

# Lecture 4: Biomechanics of muscle and ligament injuries at the ankle and the knee joint



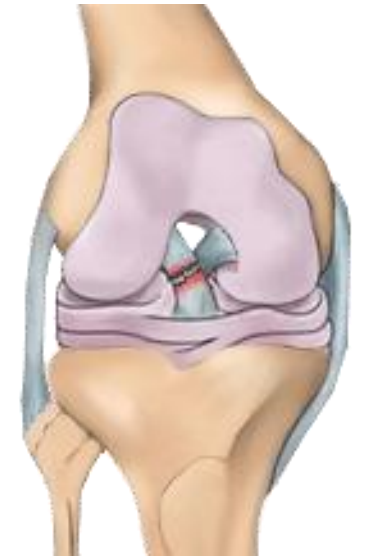
Calf strain /  
Achilles tendon  
rupture



Ankle lateral  
Ligamentous sprain



Hamstring strain



Anterior cruciate  
ligament  
rupture



**Dr Daniel T.P. Fong 方迪培博士**

Reader in Sports Medicine and Biomechanics, Loughborough University

Adjunct Associate Professor, The Chinese University of Hong Kong

Editor-in-Chief, Sports Biomechanics Journal

BSc (Physics), MSc (Exercise Science), PhD (Orthopaedics and Traumatology)



# Loughborough? Lufbra? and Leicestershire?



School of Sport, Exercise and Health Sciences

## Academics (~180)

|                    |    |
|--------------------|----|
| Professor          | 36 |
| Reader             | 39 |
| Senior Lecturer    | 38 |
| Lecturer           | 22 |
| University Teacher | 45 |

## Students (~4000)

|                    |       |
|--------------------|-------|
| PhD                | ~350  |
| MSc/Postgraduate   | ~650  |
| Undergraduate/MSci | ~3000 |

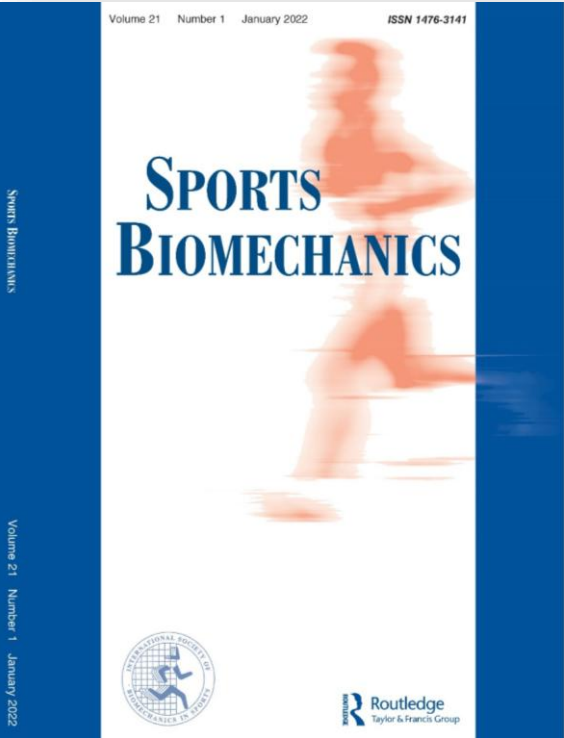


NUMBER 1 IN THE WORLD  
FOR SPORTS-RELATED SUBJECTS  
10 YEARS RUNNING

QS World University Rankings by Subject 2017-2026

PRONOUNCE:  
LOUGHBOROUGH

# Sports Biomechanics Journal, Taylor and Francis (@sportsbiomechj)



**EDITOR-IN-CHIEF**  
**Daniel Fong**

**ASSOCIATE EDITORS**  
**Liz Bradshaw**  
**Kim Hébert-Losier**

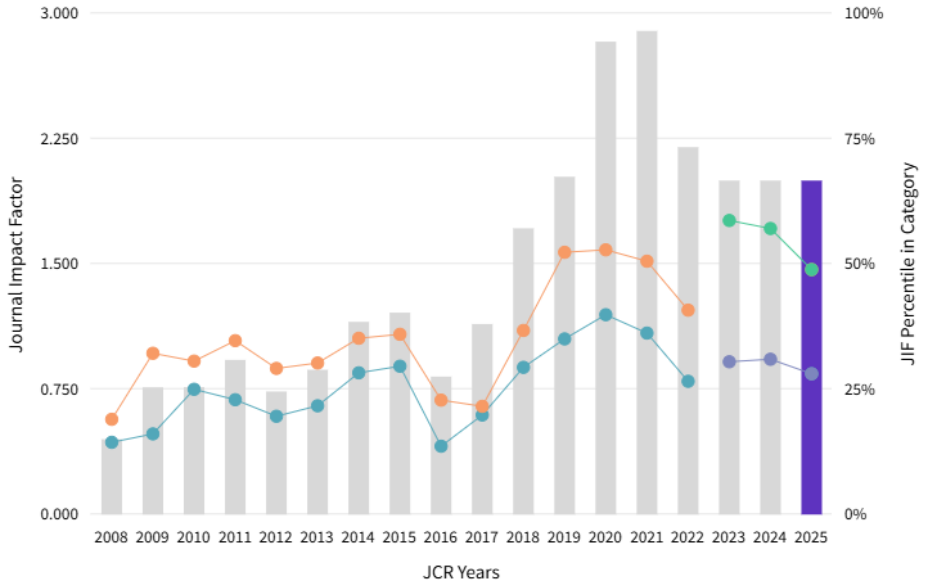
**EDITORIAL BOARD**  
Arif Mithat Amca - Hacettepe University, Turkey  
Charlotte Apps - Nottingham Trent University, UK  
Simon Augustus - Kingston University of London, UK  
Mélanie Beaulieu - University of Michigan, USA  
Ian Bezodis - Cardiff Metropolitan University, UK  
Neil Bezodis - Swansea University, UK  
Sara Brice - James Cook University, Australia  
Heiliane de Brito Fontana - Federal University of Santa Catarina, Brazil  
Susan Brown - Edinburgh Napier University, UK  
Nicholas Busu  
Mohamed Souto  
**Roy Cheung**  
Paul Comfort  
Filipe Conceição - University of Porto, Portugal  
Katherine Daniels - Manchester Metropolitan University, UK  
Sina David - Vrije Universiteit Amsterdam, The Netherlands  
Olyvia Donti - National and Kapodistrian University of Athens, Greece  
Tim Doyle - Macquarie University, Australia  
Juliana Exel - University of Vienna, Austria  
Tim Exell - University of Portsmouth, UK  
Ricardo Fernandes - University of Porto, Portugal  
Pablo Floria - Pablo de Olavide University, Spain  
Alycia Fong Yan - The University of Sydney, Australia  
Carlos de la Fuente - Andres Bello University, Chile  
Marianne Gittoes - Cardiff Metropolitan University, UK  
Tomohiro Gonjo - Heriot-Watt University, UK  
Yaodong Gu - Ningbo University, China  
Chengtu Hsieh - California State University, Chico, USA  
Rony Ibrahim - Qatar University, Qatar  
Parunchaya Jamkrajang - Mahidol University, Thailand  
Ina Janssen - Netherlands Olympic Committee, The Netherlands  
Hoon Kim - Soonchunhyang University, South Korea  
Hyun Kyung Kim - Louisiana State University (Baton Rouge), USA  
Duane Knudson - Texas State University, USA

**Editorial board**  
Karla de Jesus - Federal University of Rio de Janeiro, Brazil  
**Veni Kong**  
**Kam-Ming Mok**  
Sakiko Oyama - University of Tsukuba, Japan  
Rodrigo Rico Bini - Universidade Federal de Minas Gerais, Brazil  
Benedicte Vanwanseele - KU Leuven, Belgium  
J. Paulo Vilas-Boas - University of Porto, Portugal

Weerawat Limroongreungrat - Mahidol University, Thailand  
Silvio Lorenzetti - Zurich University of Applied Sciences, Switzerland  
Stuart McLerrain-Naylor - Loughborough University, UK  
Jorge Morais - Instituto Politécnico de Bragança, Portugal  
Pedro Morouço - Polytechnic Institute of Leiria, Portugal  
Archit Navandar - Universidad Politécnica de Madrid, Spain  
Carina Price - University of Salford, UK  
Xiao Qiu - Hong Kong Sports Institute, Hong Kong, China  
Paige Rice - Wake Forest University, USA  
Hannah Rice - Norwegian School of Sport Sciences, Norway  
Mark Robinson - Liverpool John Moores University, UK  
Natsuki Sado - University of Tsukuba, Japan  
Karine Sarro - University of Campinas, Brazil  
Shogo Sasaki - Tokai University, Japan  
Raihana Sharir - Universiti Teknologi MARA, Malaysia  
Kelly Sheerin - Auckland University of Technology, New Zealand  
Yo Shih - University of Oklahoma, USA  
Amanda Silvatti - Federal University of Viçosa, Brazil  
Qipeng Song - Shandong Sport University, China  
Yu Song - The University of Kansas, USA  
Yunqi Tang - Shaanxi University of Science and Technology, China  
Rohit Kumar Thapa - Symbiosis International (Deemed University), India  
Roland van den Tillaar - Nord University, Norway  
Jasper Verheul - Cardiff Metropolitan University, UK  
Dan Wang - Shanghai University of Sport, China  
Genevieve Williams - University of Exeter, UK  
Steffen Willwacher - Offenburg University of Applied Sciences, Germany  
Hannah Wyatt - University of Canterbury, New Zealand  
Shuqi Zhang - Boise State University, USA

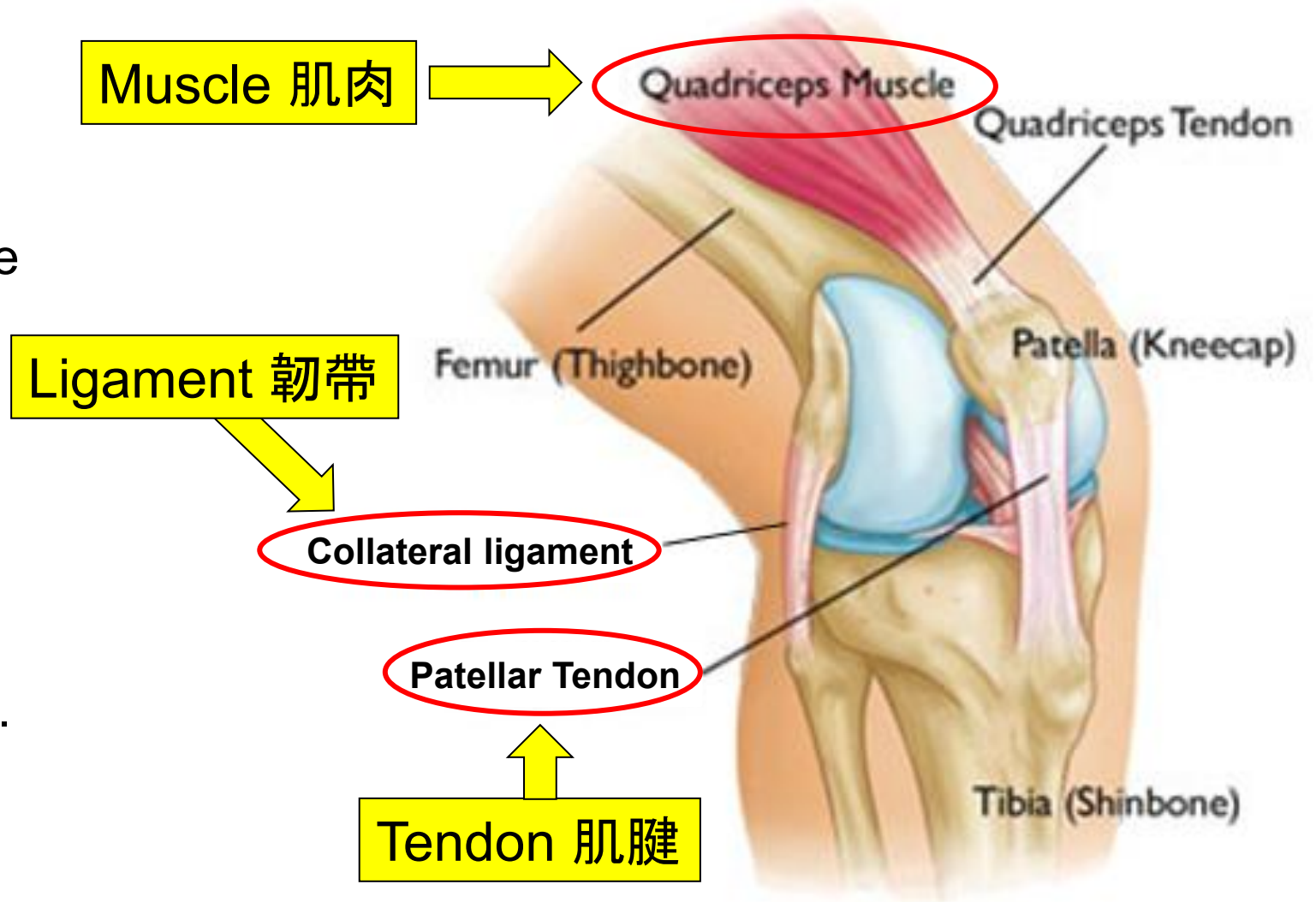


@dtpfong / @sportsbiomechj Sports Biomechanics – Editor Report (Authored by Daniel Fong)

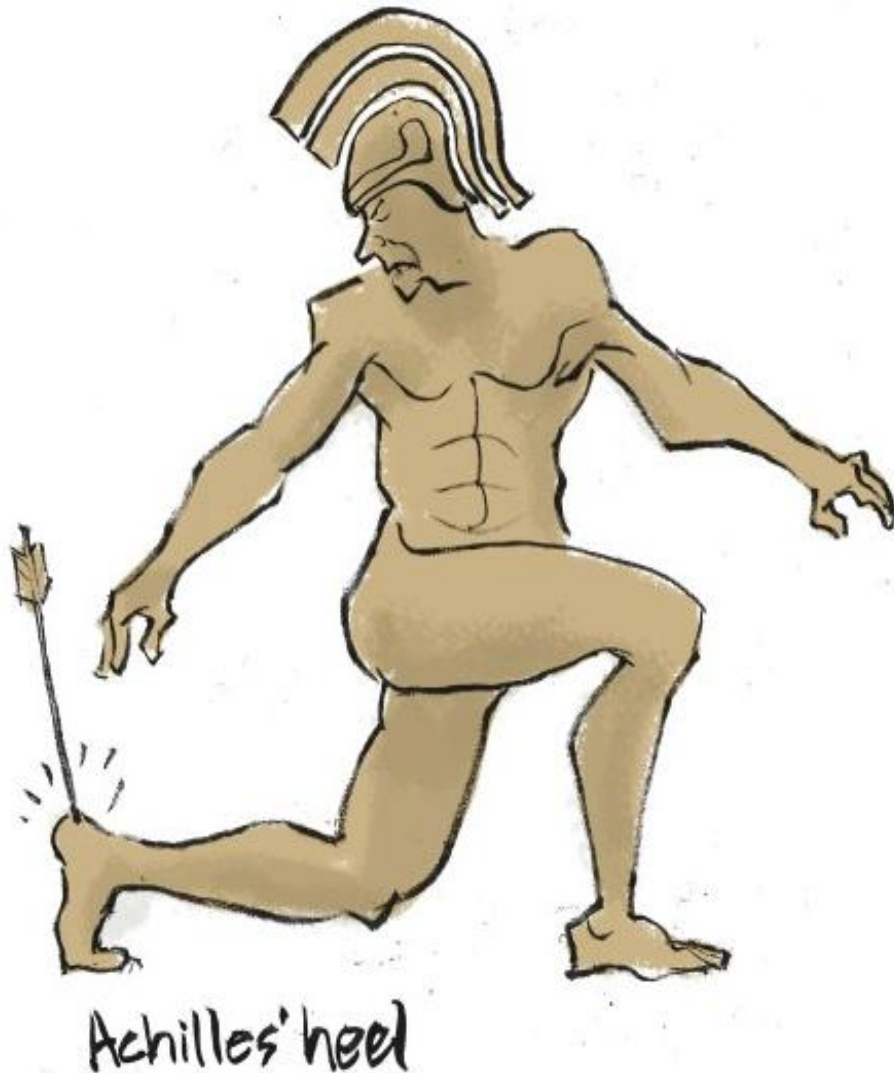


# Muscle? Tendon? Ligament? 何謂肌肉? 何謂肌腱? 何謂韌帶?

- Muscle: contract and shorten to produce muscular force.
- Tendon: connects muscle to bone. Transfer muscle force to the bone to initiate movement.
- >>> musculotendinous (or muscle-tendon) unit / junction
- Ligament: connects bone to bone. Maintains joint stability.



# Calf strain (pulled calf) and Achilles tendon rupture



- Main propellant to push off.
- Forceful contraction, especially eccentric, may cause Achilles tendon rupture.
- Symptoms and Signs
  - Sudden onset pain
  - Hear/feel a 'pop' sound
  - Heel area swollen and bruised
  - Palpable defect in the tendon
  - Weak plantarflexion
  - Unable to lift up toes
  - walk properly
  - 'Dropped' foot during walking

# Injury mechanism: eccentric contraction / action

## David Beckham in tears as cruel achilles injury in AC Milan win wrecks World Cup dream

By Matt Lawton for the Daily Mail  
Chief Football Correspondent  
UPDATED: 13:00, 15 March 2010



- Foot backward, heel on ground.
- Knee forcefully extended.



# Injury mechanism: biomechanics

Am J Sports Med. 2019 Aug;47(10):2360-2366. doi: 10.1177/0363546519858609. Epub 2019 Jul 3.

**Epidemiology and Video Analysis of Achilles Tendon Ruptures in the National Basketball Association**

Nicholas J Lemme<sup>1</sup>, Neill Y Li<sup>1</sup>, Justin E Kleiner<sup>1</sup>, Sydney Tan<sup>1</sup>, Steven F DeFroda<sup>1</sup>, Brett D Owens<sup>1</sup>

BMJ Open Sport Exerc Med. 2022 Sep 22;8(3):e001419. doi: 10.1136/bmjsem-2022-001419. eCollection 2022.

**Video analysis of Achilles tendon rupture in male professional football (soccer) players: injury mechanisms, patterns and biomechanics**

Francesco Della Villa<sup>1</sup>, Matthew Buckthorpe<sup>1 2</sup>, Fillippo Tosarelli<sup>1</sup>, Matteo Zago<sup>3</sup>, Stefano Zaffagnini<sup>4</sup>, Alberto Grassi<sup>4</sup>

J Appl Biomech. 2022 Oct 20;38(6):398-403. doi: 10.1123/jab.2022-0088. Print 2022 Dec 1.

**Mechanisms of Achilles Tendon Rupture in National Basketball Association Players**

Adam J Petway<sup>1 2</sup>, Matthew J Jordan<sup>3</sup>, Scott Epsley<sup>4</sup>, Philip Anloague<sup>5</sup>

Case Reports > Knee Surg Sports Traumatol Arthrosc. 2022 Dec;30(12):4198-4202. doi: 10.1007/s00167-022-07078-0. Epub 2022 Jul 28.

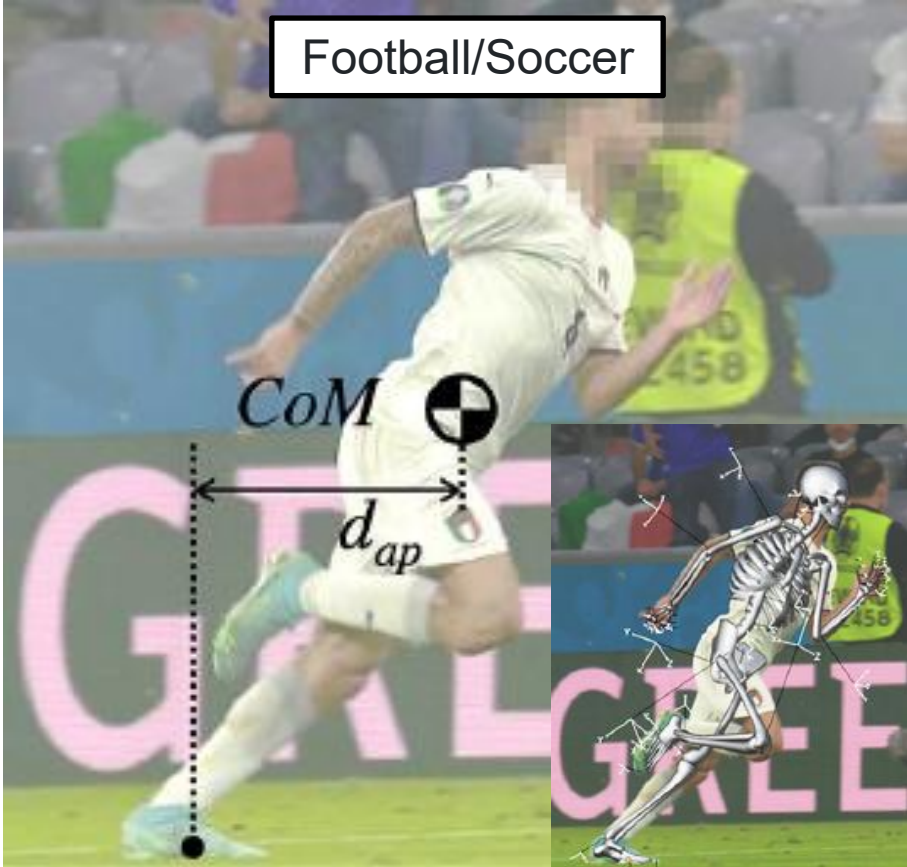
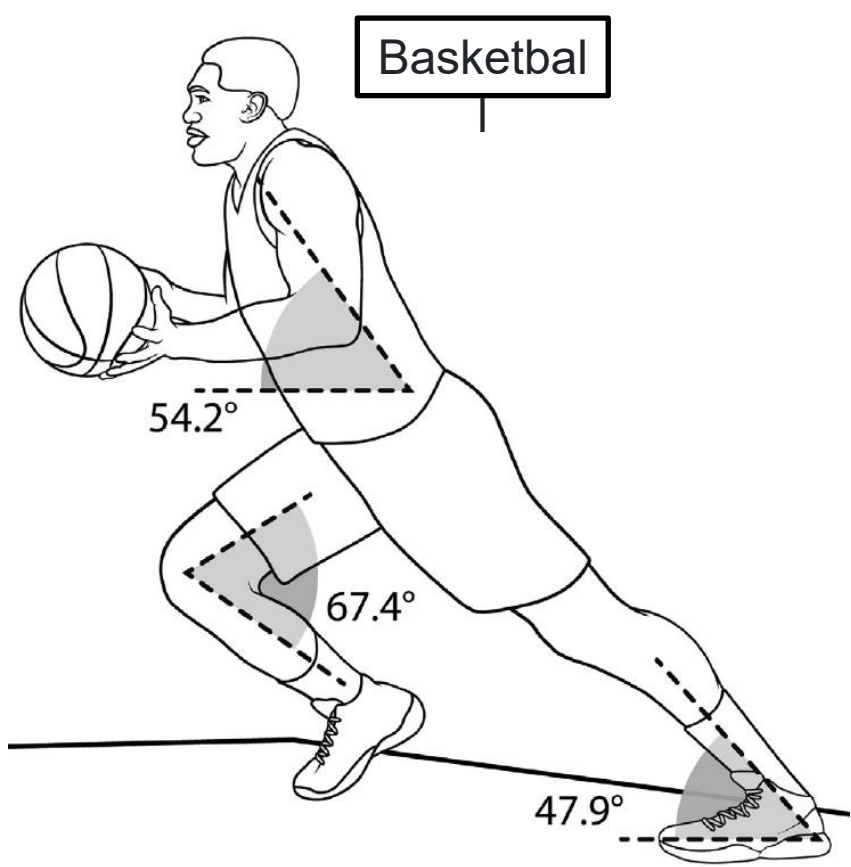
**The three-dimensional reconstruction of an Achilles tendon rupture in a professional football player reveals a multiplanar injury mechanism**

Francesco Della Villa<sup>1</sup>, Fabio Esposito<sup>2 3</sup>, Mattia Busà<sup>4 2</sup>, Susanna Stillavato<sup>2 5</sup>, Matteo Zago<sup>2</sup>

Knee Surg Sports Traumatol Arthrosc. 2023 Jun;31(6):2236-2245. doi: 10.1007/s00167-023-07384-1. Epub 2023 Mar 28.

**Video analysis of Achilles tendon ruptures in professional male football (soccer) reveals underlying injury patterns and provides strategies for injury prevention**

Tim Hoenig<sup>1</sup>, Thomas Gronwald<sup>2</sup>, Karsten Hollander<sup>2</sup>, Christian Klein<sup>3</sup>, Karl-Heinz Frosch<sup>4</sup>, Peter Ueblicher<sup>4 5 6</sup>, Tim Rolvien<sup>4</sup>



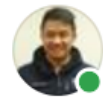
- “False-step mechanism” – a rearward step posterior to their centre of mass.
- sudden ankle dorsiflexion with internal plantarflexion moment during push-off.

# My personal experience



**Daniel Fong** @dtpfong · Oct 31, 2022 ...

Best way to teach sports injuries is to have them yourself, so you can really tell the students what is so-called a pop sound/feeling, and why a dropped foot after a pulled calf muscle! You can also impress the triage staff when you can say out the name of their clinical test!



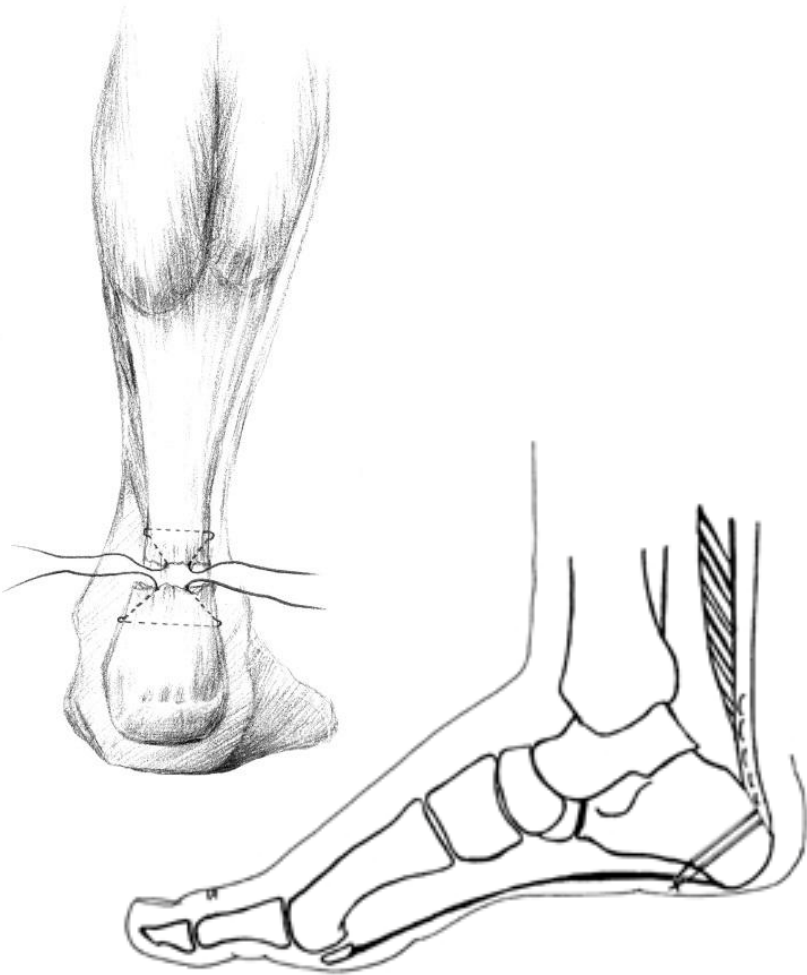
Daniel Fong

October 31, 2022 · 🌐

同班朋友打籃球，打左唔夠一陣就掛彩，就咁原地企係度之嘛咩都無做就咁pop一聲就斷左小腿肌肉，就好似碧咸2010年斷Achilles咁樣，好在係肌肉開端唔係遠端唔係就大鑊了。第二朝去睇醫生，醫生見我描述受傷過程簡而精又中Point，佢做測試我又喻得出D名，知道我食過夜粥，跟住就話我應該都知道來睇醫生無咩嘢好做，問我有咩需要，我話行唔到路返唔到工所以想借拐杖，點知對拐杖唔駛錢租仲唔駛還，永久擁有，不枉我交左咁多年重稅。自己教呢D運動創傷咁多年真係自己親身體驗過先可以達到爐火純青的境界



# Management



- Suture or reattach the Achilles tendon back to calcaneus.



