EHF SCIENTIFIC CONFERENCE 2015

3rd EHF Scientific Conference

EUROPEAN HANDBALL FEDERATION

Injury mechanisms and biomechanical perspectives for prevention in handball

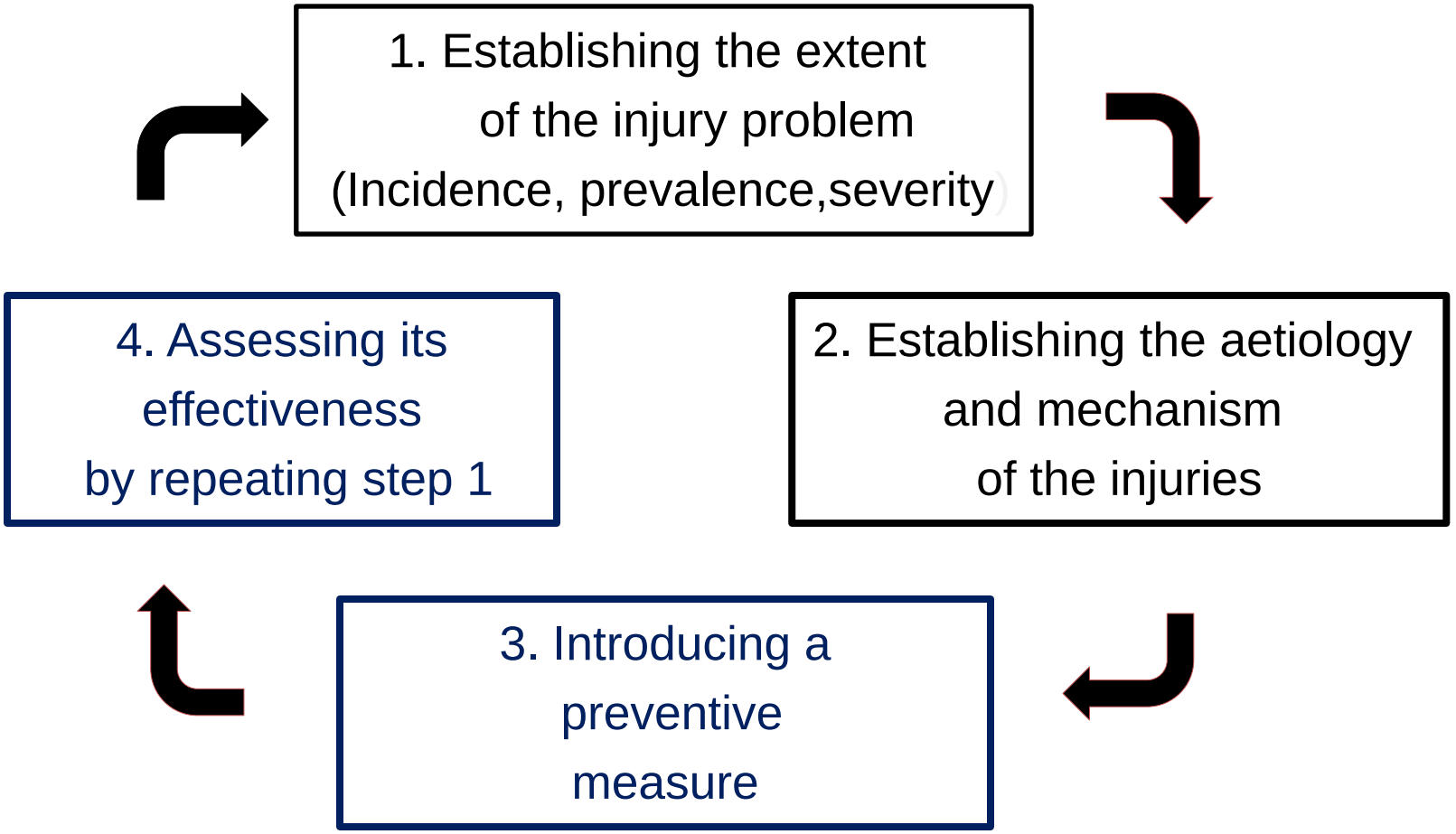
Jesper Bencke, PhD

Laboratory of Human Movement Analysis,
Dep. of Orthopaedic Surgery
Copenhagen University Hospital, Hvidovre, Denmark
&
Research Unit for Biomechanics of Sports Injury Prevention
&
Copenhagen IOC Research Center for Prevention of Injury and Protection of Athlete Health

Merete Møller, PT, MHSc, PhD-stud

Mette K. Zebis, PhD, Senior Researcher

The sequence of injury prevention

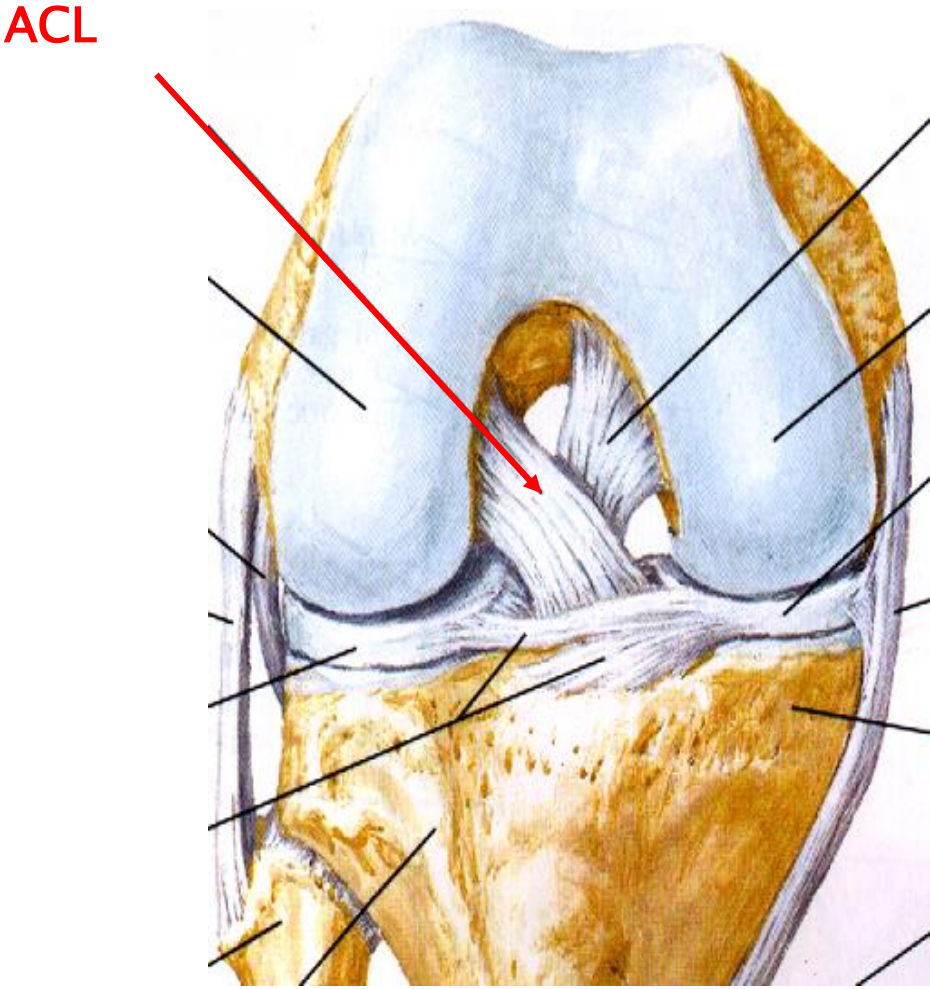


van Mechelen et al, Sports med, 1992

The ACL injury is a frequent and serious injury

The ACL constraints knee movements in 3D:

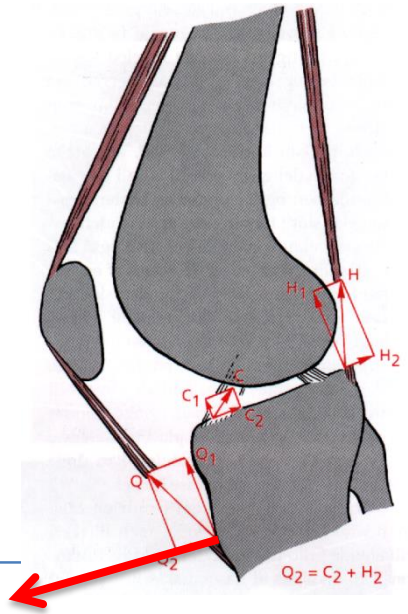
- Sagittal plane:
  Anterior translations of tibia.
- Frontal plane:
  Valgus-movement
- Transversal plane:
  Rotations of tibia

