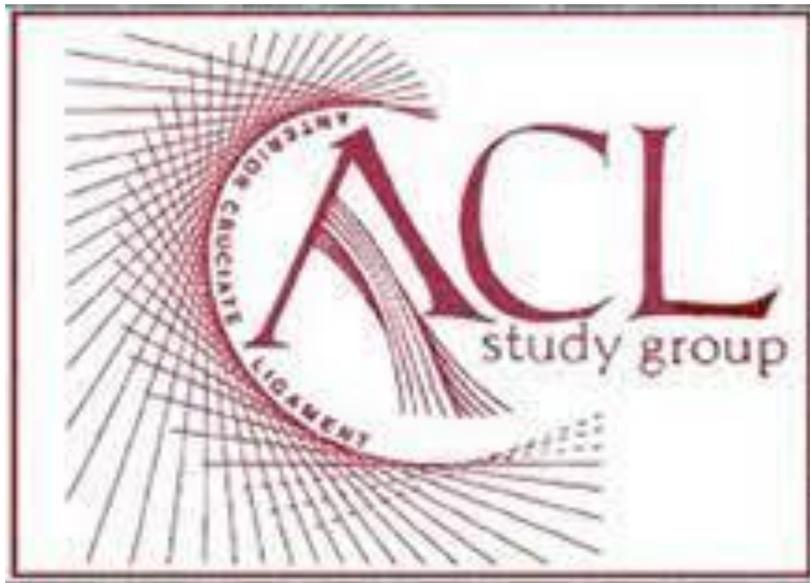
OpenCap AI: Cutting Edge Motion Capture Using Smartphones