- Walker boot with adjustable plantarflexion angle



- Eccentric exercises

# What is an ankle sprain?



Prof Patrick Yung  
容樹恒教授

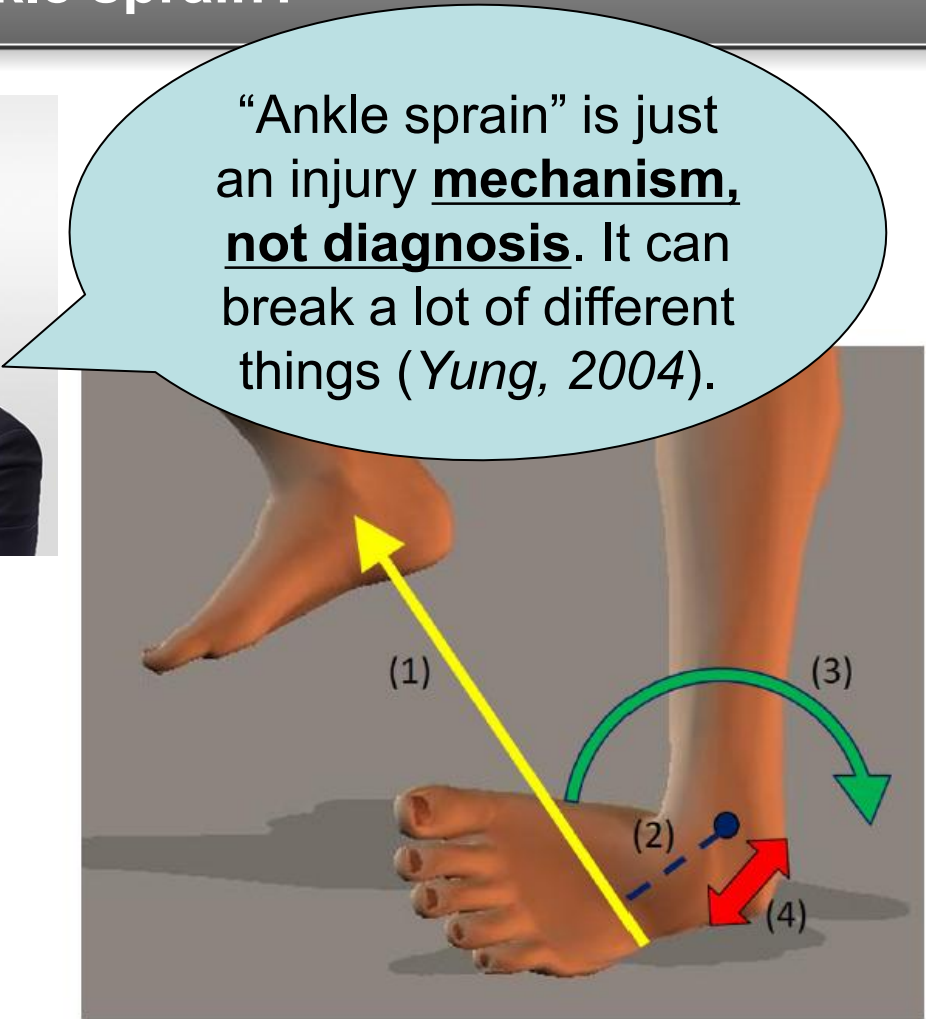
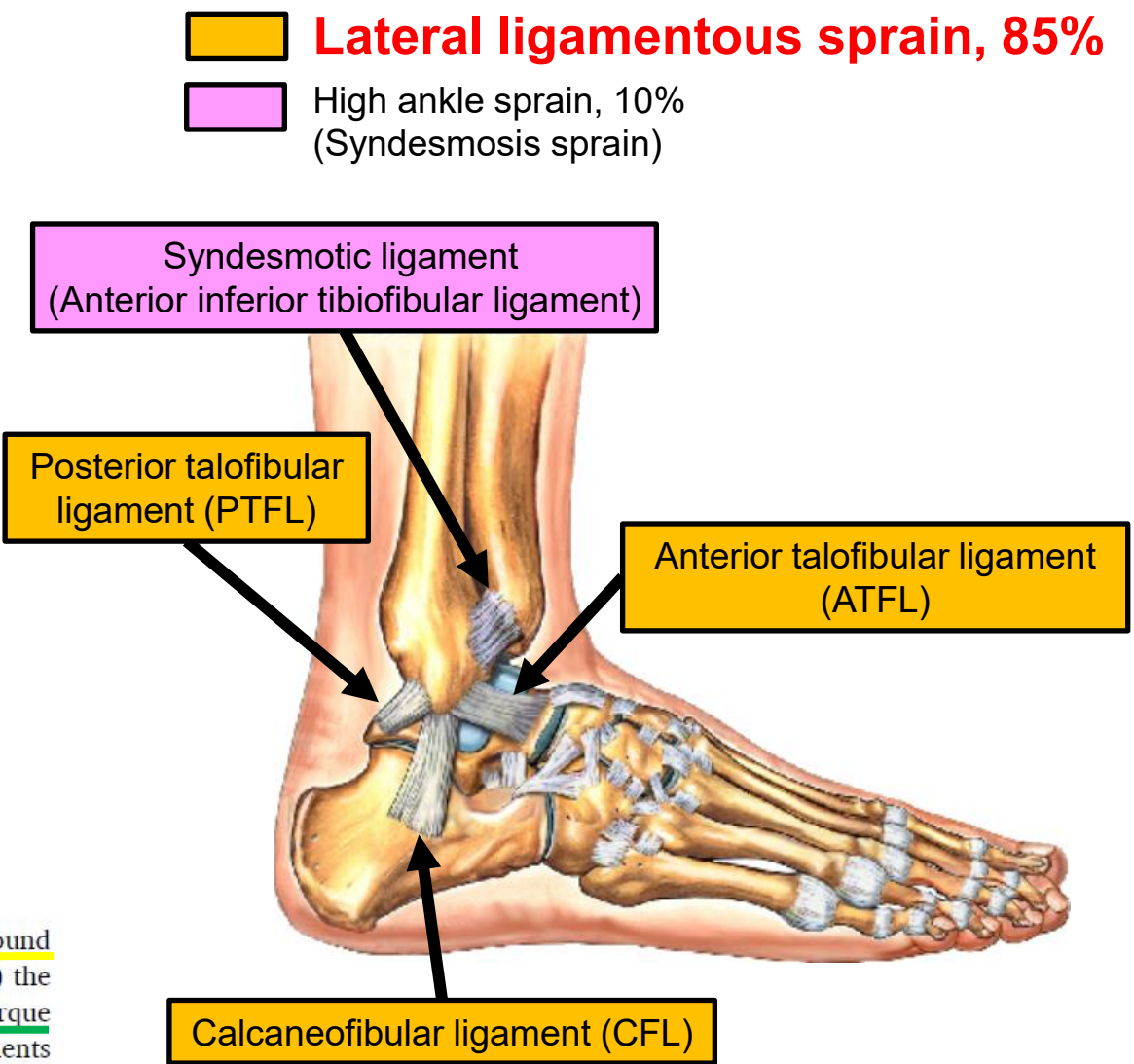


Fig. 3. Sequence of inversion ankle sprain: (1) A medially deviated ground reaction force when the foot strike with an inverted ankle orientation, (2) the presence of a moment arm along the ankle joint centre, (3), a twisting torque generated and created vigorous ankle inversion motion, (4) lateral ligaments being overstretched and sprained. [Mok KM et al (2021), Foot, 48: 101853.]



# Mechanism of ankle sprain injury in football/soccer (qualitative)

What is the mechanism of lateral ankle sprains?

- Sudden twisting, turning, or rolling
- Excessive inversion / supination
- When a plantar-flexed foot is forcefully inverted

## Video Analysis of the Mechanisms for Ankle Injuries in Football

Thor Einar Andersen,\* MD, Tonje Waale Floerenes, stud med, Arni Arnason, MSc, PT, and Roald Bahr, MD, PhD  
*From the Oslo Sports Trauma Research Center, University of Sports and Physical Education, Oslo, Norway*



[Andersen et al, AJSM, 2004, 32(1):S69-79.]

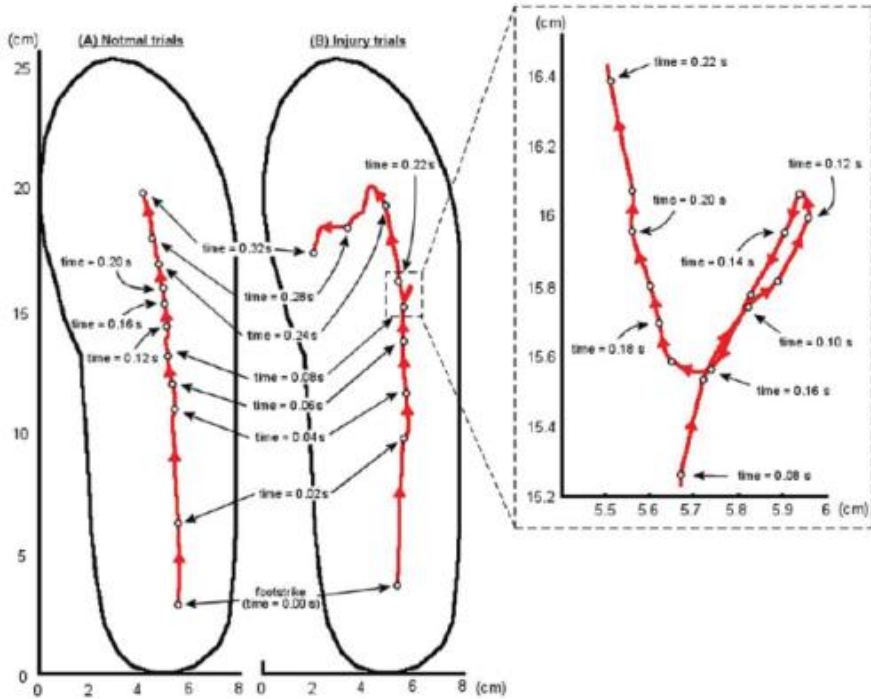
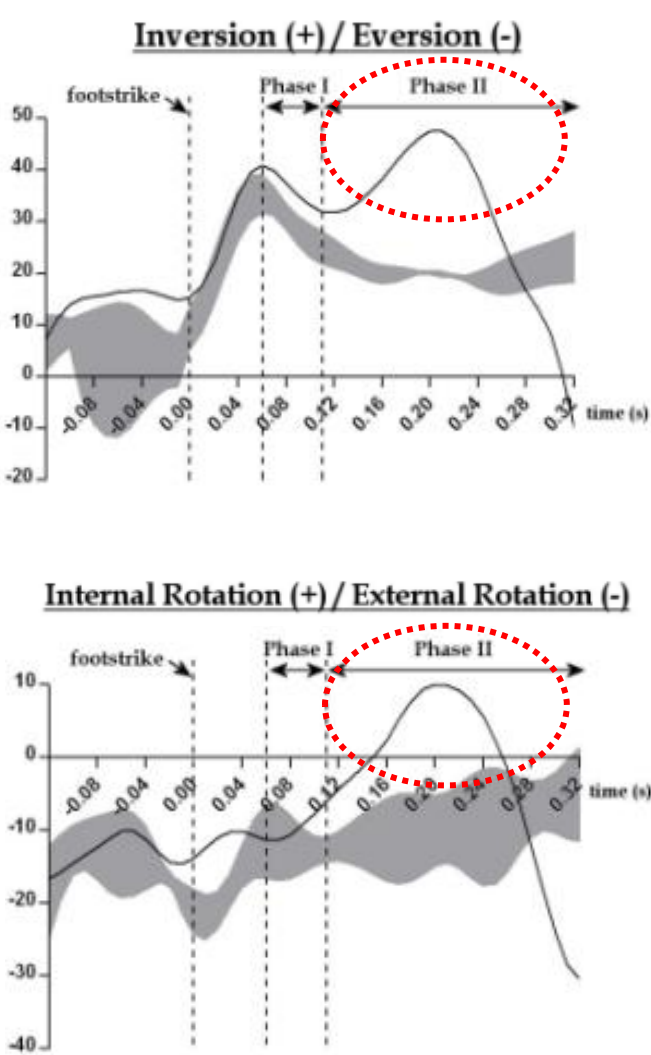
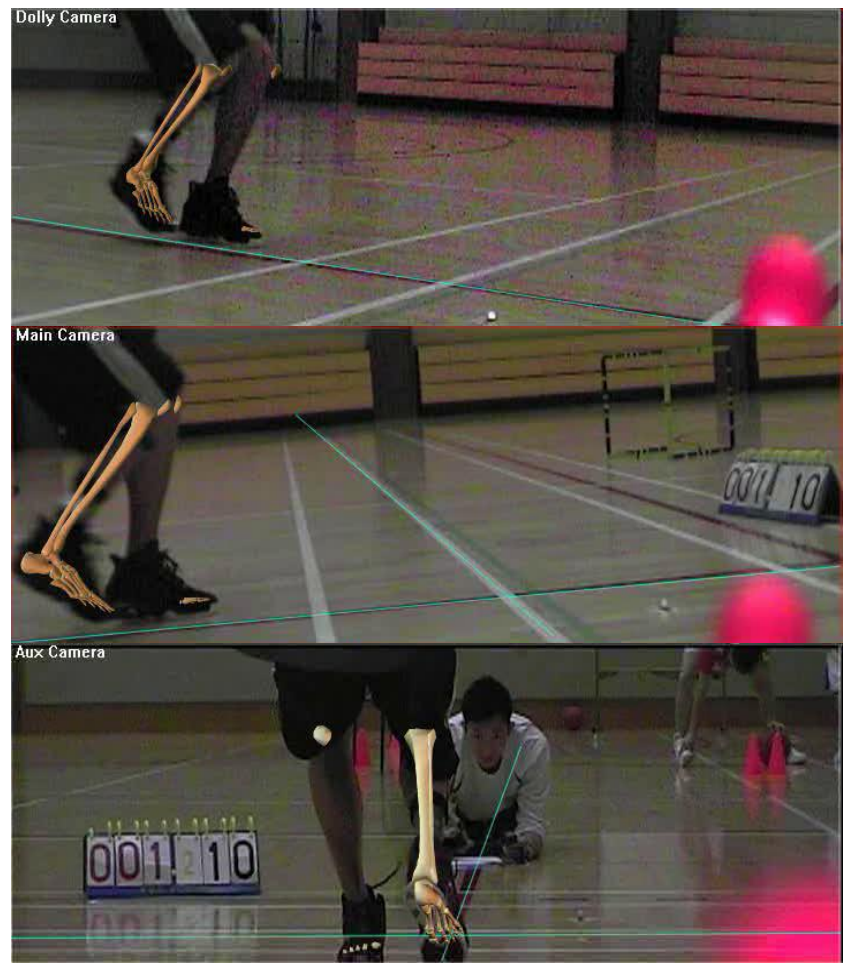


Impact by opponent on the medial aspect of the leg just before or at foot strike, resulting in a laterally directed force causing the player to land with an inverted ankle.



Forced plantarflexion when the injured player hit the opponent's foot when attempting to shoot or clear the ball.

# Ankle inversion sprain mechanism (with quantity)



- 48° inversion and 10° internal rotation. (normal?)
- Peak inversion velocity = 638 deg/s. (speedy motion ruptures the viscoelastic ligaments?)
- Dorsiflexion but not plantarflexion (not supination?)
- Laterally shifted center of plantar pressure. (foot rolling over lateral edge?)

[Fong DTP et al (2009). AJSM, 37(4), 822-827]

# Ankle inversion sprain mechanism (latest update)

SPORTS BIOMECHANICS  
2022, VOL. 21, NO. 4, 359–379  
<https://doi.org/10.1080/14763141.2022.2035801>



OPEN ACCESS

## What have we learnt from quantitative case reports of acute lateral ankle sprains injuries and episodes of ‘giving-way’ of the ankle joint, and what shall we further investigate?

Filip Gertz Lysdal<sup>a,b</sup>, Yuehang Wang<sup>c</sup>, Eamonn Delahunt<sup>d,e</sup>, Dominic Gehring<sup>f</sup>, Kyle B. Kosik<sup>g</sup>, Tron Krosshaug<sup>h</sup>, Yumeng Li<sup>i</sup>, Kam-Ming Mok<sup>j,k</sup>, Kati Pasanen<sup>l,m</sup>, Alexandria Remus<sup>n</sup>, Masafumi Terada<sup>o</sup> and Daniel T. P. Fong<sup>c</sup>



Filip Lysdal



Yuehang Wang  
(Harry 王悅航)



Eamonn  
Delahunt



Dominic  
Gehring



Kyle Kosik



Tron  
Krosshaug



Yumeng Li



Kam-Ming  
Mok



Kati Pasanen



Alexandria  
Remus



Masafumi  
Terada



Daniel Fong

Peak inversion angle of 67.5 deg (2.0 - 142)  
Peak inversion velocity of 974 deg/s (468 - 1752)  
Mean inversion velocity of 337 deg/s (117 - 1400)

## Another injury aetiology (or etiology) – delayed peroneal reaction

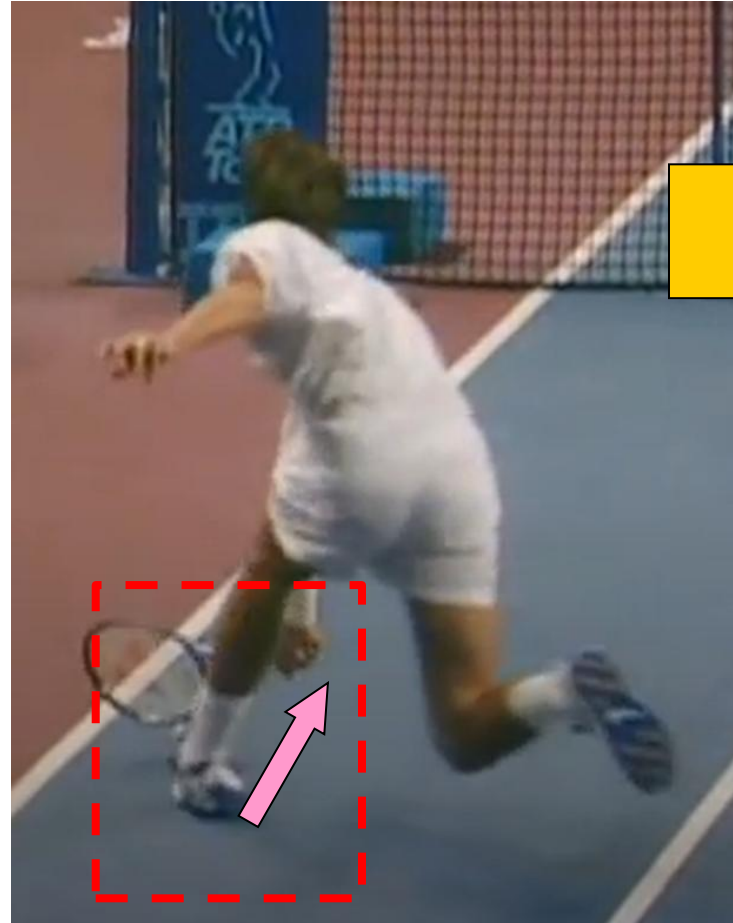
- Ankle sprain happens within **40ms** after touchdown.
- Peroneal reaction time is 57-69ms (healthy) and 82-85ms (instability).
- Eversion torque at 135ms, eversion motion at 176ms.

### The "100-millisecond rule"

The "100-millisecond rule" is a common guideline used in sprinting to determine whether a false start has occurred. According to this rule, **any athlete who reacts within 100 milliseconds of the gun going off is considered to have false started.**

This is because it is believed that a physiological reaction time of less than 100 milliseconds is impossible, and any movement made within this timeframe is likely a result of anticipation rather than a reaction to the gun.

This rule is in place to ensure that all athletes start the race on an even footing and to prevent any advantage gained from an early start.



Incorrect landing  
(non-vertical)

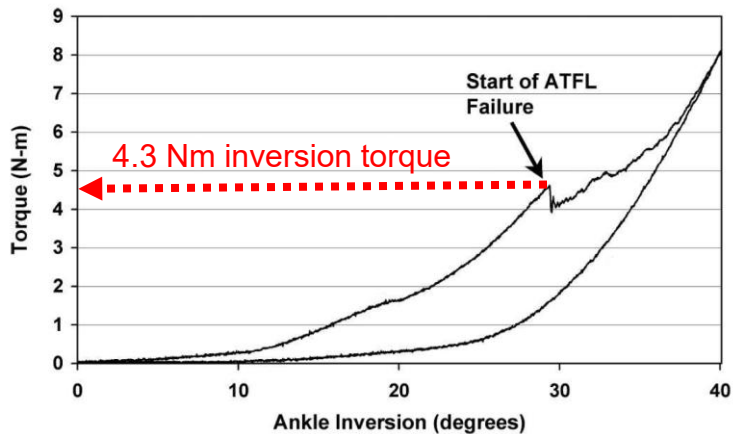
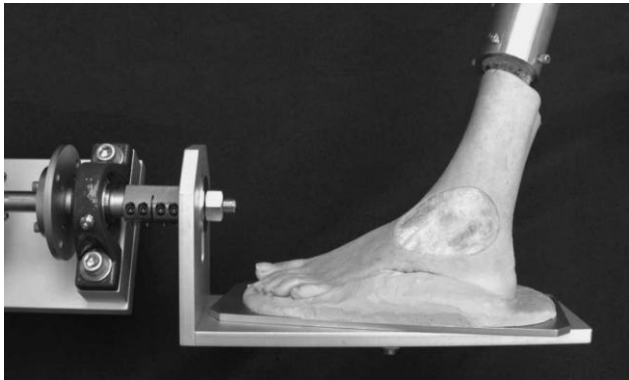


Delayed peroneal reaction

# How much torque would cause ankle lateral ligament rupture?

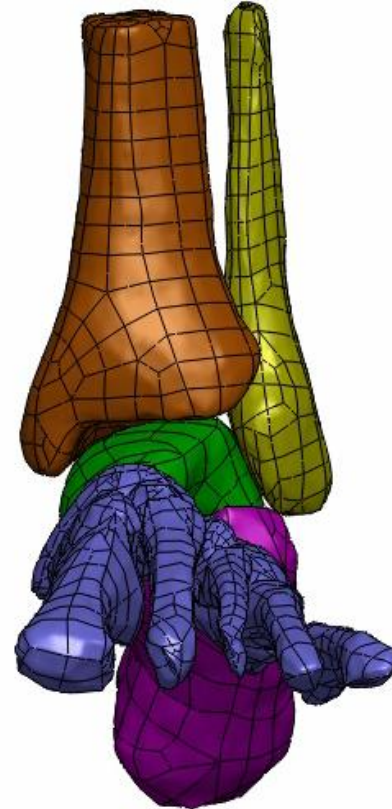
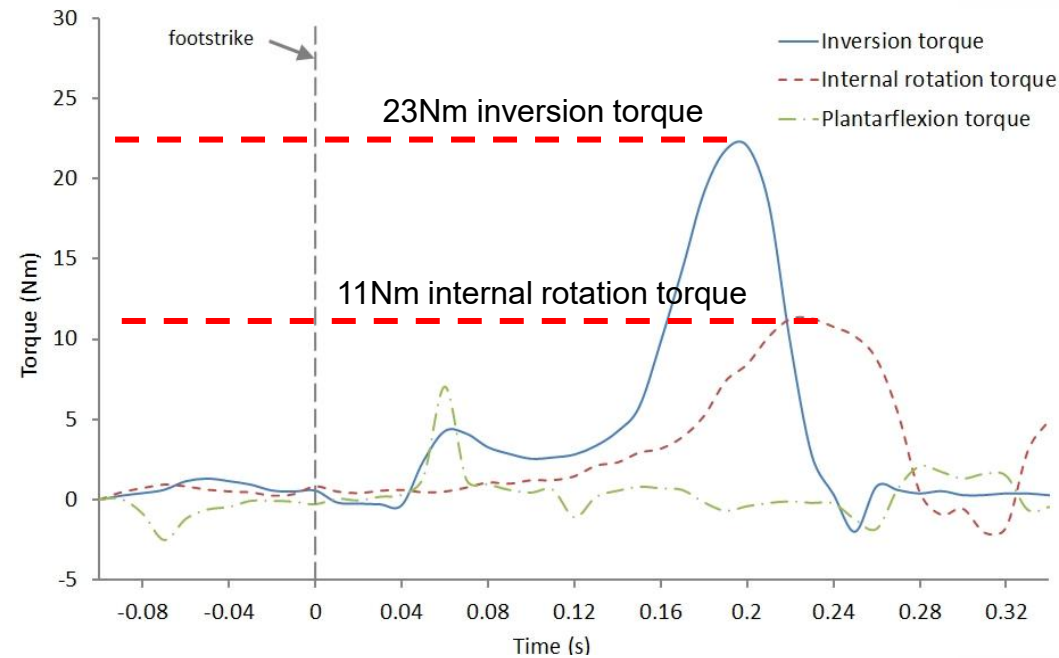
- 4.3Nm start overstretch ATFL.
- 10-12Nm introduce discomfort.
- 41-45Nm cause total rupture.

[Markolf et al, 1989; Aydodan et al, 2006]

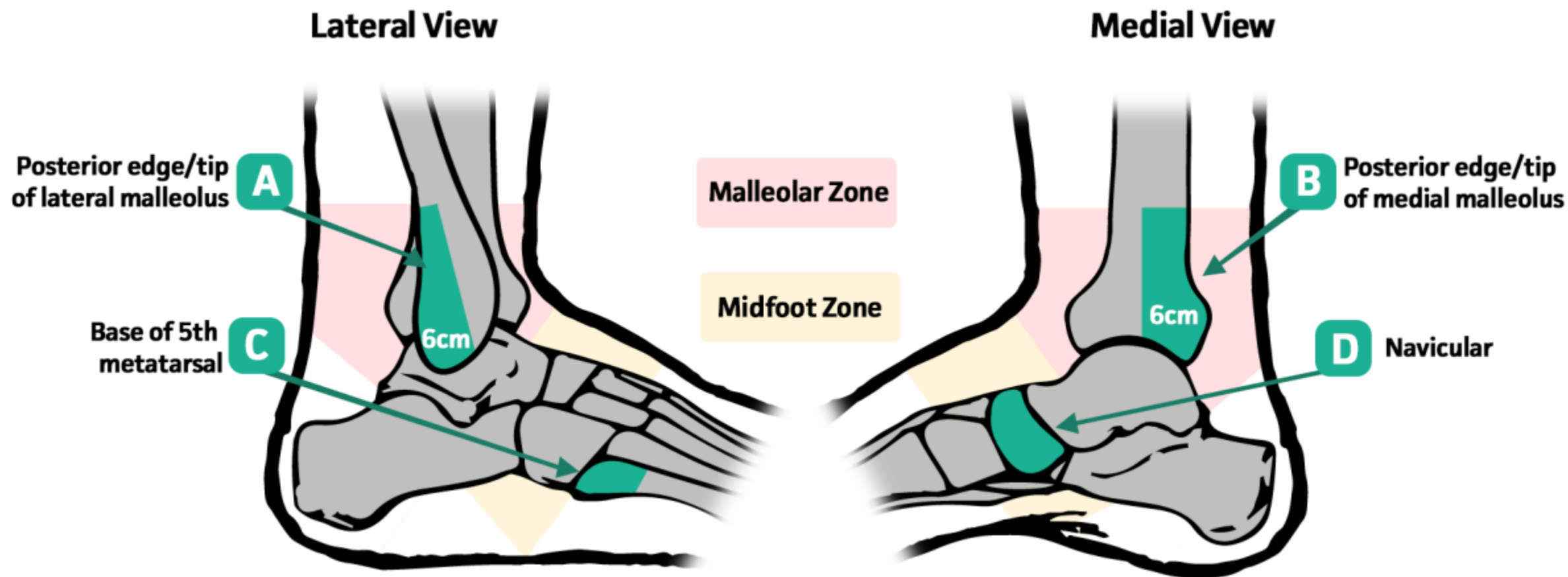


- 11Nm internal rotation torque and 23Nm inversion torque was observed in an injury case.

[Wei F, Fong DTP, et al (2015). Computer Methods in Biomechanics and Biomedical Engineering, 18(3), 243-248.]



# Self-check for possible fractures – Ottawa Ankle Rules



- Inability to bear weight > also need x-ray.
- ~100% Sensitivity, moderate specificity, reduced unnecessary x-rays, less waiting time.
- Better specificity after 5-7 days when swelling is reduced.