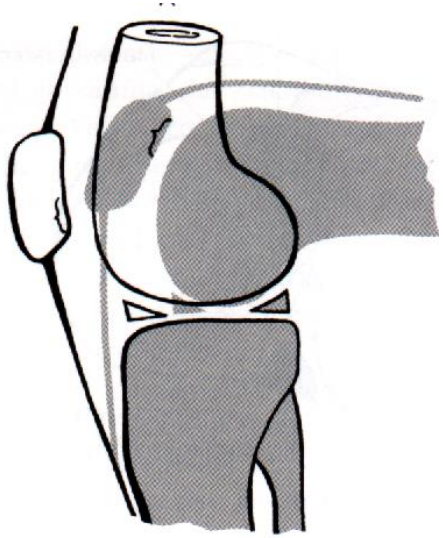


Biomechanical loading of the ACL: Sagittal plane

Anterior translation of tibia

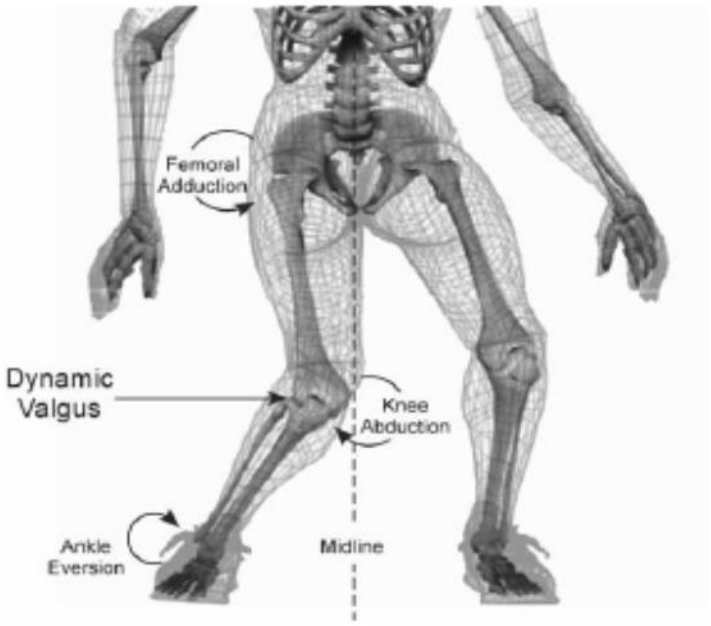
- < 30° of flexion may load the ACL through anterior translation
- At 90° knee flexion no anterior translation is present due to reduced angle of patella ligament.





Biomechanical loading of the ACL: Frontal and transverse plane

- Forcefull valgus movement
- Forcefull inward or outward rotations



The injury mechanism

External loading of a joint structure

Internal counter-acting factors

Injury!!

The injury mechanism

External loading of a joint structure

Internal counter-acting factors

Injury!!

Preventing injuries

External loading of a joint structure

Internal counter-acting factors

Preventing injuries

External loading of a joint structure

Internal counter-acting factors

Preventing injuries

External loading of a joint structure

Internal counter-acting factors

Biomechanical r

D orce

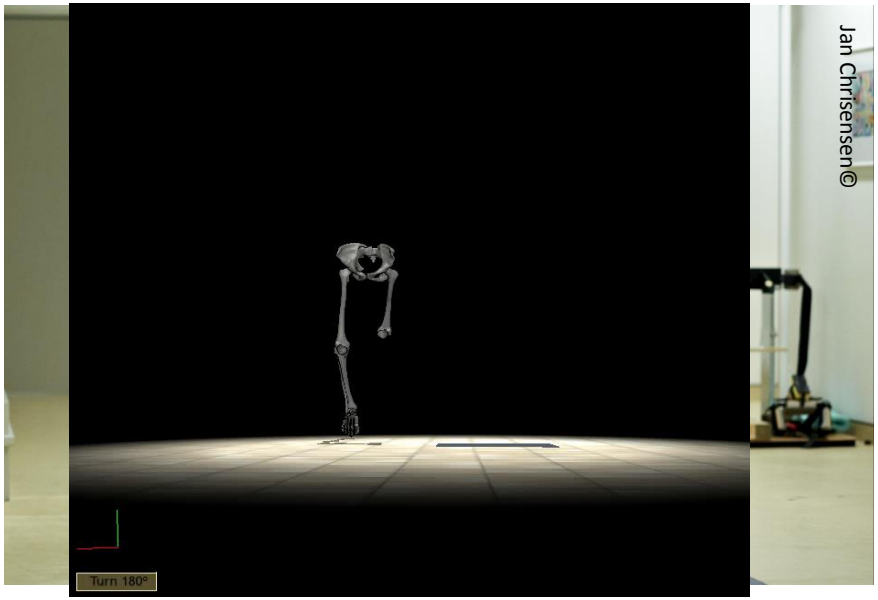
Passive tissue resistance

Risk situation in handball

- The sidecut maneouvre is the single movement with the highest risk of ACL-injury. (Strand et al, 1990)
- Injuries to the ACL have previously been reported to occur early (<40 ms) in the eccentric part of a handball sidecut manoeuvre with:
  - the knee near full extension,
  - in outward or internal rotation, and
  - with increased valgus movement.
    (Olsen et al., 2004; Krosshaug et al., 2007, Koga 2010)

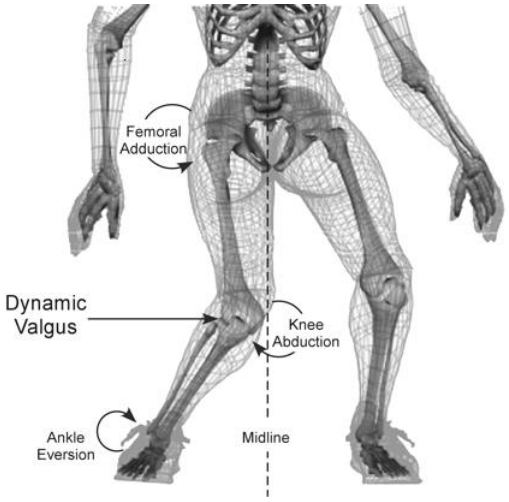
Biomechanical movement analyses

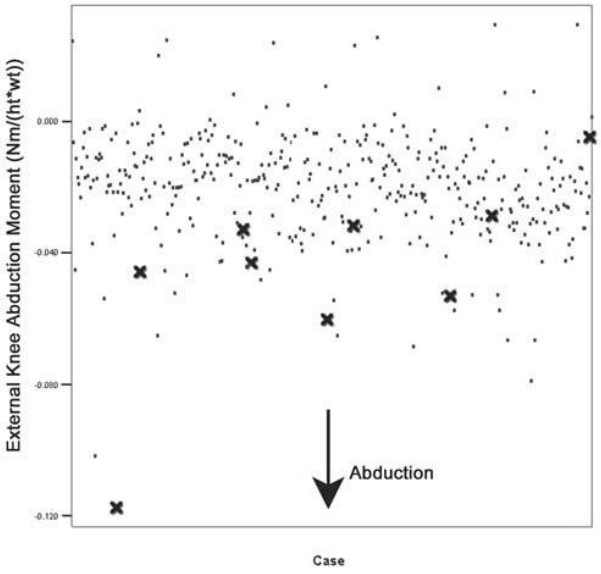
- External loading
  - Kinematics
    - Joint angles in 3D
  - Kinetics
    - Net joint moments in 3 D
    - Power
- Internal counter-acting
  - Electromyography (EMG)
    - Neuromuscular coordination

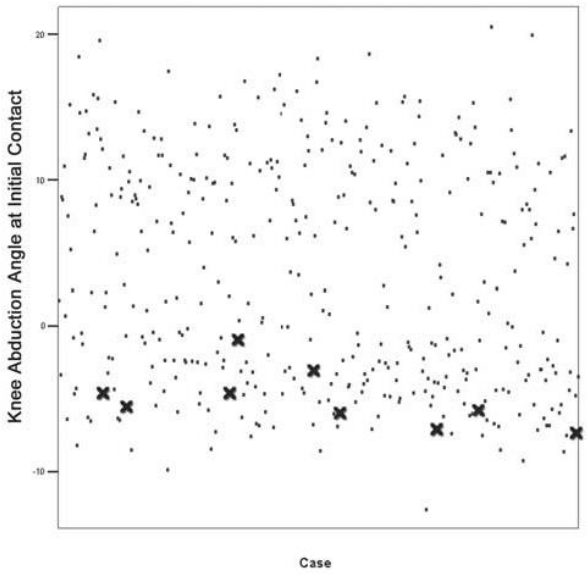


Knee joint loading in the frontal plane is not good

Drop jump, n=205







Hewett et al., 2005

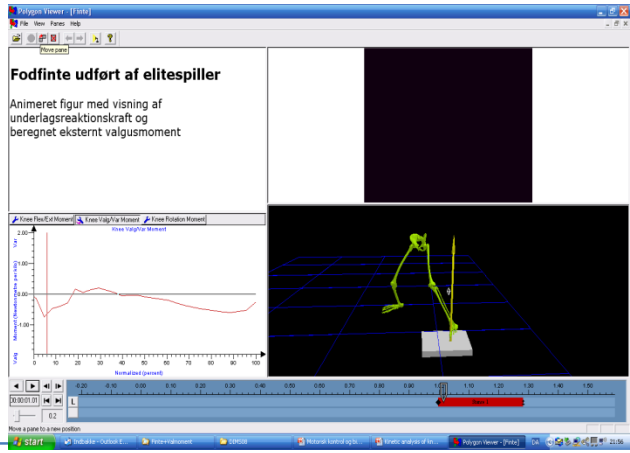
The handball side step cut

Knee Surg Sports Traumatol Arthrosc (2013) 21:1876–1881
DOI 10.1007/s00167-012-2199-8

KNEE

Biomechanical evaluation of the side-cutting manoeuvre associated with ACL injury in young female handball players

Jesper Bencke · Derek Curtis · Christina Krogshede · Line Klemmensen Jensen · Thomas Bandholm · Mette Kreutzfeldt Zebis



Hip joint kinematics may influence knee joint moments

- Significant relation between hip joint internal rotation and knee valgus moments during sidecutting.
  (Bencke, Zebis et al. BJSM, 2014)

Why do so many ACL-injuries occur during sidecutting?