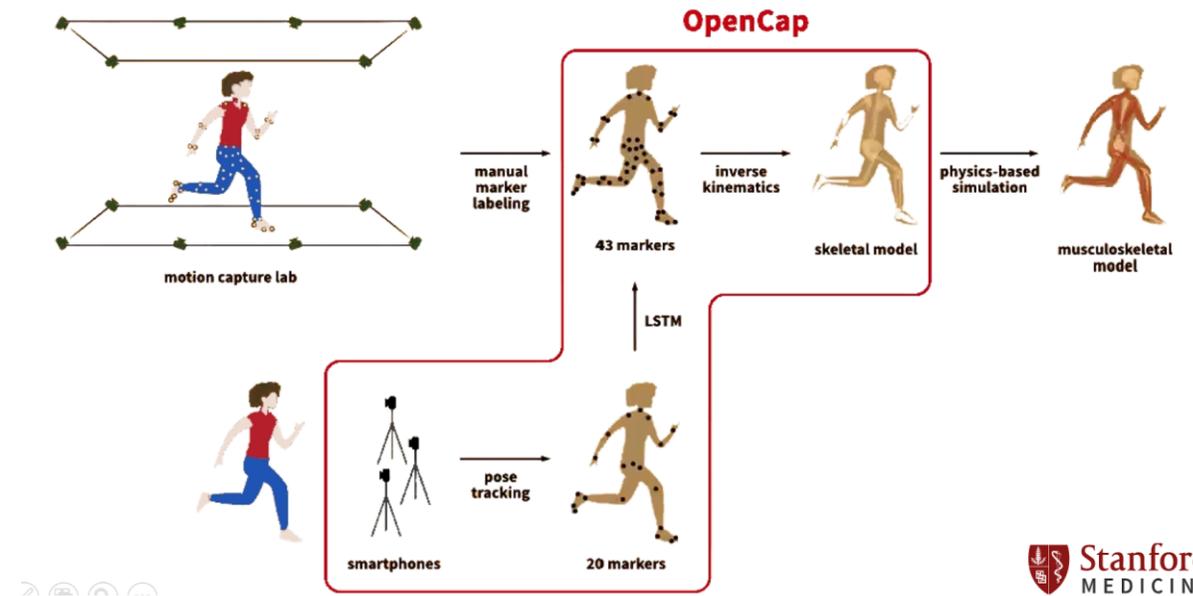
Niseko 2024



OpenCap: Cutting Edge Motion Capture Using Smartphones



Niseko 2024

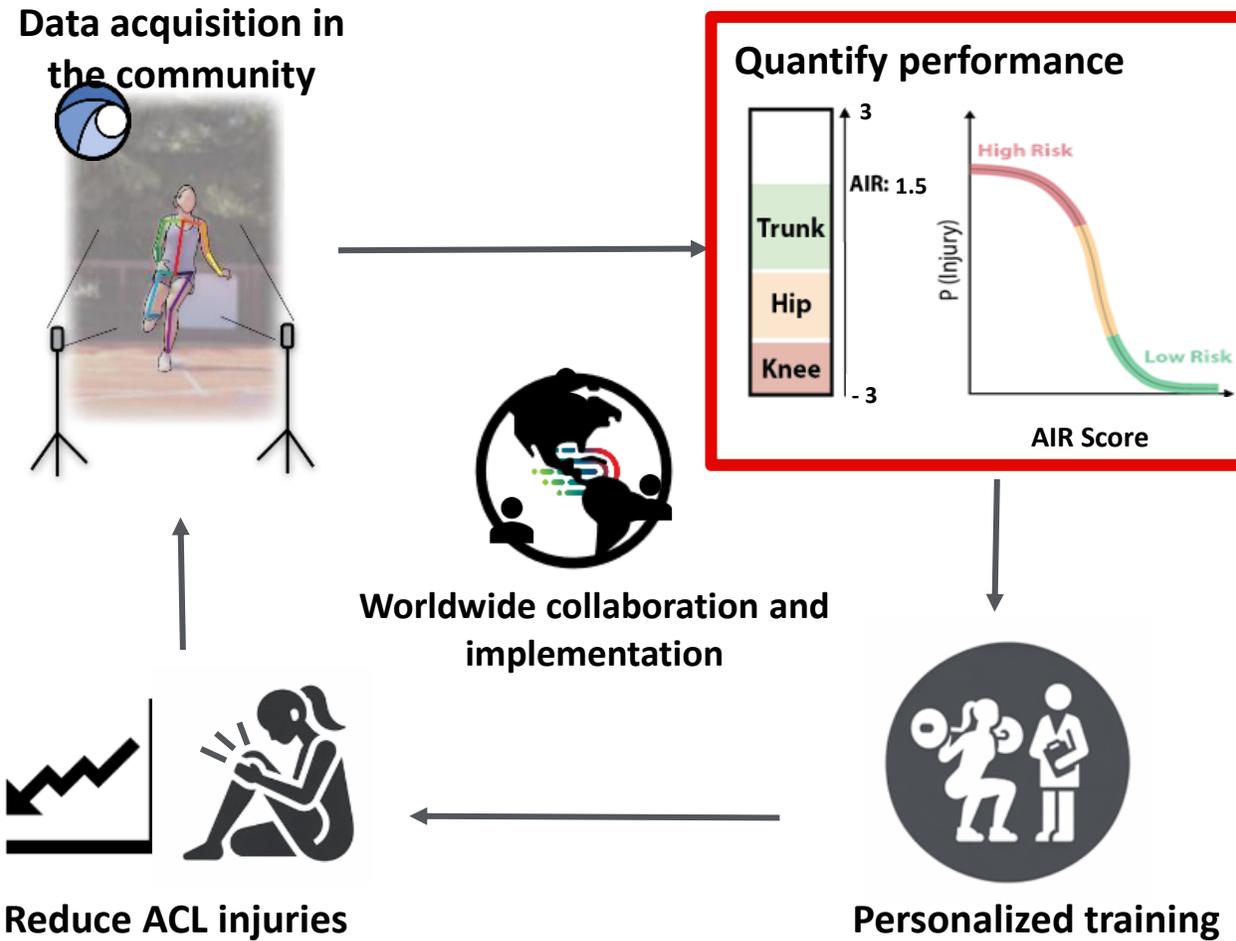


OpenCap: 3D human movement dynamics from smartphone videos

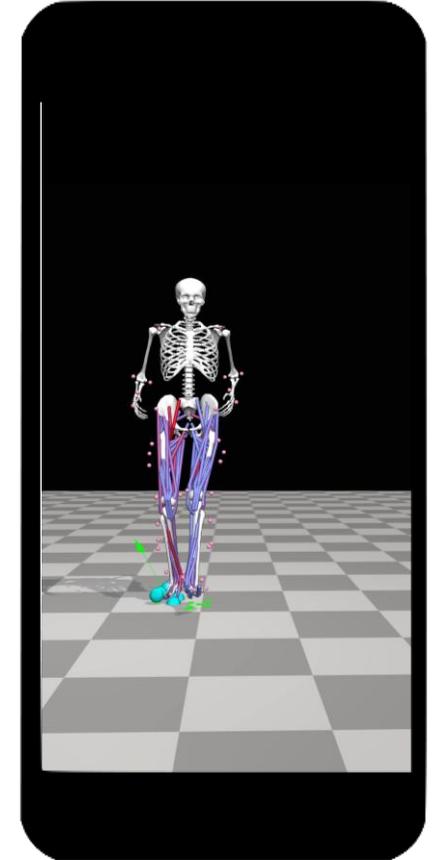
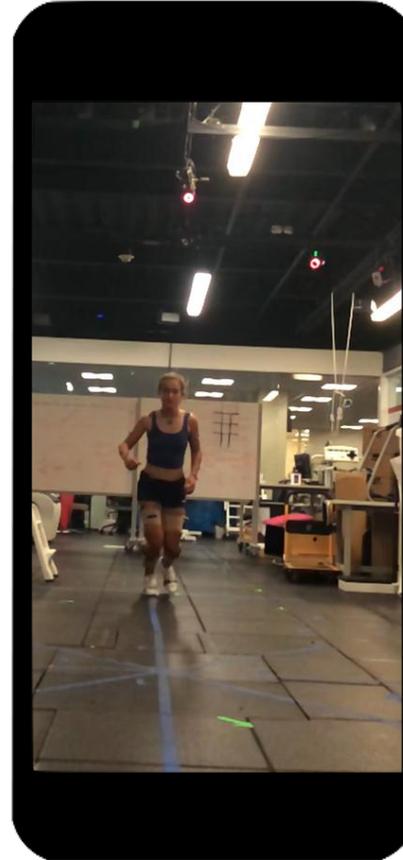
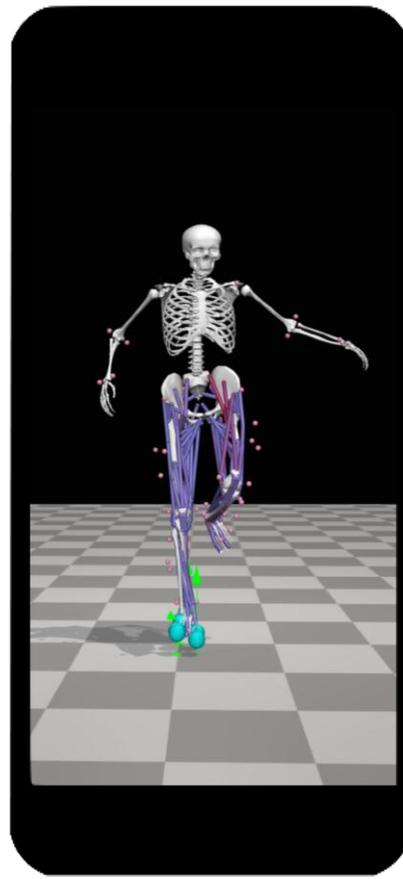
Scott D. Uhlich^{1*}, Antoine Falisse^{1*}, Łukasz Kidziński^{1*}, Julie Muccini², Michael Ko², Akshay S. Chaudhari^{2,3}, Jennifer L. Hicks¹, Scott L. Delp^{1,4,5}



Moonshot Concept



Development of the AIR Score (ACL Injury Resilience Score)



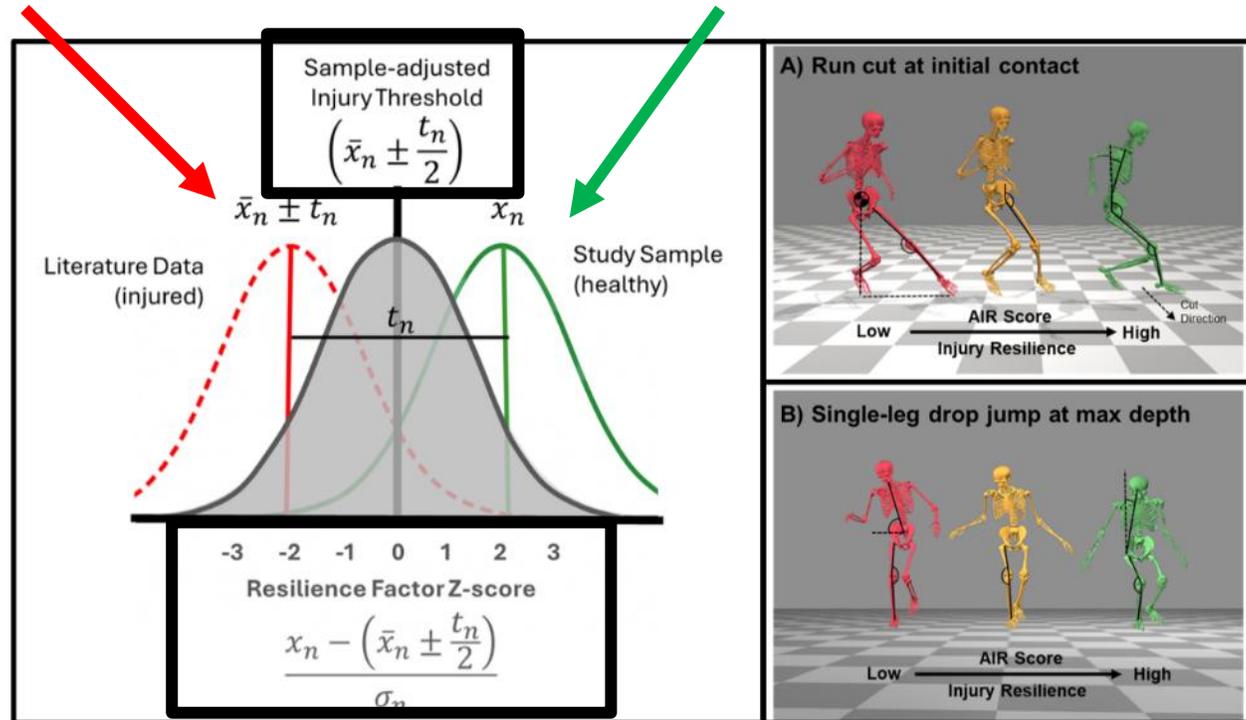
Single Leg Drop Jump

Run Cut 90°

Development of the AIR Score (ACL Injury Resilience Score)

Body Segment & AIR <u>Subscore</u>	ACL Injury Risk Factors for Single-Leg Drop Vertical Jumps & 90-degree Run Cuts
Trunk	Peak Trunk Lean Angle
	Trunk Flexion Angle at Initial Contact
Hip	Hip Flexion Angle at Initial Contact
Knee	Peak Knee Flexion Angle
	Knee Valgus Angle at Initial Contact
	Knee Valgus Moment at Initial Contact
Foot	Ankle Plantarflexion at Initial Contact
	Peak Vertical Ground Reaction Force

The ACL Injury Resilience (AIR) Score as an objective measure of an athlete's readiness and ability to avoid injury



- Each risk factor compared with literature based injured cohorts to establish risk thresholds
- For each metric, calculate a Resilience Factor Z-score, which is equal to the **number of standard deviations from the mean difference between the injured and healthy group**

HIGHER POSITIVE VALUES = GREATER INJURY RESILIENCE

ACL Expert Survey:

ACL Expert Survey Screening Activities & Metrics that Predict ACL Injury Risk



Summary Report

Wu Tsai Human Performance Alliance &
Stanford Human Performance Lab

Digital Athlete Performance
Improvement and Injury
Prevention Program

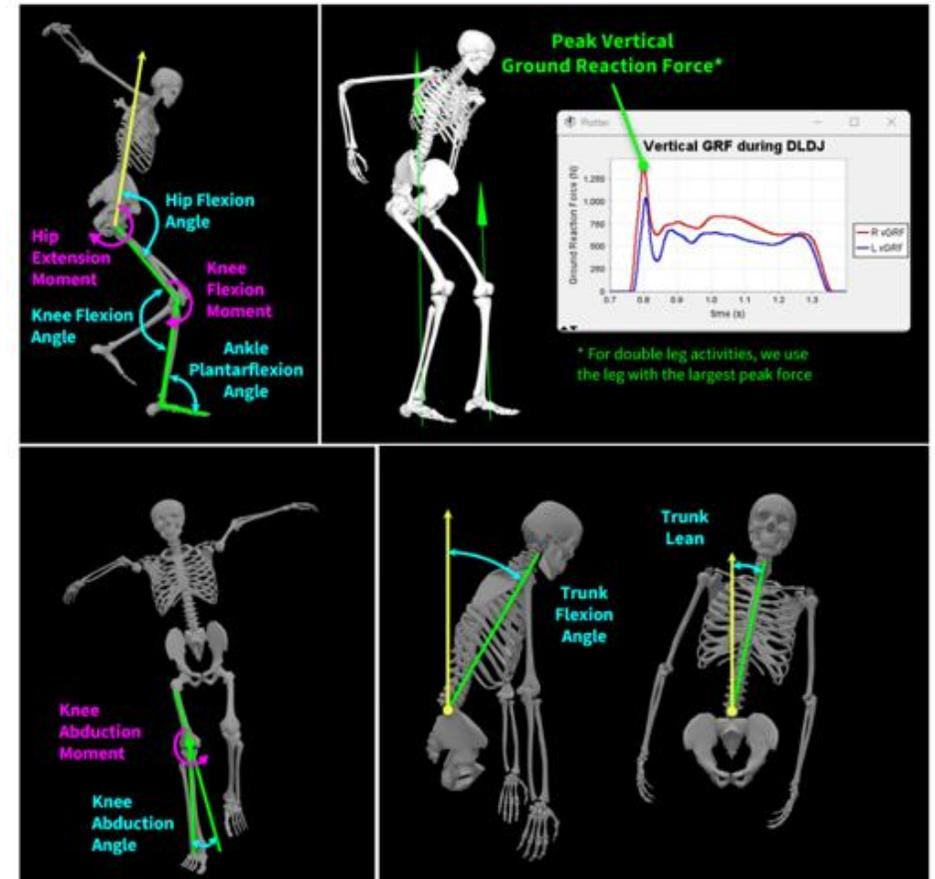
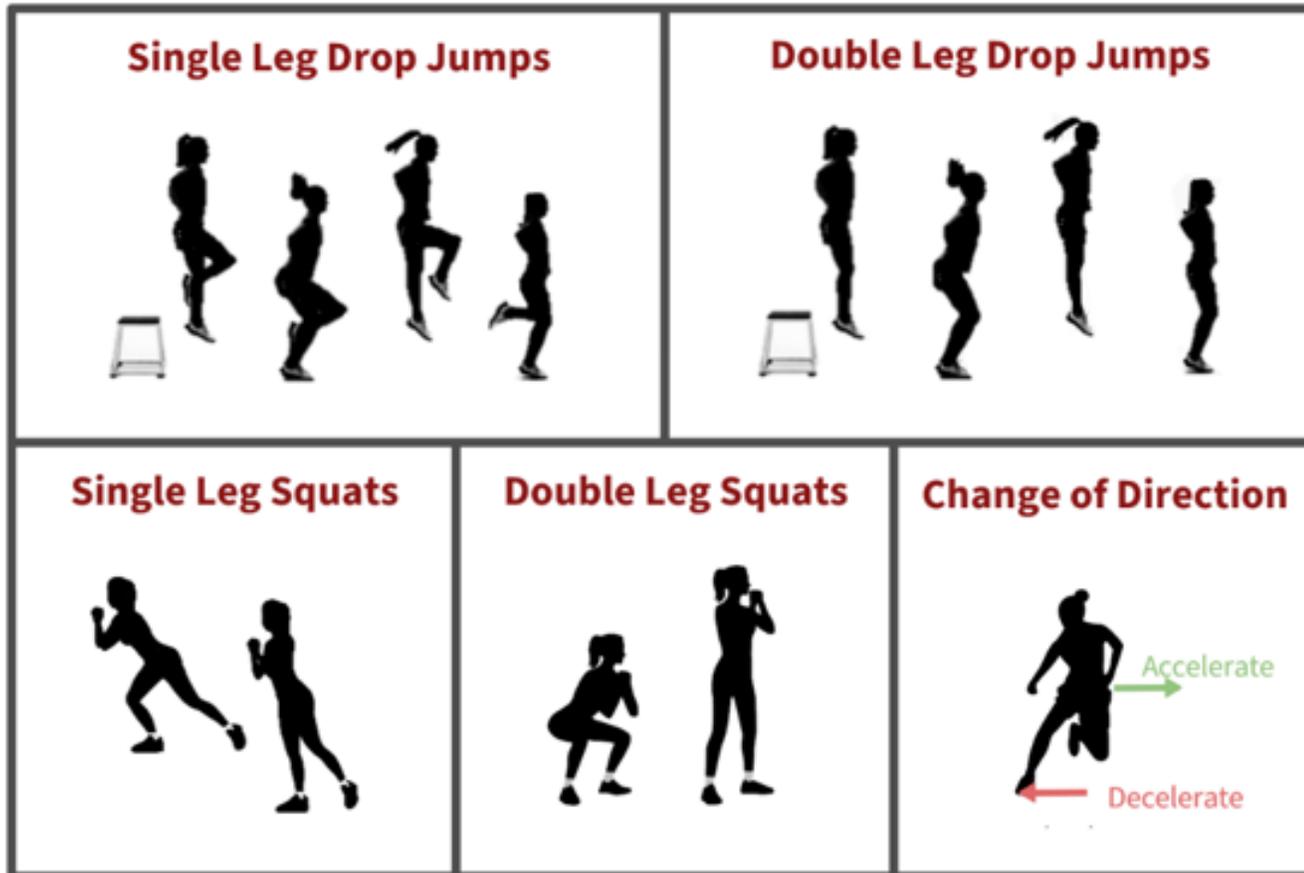


Name	Title	Affiliation
Constance Chu, MD	Professor and Vice Chair Research, Orthopaedic Surgery; Director, the Joint Preservation Center and Chief of Sports Medicine	Stanford University; VA Palo Alto
Tyler Collings, PhD	Lecturer and Researcher in Biomechanics & Injury Prevention	Griffith Centre of Biomedical and Rehabilitation Engineering (GCORE), Griffith University
Scott Delp, PhD	James H. Clark Professor of Bioengineering, Mechanical Engineering, and Orthopaedic Surgery	Stanford University; Wu Tsai Human Performance Alliance
Julie Kolesar, PhD	Research Biomechanist	Stanford University; Wu Tsai Human Performance Alliance
Lise Léveillé, MD, PhD	Director UGME, Dept Orthopaedics; Pediatric Orthopaedic Surgeon	University of British Columbia
Greg Myer, PhD	Professor, Orthopaedics; Director	Emory University; Sports Performance And Research Center (SPARC)
Kevin Shea, MD	Vice Chief of Pediatric Orthopaedic Surgery for Research; Director of Pediatric Sports Medicine; Professor of Orthopaedic Surgery	Stanford University, Lucille Packard Children's Hospital and Stanford Children's Hospital
Seth Sherman, MD	Orthopedic Surgeon for Cardinal Football; Sports Medicine Fellowship Director; Associate Professor of Orthopaedic Surgery	Stanford University, Stanford Hospital
Gillian Weir, PhD	Senior Biomechanist	New York Yankees (Major League Baseball)