# Sensitivity and specificity

|        | Disease                  | No Disease               |
|--------|--------------------------|--------------------------|
| Test + | True Positive (TP)<br>a  | False Positive (FP)<br>b |
| Test - | False Negative (FN)<br>c | True Negative (TN)<br>d  |

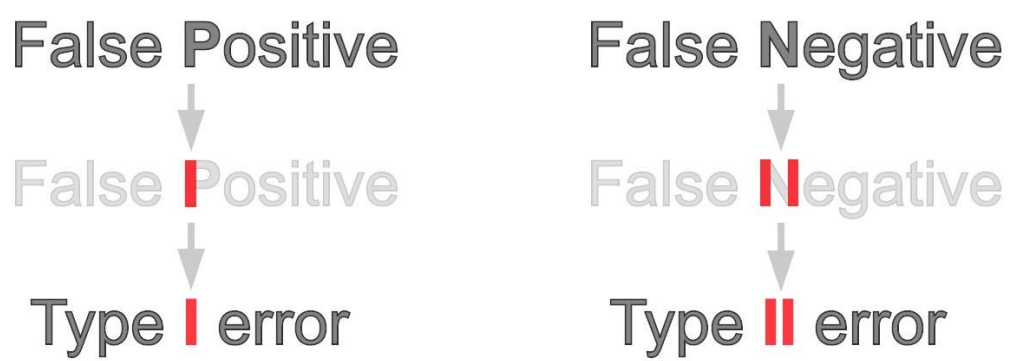
**Type I error** (points to FP)

**Type II error** (points to FN)

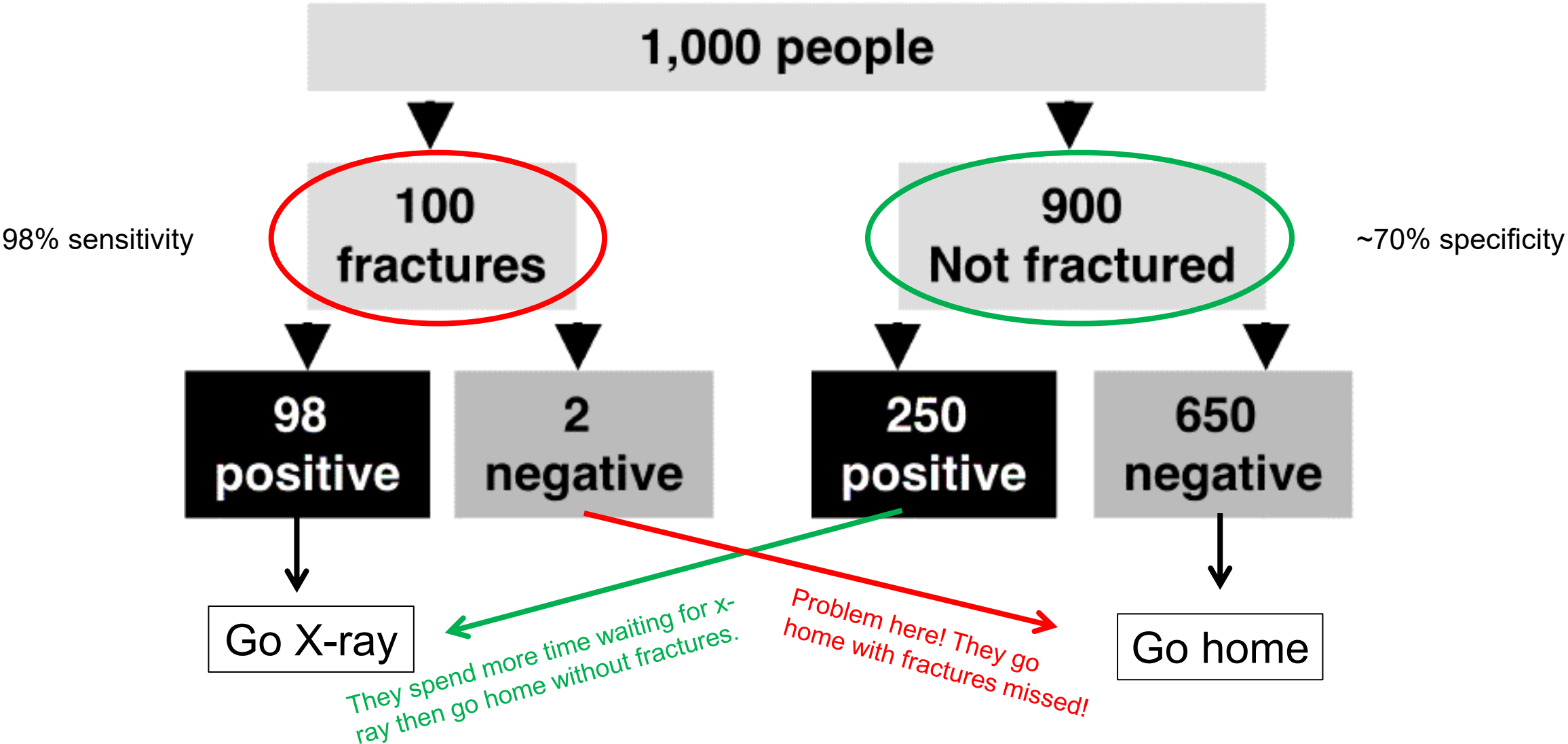
**Sensitivity**  
$$\frac{TP}{TP + FN} = \frac{a}{a + c}$$

**Specificity**  
$$\frac{TN}{TN + FP} = \frac{d}{b + d}$$

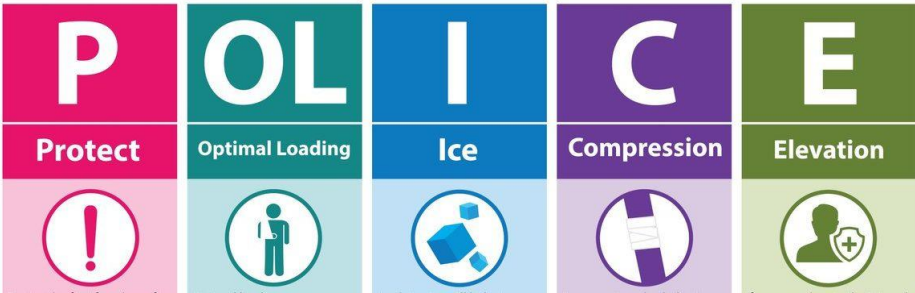
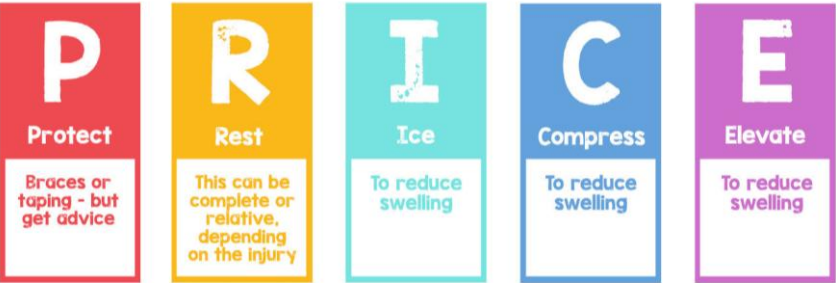
## Type I & type II errors



# Sensitivity and specificity: which one is more important?



# Acute management: RICE, PRICE, POLICE, versus PEACE & LOVE



## Leave the frozen peas on ice! Treating sprains using ice is BAD for you

- Dr Gabe Mirkin came up with the RICE acronym for treating injuries in 1978
- It stands for Rest, Ice, Compression and Elevation but says it could do more harm
- Dr Mirkin says ice could 'delay' healing rather than hastening injury recovery
- He wrote about 22 science articles showing almost no evidence on blog, in 2015
- Now the Chartered Society of Physiotherapy says medics should stop using ice

By PHOEBE ECKERSLEY FOR MAILONLINE  
PUBLISHED: 09:24, 20 October 2019 | UPDATED: 00:07, 21 October 2019



A doctor who wrote the rules on how to treat a sprained ankle has revealed putting ice on the injury does more harm than good.

Dr Gabe Mirkin came up with the RICE acronym in 1978 which became popular for treating muscle soreness and pain.

It stands for Rest, Ice, Compression and Elevation - and said people should put an ice pack on their injuries followed by a compression bandage and then elevate the injury to prevent swelling.

But best-selling author Dr Gabe has now told an Australian newspaper that cold and ice 'delay healing' despite being 'safe pain medicines'.



Dr Gabe Mirkin came up with the RICE acronym for treating injuries in 1978



Daniel Fong  
@dtpfong

Took a friend with a sprained and dislocated ankle to Leicester Royal Infirmary Emergency Department and glad to hear the medical staff advising RICE without ice as the acute treatment. Exactly the way I teach my students. Who can remember the new long acronyms?



# Hamstring strain 大腿肌肉撕裂



- Also called “pulled muscle”.
- Over-elongation, usually contracting (e.g. eccentric).
- Hip flexion plus knee extension, as hamstring spans across these two joints, e.g. clearing hurdles.
- Terminal swing phase in sprinting, forceful kick missing a ball.
- Acute sharp pain. Pop sound/feeling.
- Limp, stop, and fall. Cannot walk afterwards.
- Localised tightness, discolouration, swelling.



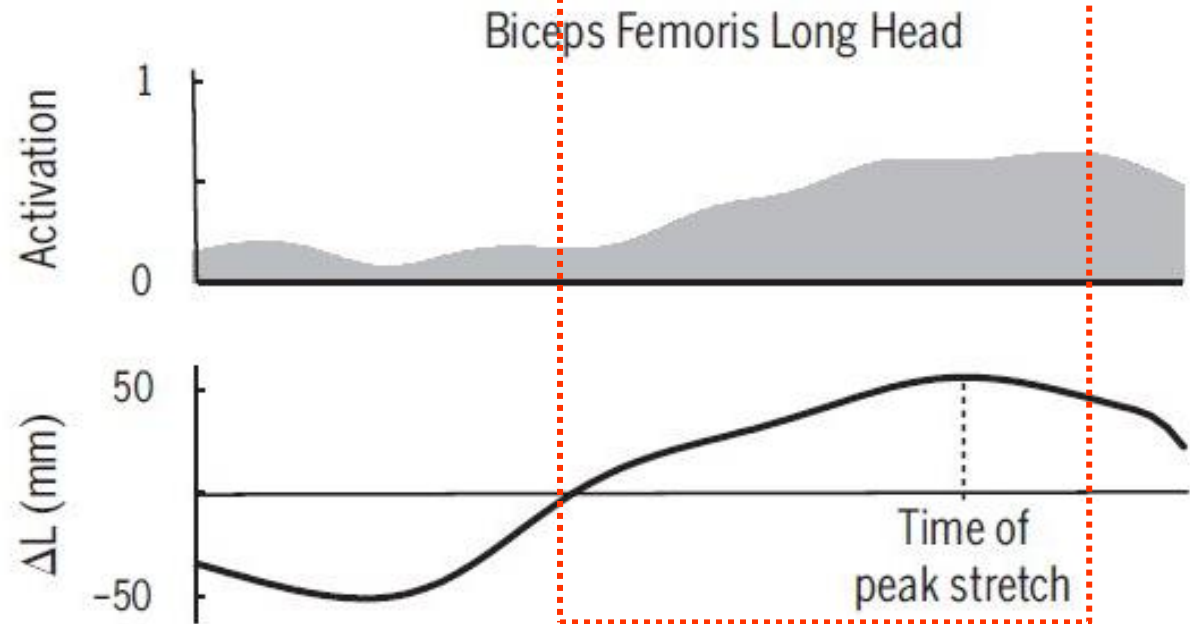
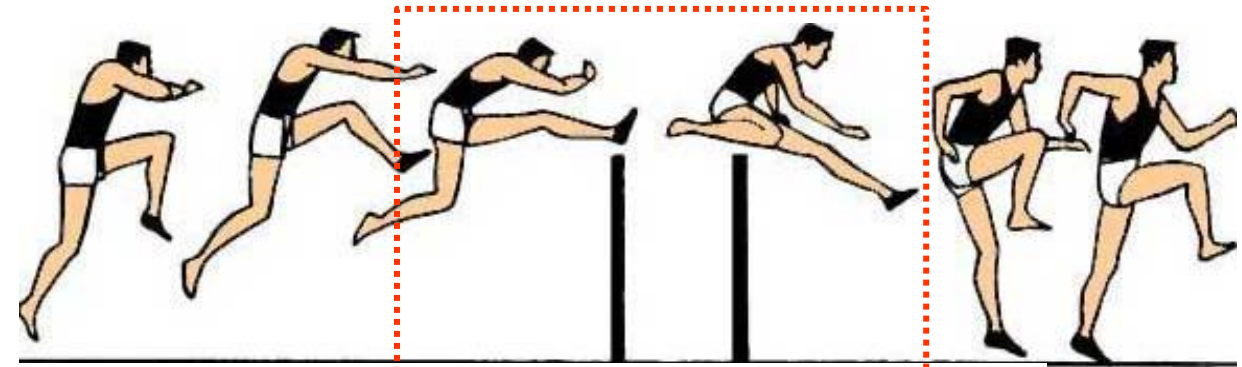
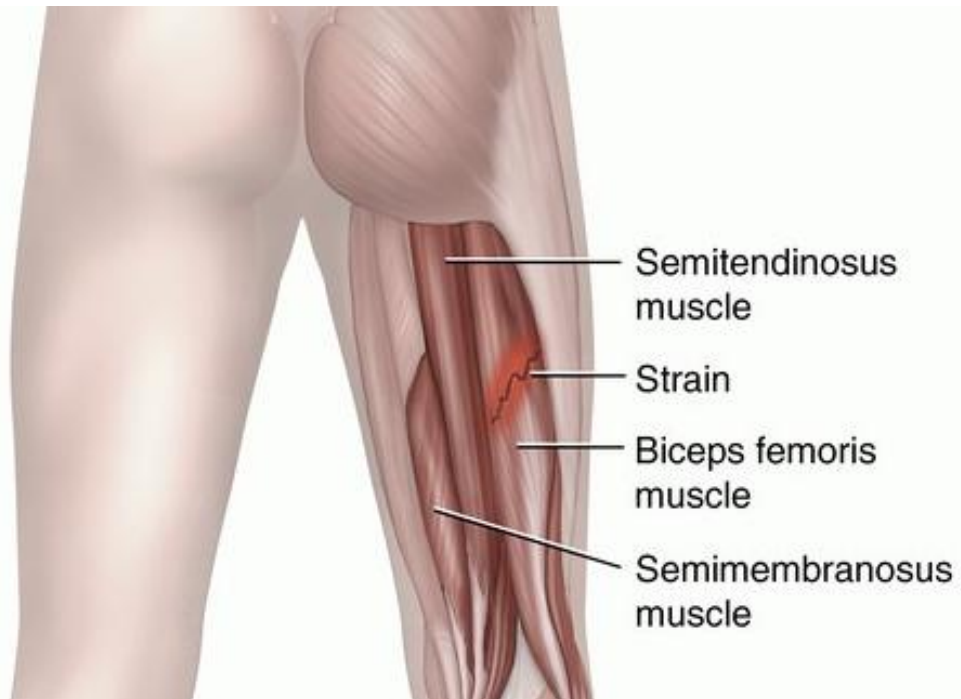
Lolo Jones (Hurdles)



Carlo Cudicini (Football)

# Injury mechanism of pulled hamstring

- Biceps femoris stretches to **110%** of the length in upright standing position.
- Semimembranosus reaches 107.5%.
- Semitendinosus reaches 108.2%.
- Can be longer in the final swing clearing hurdle with maximum knee extension and hip flexion.



Elongation of 50mm (5 cm), or ~110% original length

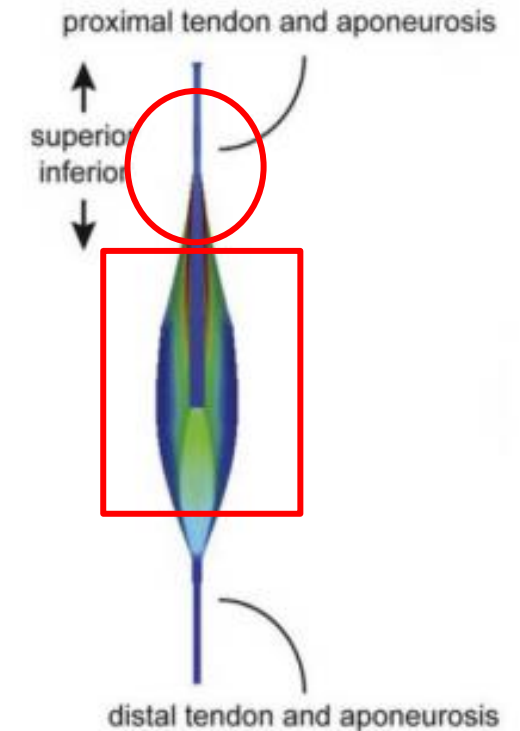
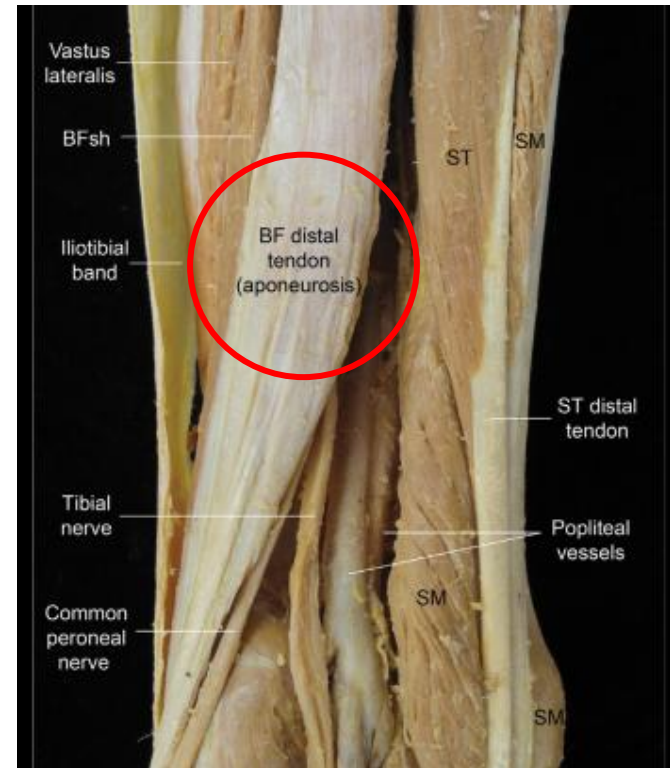
# Jurgen Klopp pulled hamstring while confronting officials (30 Apr 2023)



# Hamstring strain injury risk factor 大腿肌肉撕裂風險因子

| Intrinsic                                           | Extrinsic          |
|-----------------------------------------------------|--------------------|
| Previous hamstring strain injury                    | Inadequate warm-up |
| Agonist-antagonist strength imbalance (H:Q ratio)   | Fatigue            |
| Bilateral asymmetry (one significantly weaker limb) | Dehydration        |
| Lack of flexibility                                 |                    |
| Older age                                           |                    |
| Hamstring muscle weakness                           |                    |
| Ethnicity (Black African, Caribbean)                |                    |

- A meta-analysis on 34 studies identified older age, previous history of hamstring strain, and increased quadriceps peak torque as risk factors.
- Hamstring:Quadriceps strength ratio was not associated.  
(Freckleton & Pizzari, 2013)



- Aponeurosis is a layer of flat broad tendons.
- High variability of size, not related to muscle size and strength.
- Large muscle with small aponeurosis is suggested as a risk factor, as the mechanical strain is concentrated to a small area.

(Evangelidis et al, 2015)

## Eccentric exercise for hamstring 大腿離心運動 (收縮+拉長)

Nordic hamstring curl



# Anterior cruciate ligament / meniscus tear 前十字/交叉韌帶及半月板撕裂

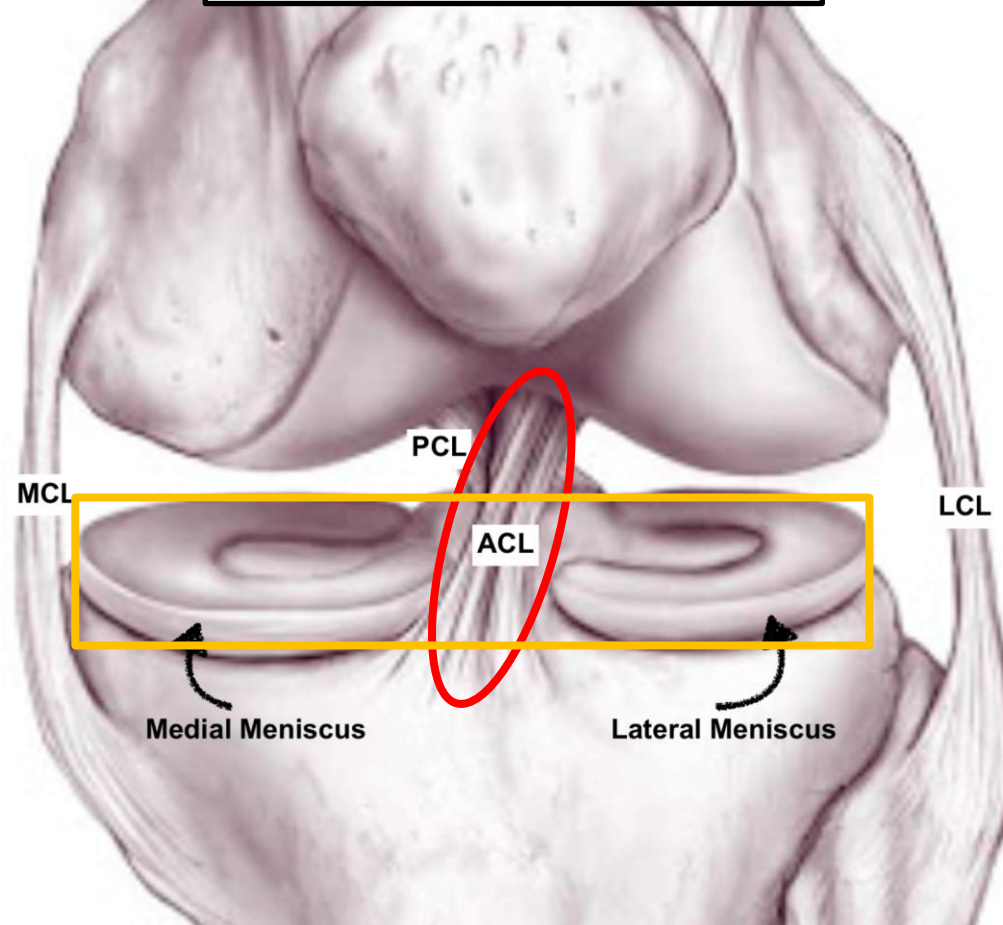
## Anterior cruciate ligament



**Michael Owen, English Footballer**  
ACL Rupture during World Cup 2006

- Internal 'brace'
- Anterior stability
- Rotational stability

## Left knee, front view



## Meniscus



**Ka-Ho Cheng, Hong Kong Wushu Athlete**  
Injury during practice, 19 Oct 2005

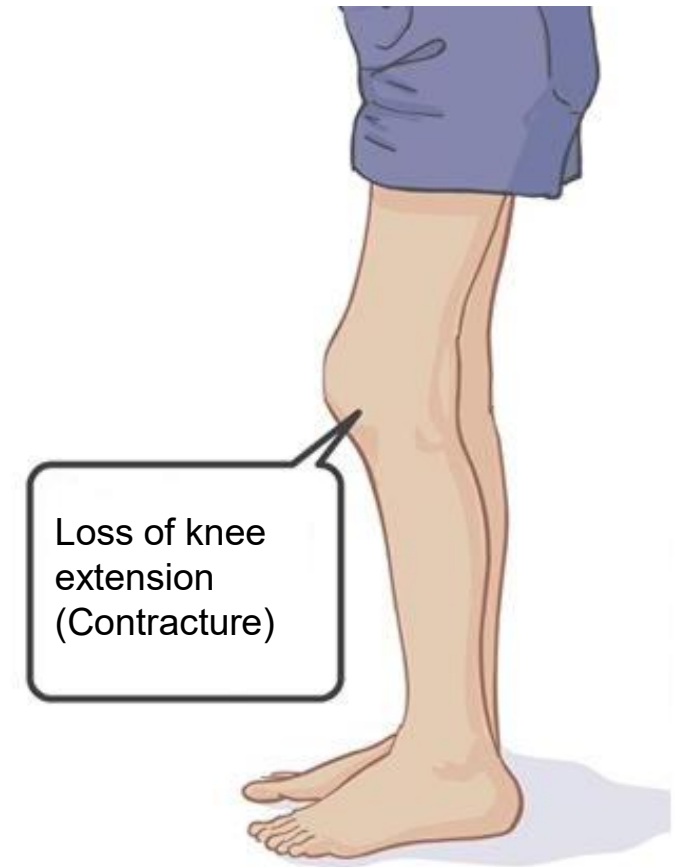
- Internal cushion
- Maintain even pressure distribution
- Protect cartilage

# Common symptoms 常見病徵

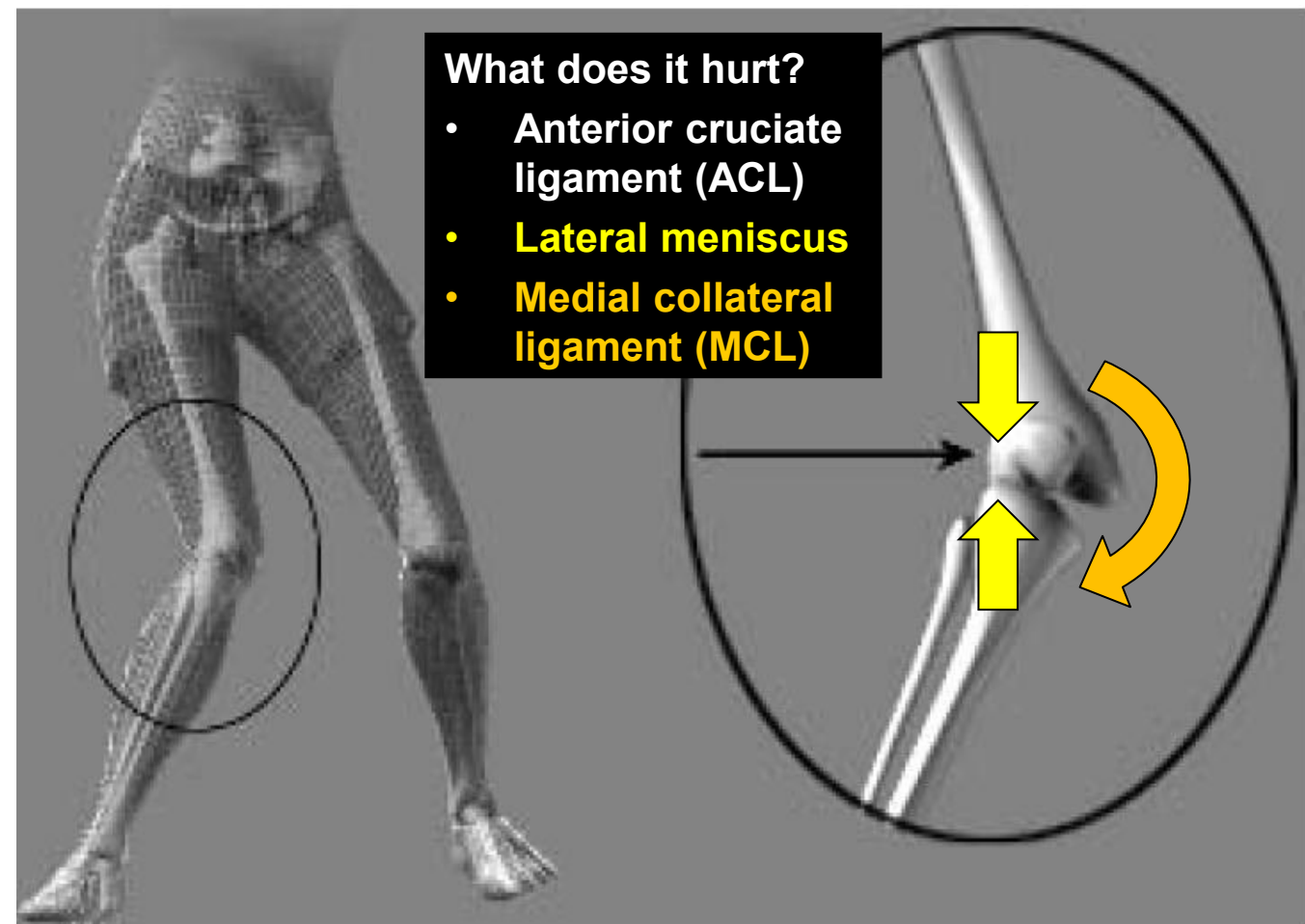
- Intensive pain
- Locking of the joint
- Reduced range of motion (contracture)
- Usually with an acute inciting event
- Feel or “hear” a pop sound during the injury
- Cannot continue to play
- Anterior tibial translation
- 75% of patients would have severe haemarthrosis (internal bleeding)
- Immediate swelling (~ 2 hours) indicates possible ACL injury
- Swelling in 24+ hours > Meniscus? (less blood supply to meniscus)



- !!! If the knee **cannot fully extend**, need early treatment, or may suffer from long-term loss of full extension.