External loading

One-legged landing demanding high muscle strength.
A frontal plane and transverse plane movement!
(Different from stopping or dropjump)

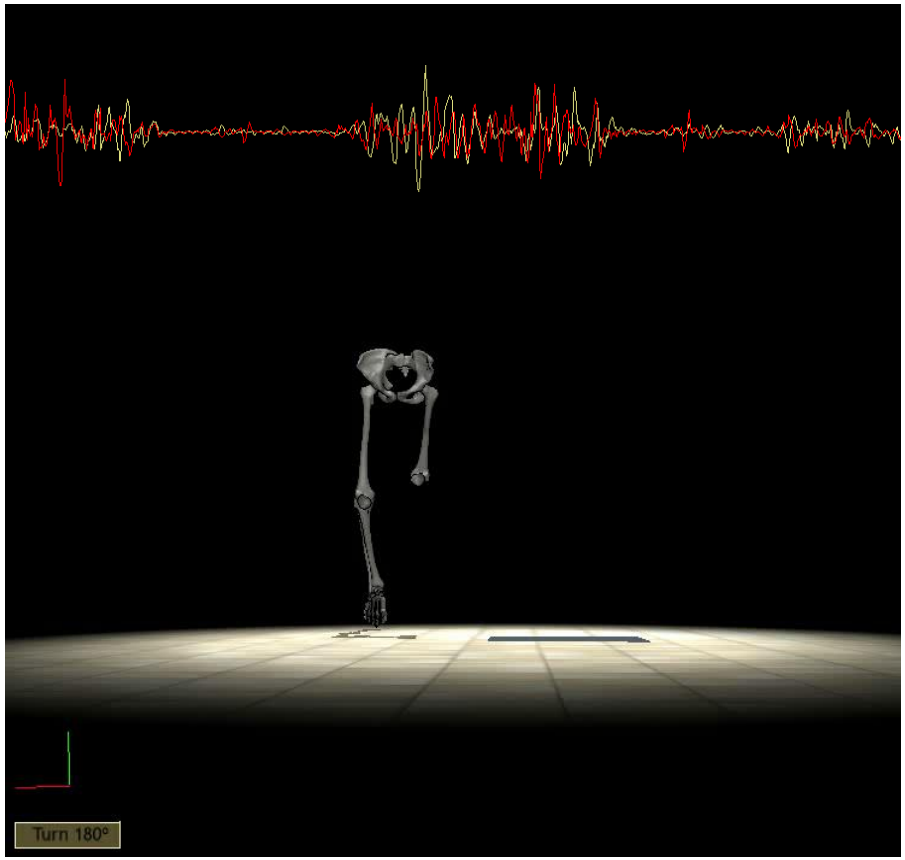
External moments trying to rotate knee or bring it in valgus → straining the ACL. Higher values than other movements.

Players should learn:
To land on flexed knees
With hips less internally rotated
With CoM more above the knee

Does good muscle strength reduce knee joint loading during sidecutting?

- No correlation between isometric hip muscle strength and knee valgus moments.
  (Bencke, Zebis et al., BJSM, 2014)
- No correlation between isometric hamstring muscle strength and knee valgus moments.
  (unpublished data, Zebis, Bencke et al.)