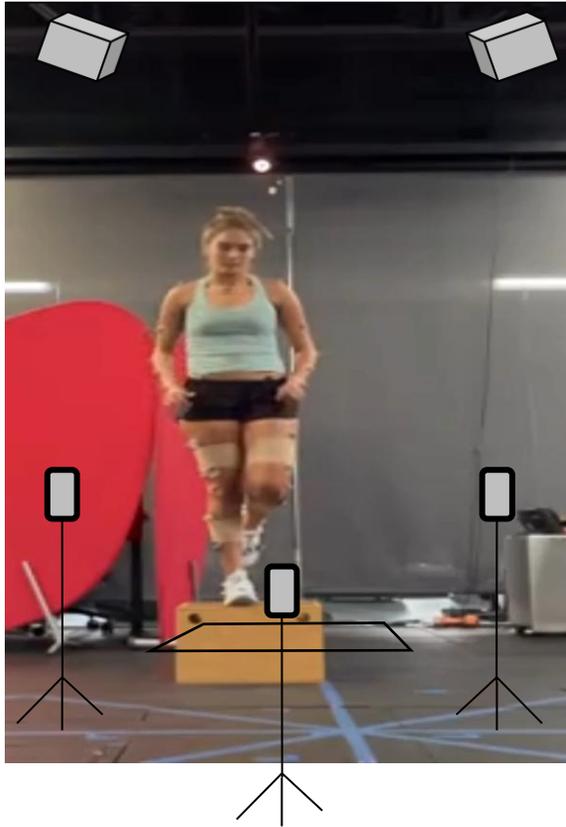
ACL Expert Survey

Activities

Metrics



Dataset to Validate OpenCap for ACL Injury Risk Screening



Time-synchronized Motion Capture and OpenCap

Five tasks: 773 trials

Single Leg Squat (SLS)



90° Drop Cut (DC) & 90° Run Cut (RC)



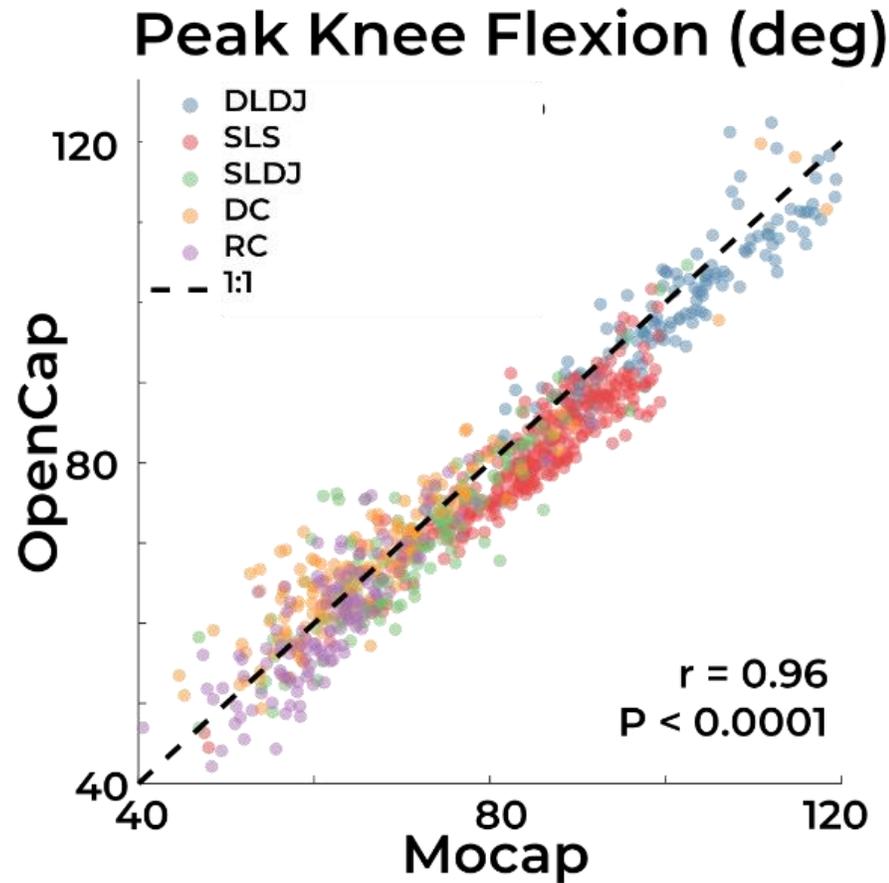
Single Leg Drop Jump (SLDJ)



Double Leg Drop Jump (DLDJ)



OpenCap metrics exhibit moderate to strong correlations with motion capture across all tasks



Correlation Coefficients

	DLDJ	SLS	SLDJ	DC	RC
Trunk Flexion Initial Contact	0.47	--	0.57	0.73	0.58
Hip Flexion Initial Contact	--	--	0.65	0.74	0.57
Hip Flexion Range of Motion	0.93	--	--	--	--
Knee Flexion Peak	0.93	0.93	0.89	0.93	0.86
Ankle Flexion Initial Contact	--	--	0.47	0.59	0.59

AIR Score assessed with as few as two activities

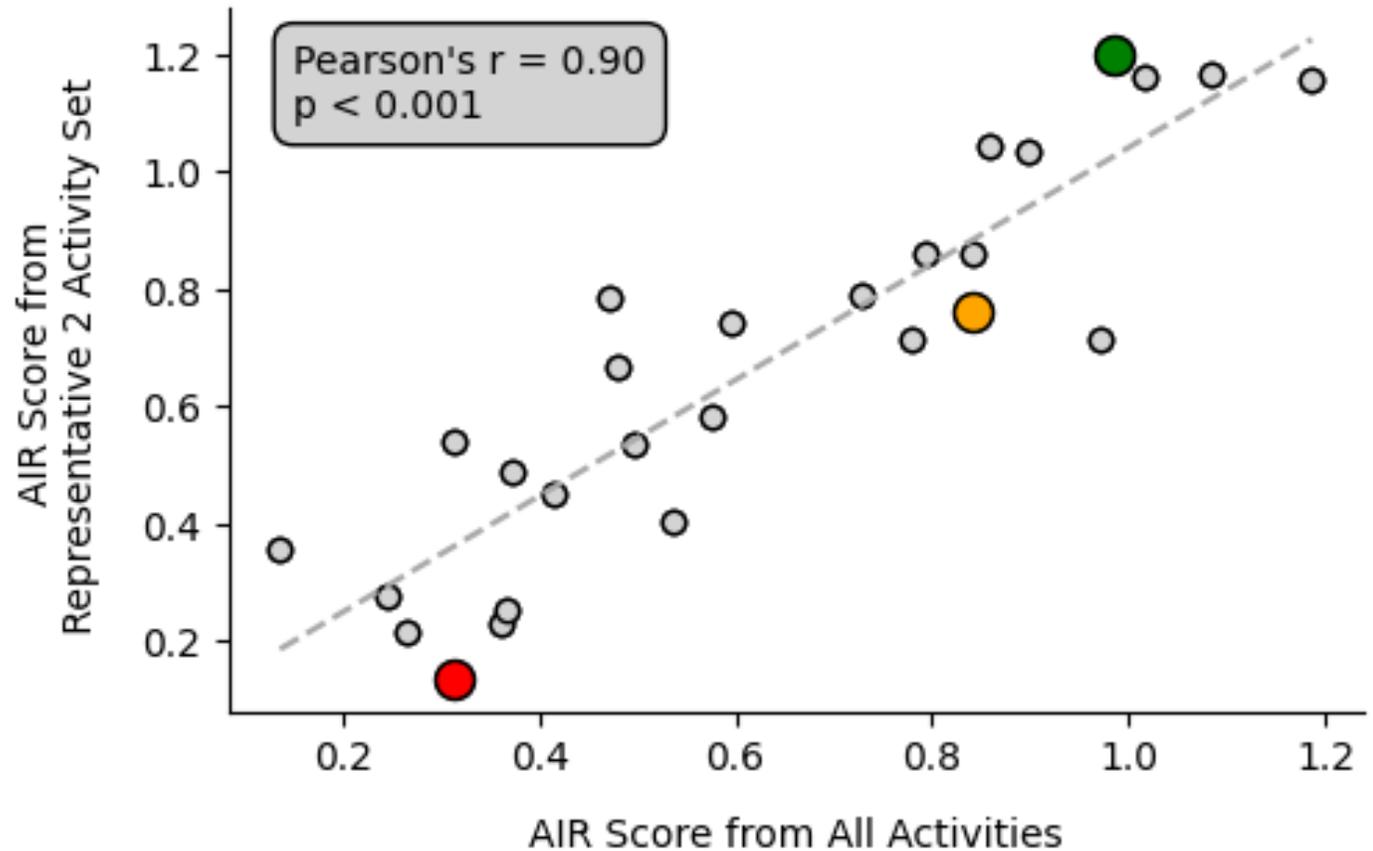
consistently reconstructs scores with metrics from all screening activities