# Injury mechanism (non-contact) 受傷機制 (非接觸式)



(Hewett & Myer 2006, American Journal of Sports Medicine, 34(2):299-311)

## Injury mechanism (contact) 受傷機制 (接觸式)

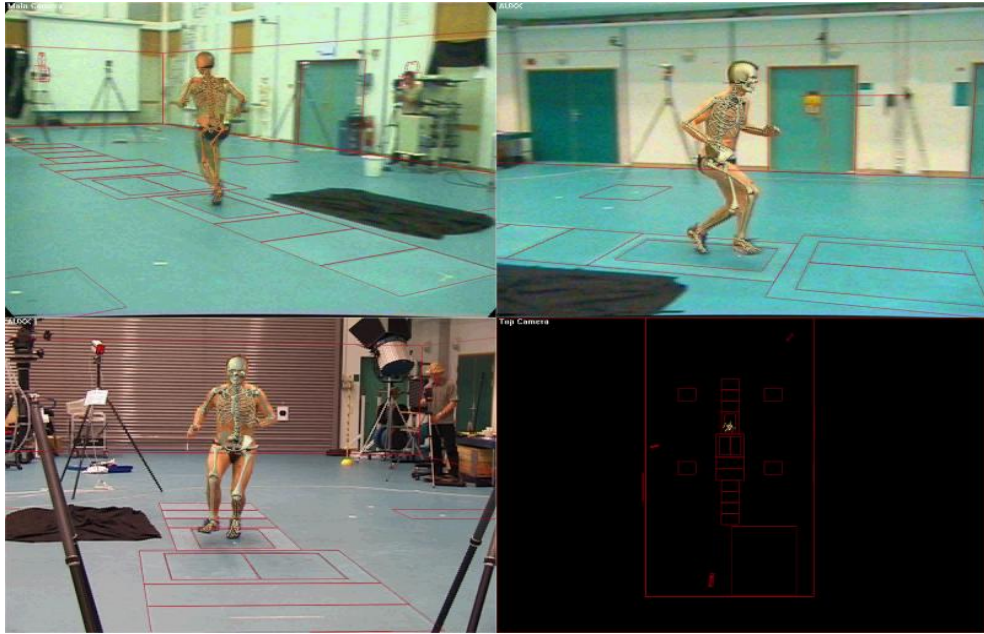


- Virgil van Dijk rupturing ACL during a premier league football match in 2021



- Abbey D'Agostino rupturing ACL during 2016 Rio Olympics 5000m race

# A Model-Based Image-Matching (MBIM) methods to study mechanism



Tron Krosshaug

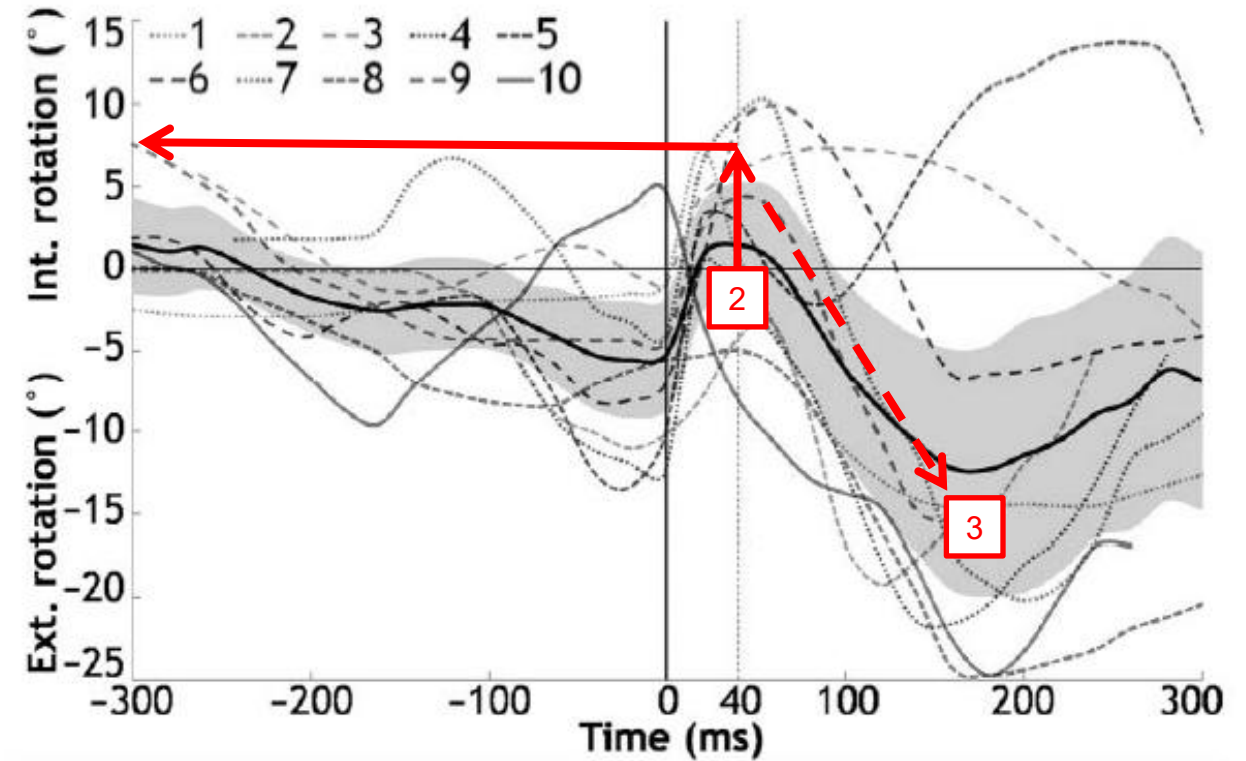
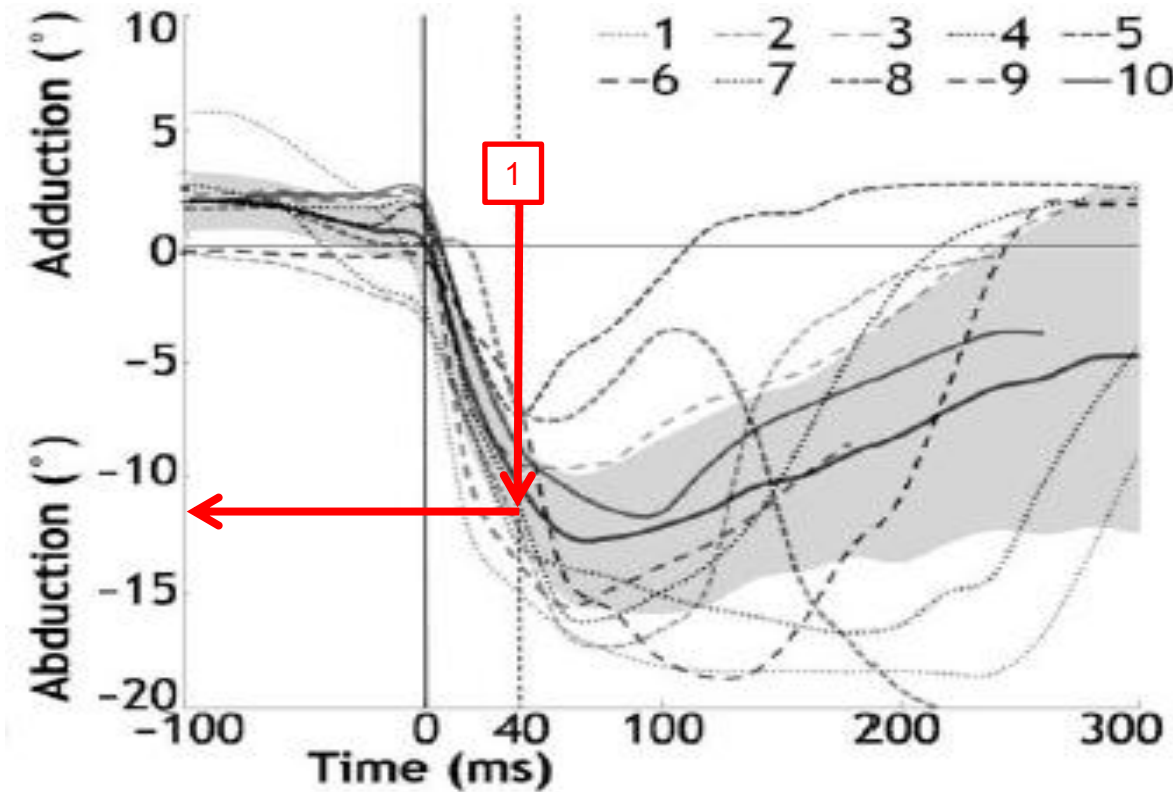


Roald Bahr



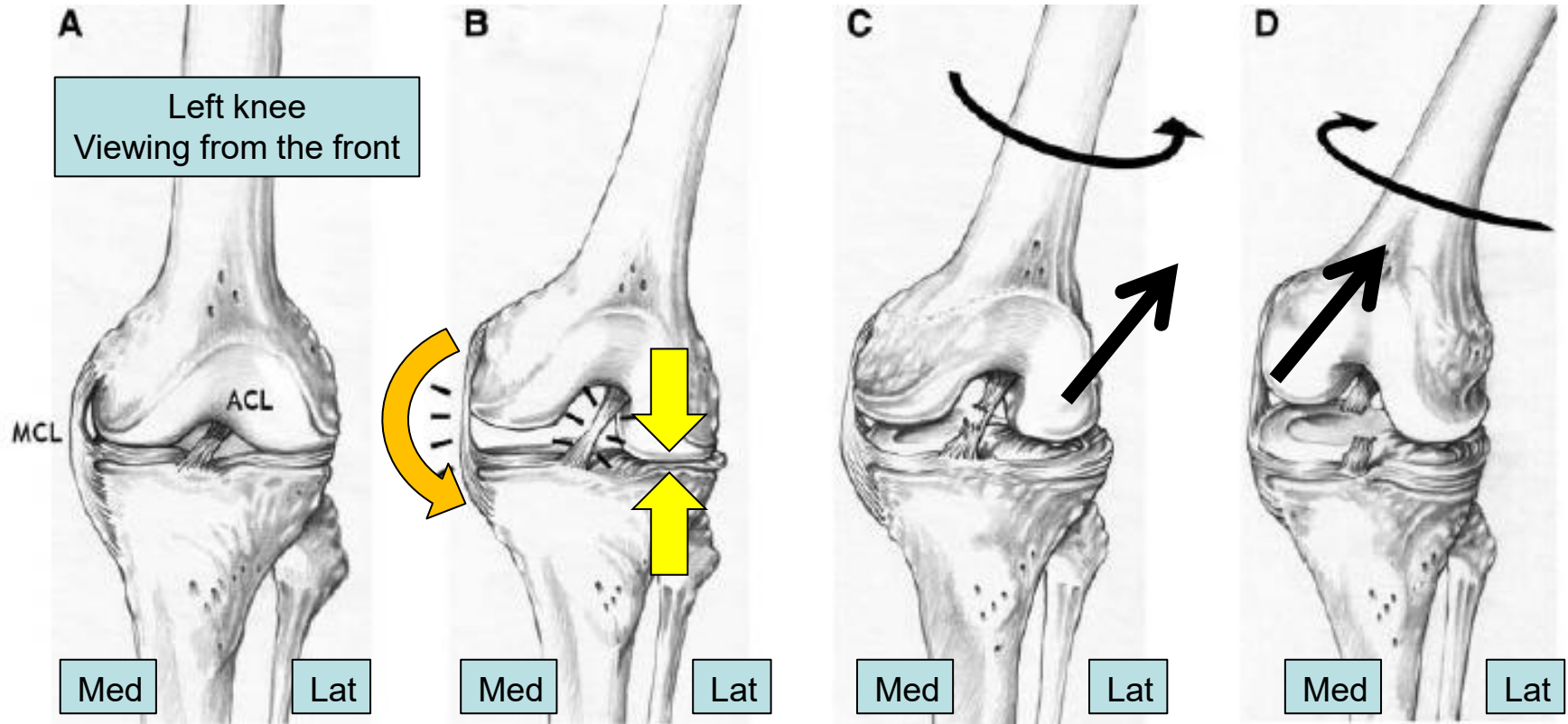
Prof Hideyuki Koga  
古賀英之教授

# Findings from 10 cases in handball and basketball



(1) 10-13° abduction (valgus) at 40ms. (2) 8° internal rotation at 40ms. (3) 17° external rotation afterwards

# ACL injury mechanism as suggested by Hideyuki Koga (2011)



A. Unloaded knee.

B. **Valgus (abduction)** torque stressed MCL and compresses lateral meniscus.

C. The compression and quadriceps contraction cause posterior translation of lateral femoral condyle (tibial **internal rotation**) and rupture the ACL in the first 40ms. (the cause?)

D. Without ACL's contribution to the joint stability, medial femoral condyle translated posteriorly, resulting in tibial **external rotation** after 40ms until 170ms. (the result?)

# Physical examination 臨床検査



Lachman test



Anterior drawer test



Pivot shift test



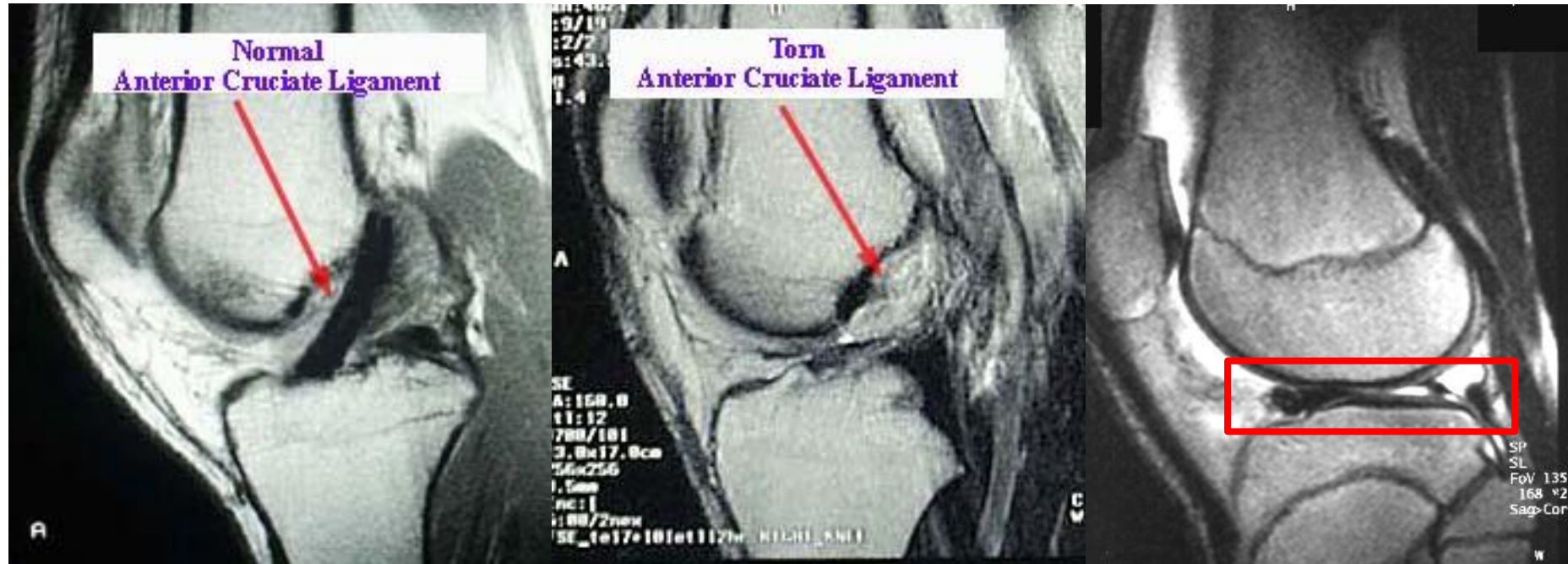
McMurray test

# Is it necessary to have X-Ray and MRI? 是否需要照X光或磁力共振顯影?



**X-ray**

- Mainly for fracture
- Cannot see soft tissues

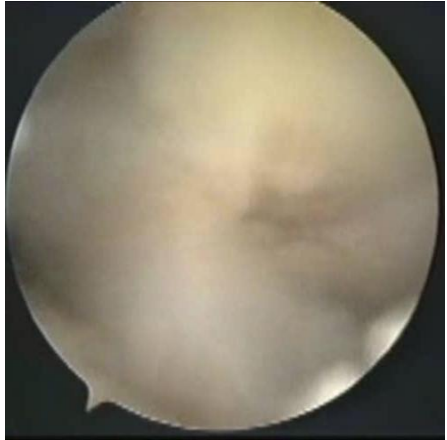


**Magnetic Resonance Imaging (MRI)**

Normal: solid black band showing the intact ACL

Torn: Disrupted ligament or patterns in lighter colour.

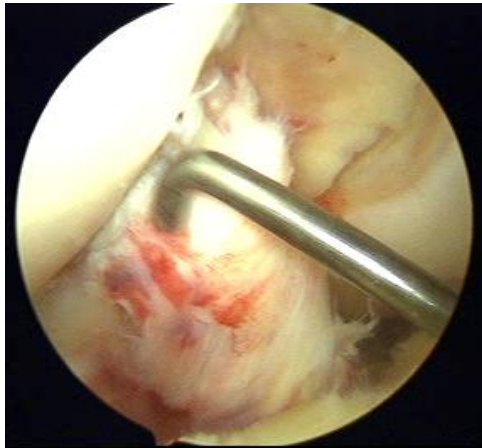
# Arthroscopy for diagnosis/treatment 使用關節鏡進行診斷及治療



Intact ACL



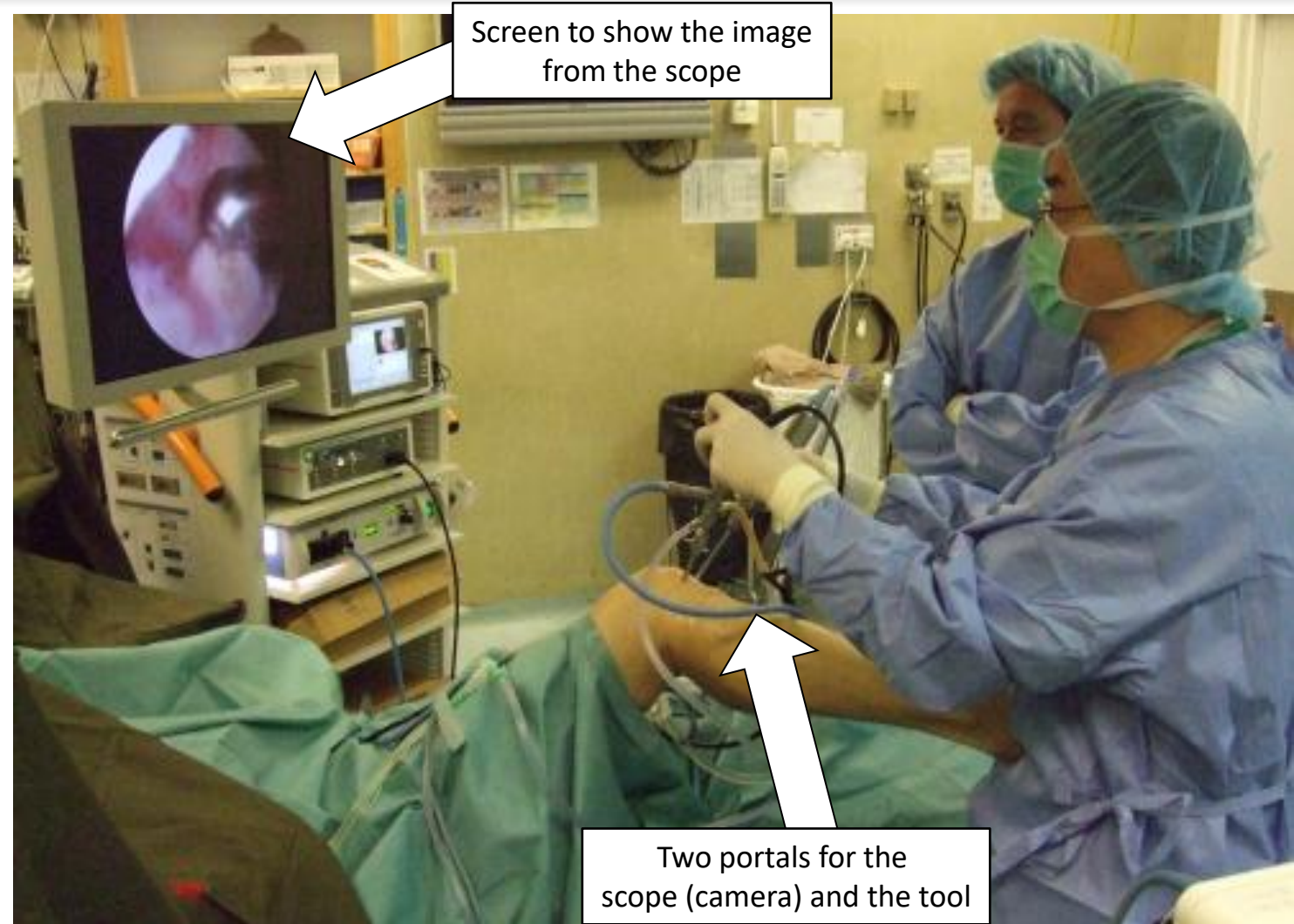
Partial tear



Partial tear



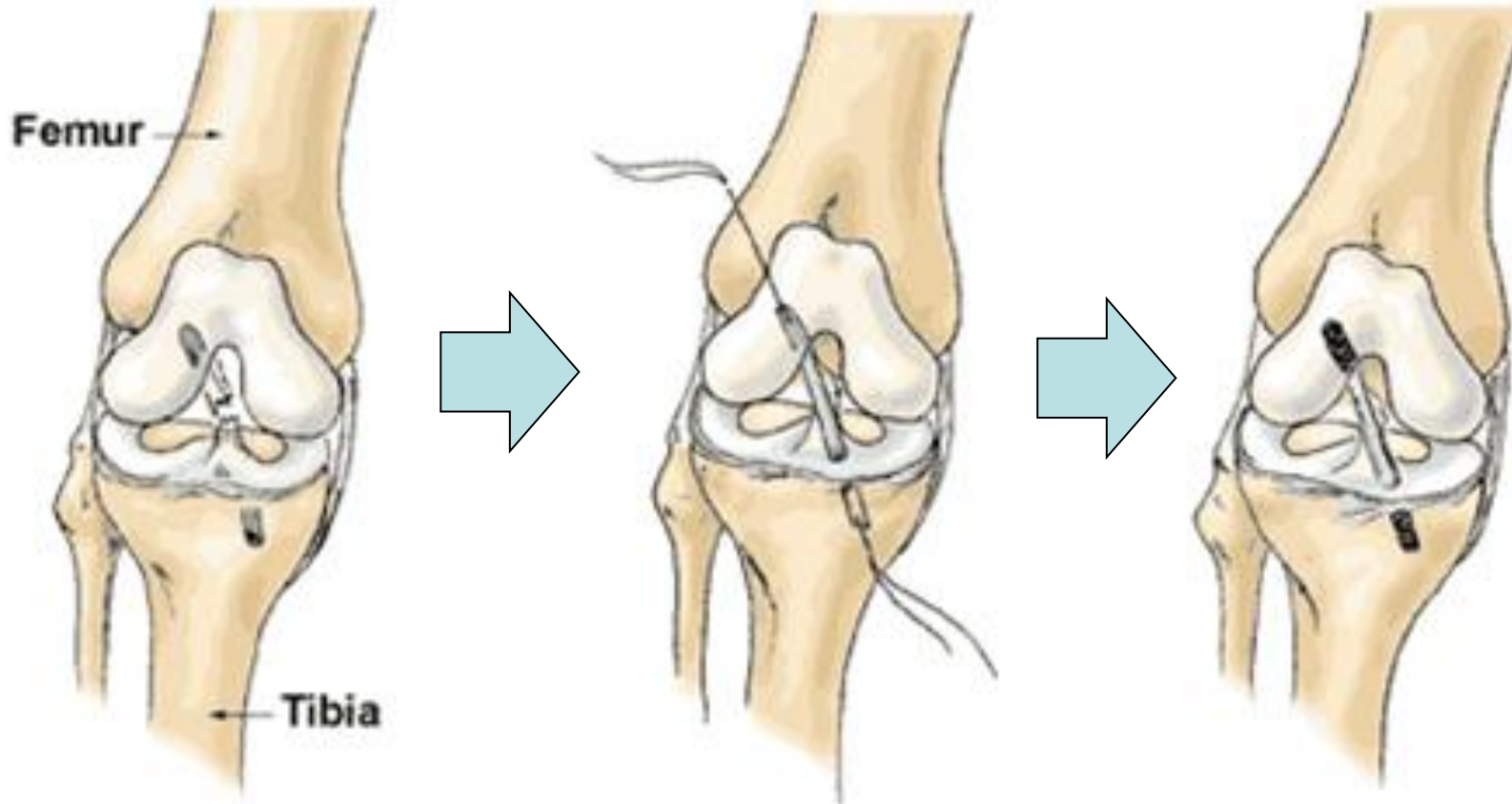
Partial meniscectomy



Screen to show the image from the scope

Two portals for the scope (camera) and the tool

# ACL reconstruction 前十字韌帶重建手術



## Considerations

- Age
- Severity of injury
- Current/future sports level
- Acceptance to surgery
- Compliance to rehabilitation
- Surgeon's expertise
- Use of braces/tapes
- Changes to other sports

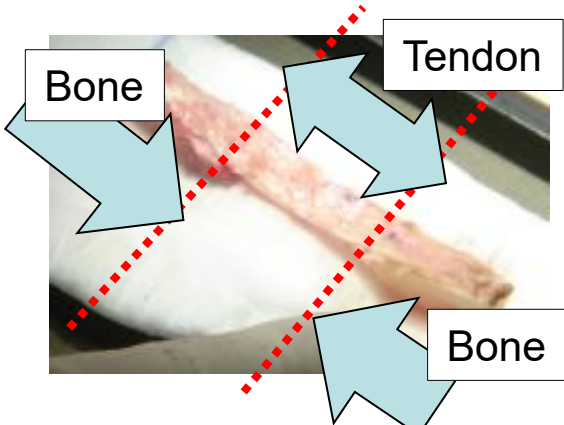
- Remove the torn ACL
- Drill tunnels at femur / tibia
- Pass the graft through the tunnels
- Fix the graft with screws

# ACL reconstruction graft choice 前十字韌帶重建替代物的選擇

- **Autograft:** a site to another, same patient.
- **Allograft:** one person to the patient.
- **Xenograft:** from one species to another.



- ~100% of ACL strength
- Graft is bigger
- Bone at one side
- Patellar strength down to 80%
- Less harm to H/Q strength ratio?



- ~140% of ACL strength, good healing

Quad-Patella Bone (Autograft)



3

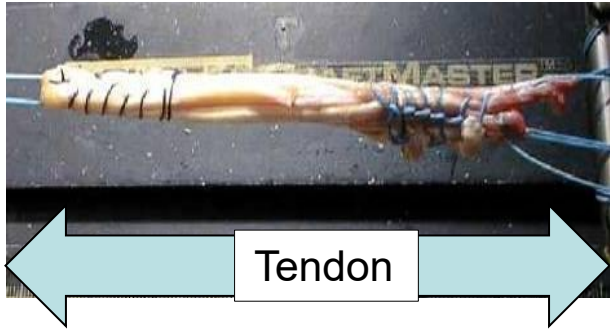
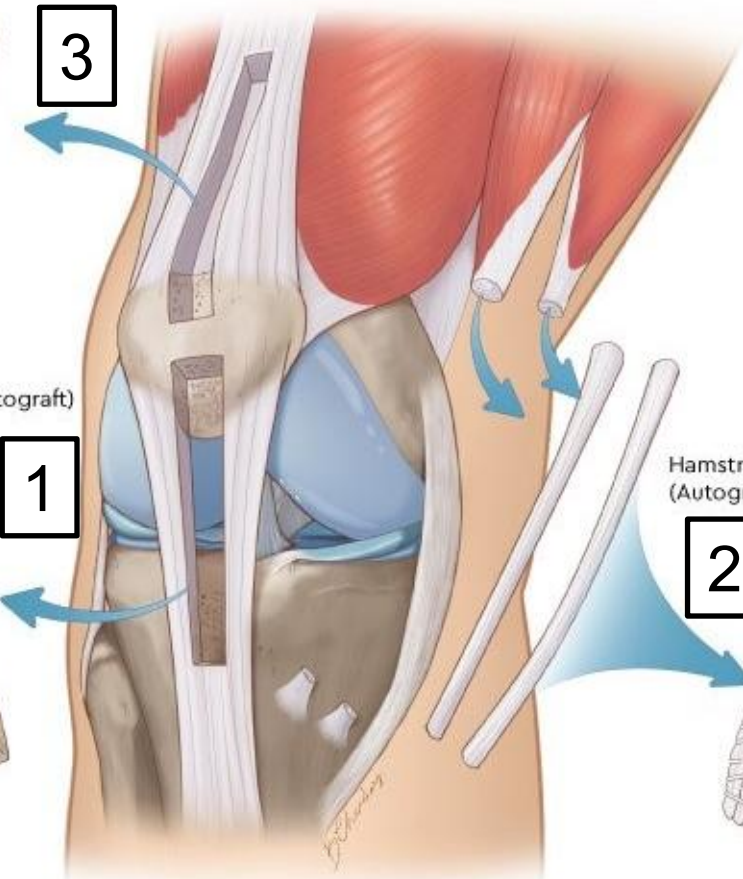
Patellar Tendon (Autograft)



1

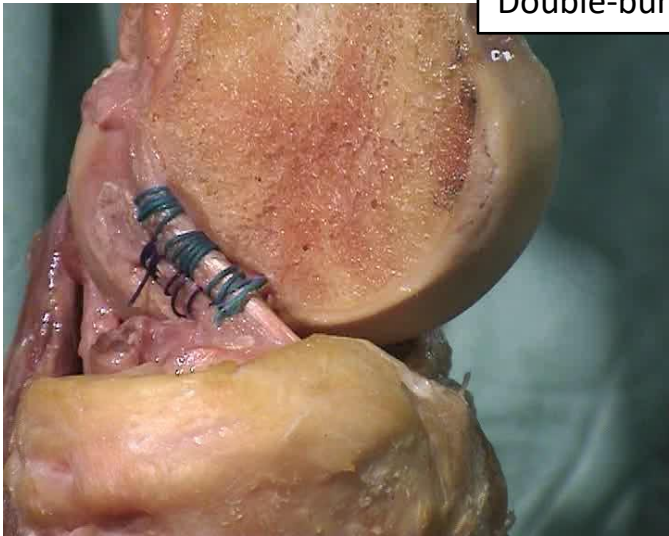
Hamstring Tendons (Autograft)

2



- ~70% of ACL strength, healing is less promising

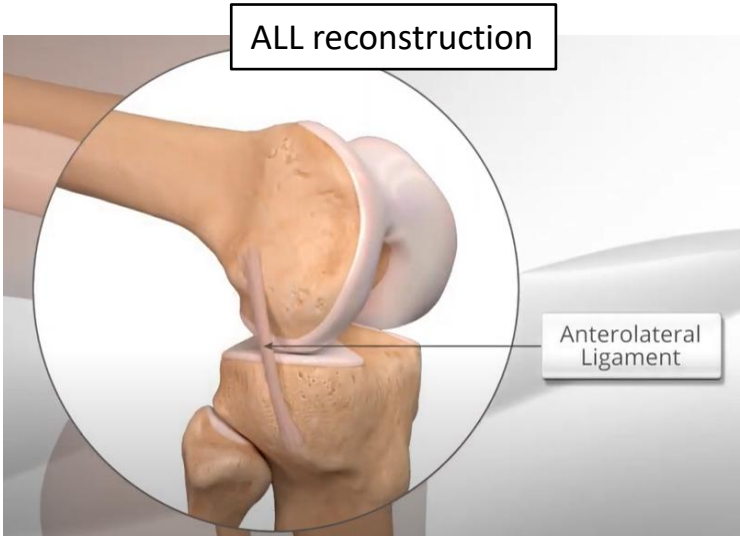
# Double-bundle/ALL/Kangaroo tendon? 雙束前十字韌帶/ALL/袋鼠肌腱?



