

# HAZARD FACTORS OF ACL RUPTURE: NEUROMUSCULAR FACTORS

KAUX JF, Delvaux F, Forthomme B, Massart N,  
Daniel C, Crielaard JM, Croisier JL

Sports Medicine and Traumatology Department (SPORTS<sup>2</sup>)  
University Hospital of Liège (Belgium)

**8<sup>th</sup>**  
European Sport Medicine  
CONGRESS OF EFSMA

et **6<sup>ème</sup>** congrès commun  
SFMES & SFTS



**Dr KAUX Jean-François**

**Sports Medicine and Traumatology Department (SPORTS<sup>2</sup>)  
University Hospital of Liège (Belgium)**

*The author had no conflict of interest concerning  
the data of the communication*

- ACL rupture ↔ **intrinsic and extrinsic factors** (Alentorn-Geli 2009, Smith 2012)
- Comprehensive approach
- Neuromuscular factors: **unconscious activation of dynamic reflex** → **compensatory biomechanical action** (Olsen 2004)





	Risk factors
Proprioception	<ul style="list-style-type: none"> <li>- Reduction in flexion of the knee and hip during high-risk activities</li> <li>- Increase in the internal rotation of the hip, abduction of the hip, external rotation of the tibia and abduction/adduction moment of the knee during high-risk activities</li> <li>- Increase in trunk displacement</li> </ul>
Muscular control	<ul style="list-style-type: none"> <li>- Reduction in the force of the quadriceps and hamstrings</li> <li>- Increase in the muscular activity of the quadriceps and reduction in hamstring activity during athletic maneuvers</li> <li>- Weakness of hip muscles</li> <li>- Early muscular fatigue</li> </ul>
Stiffness of the knee	<ul style="list-style-type: none"> <li>- Reduction of passive and active stiffness of the knee</li> </ul>

# Proprioceptive control

# Proprioceptive control

- Proprioception = capacity of the body to **maintain** and/or **recover** a defined body **position** after disturbance (Alentorn-Geli 2009, Smith 2012)



- Video analysis

- *women*: landing from jump with **knee valgus**

- and **lateral movement of trunk** (Hewett 2009)



- Biomechanical observations

- *ACL rupture*: **forced valgus and tibial rotation, knee locked in extension** (Ferretti 1992, Olsen 2004)



- Influence of **sexual dimorphism** increased risk of ACL rupture (**x4.5**) (Griffin 2005, Shultz 2010)
- Relationship still remain vague
- Jump and pivot actions in women: **increase internal rotation** of the **hip** with **decrease** of **external rotation** of the **tibia** and **increased activation** of the **quadriceps** (Griffin 2005, Hewett 2010)
  - ***increase risk of ACL injury***