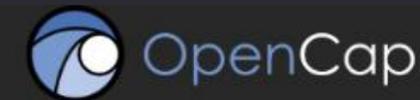


Single-leg Drop Jump



Run Cut 90°





Trial name

START RECORDING

- WC90_L2
- WC90_L3
- WC90_R2
- WSLDJ_R3
- WDC_L1

Show removed trials

NEW SESSION, SAME SETUP

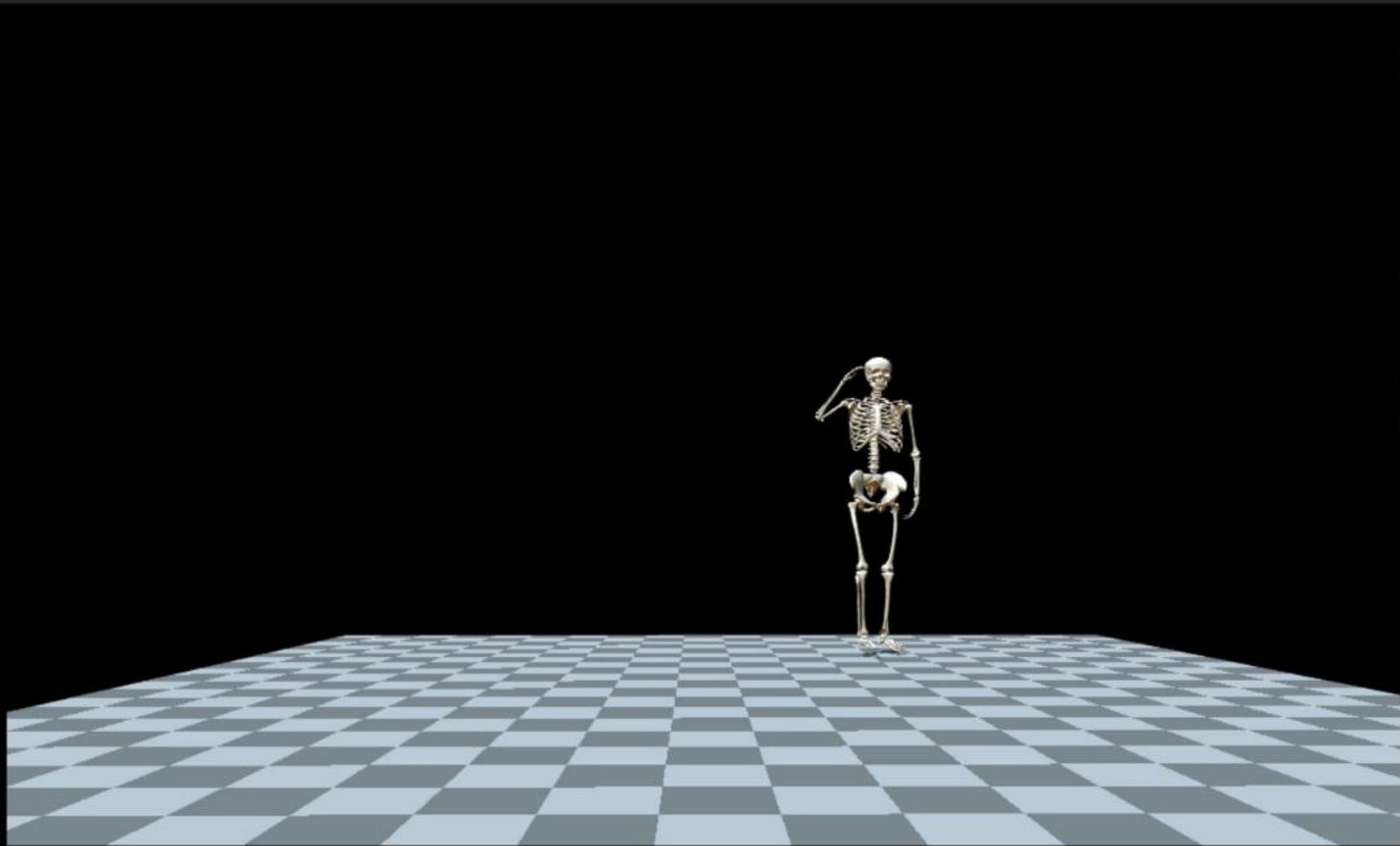
NEW SESSION

SHARE SESSION PUBLICLY

DOWNLOAD DATA

DASHBOARD KINEMATICS

BACK TO SESSION LIST



Time (s) 0

0.1x 0.25x 0.5x 0.75x 1x 2x

⏪ ⏩ ⏴ ⏵

Trial name

- START RECORDING
- WC90_L2
 - WC90_L3
 - WC90_R2
 - WSLDJ_R3