Double-bundle ACL reconstruction

| Why has DB ACL-R been faded away? |                                    |                  |                                                                      |                    |               |
|-----------------------------------|------------------------------------|------------------|----------------------------------------------------------------------|--------------------|---------------|
| After 2010,                       |                                    |                  |                                                                      |                    |               |
| Year                              | Paper                              | Group            | Geography                                                            | Double bundle      | Single bundle |
| 2011                              | Chechik O, et al., Int Orthop 2012 | AAOS & EFORT     | 53% - Europe<br>23% - USA<br>7% - Asia<br>17% - Others               | 33%                | 67%           |
| 2014                              | Lee YDH, et al. AP-SMART 2014      | Magellan society | 33% -Europe<br>42%-USA & Canada<br>21% - Asia Pacific<br>4% - Others | 3% DB or SB<br>22% | 75%           |
| 2019                              | Vascellari A, et al. KSSTA. 2020   | ESSKA            | 63% - Europe<br>37% - Others                                         | 8%                 | 92%           |

➤ Double bundle ↓ Single bundle↑

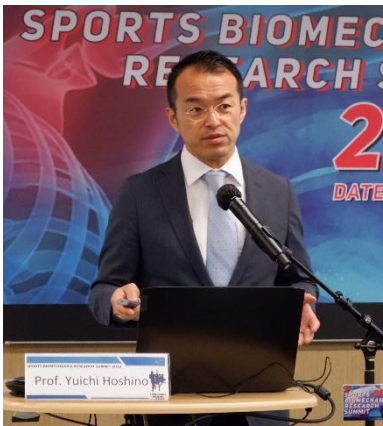


ALL reconstruction

Anterolateral Ligament



- Double-bundle ACL reconstruction proposed by Freddie Fu (傅浩強) from Pittsburgh.



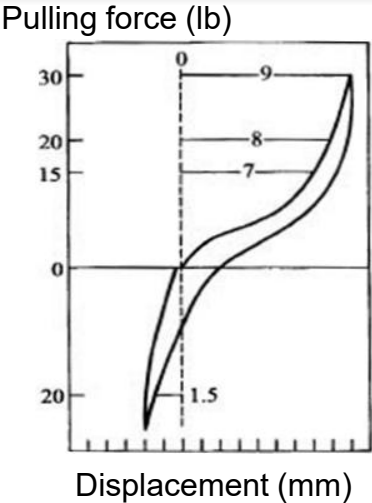
Yuichi Hoshino:

- Technical difficulty.
- Not much additional benefits.
- Double donor site morbidity.

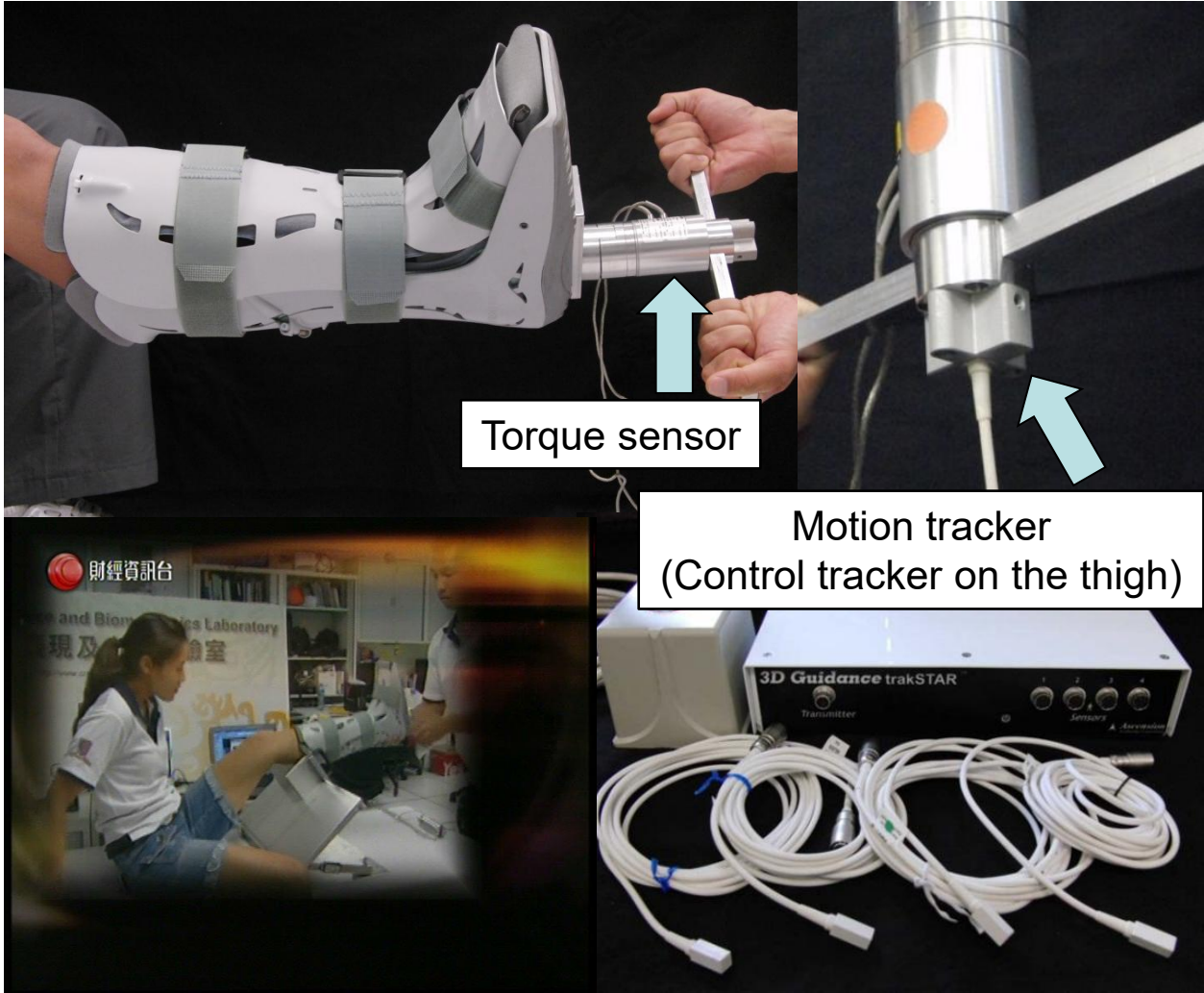
Use of Kangaroo tendon for ACL reconstruction



# Static translational / rotational stability in living human patients

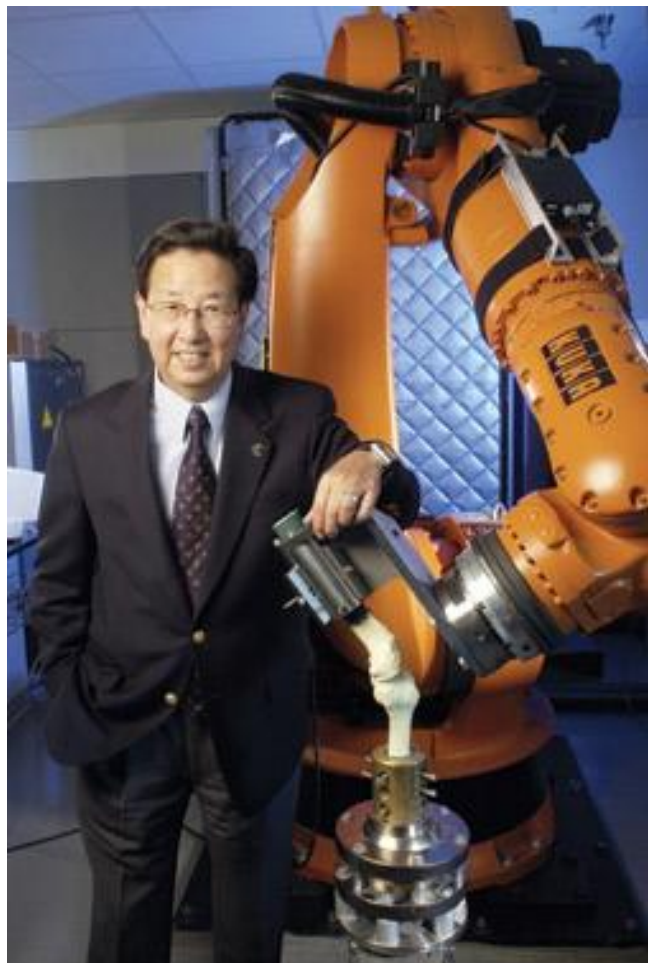


Knee Ligament Arthrometer KT1000/KT2000



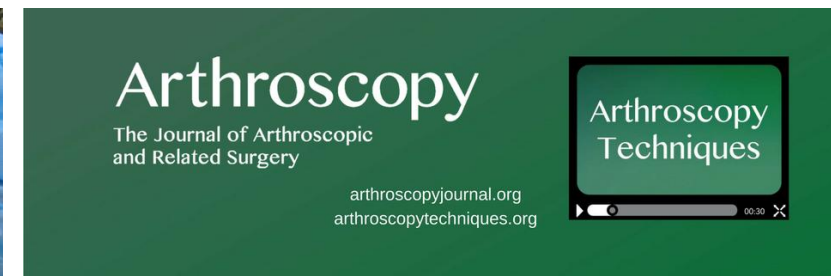
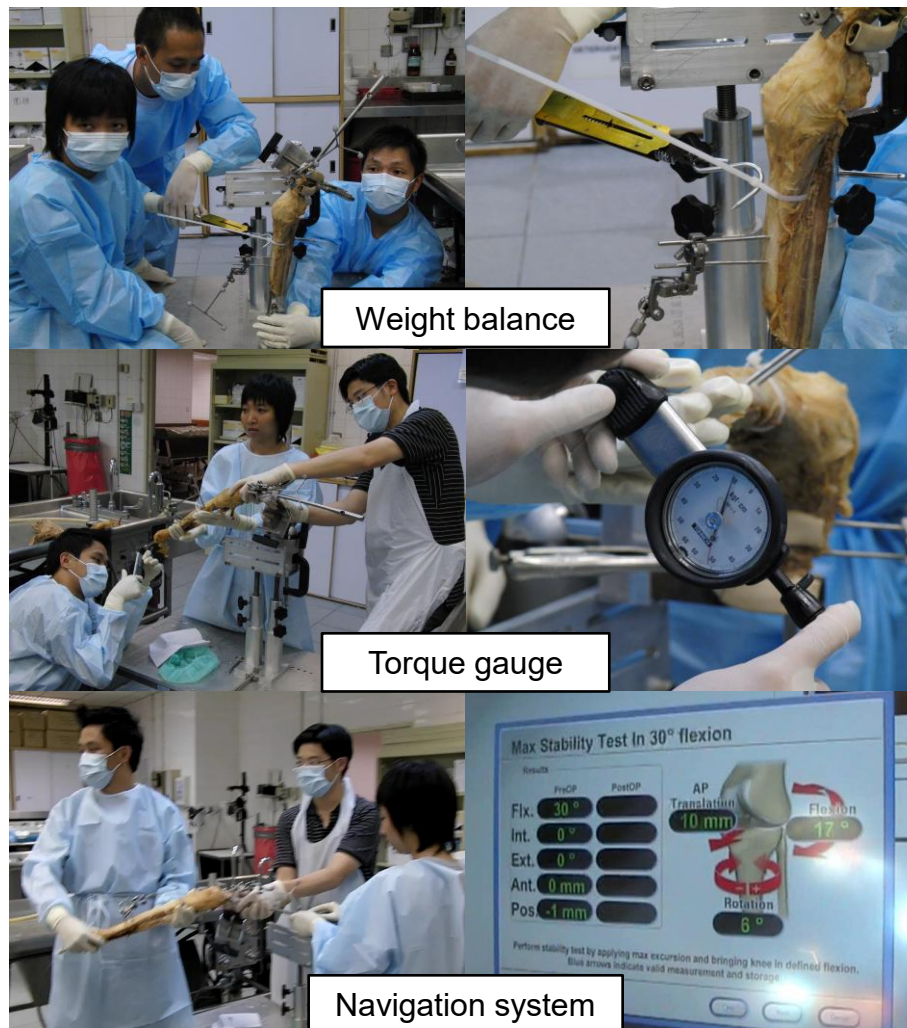
Project funded by Innovation and Technology Fund

# Biomechanical evaluation on cadaveric specimen



Prof Savio Woo with his Universal Force-Moment Sensor at University of Pittsburgh

6 degree-of-freedom, 134N / 5Nm



Comparative Study > [Arthroscopy](#). 2011 Jan;27(1):89-96.  
doi: 10.1016/j.arthro.2010.06.006. Epub 2010 Nov 2.

## Comparison of 2 surgical techniques for reconstructing posterolateral corner of the knee: a cadaveric study evaluated by navigation system

Eric Po-Yan Ho<sup>1</sup>, Mak-Ham Lam, Mandy Man-Ling Chung,  
Daniel Tik-Pui Fong, Billy Kan-Yip Law, Patrick Shu-Hang Yung,  
Wood-Yee Chan, Kai-Ming Chan

Affiliations: [— collapse](#)

### Affiliation

<sup>1</sup> Department of Orthopaedics and Traumatology, Prince of Wales Hospital, Faculty of Medicine, The Chinese University of Hong Kong, Hong Kong, China.

# Dynamic functional test

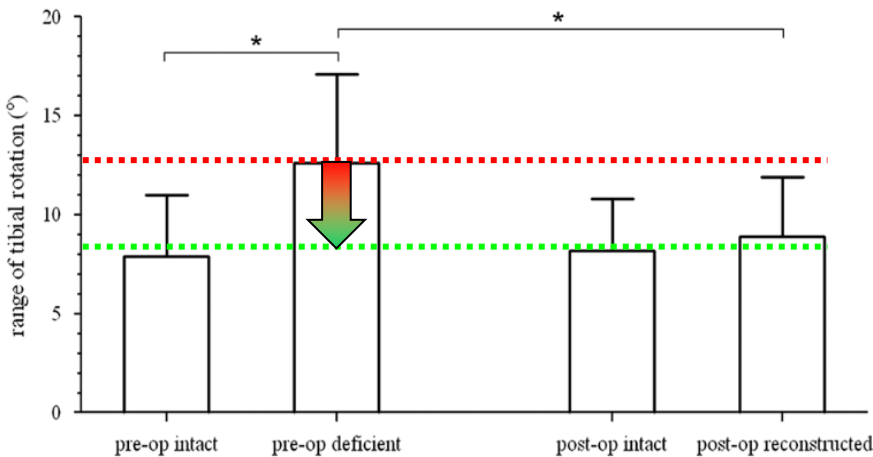
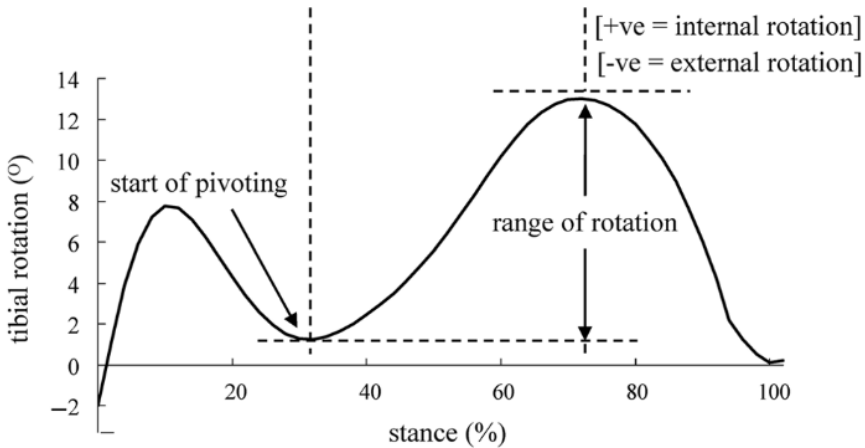
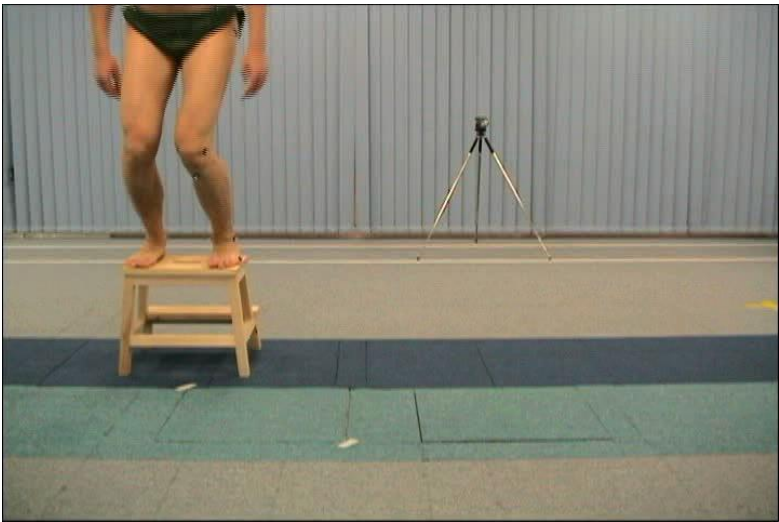
## ACL Reconstruction Techniques



Single Bundle



Double Bundle



> Am J Sports Med. 2011 May;39(5):1032-8.  
doi: 10.1177/0363546510394430. Epub 2011 Feb 18.

## Knee rotational stability during pivoting movement is restored after anatomic double-bundle anterior cruciate ligament reconstruction

Mak-Ham Lam<sup>1</sup>, Daniel Tik-Pui Fong, Patrick Shu-Hang Yung, Eric Po-Yan Ho, Kwai-Yau Fung, Kai-Ming Chan

Affiliations — collapse

### Affiliation

<sup>1</sup> Department of Orthopaedics and Traumatology, Prince of Wales Hospital, Faculty of Medicine, The Chinese University of Hong Kong, Hong Kong, China.

# X-ray motion analysis



Harvard (Guoan Li)



Pittsburgh (Scott Tashman / William Anderst)



CUHK (Michael Ong)

# How to prevent ACL injury? 如何預防前十字韌帶創傷?

Journal of Applied Biomechanics, 2023, 39, 110-117  
https://doi.org/10.1123/jab.2021-0107  
© 2023 Human Kinetics, Inc.

Human Kinetics  
ORIGINAL RESEARCH

## Effects of Gluteus Medius and Biceps Femoris Stimulation on Reduction of Knee Abduction Moment During a Landing Task

Dan Wang,<sup>1,2</sup> Man Wang,<sup>3</sup> Vikki Wing-Shan Chu,<sup>3</sup> Patrick Shu-Hang Yung,<sup>3,4</sup> and Daniel T.P. Fong<sup>5</sup>  
<sup>1</sup>School of Elite Sport, Shanghai University of Sport, Shanghai, China; <sup>2</sup>College of Acupuncture and Tuina, Health Preservation and Rehabilitation, Nanjing University of Chinese Medicine, Nanjing, JS, China; <sup>3</sup>Department of Orthopaedics and Traumatology, Faculty of Medicine, Prince of Wales Hospital, The Chinese University of Hong Kong, Hong Kong, China; <sup>4</sup>Faculty of Medicine, The Hong Kong Jockey Club Sports Medicine and Health Sciences Center, The Chinese University of Hong Kong, Hong Kong, China; <sup>5</sup>National Center for Sport and Exercise Medicine, School of Sport, Exercise and Health Sciences, Loughborough University, Loughborough, United Kingdom



### FIFA 11+

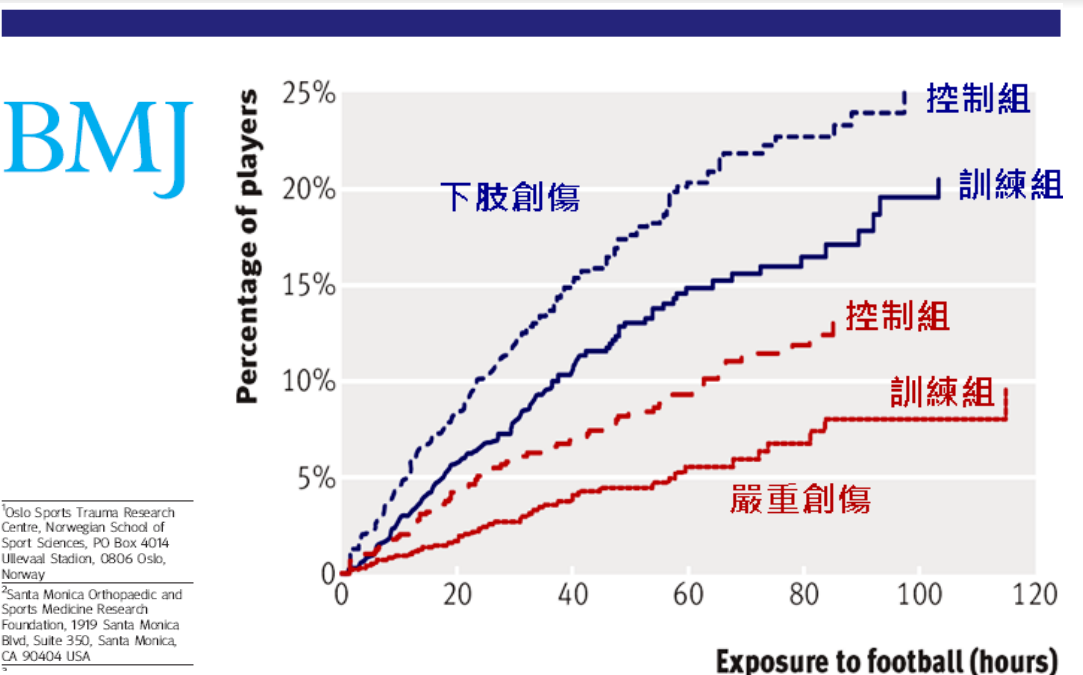
PART 1 RUNNING EXERCISES - 8 MINUTES

- 1. RUNNING STRAIGHT AHEAD
- 2. RUNNING HIP OUT
- 3. RUNNING HIP IN
- 4. RUNNING SHOULDER CONTACT
- 5. RUNNING QUICK FORWARDS & BACKWARDS

PART 2 STRENGTH - PLYOMETRICS - BALANCE - 10 MINUTES

- 6. THE BRUSH STATIC
- 7. THE BRUSH ALTERNATE LEGS
- 8. THE BRUSH ONE LEG LIFT AND HOLD
- 9. SIDEWAYS BRUSH STATIC
- 10. SIDEWAYS BRUSH RAISE & LOWER HIP
- 11. SIDEWAYS BRUSH WITH LEG LIFT
- 12. HAMSTRINGS BEGINNER
- 13. HAMSTRINGS INTERMEDIATE
- 14. HAMSTRINGS ADVANCED
- 15. SINGLE LEG STANCE HOLD THE BALL
- 16. SINGLE LEG STANCE THROWING BALL WITH PARTNER
- 17. SINGLE LEG STANCE TEST YOUR PARTNER
- 18. SQUATS WITH TOE RAISE
- 19. SQUATS WALKING LUNGES
- 20. SQUATS ONE-LEG SQUATS
- 21. JUMPING VERTICAL JUMPS
- 22. JUMPING LATERAL JUMPS
- 23. JUMPING BOX JUMPS

### Nordic hamstring curl 北歐式腿後彎舉



### Walking lunges 箭步蹲



### Bounding 羚羊跳



# How to prevent ACL injury? 如何預防前十字韌帶創傷?

Journal of Biomechanics 109 (2020) 109906



ELSEVIER

Contents lists available at ScienceDirect

Journal of Biomechanics

journal homepage: [www.elsevier.com/locate/jbiomech](http://www.elsevier.com/locate/jbiomech)  
[www.JBiomech.com](http://www.JBiomech.com)



## Falling as a strategy to decrease knee loading during landings: Implications for ACL injury prevention

Ling Li<sup>a</sup>, Marten Baur<sup>a</sup>, Kevin Baldwin<sup>a</sup>, Taylor Kuehn<sup>a</sup>, Qin Zhu<sup>a</sup>, Daniel Herman<sup>b</sup>, Boyi Dai<sup>a,\*</sup>

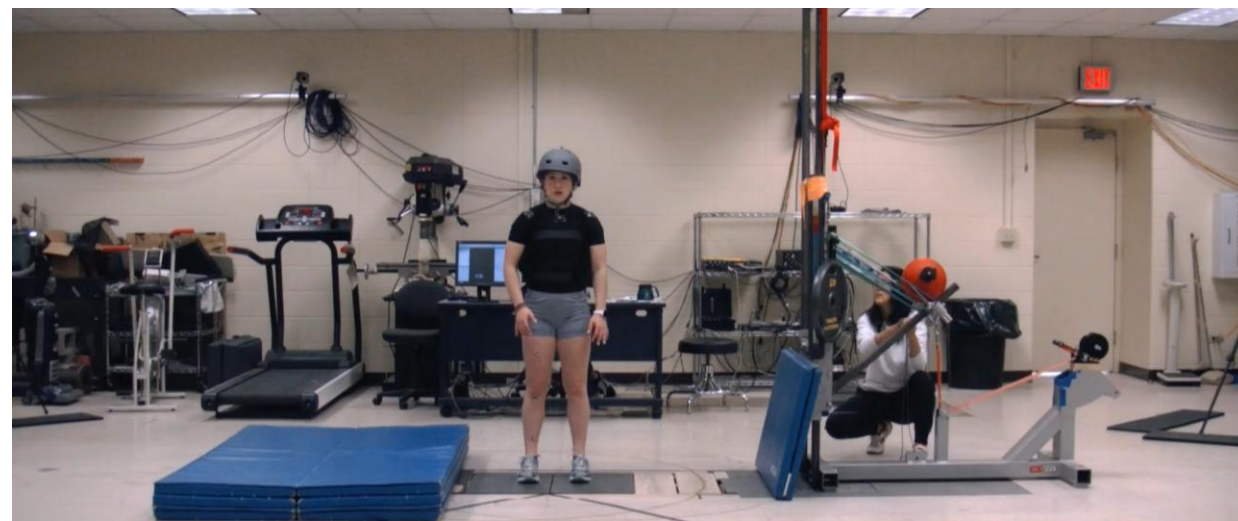
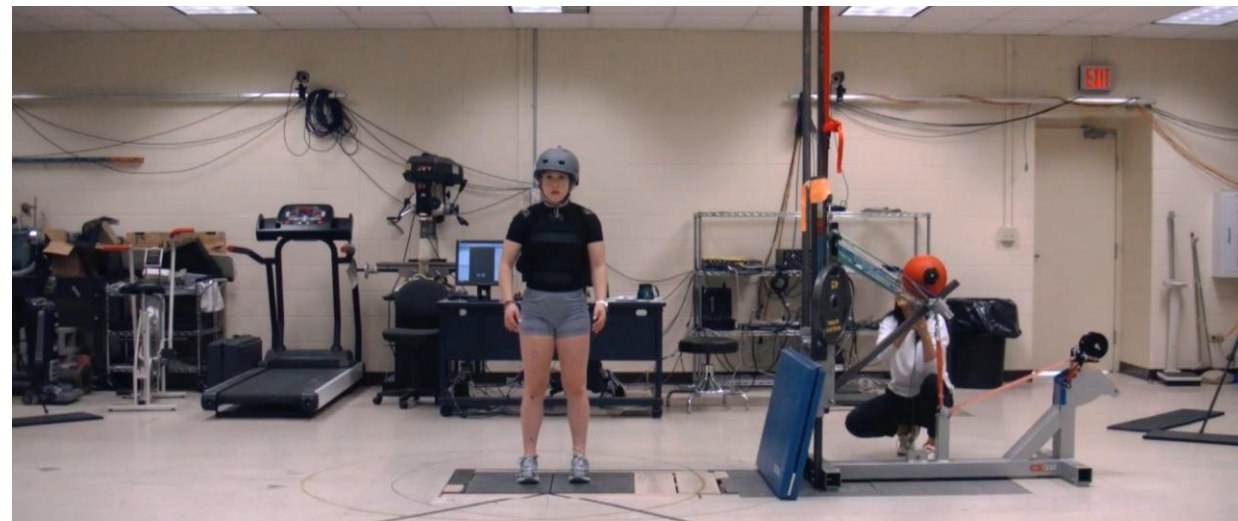
<sup>a</sup> Division of Kinesiology and Health, University of Wyoming, Laramie, USA

<sup>b</sup> Department of Orthopaedics and Rehabilitation, University of Florida, Gainesville, USA

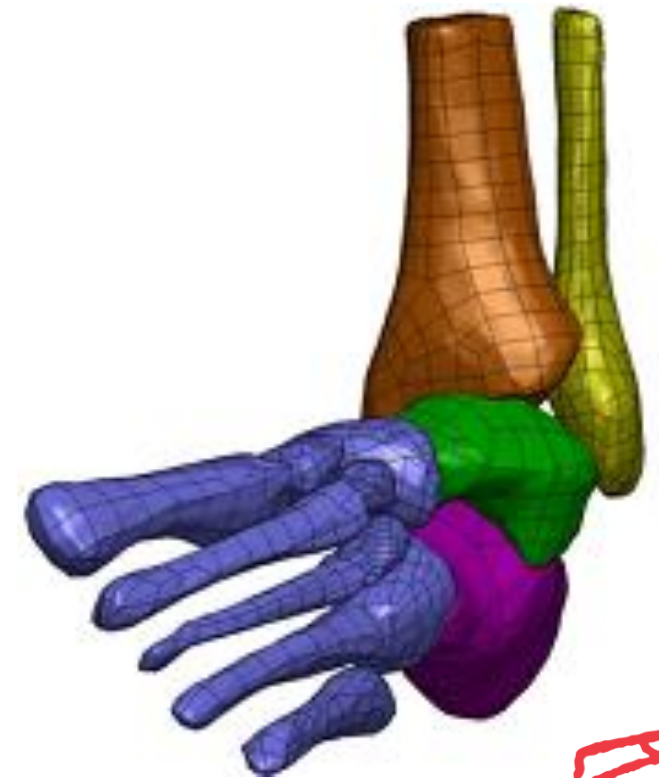
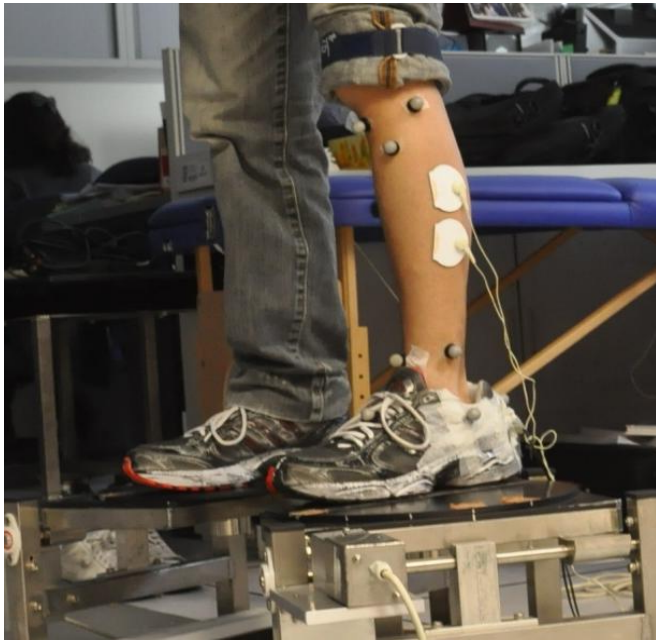


## 借力打力

借力打力，太極拳技擊技法的重要原則。在技擊上，太極拳理把對立雙方看做是兩個獨立的太極體，要求在意識上做到“彼此之力不混合”，“你是你，我是我”。對方之力打來，我只是在保持自身太極體完整的前提下迎接對方，也就是意在阻止對方改變我太極體狀態或對我太極體進行損害的企圖。其情形如同我太極體是運動的，對方的力如同打在飛轉的車輪上，那麼打來的力越大，對方自受危害也越大。所以借力打力並不含有主動出擊的意思，而只是以反作用力使進攻者受挫。



# Extra Lecture: Biomechanics forensic investigation and prevention of ankle sprain



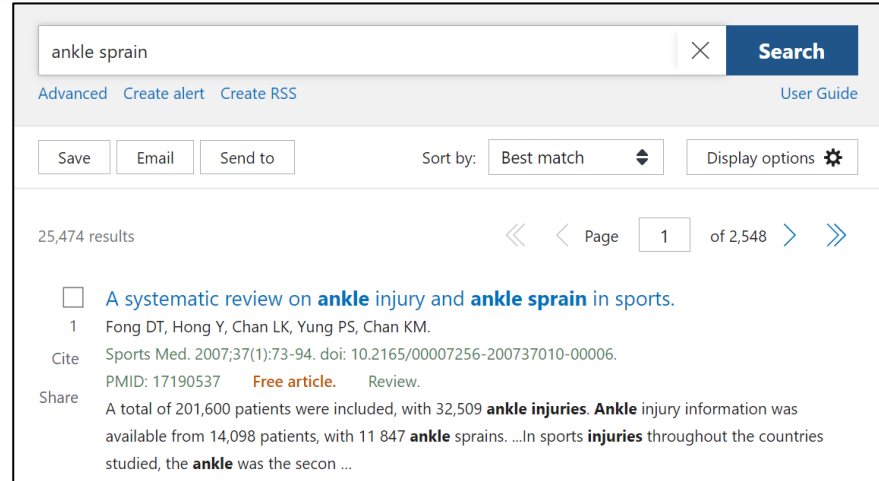
**Dr Daniel T.P. Fong 方迪培博士**

Reader in Sports Medicine and Biomechanics, Loughborough University  
Adjunct Associate Professor, The Chinese University of Hong Kong  
Editor-in-Chief, Sports Biomechanics Journal  
BSc (Physics), MSc (Exercise Science), PhD (Orthopaedics and Traumatology)



# How much am I relevant to this topic?

- I started ankle sprain research since 2004 (20 years now).
- I published the first ankle sprain biomechanics case report in 2009.
- I invented a patented anti-sprain system in 2012.
- My article came first when searched 'ankle sprain' in PubMed, sorted 'Best Match' (also 'ankle injury' and 'sports biomechanics').
- BJSM called me 'Ankle authority'.
- I co-authored consensus and position statements with the International Ankle Consortium.