Internal counter-acting factors



Neuromuscular factors

Important muscles for prevention of ACL injury

Avoid extended knee

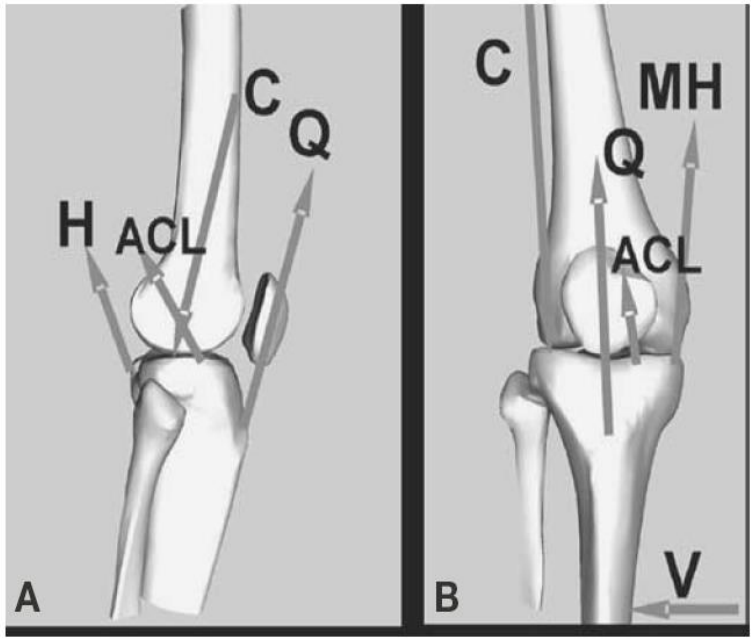
→quadriceps ↑

Resist valgus moments

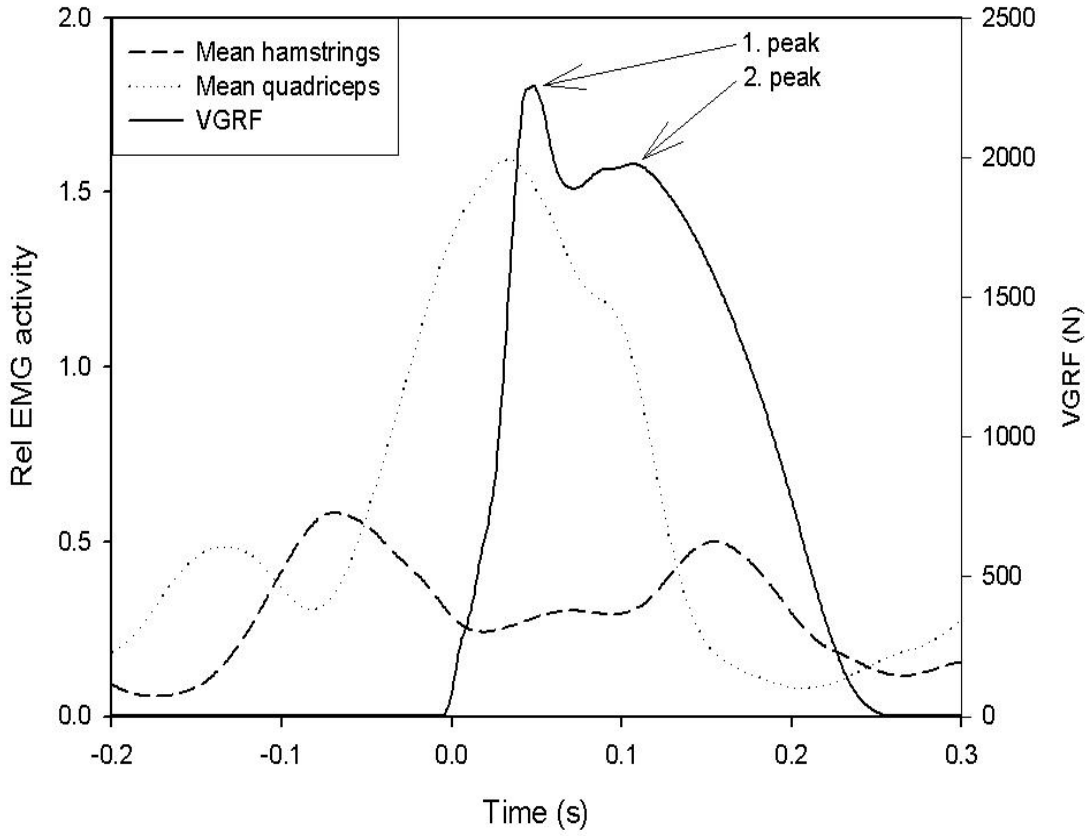
→ Medial hamstrings↑

Resist external rotation moments

→ Medial hamstrings↑



Neuromuscular coordination during sidecutting in handball



Bencke & Zebis, JEK 2011

Gender differences in neuromuscular coordination

Hamstring-to-quadriceps preactivity ratio

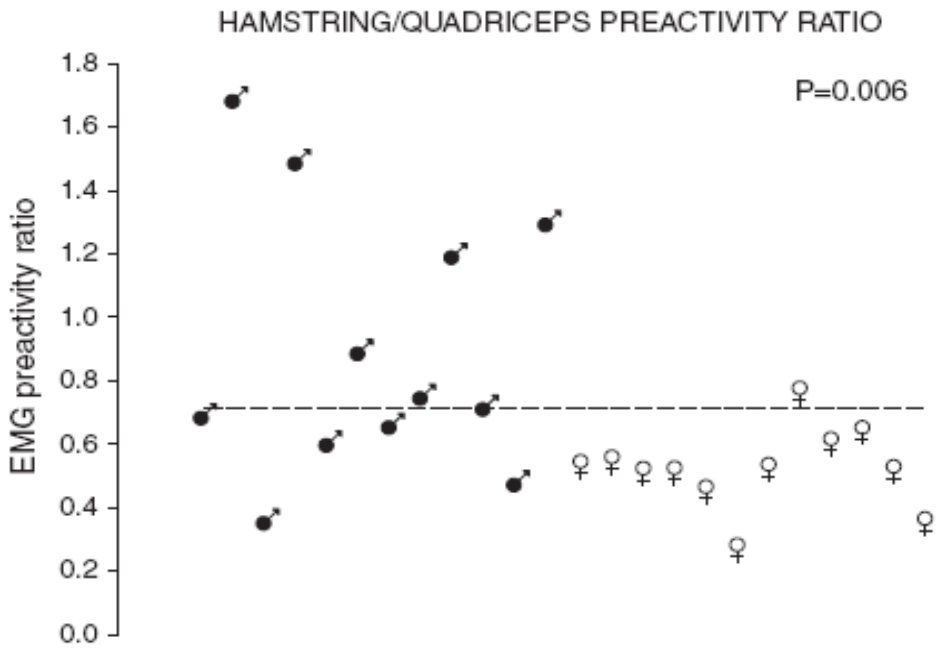
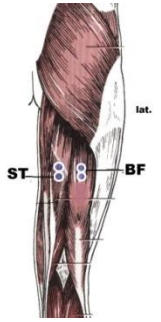


Fig. 3. Electromyography (EMG) hamstring-to-quadriceps pre-activity ratio during side-cutting. ♂: Male players. ♀: Female players. Dashed line indicates overall mean. The *P* value shows the significant difference level between the 2 groups.

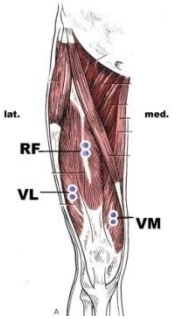
Bencke & Zebis, JEK 2011

Neuromuscular coordination during sidecutting in handball

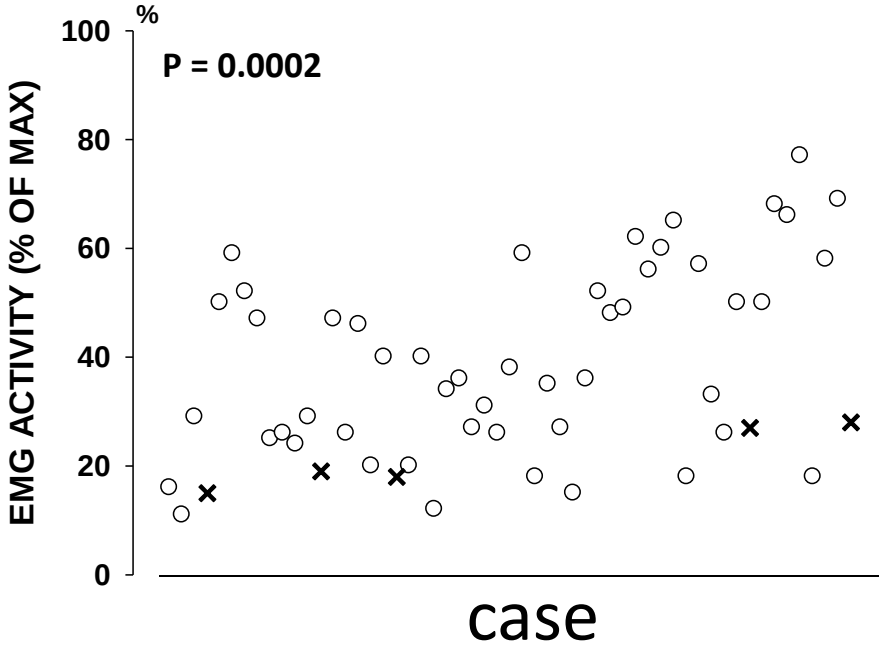


X : ACL cases (n=5)

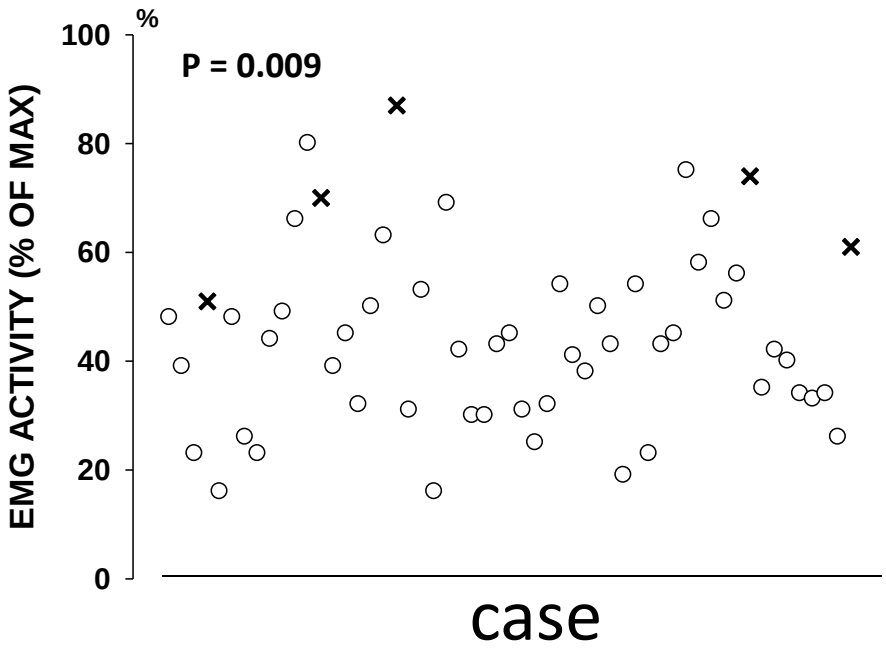
O: Non-injured (n=50)



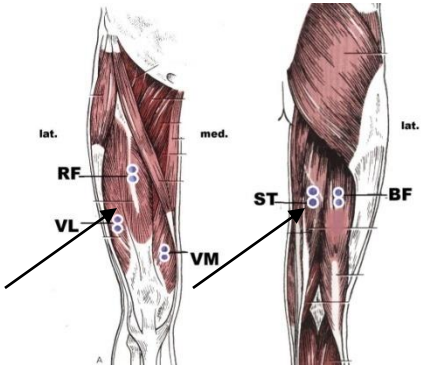
NEUROMUSCULAR ACTIVITY OF ST (10 ms pre-landing)



NEUROMUSCULAR ACTIVITY OF VL (10 ms pre-landing)

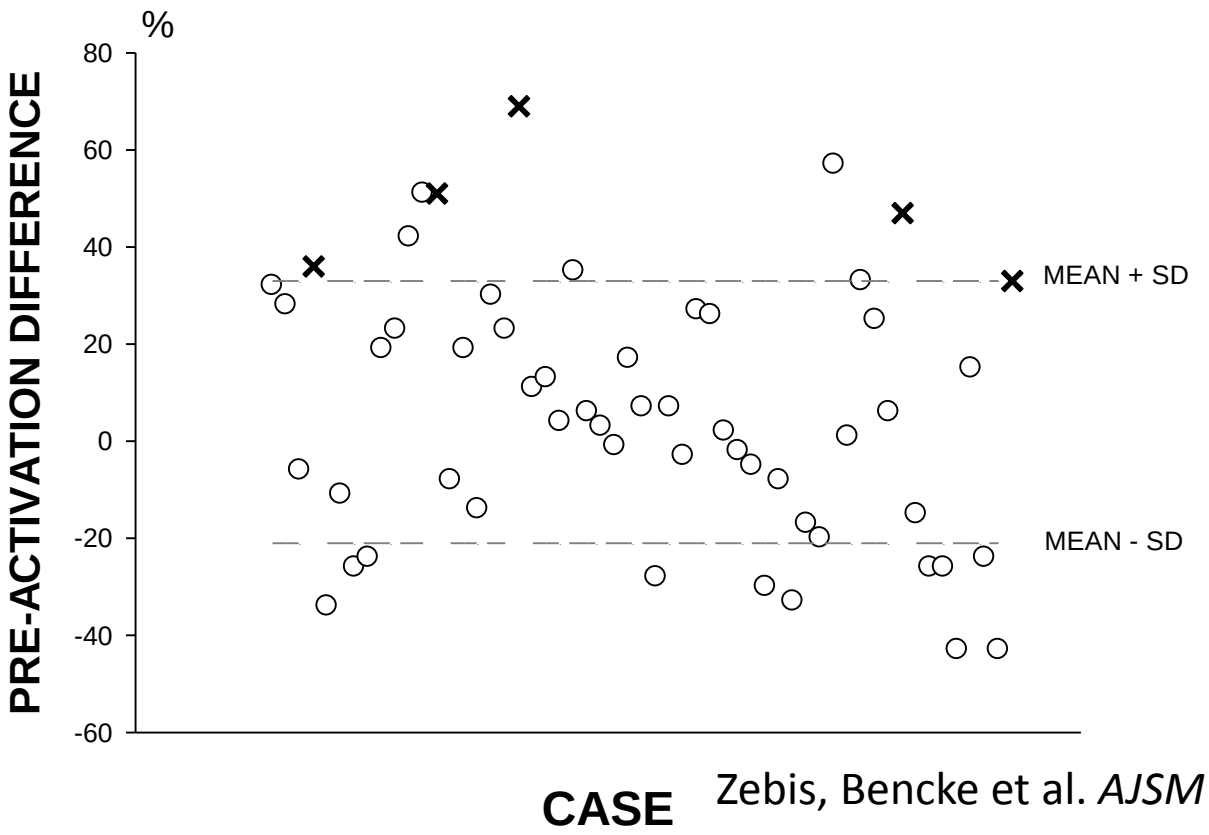


Zebis, Bencke et al. *AJSM 2009*



HIGH RISK ZONE?