 - WDC_L1

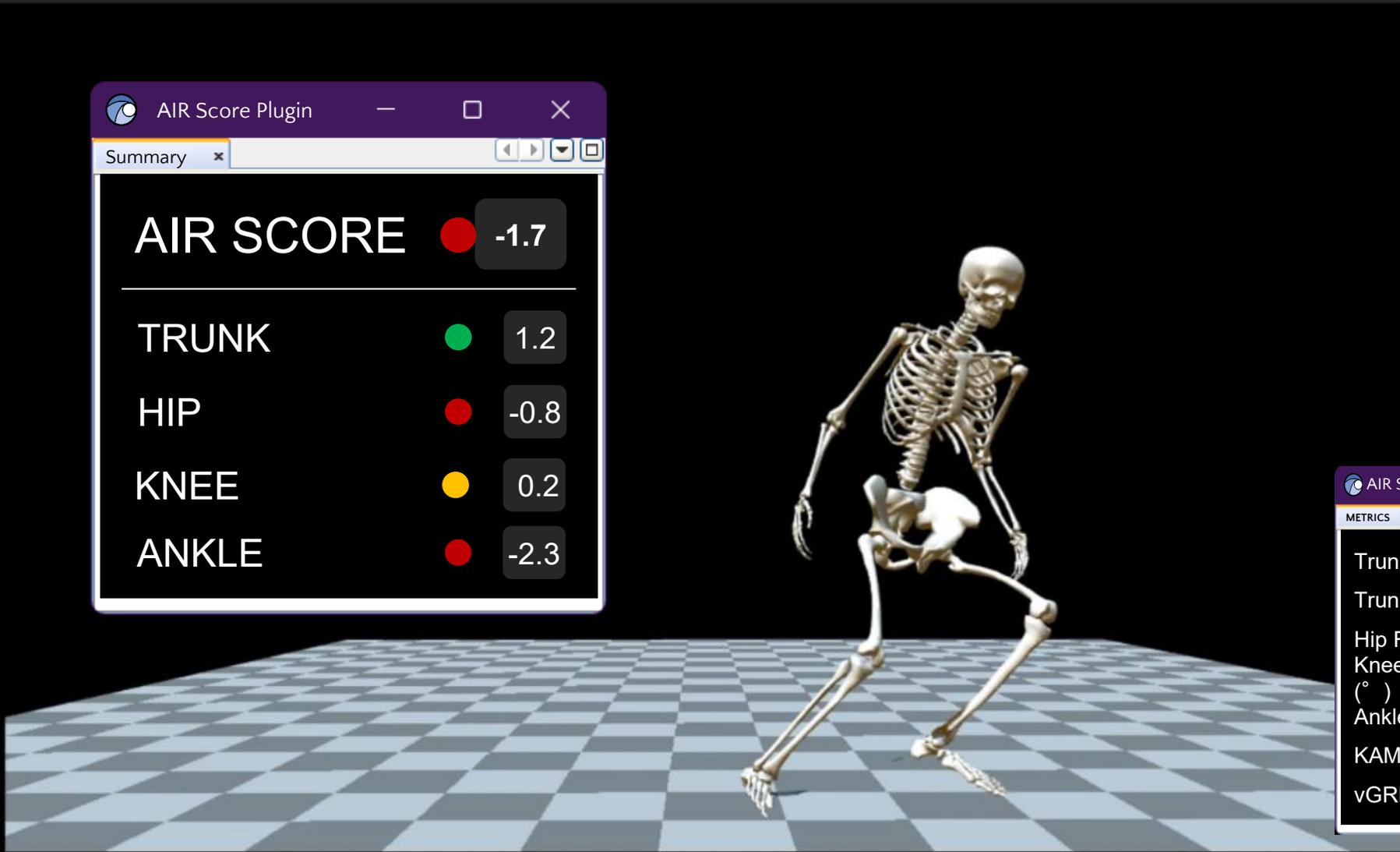
Show removed trials

- NEW SESSION, SAME SETUP
- NEW SESSION
- SHARE SESSION PUBLICLY
- DOWNLOAD DATA
- DASHBOARD KINEMATICS
- BACK TO SESSION LIST

AIR Score Plugin

Summary

AIR SCORE	●	-1.7
TRUNK	●	1.2
HIP	●	-0.8
KNEE	●	0.2
ANKLE	●	-2.3



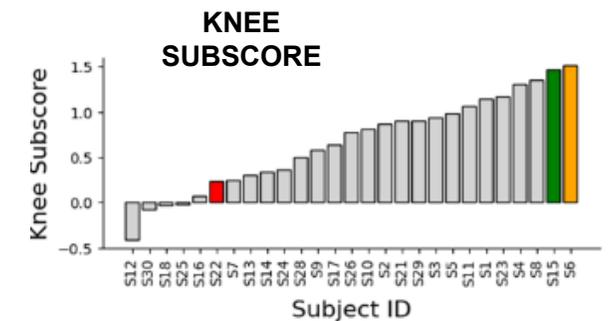
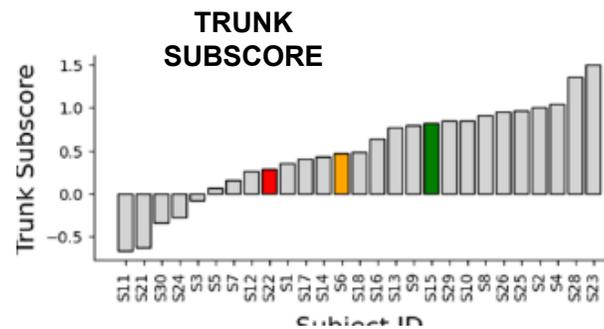
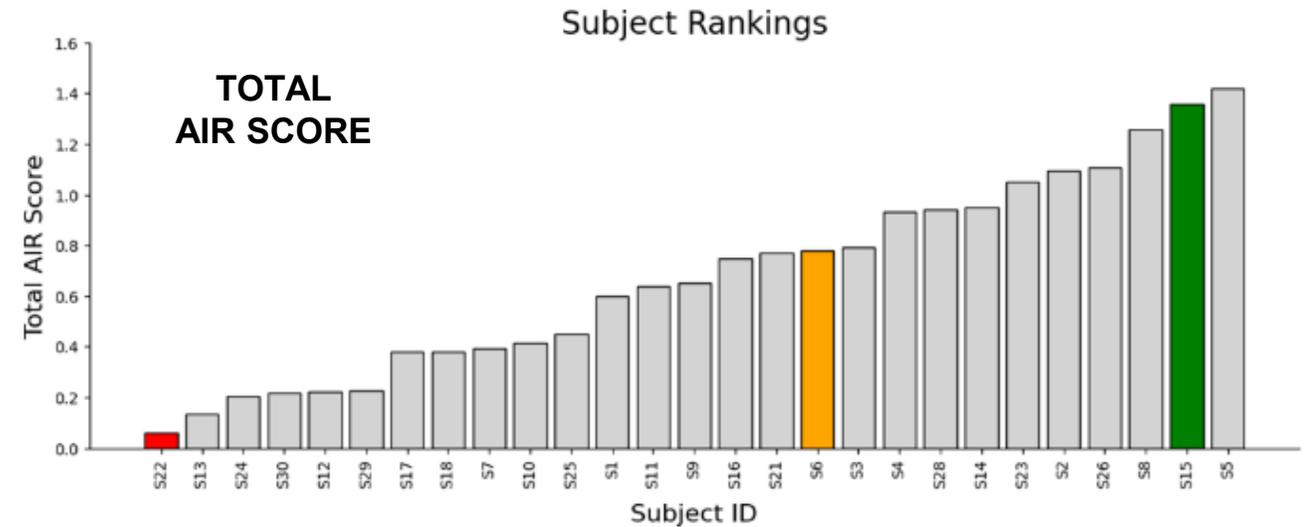
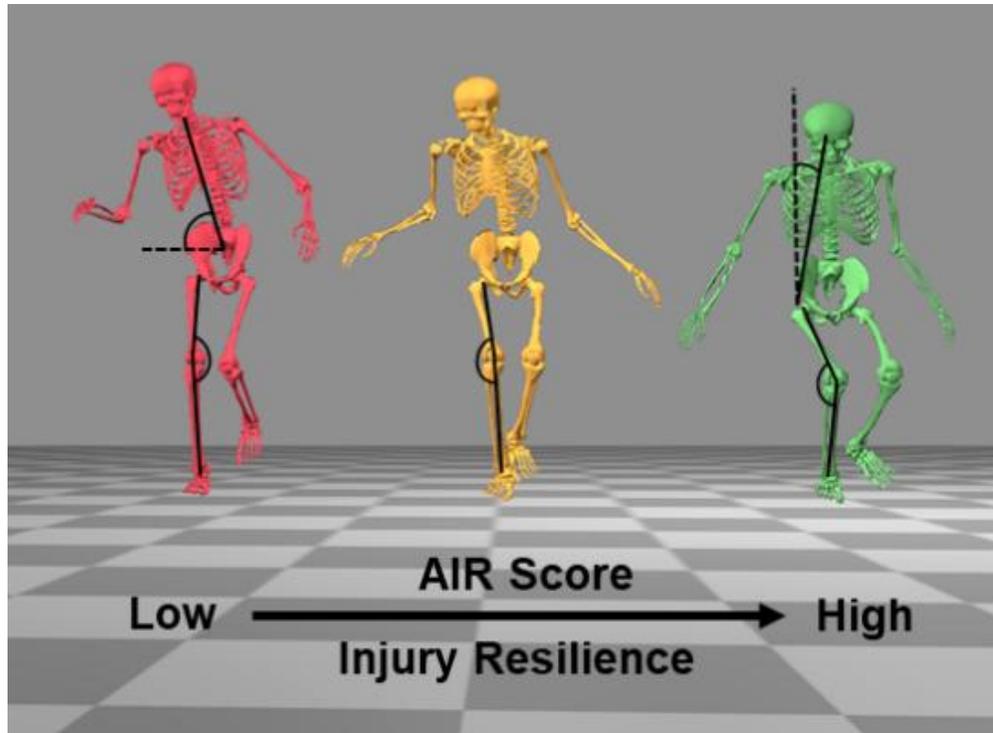
AIR Score Plugin