Shout out: Dr Daniel Fong @dtpfong  
Fellow Editor-in-Chief. Ankle  
authority. 🌟🇬🇧



00:23 · 13/07/2020 · Twitter Web App

## Sports Medicine

### INJURY CLINIC

Sports Med 2007; 37 (1): 73-94  
0112-1642/07/0001-0073/\$44.95/0

© 2007 Adis Data Information BV. All rights reserved.

## A Systematic Review on Ankle Injury and Ankle Sprain in Sports

*Daniel Tik-Pui Fong,<sup>1</sup> Youlian Hong,<sup>2</sup> Lap-Ki Chan,<sup>1</sup> Patrick Shu-Hang Yung<sup>1</sup> and Kai-Ming Chan<sup>1</sup>*

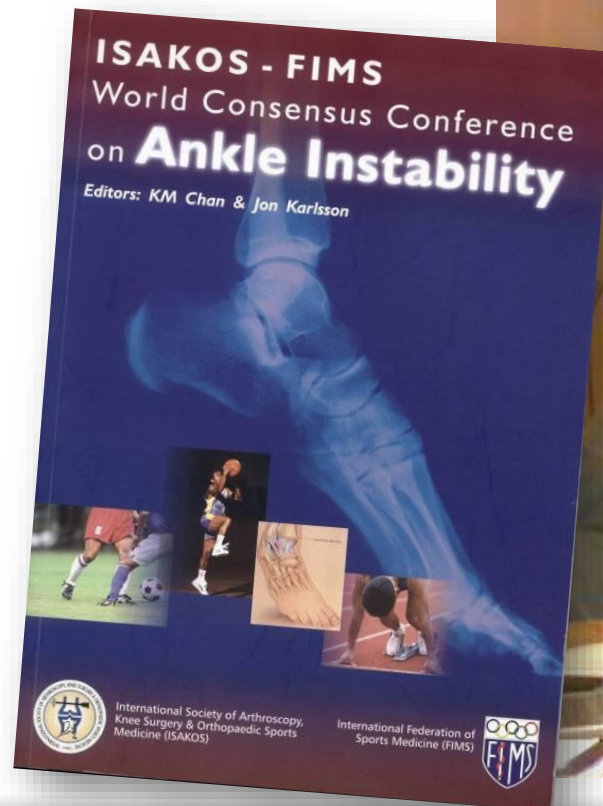
1 Department of Orthopaedics and Traumatology, Prince of Wales Hospital, Faculty of Medicine, The Chinese University of Hong Kong, Hong Kong, China

2 Department of Sports Science and Physical Education, Faculty of Education, The Chinese University of Hong Kong, Hong Kong, China

- Ankle sprain is very common in sports (Fong et al, 2007).
- Citations as of 25 Jun 2024: Google Scholar = 1984, Scopus = 942, Clarivate = 912

# Prof KM Chan: Go outside and see the world first

- 20+ experts from ISAKOS and FIMS met in HK in 2004.
- Different ways to treat ankle instability
- Can we try prevent?



## Considerations along the research direction

|                                                   |                                                                           |
|---------------------------------------------------|---------------------------------------------------------------------------|
| 1. Is it worth preventing ankle sprain?           | Yes? No?                                                                  |
| 2. What must we know first?                       | Risky group? Cause? Process?                                              |
| 3. How can we tackle the problem?                 | Devices? Exercise?                                                        |
| 4. Can prevention and rehabilitation be combined? | Hopefully yes, so sports scientists can do things to help rehabilitation? |

# 1. Is it worth preventing ankle sprain?



- Most common injuries since 1977 (as reported by Garrick).  
[Fong DTP et al, Sports Medicine, 2007;37(1):73-94]
- 1 in 6 would seek consultation.  
[Chan KM et al, 1984, BJSM, 18(3):195-202]
- Repeated sprains (> 5 times) may lead to ankle instability.  
[Yeung MS et al, BJSM, 1994;28(2):112-116]
- In the UK, annual cost to treat is £1-2 billion.
- Half (49%) are re-injuries.
- If this is reduced by 1%, we save £5-10 million a year.
- So, why not worth?

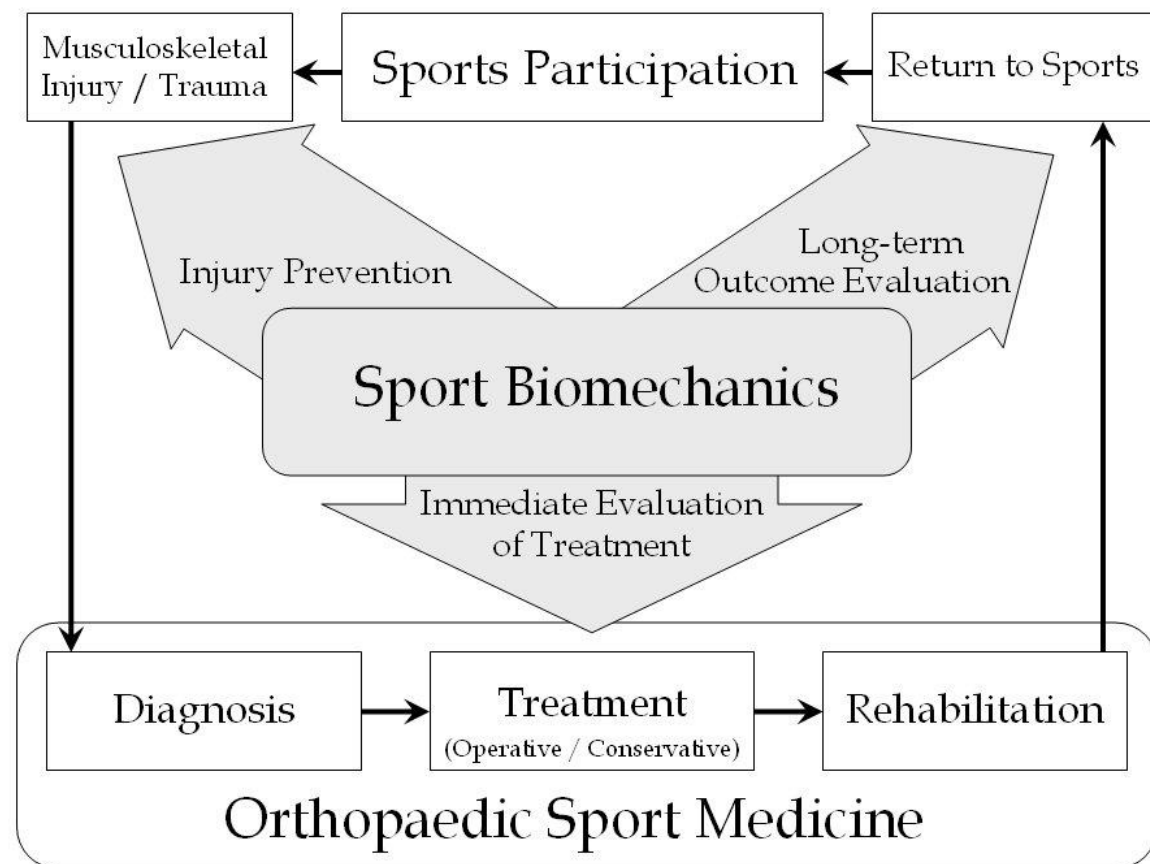
# How can biomechanics contribute to injury prevention?

Review > Clin Biomech (Bristol, Avon). 2008;23 Suppl 1:S21-30.

doi: 10.1016/j.clinbiomech.2007.10.007. Epub 2007 Dec 3.

## Orthopaedic sport biomechanics – a new paradigm

Kai-Ming Chan<sup>1</sup>, Daniel Tik-Pui Fong, Youlian Hong, Patrick Shu-Hang Yung, Pauline Po-Yee Lui



Sportsroad: <https://www.sportsroad.hk/archives/476782>



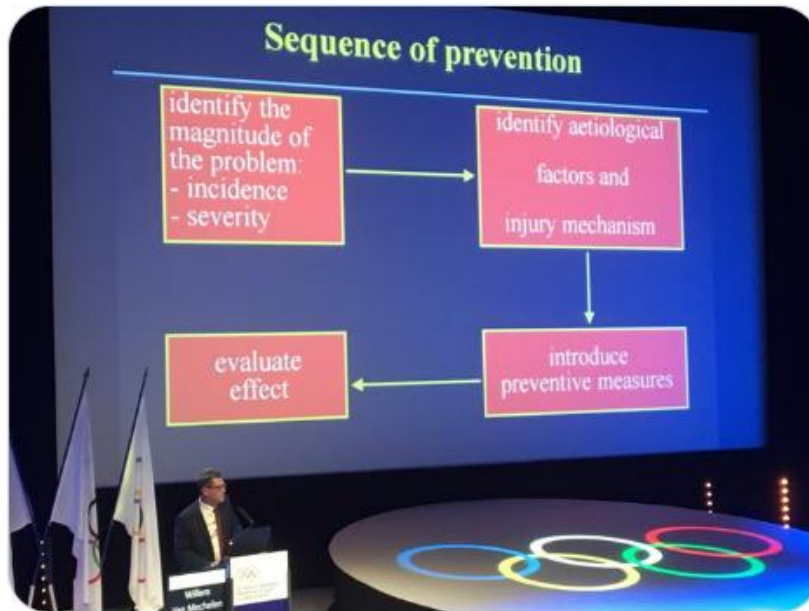
【體路專欄】運動生物力學，是運動科學中的其中一個分支，是以物理及力學方法分析及量化運動員動作及表現。運動生物力學當中有兩大分支，包括（一）運動學 (Kinematics)：一般以高速攝影技術或者可穿戴動作傳感器來量化運動員動作的線性移動距離和關節角度及其變化；（二）動力學 (Kinetics)：一般通過安裝在地面的測力板測量地面反作用力，加上數學推算關節扭力，或者透過壓力鞋墊分析足底壓力分佈。

運動生物力學若應用在骨科運動醫學，可以用於：分析運動創傷的成因及過程，從而制定預防方法及設計運動服裝及器材；評定及量化骨科手術及物理治療的功效；及制定康復後返回運動的檢查條件。香港中文大學運動醫學團隊於20年前開始將運動生物力學結合於運動創傷研究，包括以鑒證錄像及電腦模擬方法分析足踝扭傷機制，從而設計出一個以電刺激小腿外側肌肉制止扭傷過程的發明專利，亦透過在手術導航及動作分析系統量化不同韌帶重建方法對膝關節穩定性及肌肉力量的影響，從而優化運動創傷的手術及康復方法。

為加強更多運動生物力學及骨科運動醫學專家之間的合作，香港中文大學醫學院於2023年4月舉辦了一場運動生物力學高峰會，邀請了30多位自美國、日本、英國、澳洲、新西蘭、荷蘭、加拿大、新加坡、及中國大陸的專家來港交流，將最新的科研技術及議題向與會者展示，並成功開展多項國際合作。

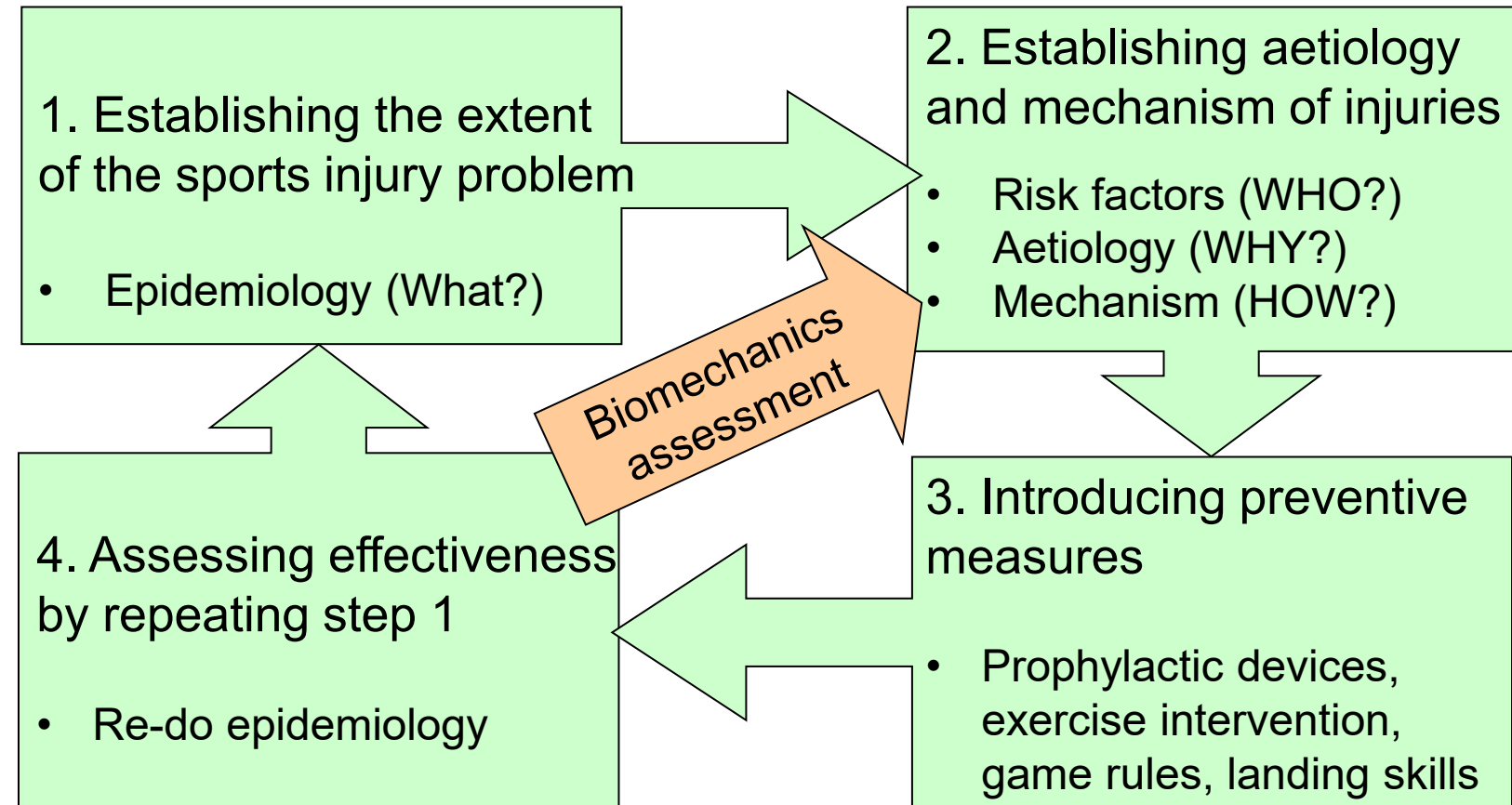
## 2. What must we know first?

The father of the injury prevention model Van Mechelen @ IOC injury prevention conference Monaco 2017



8:51 AM • Mar 16, 2017

## Sequence of injury prevention



[van Mechelen et al (1992), Sports Med, 14(2):82-99]

# Risk factors of inversion ankle sprain

| Intrinsic                                                                 | Extrinsic                                     |
|---------------------------------------------------------------------------|-----------------------------------------------|
| Previous sprain history ↑ (4.9x)                                          | Use of shoes with air cells ↑ (4.3x)          |
| Overweight ↑ (3.9x)                                                       | Do not stretch before exercise ↑ (2.6x)       |
| Inferior single leg balance ↑ (2.4x)                                      | Use of high top shoe ×                        |
| Foot size with increased width ↑                                          | Use of orthosis ↓                             |
| Increased calcaneal eversion range ↑                                      | Use of artificial turf for football ↑         |
| Reduced ankle dorsiflexion range ↑                                        | Increased exercise intensity in football ↑    |
| A posteriorly positioned fibula ↑                                         | Player positions in football and basketball × |
| Laterally shifted centre of plantar pressure at initial contact in gait ↑ |                                               |
| Ankle instability ×                                                       |                                               |
| High general joint laxity ×                                               |                                               |

- Also categorised into modifiable and non-modifiable risk factors.
- Note: Risk factors only correlate with ankle sprain injury. There is no causal relationship.
- Another note!!!: **Risk factors are not injury risk**, which must be a comparison of the injury number between two groups, presented as Odds Ratios (OR) or Relative Risk (RR)

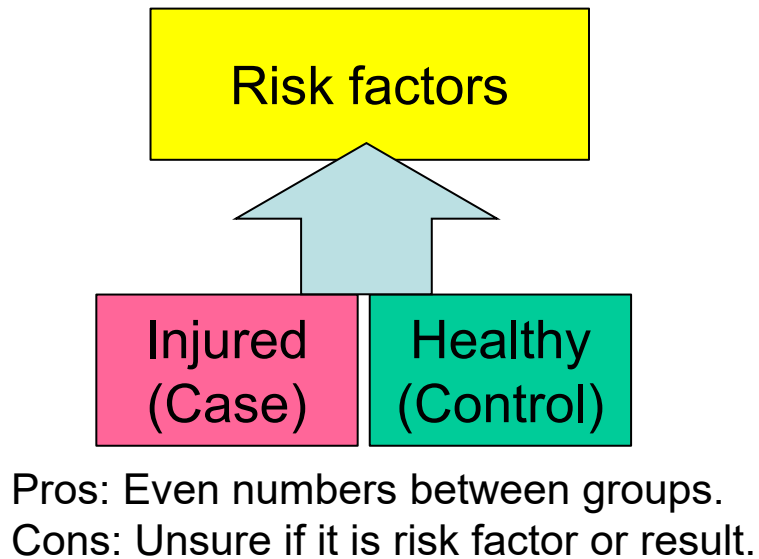
# Risk factor study designs

PAST

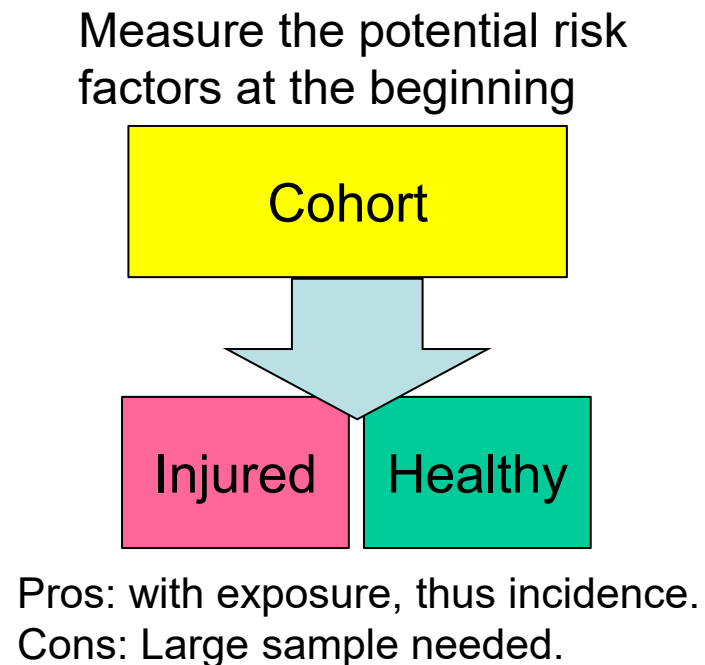
NOW

FUTURE

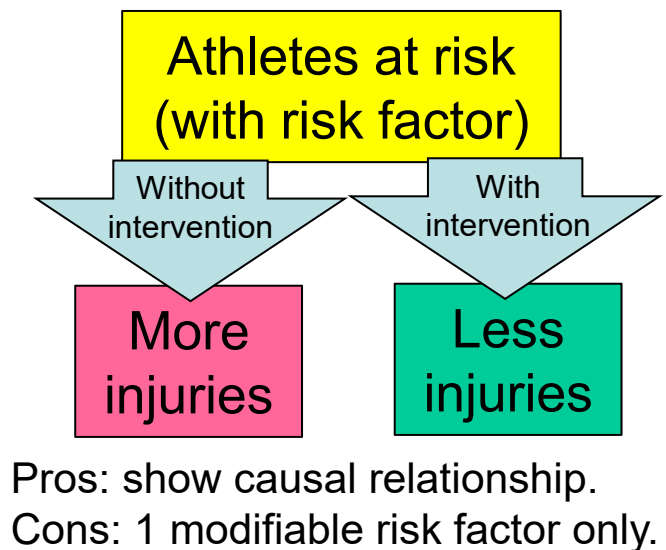
## Case control study design (Retrospective)



## Cohort study design (Prospective)

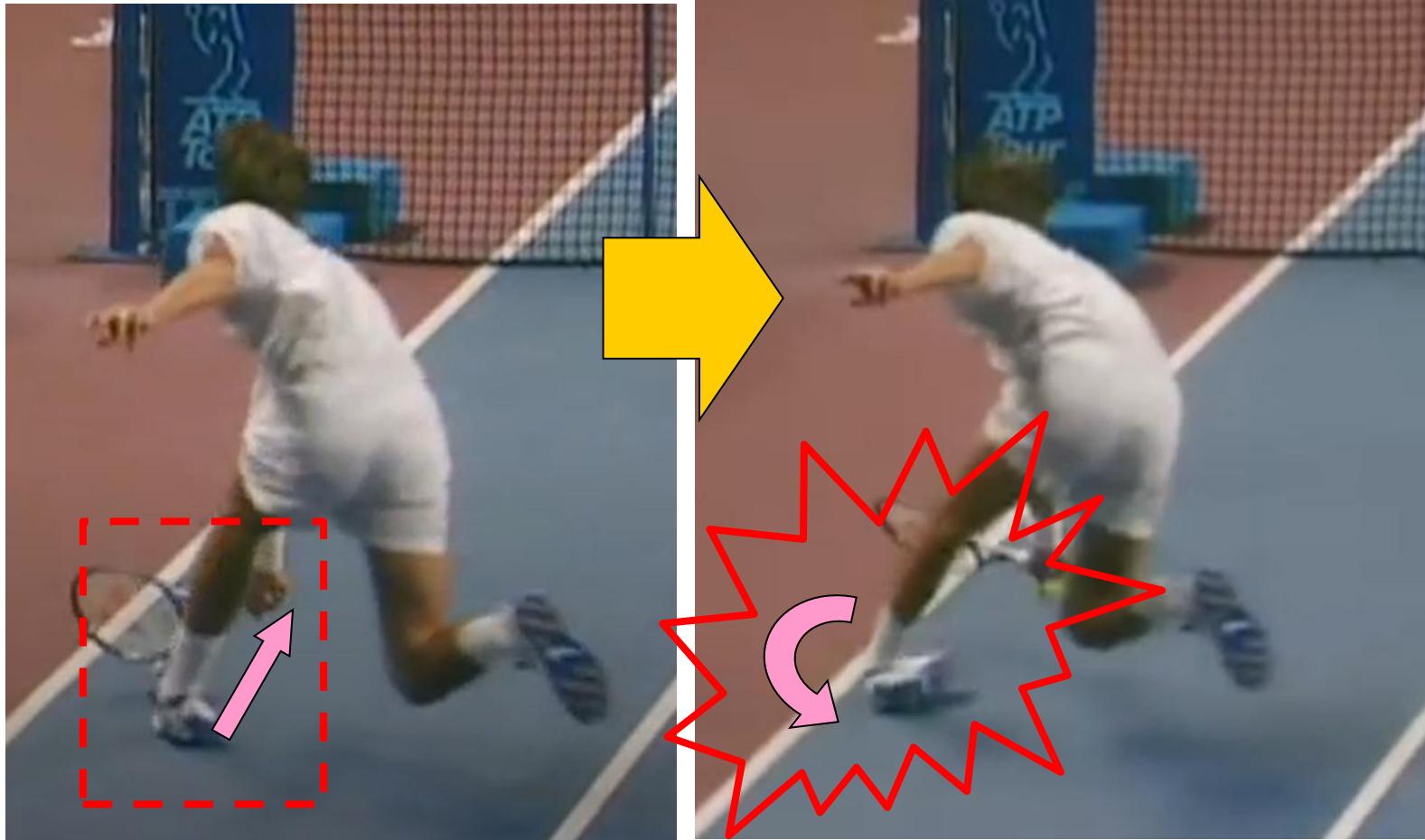


## Intervention / RCT (Prospective)



!!! Can be considered unethical if no intervention is given to those at risk.