VL – ST

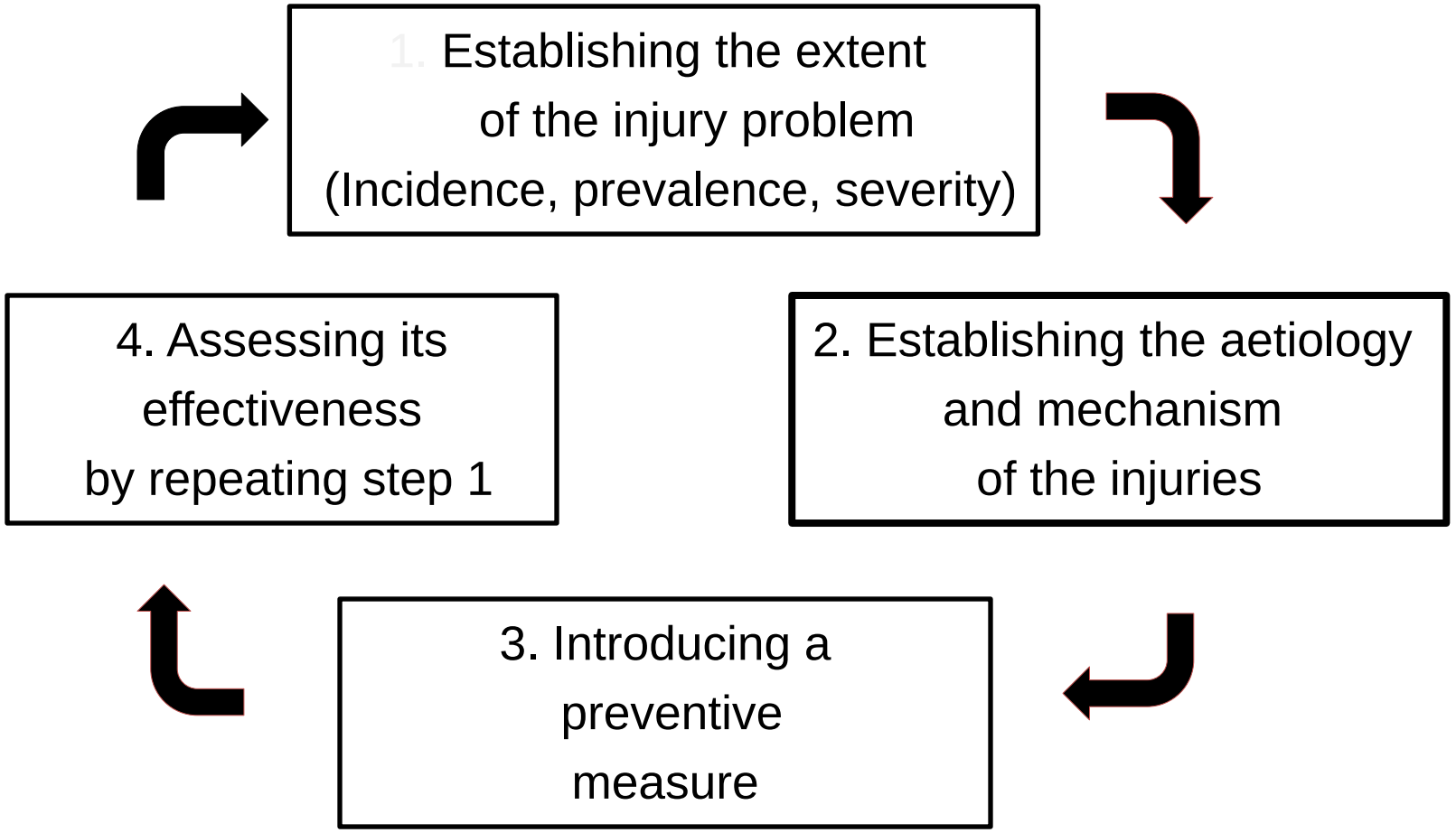


Zebis, Bencke et al. *AJSM 2009*

Why are some players more at risk?

- Unfortunate technique during sidecutting, thus increasing external moments?
- Lower activation of hamstring muscles prior to ground contact during sidecutting!
- Lack of adequate explosive muscle strength may also be a factor, especially in the hamstrings.

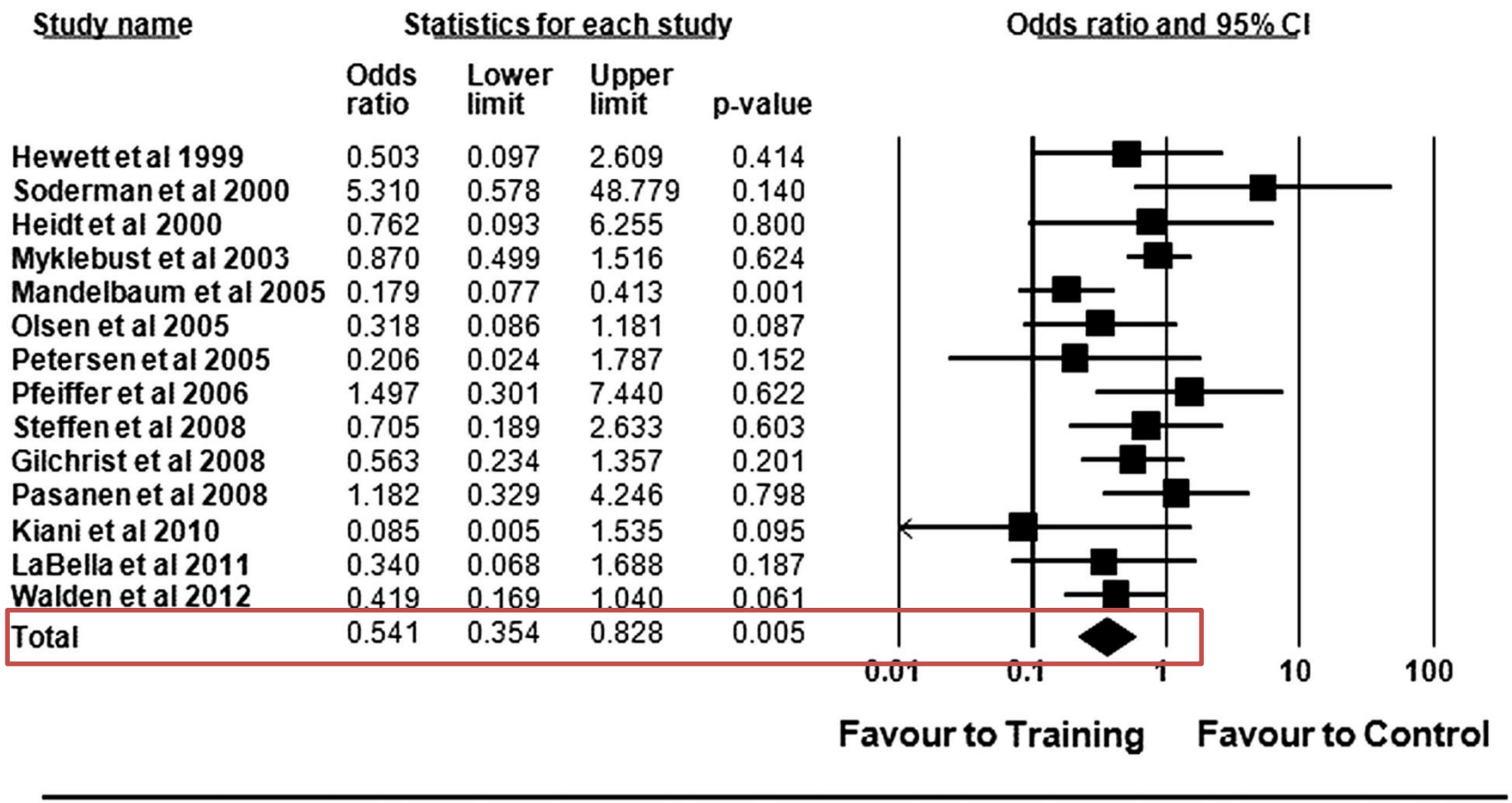
The sequence of injury prevention



van Mechelen et al, Sports med, 1992

Can ACL injuries be prevented?