METRICS

Trunk Flexion (°)	●	38
Trunk Lean (°)	●	3
Hip Flexion (°)	●	37
Knee Valgus (°)	●	7
Ankle P.flexion (°)	●	13
KAM (%BW*ht)	●	3.6
vGRF (%BW)	●	4.4

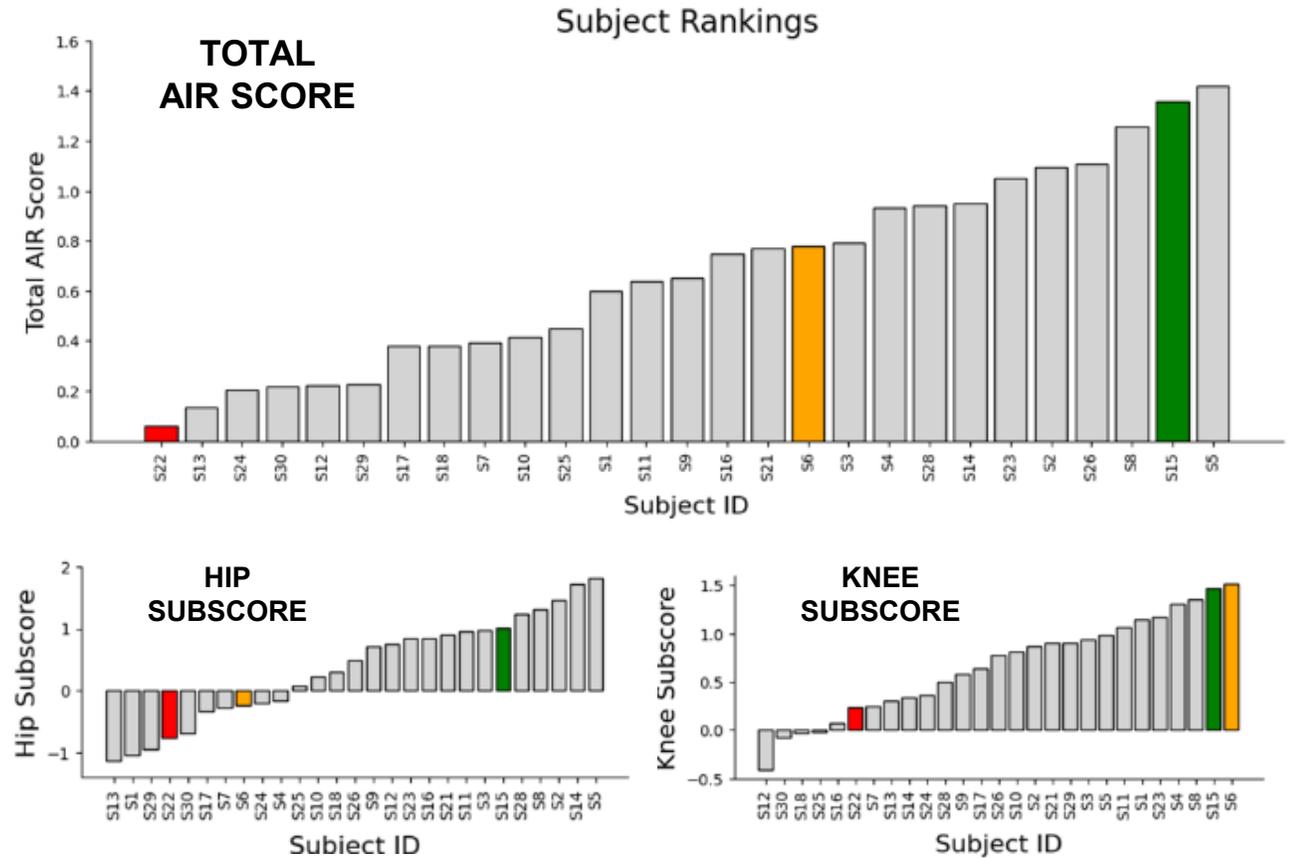
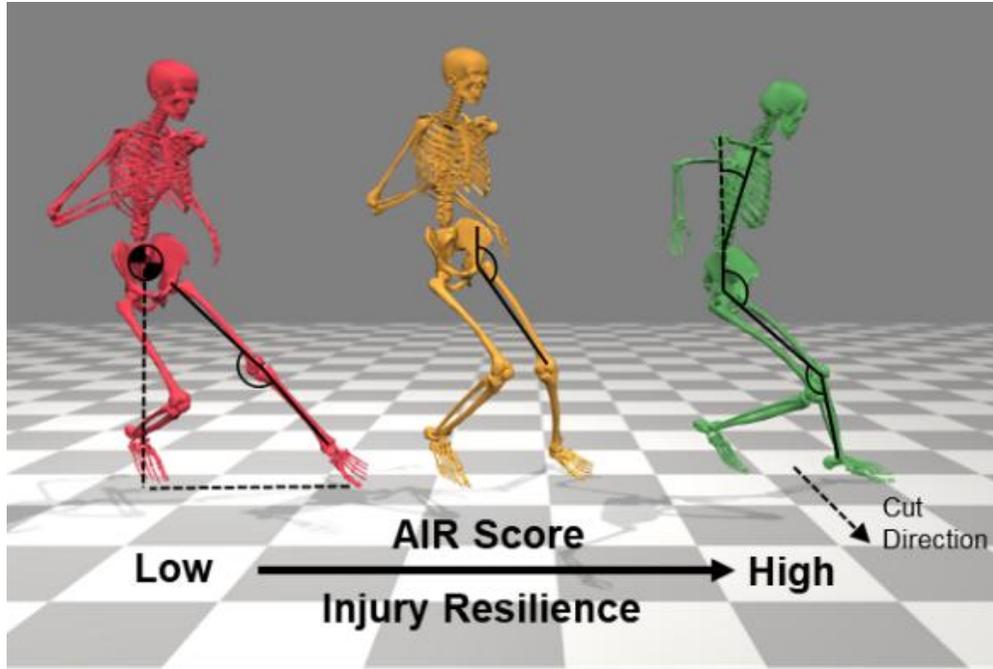
AIR Score Evaluation

Single Leg Drop Jump at Max Depth



AIR Score Evaluation

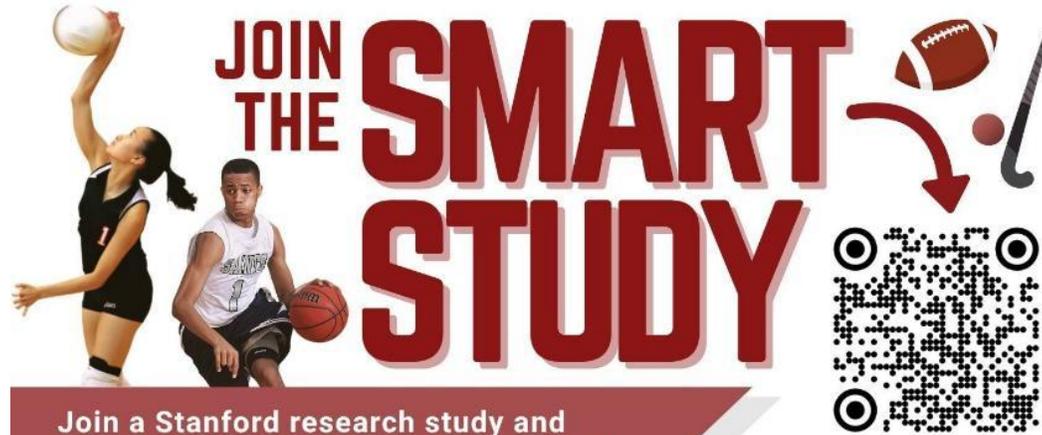
Run Cut 90° at Initial Contact



The Smartphone Motion Analysis with Rapid Testing (SMART) Study for ACL Injury Resilience

3 year prospective observational study to validate AIR score and screening for ACL injury risk

SHAPE THE FUTURE OF HUMAN PERFORMANCE



Join a Stanford research study and contribute to smartphone tech that will evaluate injury resilience with a brief 10-20 minute video assessment

LEARN MORE AND SIGN UP AT:
[DIGITALATHLETEDAY.STANFORD.EDU](https://digitalathleteday.stanford.edu)

WHO CAN JOIN?