# The two widely accepted aetiologies



Incorrect landing  
(non-vertical)

Delayed peroneal reaction

## Bradford Hill's criteria (1965)



1. Strength of Association
2. Consistency
3. Specificity
4. Temporality
5. Biological gradient (dose response)
6. Plausibility
7. Coherence
8. Experimental Evidence
9. Analogy

AB Hill: The Environment and Disease: Association or Causation?  
Proc Royal Soc Med 1965;58:295-300

# Delayed ankle muscle reaction in football

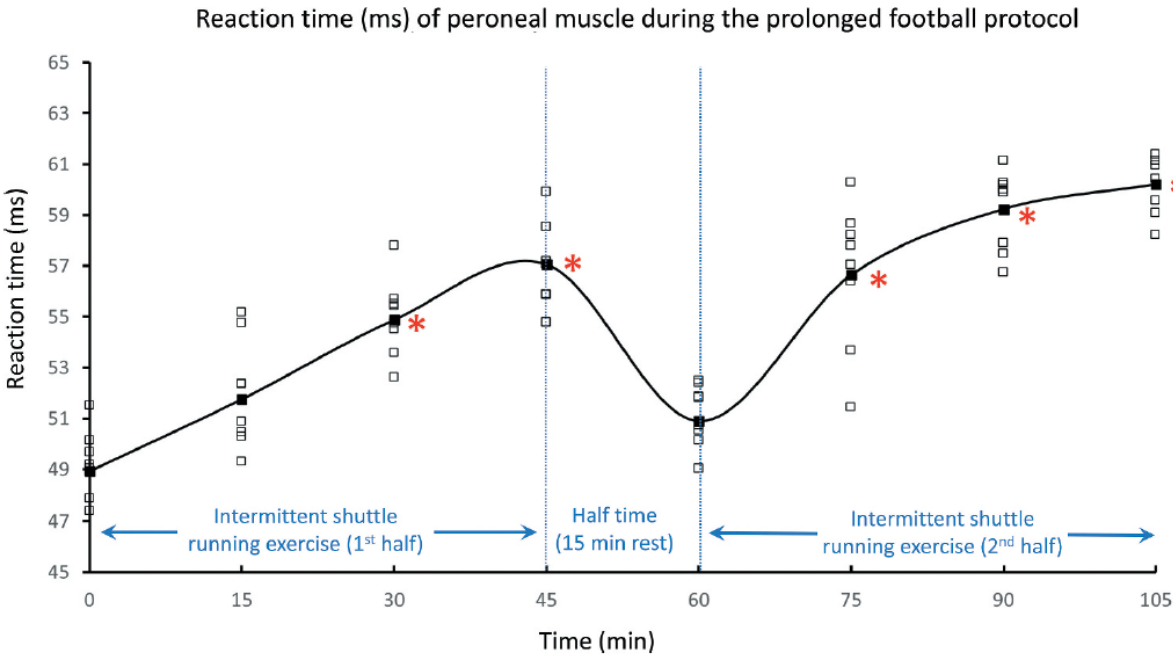
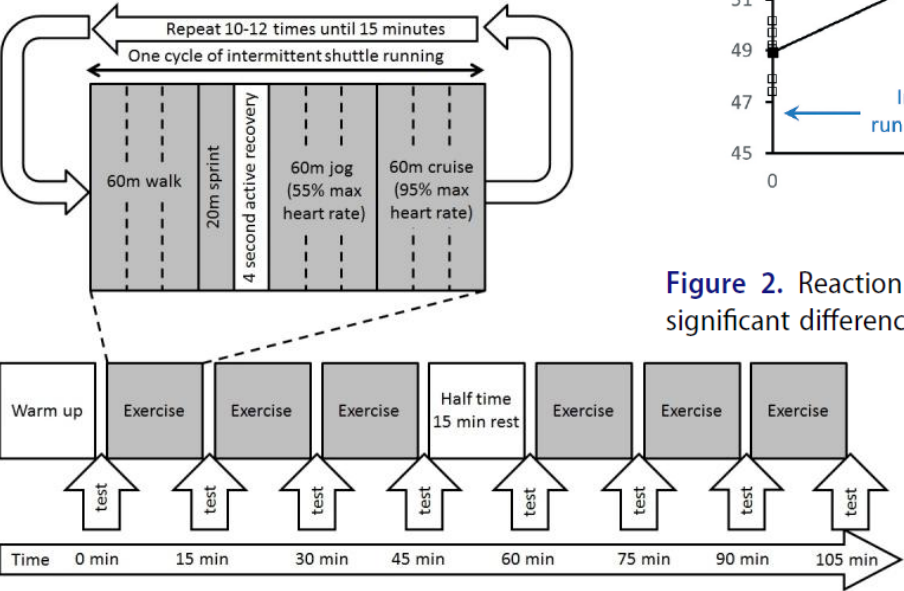
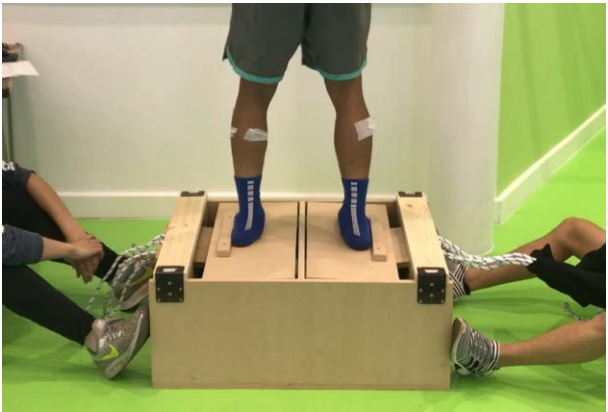


**Figure 2.** Reaction time of peroneal muscle during the prolonged football protocol (\*Indicated significant difference from baseline (0 min),  $p < 0.05$ ).



**Dr SUN Wei**  
孫威博士

[Fong DTP et al (2020). Journal of Experimental Orthopaedics, 7, 54]  
[Sun W et al (2021). Research in Sports Medicine, 29(4), 364-372]  
[Huang Z et al (2021). Research in Sports Medicine, 29(6), 557-570]

# Delayed ankle muscle reaction and landing posture in badminton



# Mechanism – how to best study it?

Review > Br J Sports Med. 2005 Jun;39(6):330-9. doi: 10.1136/bjsm.2005.018358.

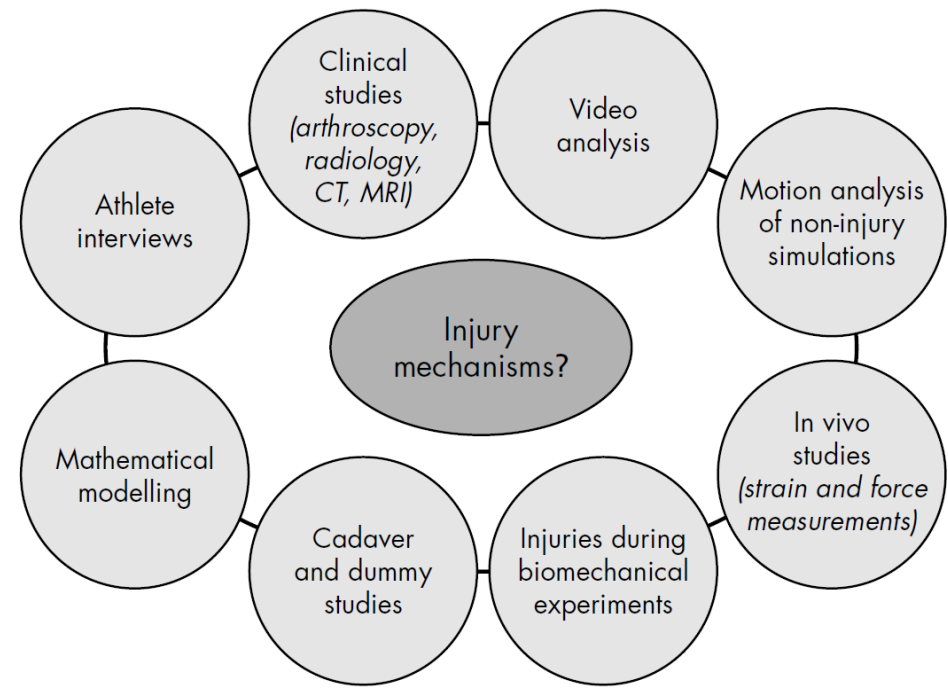
## Research approaches to describe the mechanisms of injuries in sport: limitations and possibilities

T Krosshaug<sup>1</sup>, T E Andersen, O-E O Olsen, G Myklebust, R Bahr

Affiliations — collapse

### Affiliation

<sup>1</sup> Oslo Sports Trauma Research Center, Norwegian University of Sport and Physical Education, Oslo, Norway.

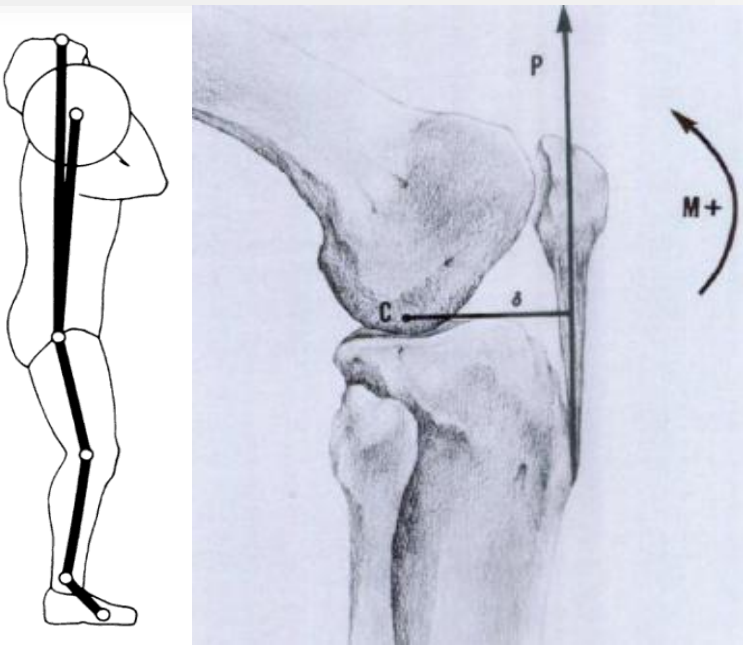


## The first ever biomechanical injury case report, 1977

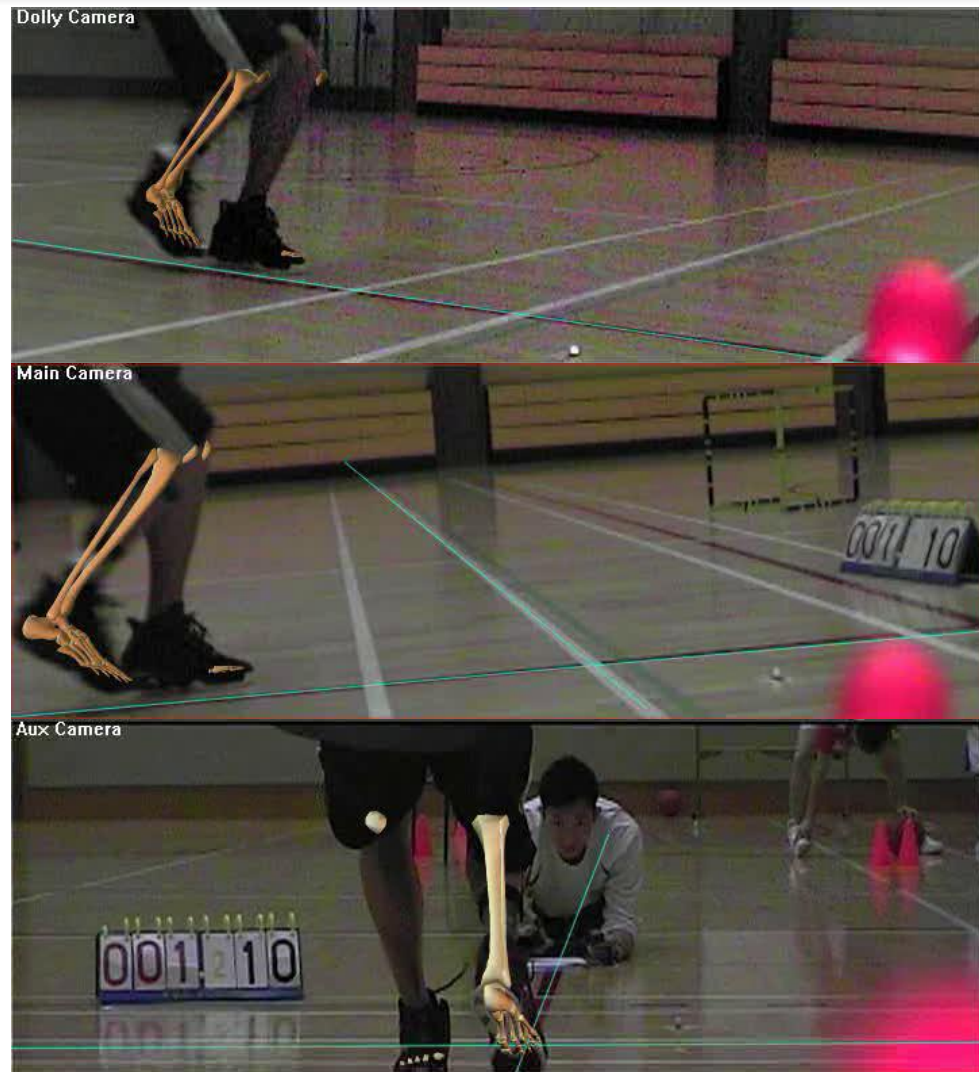
# Human Patellar-Tendon Rupture

### A KINETIC ANALYSIS\*

BY RONALD F. ZERNICKE, PH.D.<sup>†</sup>, JOHN GARHAMMER, M.SC.<sup>†</sup>, AND  
FRANK W. JOBE, M.D.<sup>‡</sup>, LOS ANGELES, CALIFORNIA



# Develop a forensic video analysis method to study ankle sprain

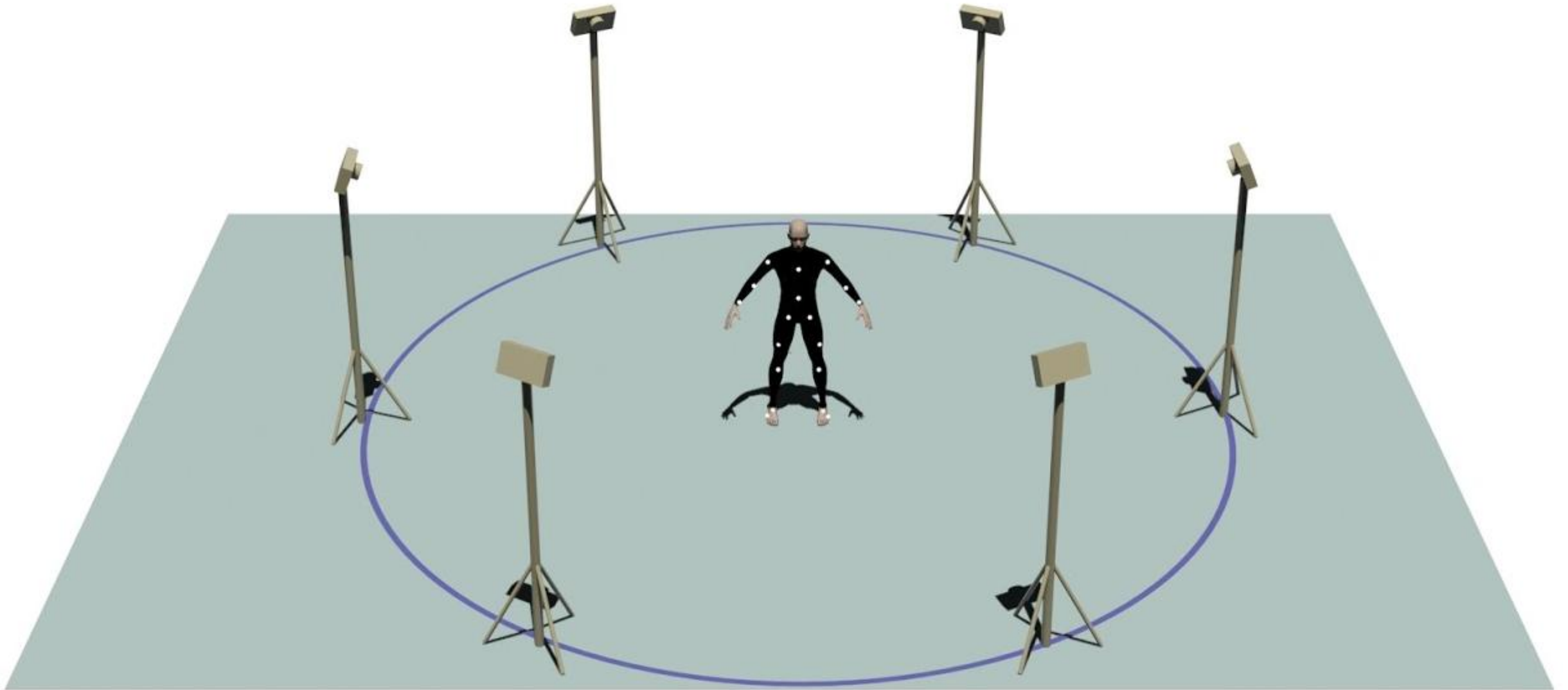


[Fong DTP et al (2009), AJSM, 37(4), 822-827]



[Mok KM, Fong DTP et al (2011), Gait and Posture, 34(1), 71-75]

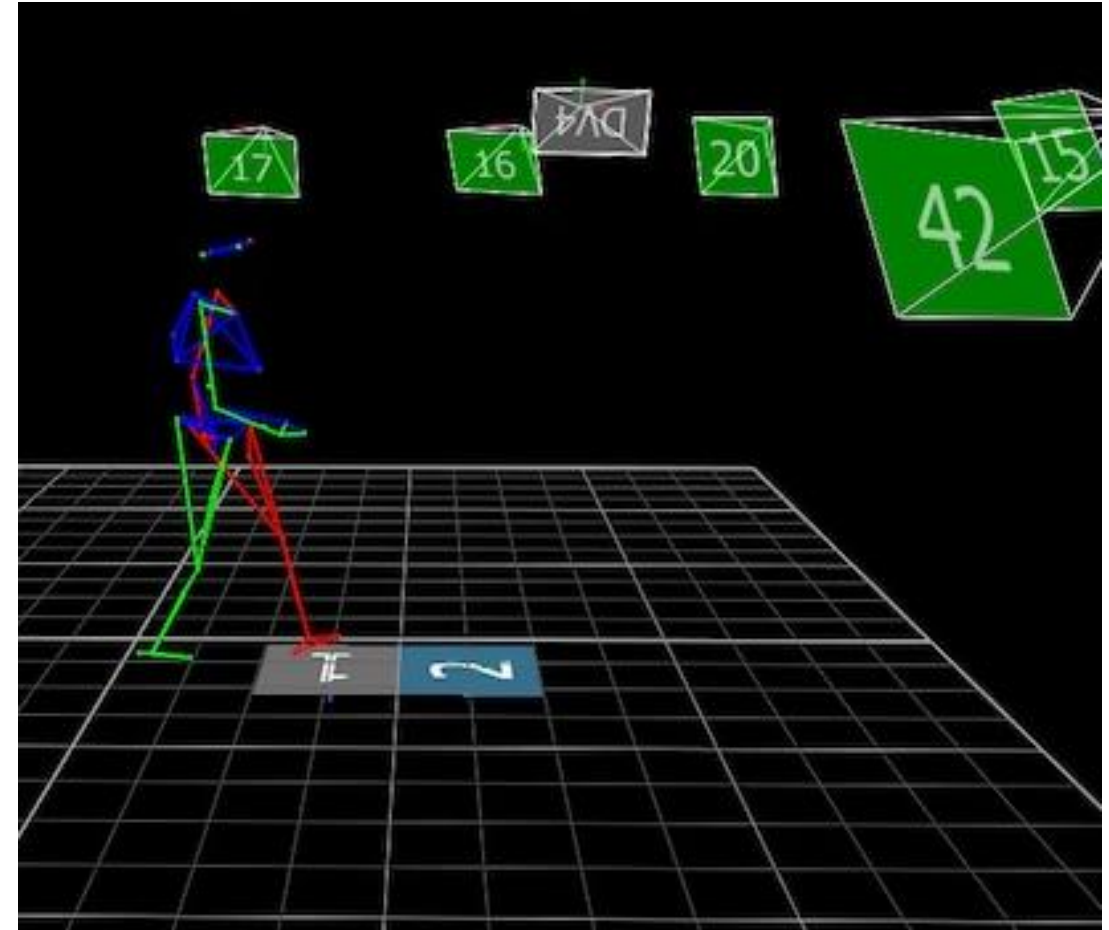
# The Model-Based Image-Matching method explained



# The Model-Based Image-Matching method explained



Trim > De-interlace > Correct distortion > Synchronise



Draw the sports court in Poser.  
Locate the cameras by the images.

# The Model-Based Image-Matching method explained



Scaled skeleton model (Zygote)  
to match the injured athlete



Match the skeleton on the  
synchronised images frame by frame.

# Validity and reliability

**Table 1**  
Accuracy and Correlation for all angles of motion in two testing conditions.

|                                              | Bare-foot    | Shoed        |
|----------------------------------------------|--------------|--------------|
| <b>Plantarflexion+/dorsiflexion–</b>         |              |              |
| Root mean square (rms) error                 | 2.08         | 2.36         |
| Mean difference (d)                          | –0.27        | 0.20         |
| S.D. of difference                           | 2.05         | 2.47         |
| 95% limits of agreement                      | –4.29 → 3.75 | –4.64 → 5.04 |
| Pearson's correlation (R)                    | 0.996        | 0.985        |
| R square (R <sup>2</sup> )                   | 0.991        | 0.971        |
| Average range of motion (°)                  | –39.7 → 67.9 | –47.6 → 48.4 |
| <b>Inversion+/eversion–</b>                  |              |              |
| Root mean square (rms) error                 | 1.99         | 2.95         |
| Mean difference (d)                          | 0.29         | 0.82         |
| S.D. of difference                           | 2.09         | 2.97         |
| 95% limits of agreement                      | –3.81 → 4.39 | –5.00 → 6.64 |
| Pearson's correlation (R)                    | 0.996        | 0.998        |
| R square (R <sup>2</sup> )                   | 0.992        | 0.996        |
| Average range of motion (°)                  | –48.7 → 82.3 | –42.5 → 61.7 |
| <b>Internal rotation+/external rotation–</b> |              |              |
| Root mean square (rms) error                 | 2.01         | 2.20         |
| Mean difference (d)                          | –0.29        | 0.40         |
| S.D. of difference                           | 1.75         | 2.87         |
| 95% limits of agreement                      | –3.72 → 3.14 | –5.23 → 6.03 |
| Pearson's correlation (R)                    | 0.952        | 0.946        |
| R square (R <sup>2</sup> )                   | 0.907        | 0.894        |
| Average range of motion (°)                  | –13.7 → 5.9  | –11.4 → 6.7  |

**Table 2**  
Intra-rater reliability (intra-class correlation).

| Researcher          | Plantarflexion/<br>dorsiflexion |       | Inversion/ever-<br>sion |       | Internal/exter-<br>nal rotation |       |
|---------------------|---------------------------------|-------|-------------------------|-------|---------------------------------|-------|
|                     | A                               | B     | A                       | B     | A                               | B     |
| <b>Bare-foot</b>    |                                 |       |                         |       |                                 |       |
| Leg 1               | 0.999                           | 0.998 | 0.997                   | 0.993 | 0.957                           | 0.968 |
| Leg 2               | 0.997                           | 0.999 | 0.999                   | 0.999 | 0.991                           | 0.987 |
| Leg 3               | 0.997                           | 0.996 | 0.992                   | 0.995 | 0.986                           | 0.983 |
| Leg 4               | 0.998                           | 0.999 | 0.997                   | 0.999 | 0.978                           | 0.981 |
| Leg 5               | 0.992                           | 0.998 | 0.999                   | 0.999 | 0.971                           | 0.958 |
| Average             | 0.997                           | 0.998 | 0.997                   | 0.997 | 0.977                           | 0.975 |
| <b>Shoe-wearing</b> |                                 |       |                         |       |                                 |       |
| Leg 1               | 0.997                           | 0.999 | 0.994                   | 0.997 | 0.928                           | 0.945 |
| Leg 2               | 0.990                           | 0.997 | 0.997                   | 0.987 | 0.940                           | 0.987 |
| Leg 3               | 0.994                           | 0.994 | 0.998                   | 0.998 | 0.980                           | 0.974 |
| Leg 4               | 0.996                           | 0.994 | 0.996                   | 0.997 | 0.976                           | 0.980 |
| Leg 5               | 0.995                           | 0.995 | 0.995                   | 0.997 | 0.953                           | 0.950 |
| Average             | 0.994                           | 0.996 | 0.996                   | 0.995 | 0.955                           | 0.967 |

**Table 3**  
Inter-rater reliability (intra-class correlation).

| Condition    | Plantarflexion/<br>dorsiflexion | Inversion/<br>eversion | Internal/external<br>rotation |
|--------------|---------------------------------|------------------------|-------------------------------|
| Bare-foot    | 0.996                           | 0.994                  | 0.952                         |
| Shoe-wearing | 0.993                           | 0.997                  | 0.948                         |



- 2 researchers.
- 5 trials.
- 5 cadaveric specimen.
- \*With/without shoes.

# Utilise the method to analyse more ankle sprains

Case Reports > Am J Sports Med. 2011 Jul;39(7):1548-52.

doi: 10.1177/0363546511399384. Epub 2011 Apr 1.

## Kinematics analysis of ankle inversion ligamentous sprain injuries in sports: 2 cases during the 2008 Beijing Olympics

Kam-Ming Mok<sup>1</sup>, Daniel Tik-Pui Fong, Tron Krosshaug, Lars Engebretsen, Aaron See-Long Hung, Patrick Shu-Hang Yung, Kai-Ming Chan

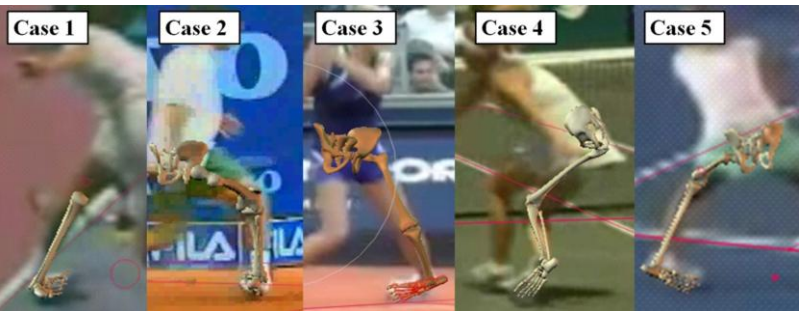


> Am J Sports Med. 2012 Nov;40(11):2627-32. doi: 10.1177/0363546512458259.

Epub 2012 Sep 11.

## Kinematics analysis of ankle inversion ligamentous sprain injuries in sports: five cases from televised tennis competitions

Daniel Tik-Pui Fong<sup>1</sup>, Sophia Chui-Wai Ha, Kam-Ming Mok, Christie Wing-Long Chan, Kai-Ming Chan



Case Reports > Asia Pac J Sports Med Arthrosc Rehabil Technol. 2018 Mar 9;12:12-16.

doi: 10.1016/j.asmart.2018.02.001. eCollection 2018 Apr.

## Kinematic analysis of a televised medial ankle sprain

Francesca E Wade<sup>1</sup>, Kam-Ming Mok<sup>2</sup>, Daniel Tik-Pui Fong<sup>1</sup>



Dr Frankie Wade (SDSU)  
Sports Biomech Editor

> J Sci Med Sport. 2017 Dec;20(12):1057-1061. doi: 10.1016/j.jsams.2017.05.006.

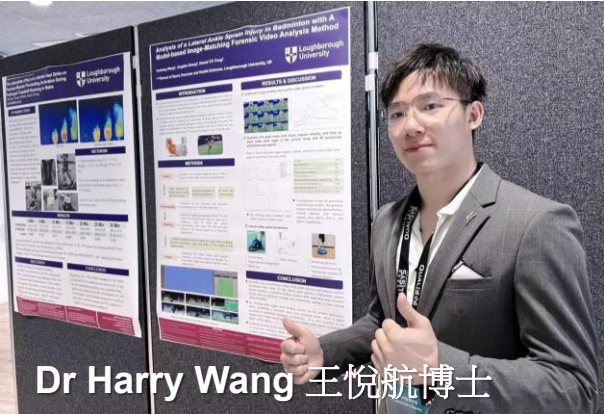
Epub 2017 May 25.

## Biomechanical analysis of ankle ligamentous sprain injury cases from televised basketball games: Understanding when, how and why ligament failure occurs

Emmanouil Panagiotakis<sup>1</sup>, Kam-Ming Mok<sup>2</sup>, Daniel Tik-Pui Fong<sup>3</sup>, Anthony M J Bull<sup>4</sup>



# Ankle sprain mechanism in badminton (funded by Badminton World Federation)



Dr Harry Wang 王悅航博士



Izzy Thompson  
now PhD student in Southampton

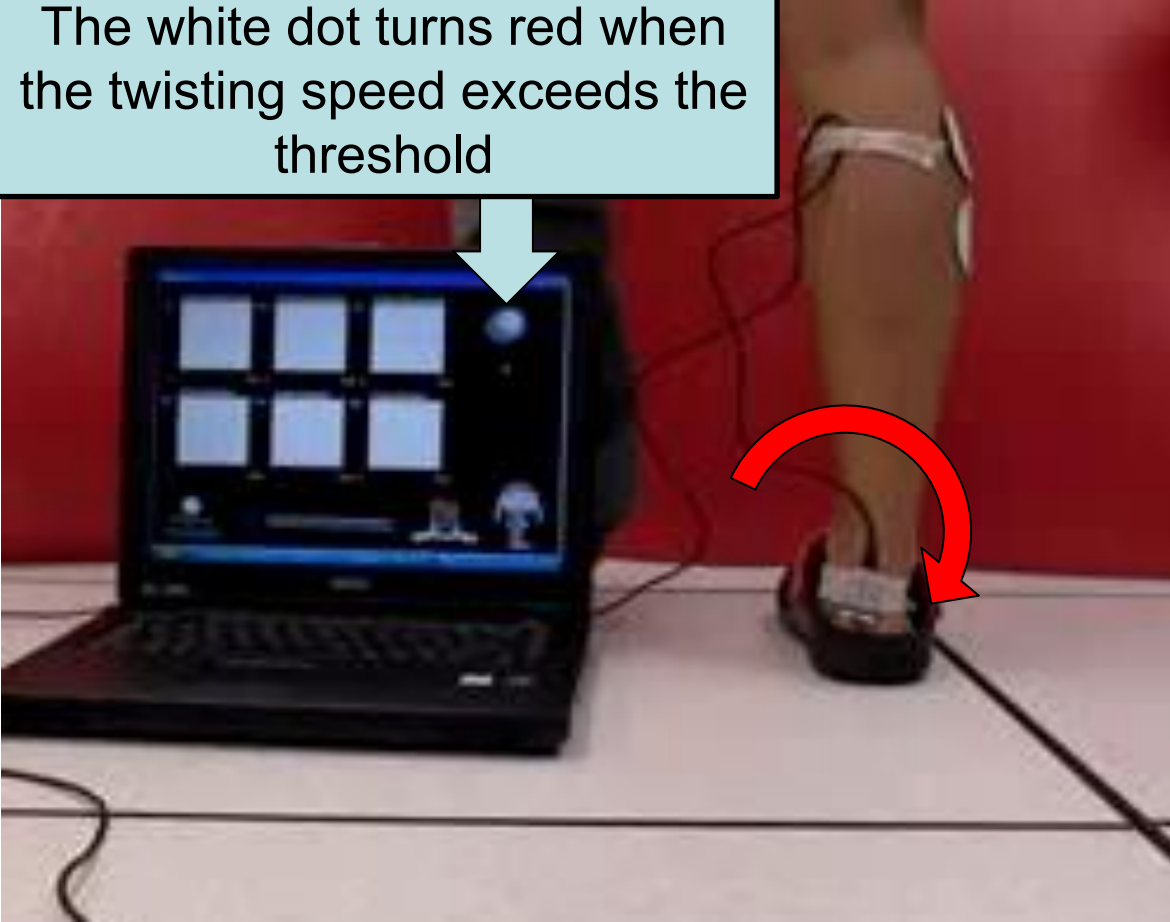


Jingdan Zhang 張競丹

[Fong DTP, Mok KM, Thompson IM, Wang Y, Shan W, King M (2023). Journal of Sport and Health Science, 12(1), 139-144.]