Can ACL injuries be prevented?



Meta Analysis, Random Model.

Sugimoto D, et al. Br J Sports Med 2015

Why do preventive training help?

External factors

- No change in biomechanical loading during sidecutting after a prevention training program known to reduce ACL-injury risk. Zebis et al, 2015
- There is very limited research on the effectiveness of injury prevention programmes on reducing biomechanical risk factors for ACL rupture during cutting tasks. Pappas et al, review BJSM 2015
- The most successful injury prevention programmes emphasised individualised biomechanical technique correction and targeted postpubertal female athletes. Pappas et al, review BJSM 2015
-

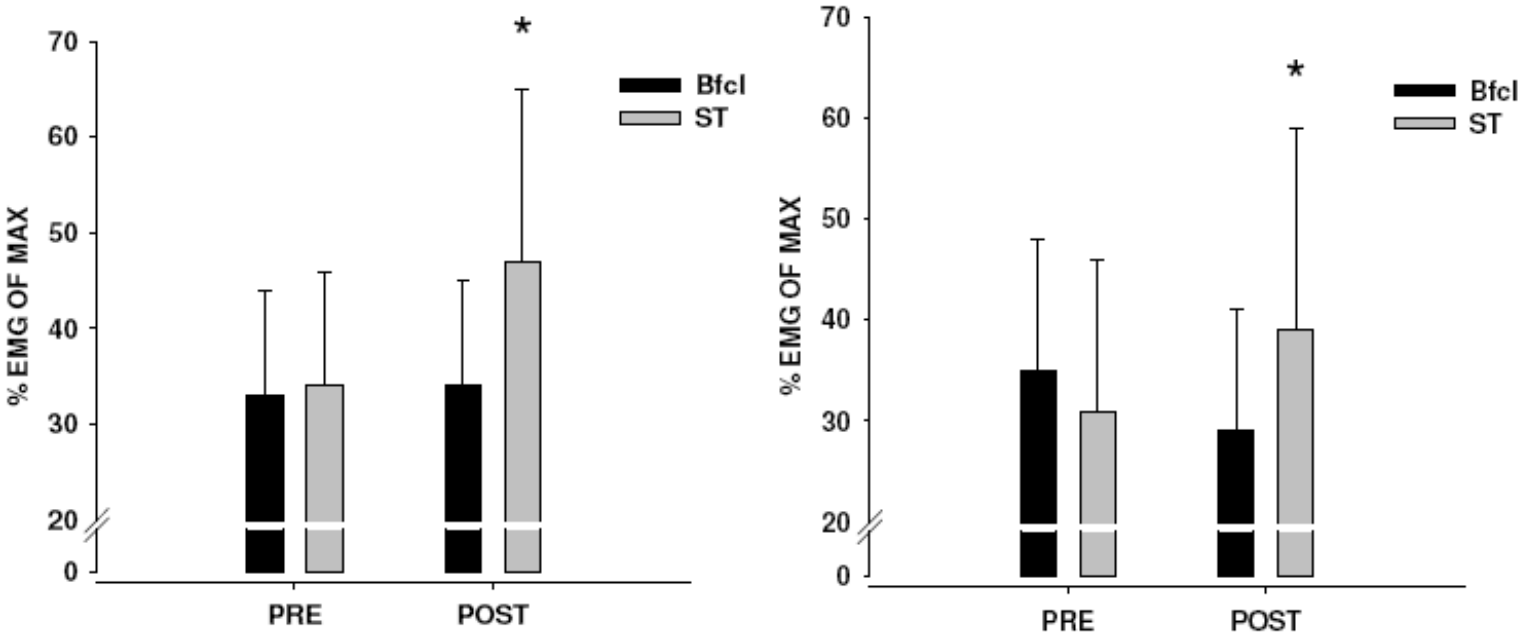
Internal counter-acting factors

- Injury prevention programmes have the potential to change cutting task biomechanics by ameliorating neuromuscular deficits linked to ACL rupture. Pappas et al, review BJSM 2015
- Prevention training programs known to reduce ACL-injury risk improves neuromuscular coordination in favour of medial hamstring activation. Zebis et al, 2008, 2015

Myklebust et al., 2002

Photo:
Geert Mørch

Effect of neuromuscular training



Zebis et al, CJSM 2008

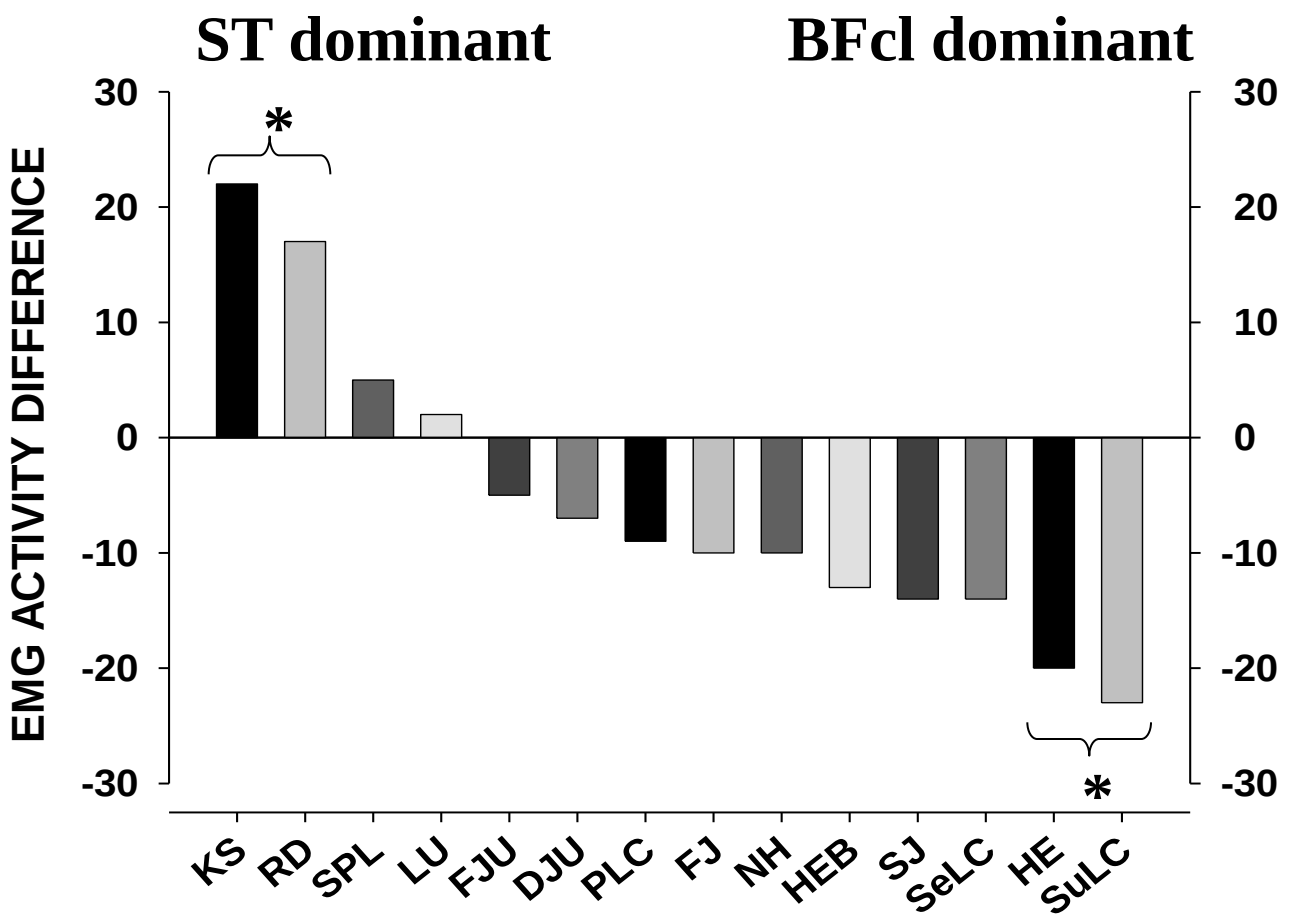
Fig.1: Neuromuscular activity in the medial (ST) and lateral (Bfcl) hamstring muscles pre and post the period of neuromuscular training. Left: Mean average EMG amplitude in the 10 ms time interval prior to the instant of foot strike. Right: Time interval 0-10 ms after landing. * denotes significant difference between pre and post, $p<0.05$.

Which exercises to choose?

- All programs have a multiple of different neuromuscular exercises mixed with strengthening exercises. Which exercises are best?
- Exercises that will increase medial hamstring activation during sidecutting and landing may be the best for ACL prevention?