- Healthy athletes ages 10-95 who can run, jump, and squat
- Athletes planning to play at least one season of the following field or court sports in the next year: soccer, volleyball, basketball, football, lacrosse, or field hockey



Protocol Director
Scott Delp, PhD
James H. Clark Professor
of Bioengineering,
Mechanical Engineering
& Orthopaedic Surgery

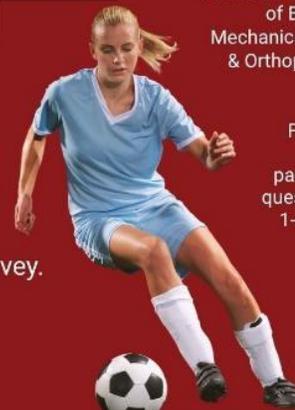
WHAT'S INVOLVED?

- Fill out surveys
- Complete a 10-20 minute video assessment

Participants may be compensated with a \$20 gift card for a completed assessment and follow-up survey.

Study Questions?

Email the team at smart-study@stanford.edu or call us at 650-721-2547



For complaints, concerns, or participant rights questions, contact 1-866-680-2906.



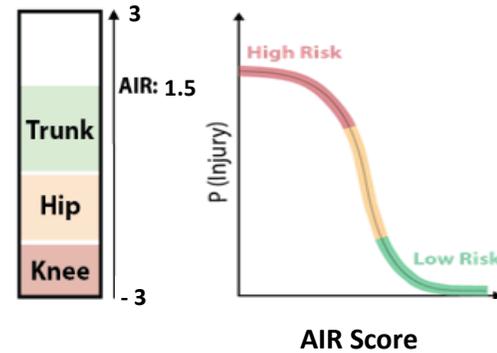
Moonshot Concept



Data acquisition in the community



Quantify performance



Worldwide collaboration and implementation



Reduce ACL injuries



Personalized training

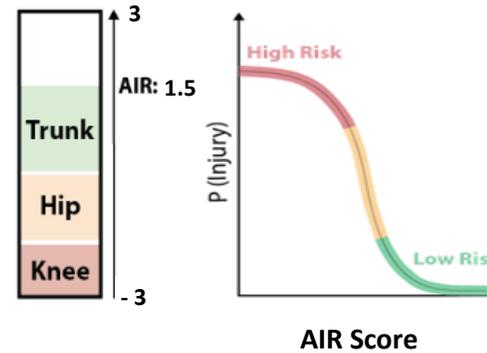
Moonshot Concept



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Worldwide collaboration and implementation

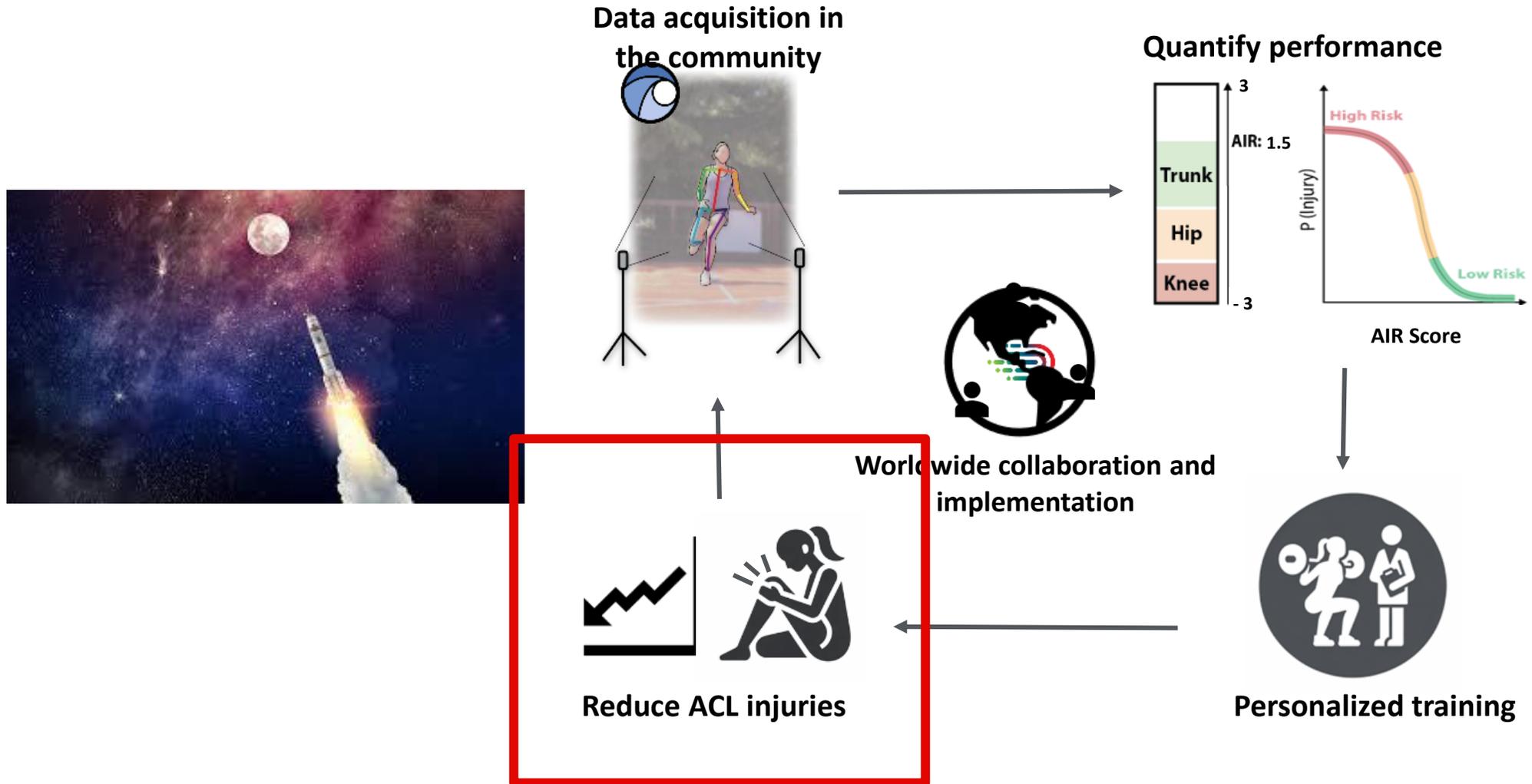


Reduce ACL injuries

Personalized training

A circular icon showing a person performing a squat or similar exercise while being coached by another person. The entire icon and text are enclosed in a red rectangular border.

Moonshot Concept



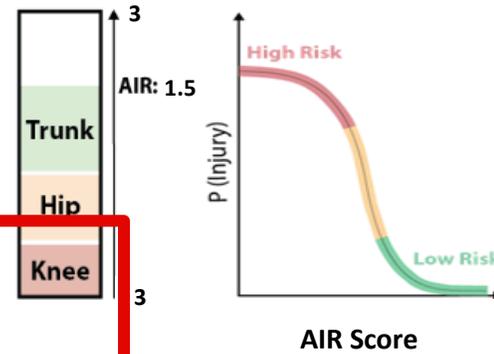
Moonshot Concept



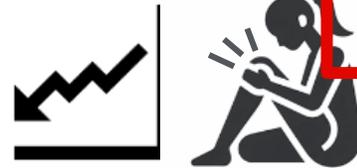
Data acquisition in the community



Quantify performance



Worldwide collaboration and implementation



Reduce ACL injuries



Personalized training

Conclusions

- Much more work to do AND more questions than answers
- Incredible and collaborative multi-disciplinary team



- Excited to involve ACLSG members in this mission!!

Thank you!
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