# Detecting the injurious motion by motion sensor

The white dot turns red when the twisting speed exceeds the threshold

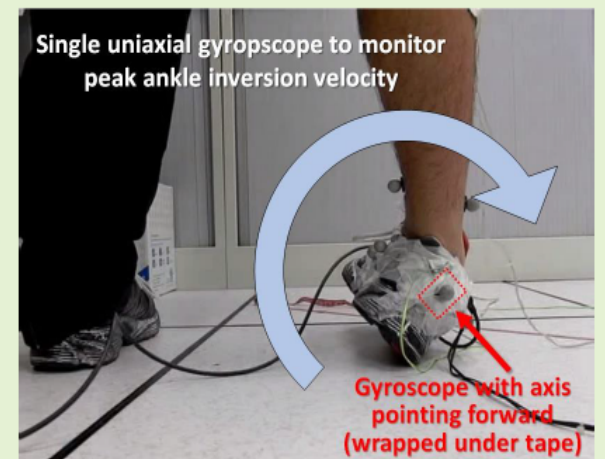


## Using a single uniaxial gyroscope to detect lateral ankle sprain hazard

Daniel T.P. Fong, Yue-Yan Chan, Vikki W.S. Chu, Alan H.F. Lam, *Member, IEEE*, Patrick S.H. Yung

**Abstract**—Lateral ankle sprain is very common in sports. Recently, there was a wearable assistive technology that stimulates the peroneal muscles to prevent this injury, but it requires a monitoring system to detect injury hazards and actuate the protection. This study presents the feasibility of a uniaxial gyroscope to monitor the peak ankle inversion velocity during common sporting motion and simulated ankle sprain motion. Ten males performed walking, running, 45-deg cutting, vertical jump-landing, stepping-down from a block, 5 kinds of simulated ankle sprain motion on sprain simulators, and a manual ankle-twisting motion in a biomechanics laboratory. The peak ankle inversion velocity was collected by an optical motion analysis system at 120 Hz. Besides, a uniaxial gyroscope was attached to the heel to collect the peak twisting velocity at 500 Hz. Pearson test showed a strong or high positive correlation between the two parameters. Independent t-test showed no difference between the two parameters in all testing motions except the manual ankle-twisting test which the value was 82% of that from the optical motion capture system and both values are above the threshold, 300 deg/s. We concluded the method is applicable to detect the hazard of lateral ankle sprain injury.

**Index Terms**—Angular rate sensors, ankle sprain, biomechanics, gyroscope, injury prevention, medical application, motion sensing, sensor application, sensor telemetry and monitoring, sensor testing and evaluation, sports medicine



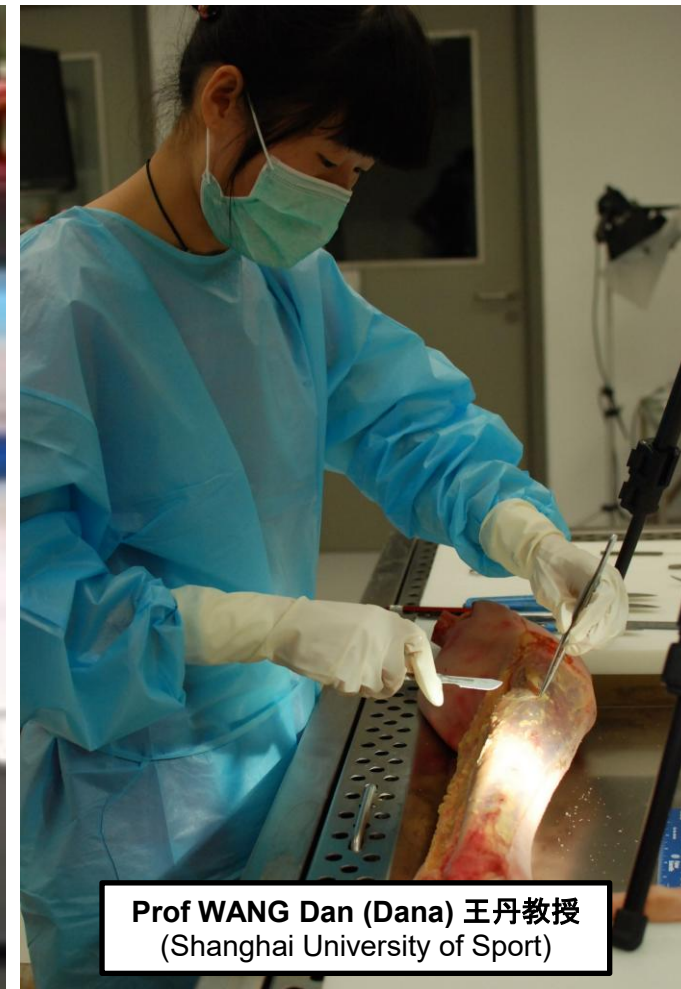
[Chu VWS, Fong DTP et al (2010). J Biomech, 43(10), 2035-2038]

[Fong DTP et al (2021). IEEE Sensors Journal, 21(3), 3757-3762.]

### 3. How can we tackle the problem?

- Warm-up exercises
- Pre-seasonal conditioning / functional training
- Sports-specific technique training
- Landing skill training
- **Prophylactic devices**
- Change of game rules
- Education

## By stimulating the peroneal muscles



[Fong DTP\*, Wang D, Chu VWS, Chan KM (2013). Journal of Biomechanics, 46(6), 1088-1091.]

# **Does the Spraino low-friction shoe patch prevent lateral ankle sprain injury in indoor sports?**

Published 2020 in:  
British Journal of Sports Medicine



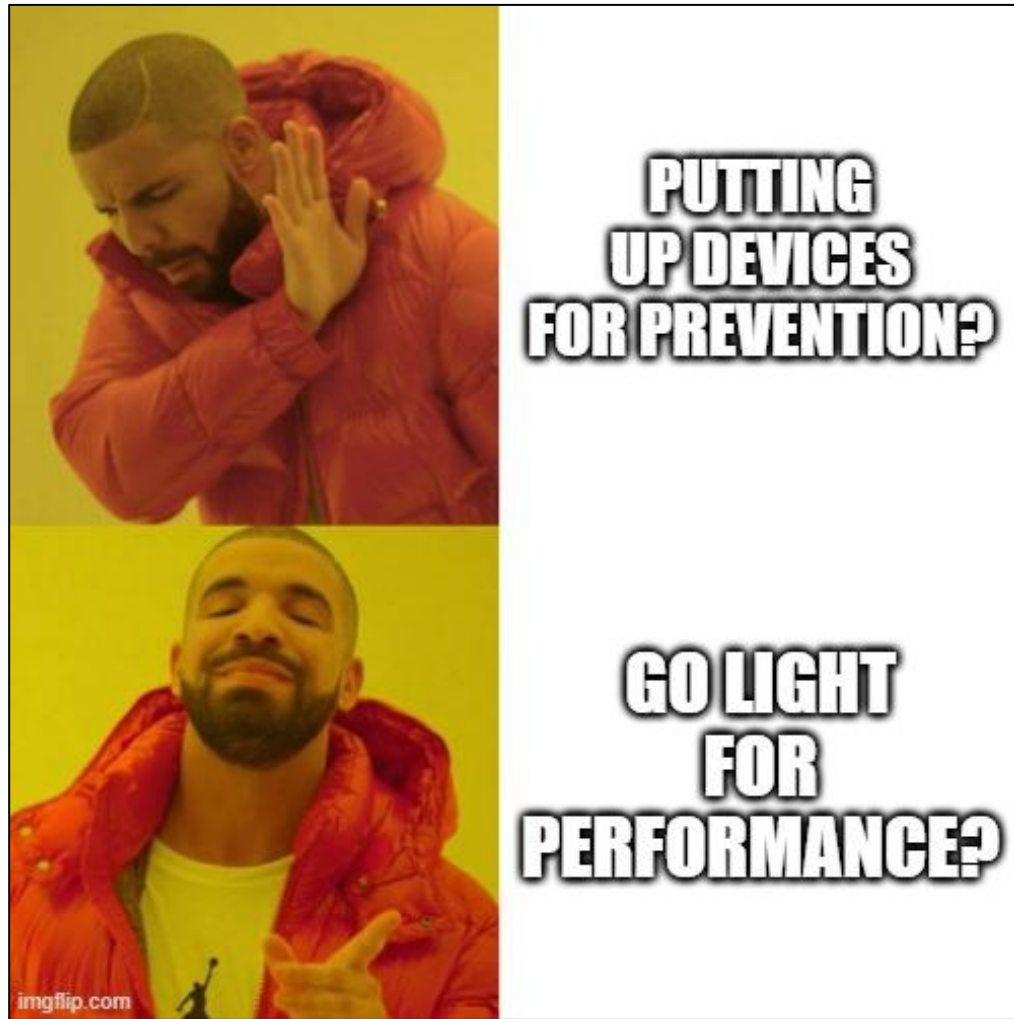
**Dr Filip Lysdal**

Post-Doc Fellow, 2021

Now Lecturer at St Mary's University



## 4. Can prevention and rehabilitation be combined?



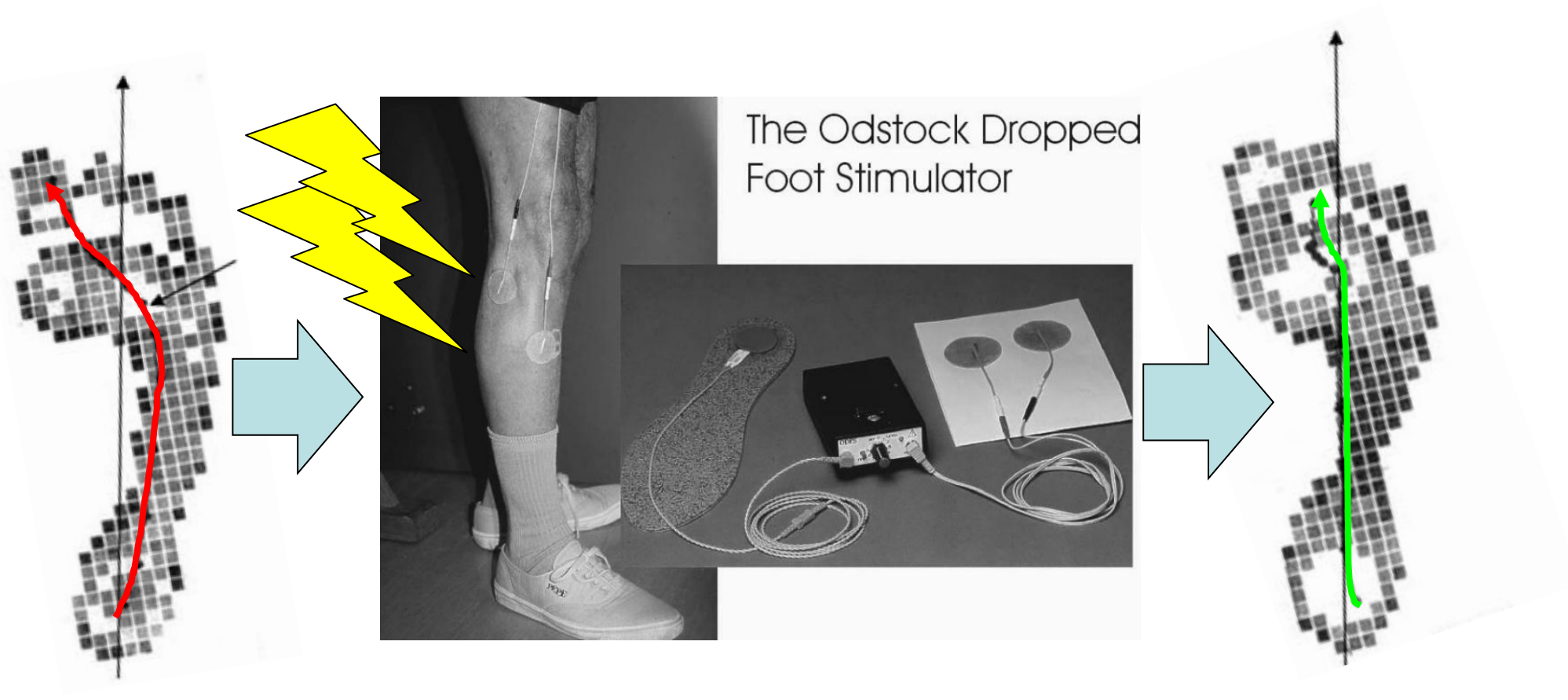
Prevention: difficult to implement!

What is prehabilitation?

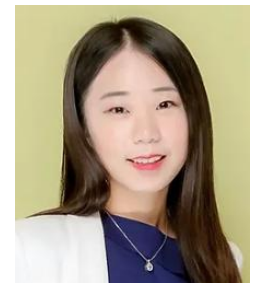
- Pre-operative / Pre-surgery Rehabilitation
- Rehabilitation for preventing the next injury
- “Prevention and Rehabilitation” as a NRC theme

<https://www.lboro.ac.uk/research/national-rehabilitation-centre/>

# Gait re-training to promote vertical landing



**Dr Zoe Bamber**  
PhD 2015-2022  
Now Assistant Professor,  
University of Nottingham



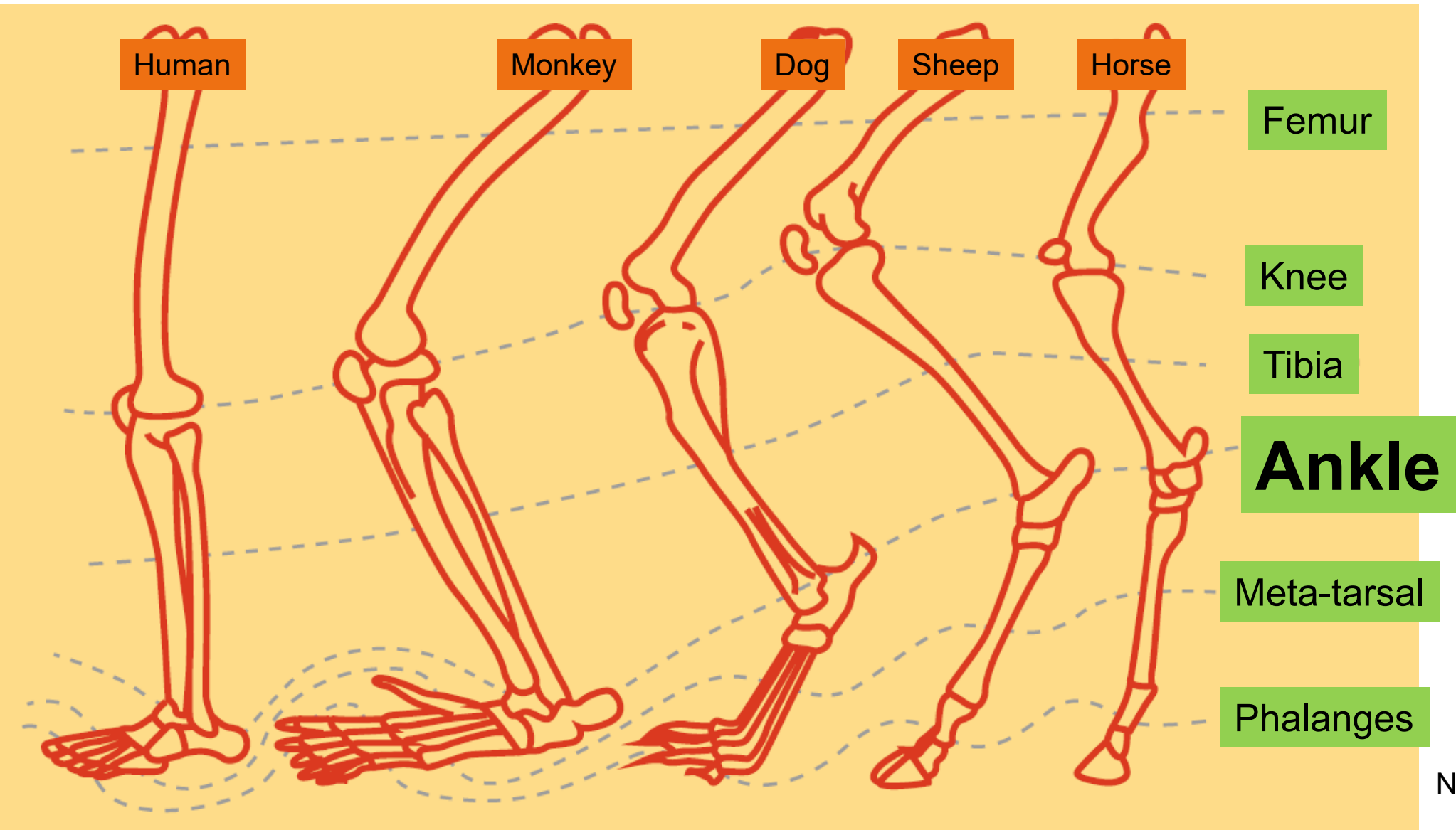
**Dr HE Xin 何欣博士**  
(CUHK / Uni of Sydney)

[Bamber et al (2021). Journal of Rehabilitation and Assistive Technologies Engineering, 8, 20556683211021526.]

[Bamber et al (2021). Cyborg and Bionic Systems, 2021, 9801097.]

[Bamber ZA, Wheeler P, He X, Ling SKK, Yung PSH, Fong DTP (2021). Research in Sports Medicine, 29(4), 323-335.]

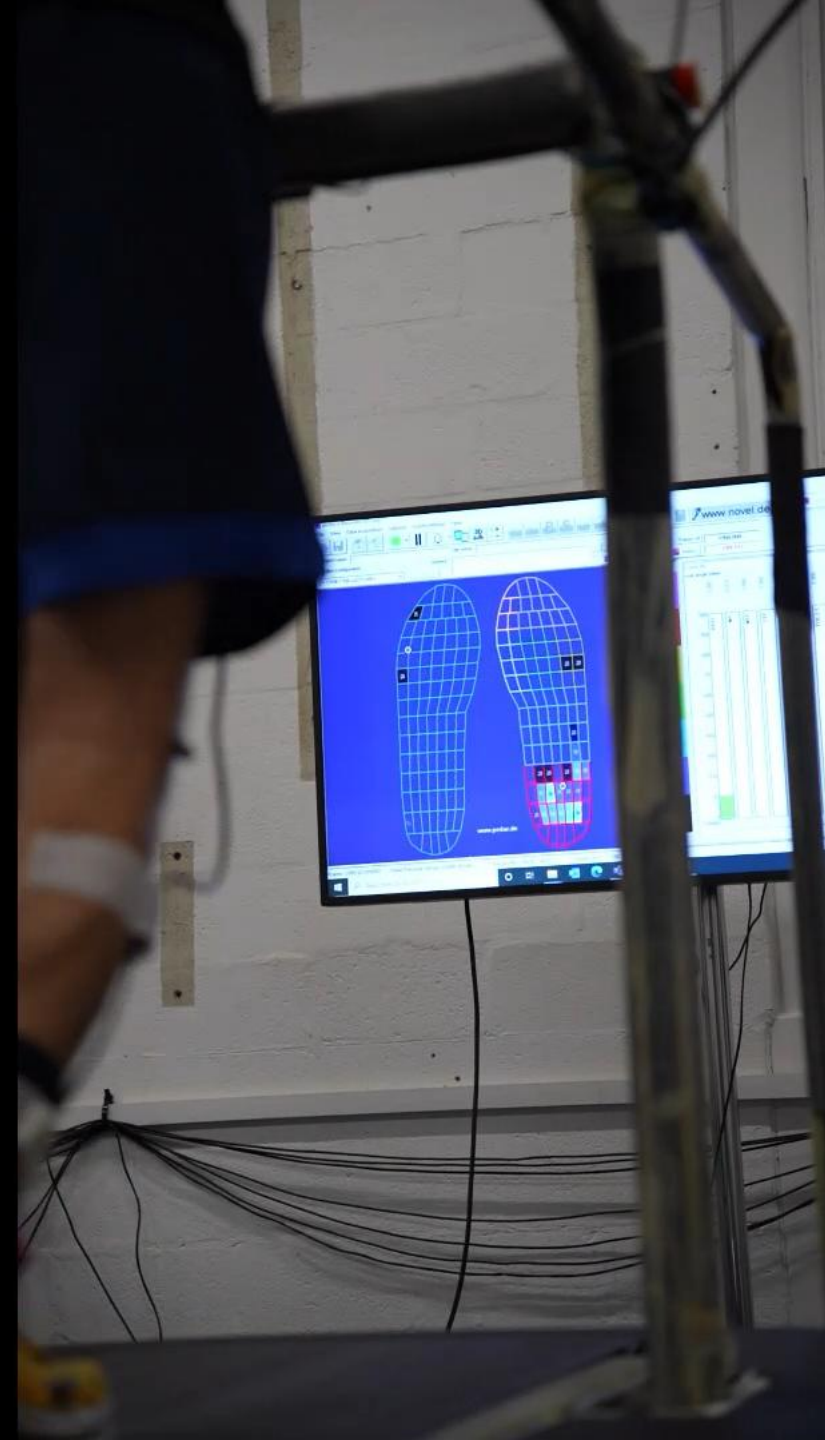
# Gentler heel strike to prevent ankle sprain



Wei Shen (Derek)  
沈瑋  
PhD 2020-2024



Morgan White  
MSc SB 2021  
Now PhD at Strathclyde



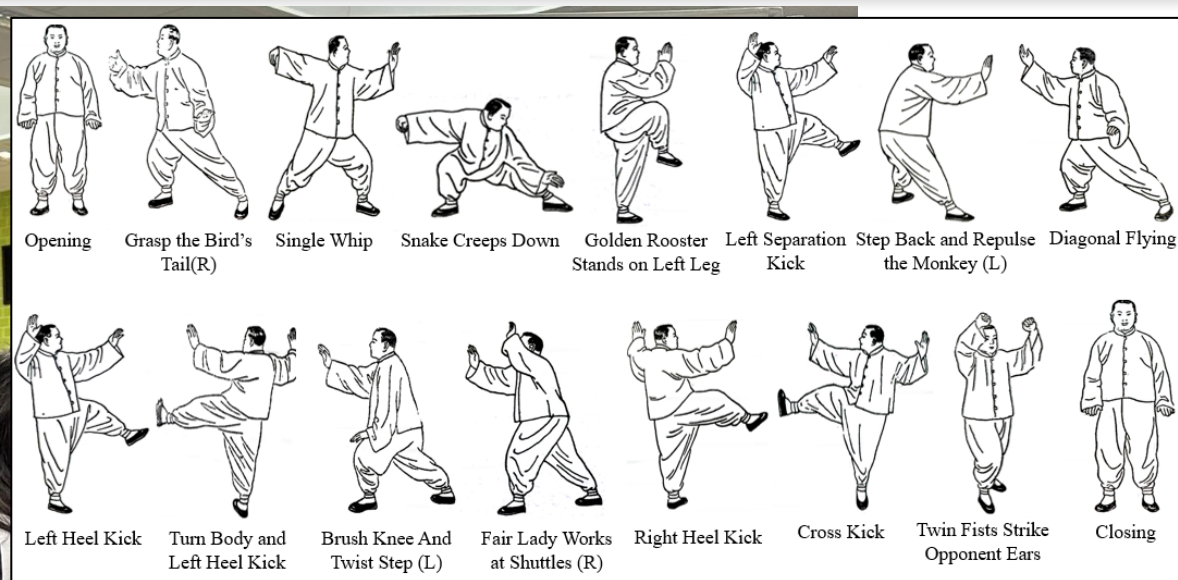
# Tai Chi for stronger ankles!



Hao Sun 孫浩  
PhD 2019-2024



Qian Qian 錢茜  
PhD 2022-



# Tackling arthrogenic muscle inhibition (AMI) in chronic ankle instability

- AMI: natural response to protect a joint from further damage.
- Cause decreased muscle activation, reduced strength, and slower reaction.
- Measured by Hoffmann reflex (h-reflex), superimposed burst (SIB) technique, or transcranial magnetic stimulation.

► Sports Med Open. 2024 Apr 10;10(1):35. doi: 10.1186/s40798-024-00710-y.

## Can Arthrogenic Muscle Inhibition Exist in Peroneal Muscles Among People with Chronic Ankle Instability? A Cross-sectional Study

Shiyu Dong<sup>1</sup>, Yanhao Liu<sup>1</sup>, Ziyin Liu<sup>1</sup>, Peixin Shen<sup>1</sup>, Hao Sun<sup>2</sup>, Ping Zhang<sup>2</sup>, Daniel T P Fong<sup>2</sup>, Qipeng Song<sup>1</sup>

Affiliations — collapse

### Affiliations

- <sup>1</sup> College of Sports and Health, Shandong Sport University, Jinan, 250102, Shandong, China.
- <sup>2</sup> National Centre for Sport and Exercise Medicine, Loughborough University, Loughborough, UK.



ZHANG Ping  
張萍



ZHANG Jingdan  
張競丹



Stella WANG  
王卓然





## PhD study on ankle sprain / instability (self-funded)

Ankle sprain injury is very common in sports. Repeated ankle sprains may lead to chronic ankle instability, wearing of the articulating cartilage, early osteoarthritis, and ultimately an ankle fusion or joint replacement surgery.

We are looking for high calibre candidates to pursue PhD study on sport-related ankle sprain injury. Possible topics include (but not limited to):

- Forensic analysis of the injury mechanism.
- Developing video analysis software to analyse televised injury incidents.
- Prevention by new prophylactic devices or exercise programmes.
- Interventions to improve peroneal muscle reaction time.
- Treatment of chronic ankle instability.
- Computational simulation of ankle fusion / replacement surgery.

Applicants should have a first or upper second class bachelor degree in medicine, or a master degree in orthopaedics, physiotherapy, rehabilitation, kinesiology, sports medicine, sports science, biomechanics, biomedical engineering, mechanical engineering, physics or related subjects. Applicants must have completed their studies in English, or have an English language qualification. Experience in publishing in academic journal is required.

This is a self-funded position (with no closing date) with the School of Sport, Exercise and Health Sciences, Loughborough University, UK. Applicants are welcome to apply for external scholarship to support the study. Enquiries should be made to Dr Daniel T.P. Fong ([d.t.fong@lboro.ac.uk](mailto:d.t.fong@lboro.ac.uk)). Please visit <http://danielfong.org> for information on previous work.



**Dr Daniel T.P. Fong** is a Fellow of The International Society of Biomechanics in Sports (ISBS), Fellow of The Hong Kong Association of Sports Medicine and Sports Science (HKASMSS), and Life Member of World Association of Chinese Biomedical Engineers (WACBE). He is currently the Editor-in-Chief of Sports Biomechanics Journal (2014-).  
LinkedIn: @dtpfong, Twitter: @dtpfong, Weibo: @方迪培DanielFong

My Site Reader

## DR DANIEL FONG SPORT INJURY LABORATORY

MENU

We investigate and prevent sport injuries.

Our main theme is on ankle sprain and related injuries. Other researches focus on knee injury and surgery, orthopaedics, and sport medicine related topics.

[Edit](#)

ABOUT DR DANIEL FONG

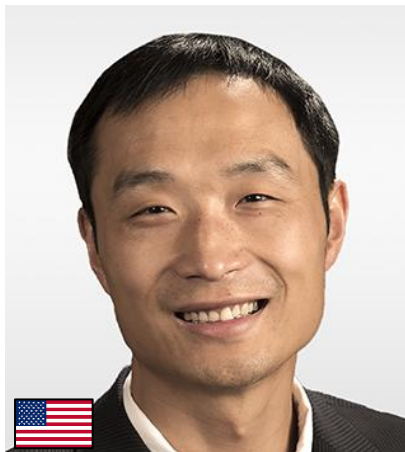
ANKLE SPRAIN RESEARCH

PEOPLE

# Lunch / Workshop 2 (CUHK Campus, Esther Lee Building)



Dr Daniel Fong  
方迪培博士



Prof Boyi Dai  
戴伯頤教授



Derek Shen  
沈瑋

**Workshop 2: Biomechanics measurement of the ankle joint**  
13:30-15:00 / Cheng Yu Tung Building

**Workshop 3: Biomechanics measurement of the knee joint**  
15:00-16:40 / Cheng Yu Tung Building

*(You will run on a treadmill and/or perform some sports movements.  
Sportswear is advised.)*