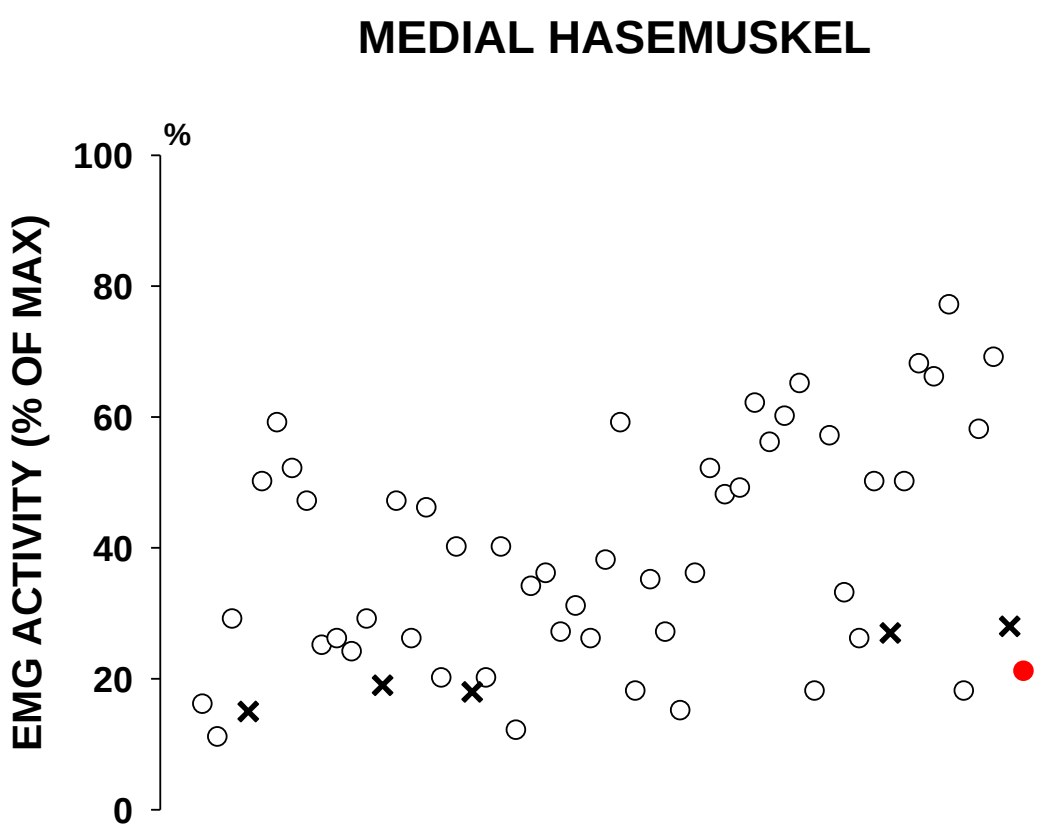
Hamstring Exercises

Zebis et al. *BJSM 2012*



Before ACL injury

- National football player -

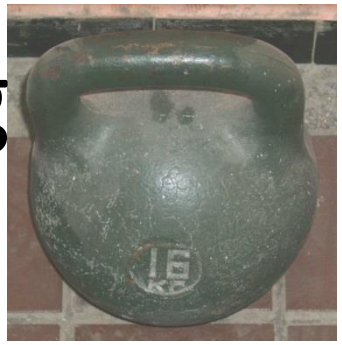


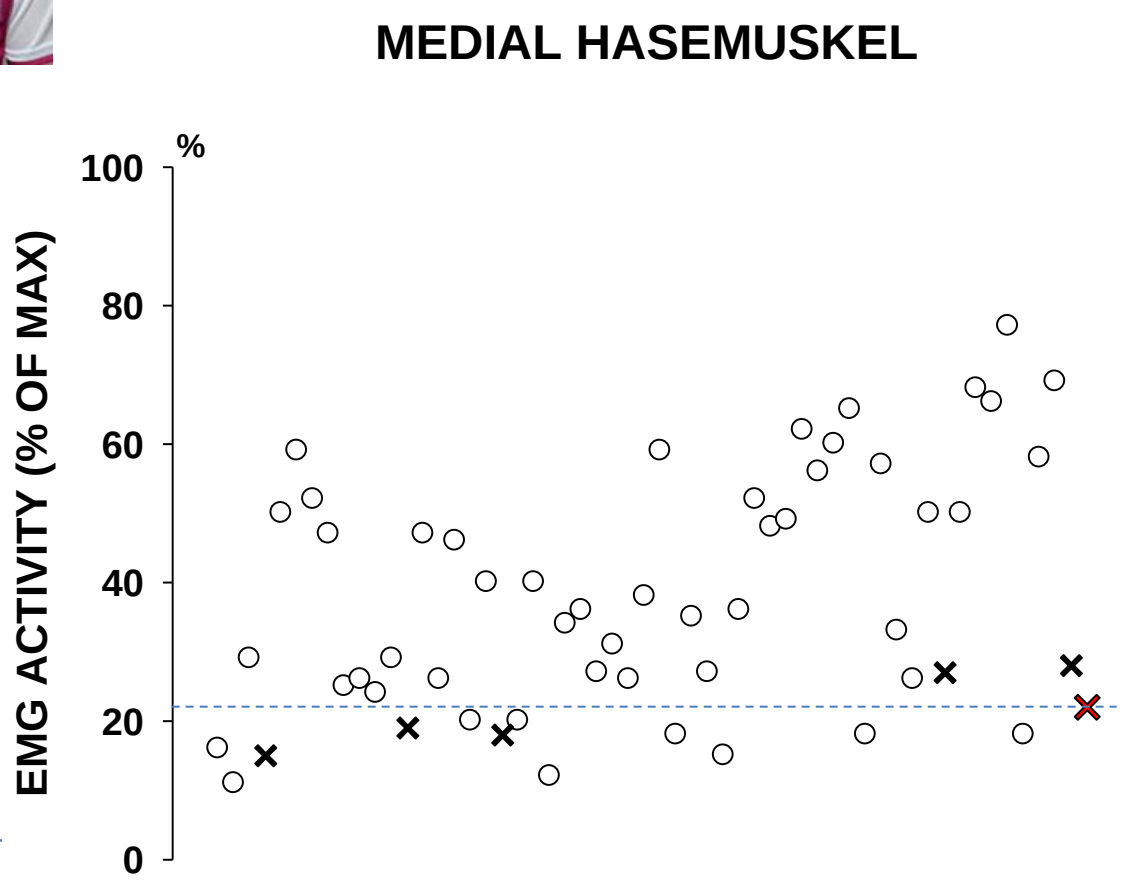
With permission

Mette Zebis

Before Kettlebell training

- National football player-



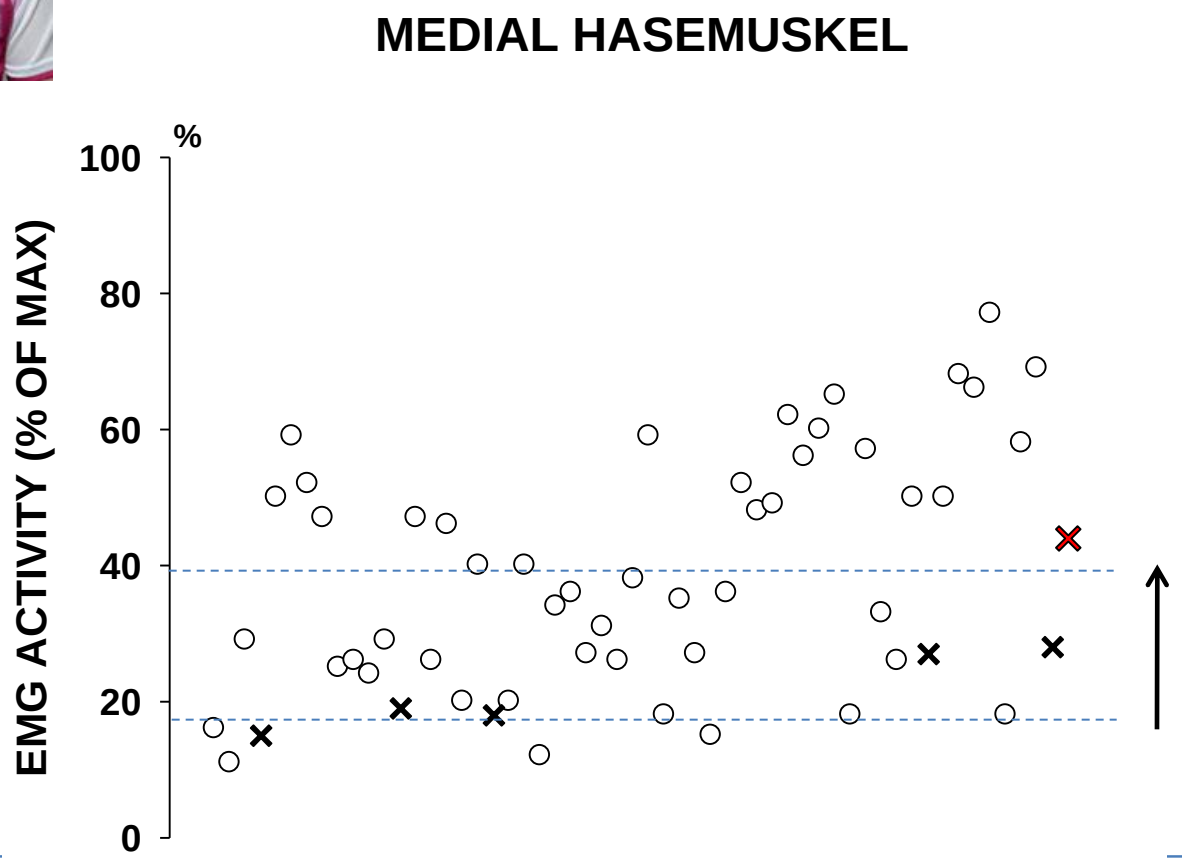


With permission

Mette Zebis

After Kettlebell training

- National football player-



With permission

Mette Zebis

Dynamic landing increase hamstring activity

- Dynamic landings were performed from a horizontal jump in randomized order on e.g. and compared with static balance on same devices:

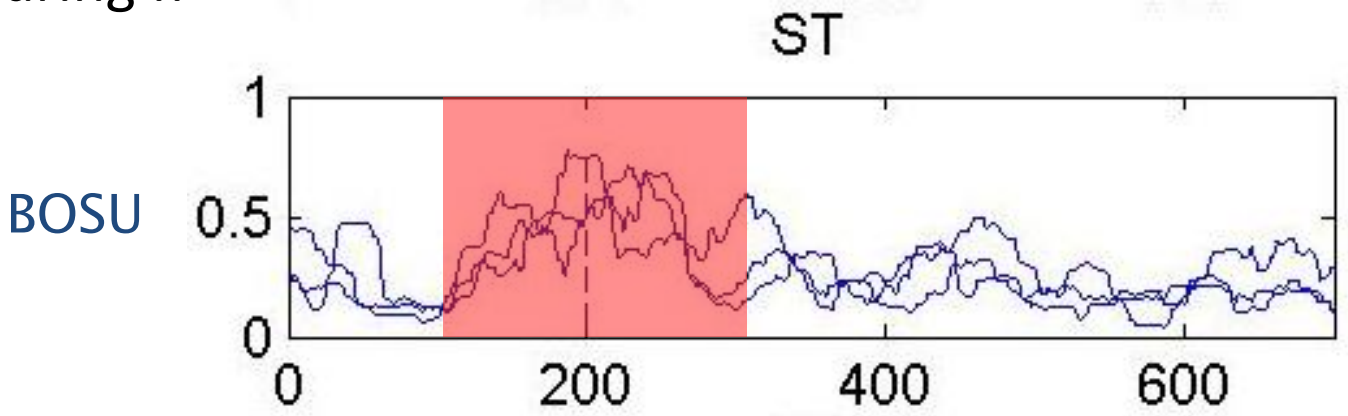
Airex mattress

BOSU-ball

Outcome parameters

Dynamic landing exercises:

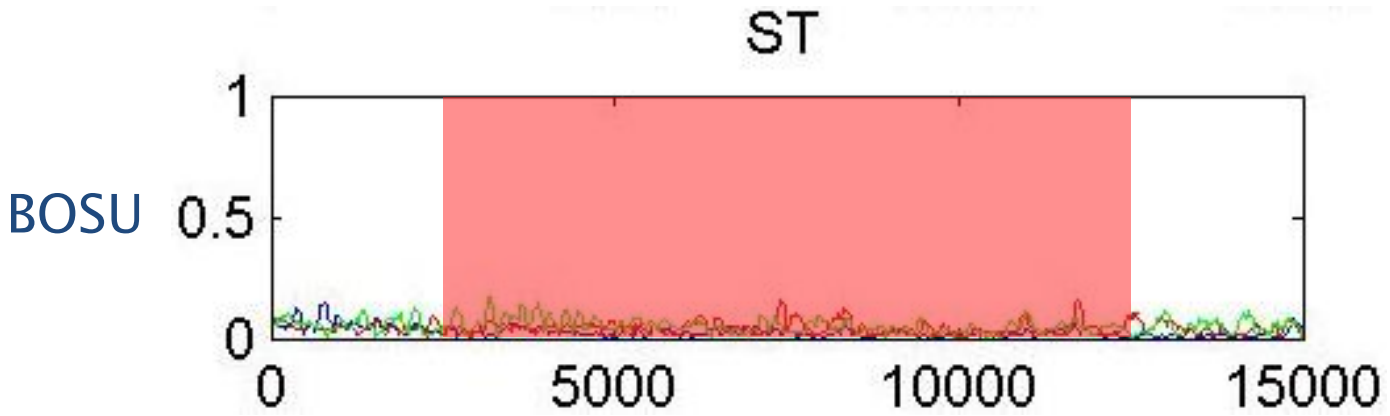
- The mean EMG activity of the lateral and medial hamstring muscles:
  - During last 100 ms before landing
  - During first 100 ms after landing



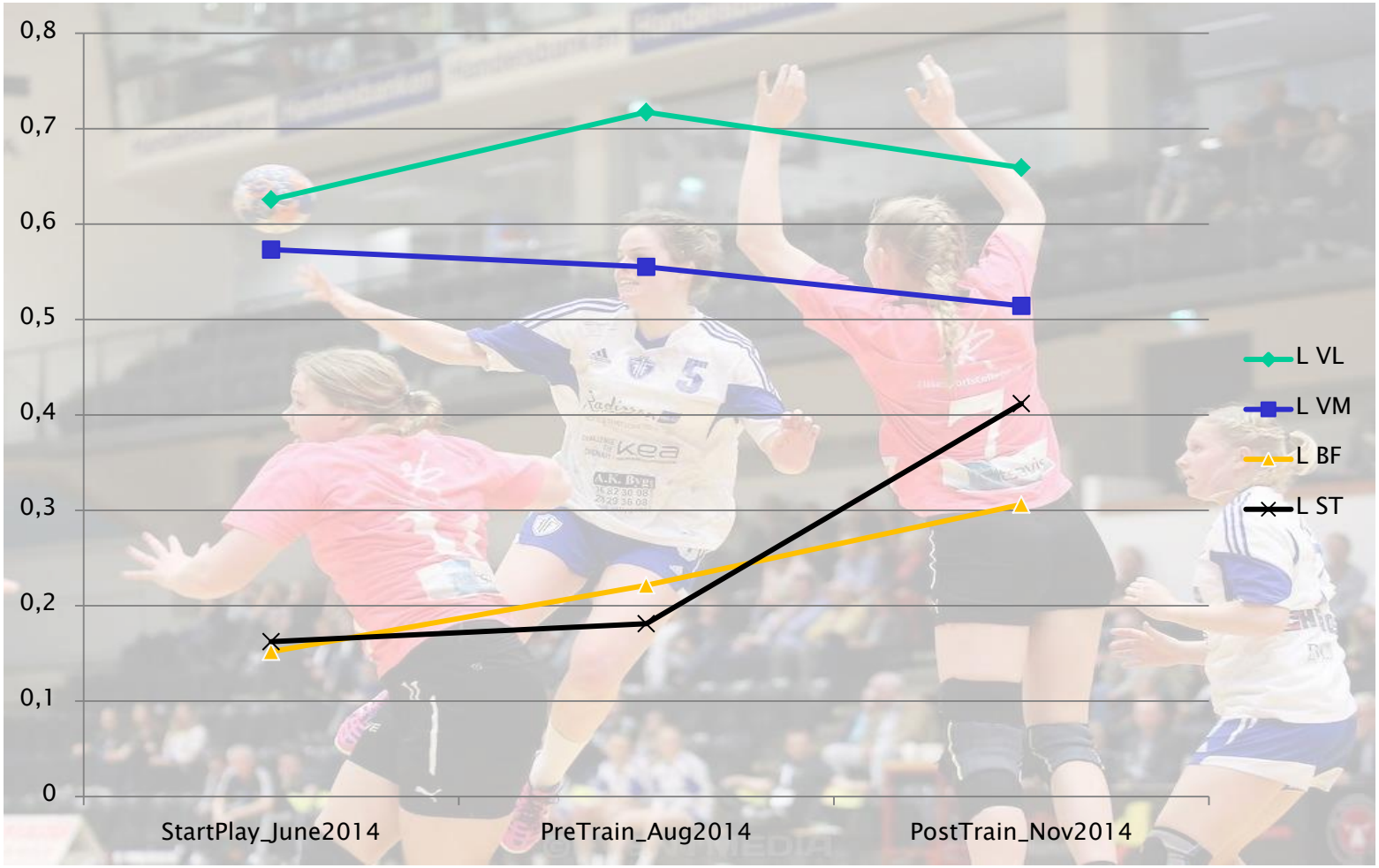
Outcome parameters

Static balance exercises:

- The mean EMG activity of the lateral and medial hamstring muscles:
  - During mid 10 sec



Case: Junior national player



More on rehabilitation to come…

Philippe Landreau (shoulder) and Lior Laver (lower extremities)

Interesting studies on shoulder injuries tomorrow:

SATURDAY, 14th November 2015

ROOM 1 (Plenary) Shoulder injuries

- **08:45 - 09:00** Lubiatowski POL: Larger glenohumeral rotation deficits (…)
- **09:00 - 09:15** …Occurrence of
- **09:15-09:30** …r proprioception
- **09:30-09:45** …rmance in male (…)
- **09:45-10:00** Wagner AUT: Shoulder stress in different team-handball throwing techniques
- **10:00-10:15** Bencke DEN: Effect of fatigue on scapula kinematics in handball
- **10:15-10:30** Grygorowicz (POL): Shoulder injury prevention exercises in overhead athletes (…)

Thank you