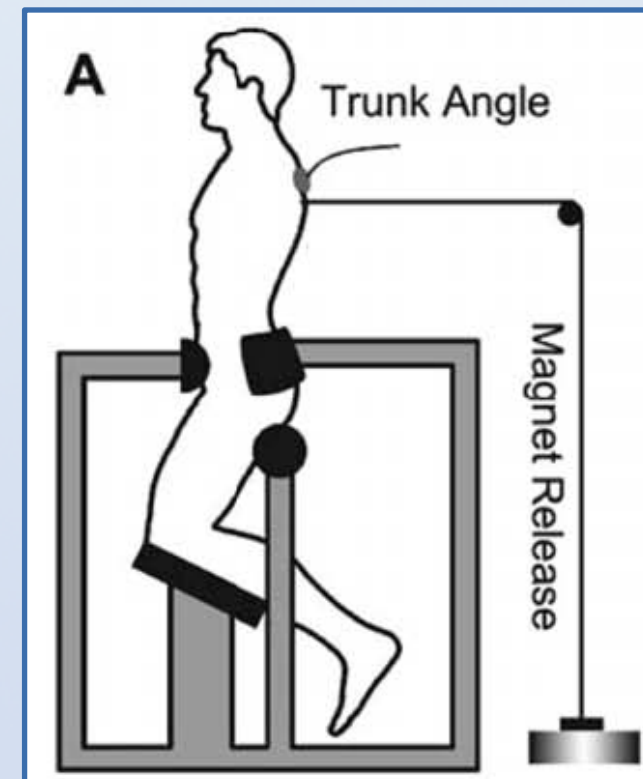
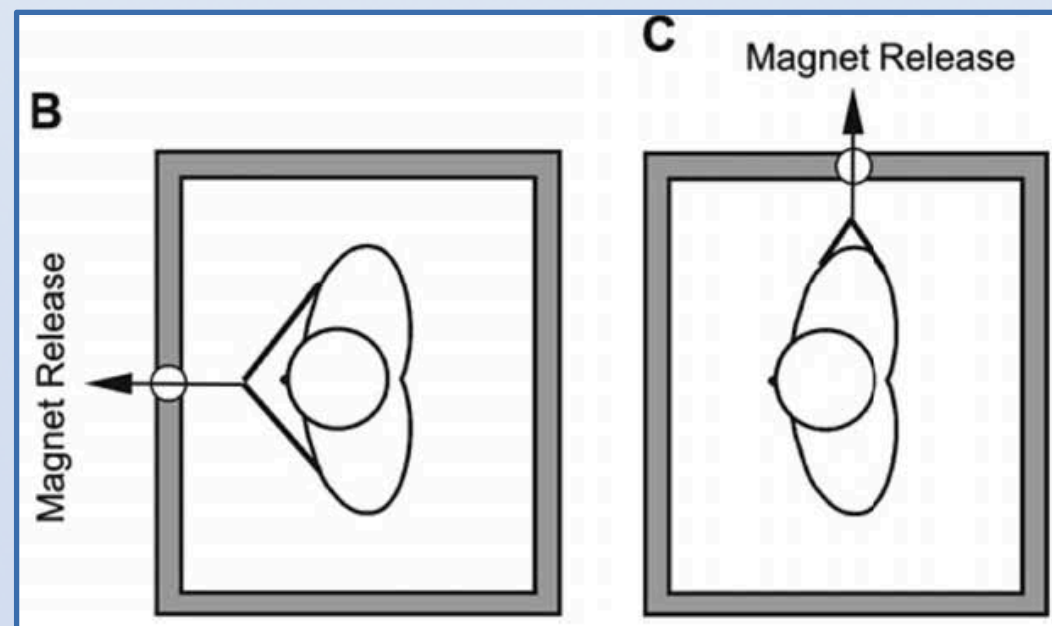


- The neuromuscular risk of ACL injury **depends on the practised sport** (Munro 2012)
  - female basketballers increased risk of ACL injury compared to female *footballers*
  - increase in the angle of frontal knee projection**



# Proprioceptive control

- **Central proprioception** analysed by trunk displacement after a sudden force release (Zazulak 2007)
- **Greater trunk displacement** → increased risk of ACL rupture
- Not clearly demonstrated that trunk displacement could relate to central proprioception





- After an **ACL reconstruction** → **biomechanical anomalies** persist despite a return to high-level performance (Hewett 2013)
- Strongly associated with a **second ACL rupture**
- Neuromuscular risk factors **residual** and **exacerbated** by the initial injury



- 3D analysis of a vertical jump and postural stability before return to pivot sports after ACL reconstruction (Paterno 2010)
  - 13% second ACL rupture
  - **hip and knee control deficit during landing and lack of postural stability**





→ interest of **prevention programs** into physical preparation and training for the different sports (Paszkewics 2012, Voskanian 2013)

# Muscular control

- **Lack of dynamic muscular control** → **increase knee valgus** and higher constrains on the knee and ACL (Ladenhauf 2013)
- **Vigorous contraction of the quadriceps** can induce a ACL rupture (DeMorat 2004)
- **Imbalances of muscular force** → ACL injury risk or injury recurrence factor (Croisier 2008)

- **Hamstring** muscles play important role in the maintenance of **knee stability** and protection for the ACL during anterior tibial translation

(Kirkley 2001, Ramesh 2005)

- *Hamstring muscles activated by the ACL receptors* (Solomonow 1987)



- Isokinetic assessment → higher frequency of **reduced hamstring/quadriceps ratios** for the *healthy controlateral knee* (Croisier 2008)
- **Reduced hamstring/quadriceps ratio + increased knee abduction in footballers** → suffered later of an ACL rupture (Soderman 2001, Ebben 2010, Hewett 2006)
- Link between **pre-existing weakness of the hamstrings** and **ACL injury**

- Protocol of muscle fatigue **alters** both the **latency** and the **extent** of the **reflex response** of **hamstring** muscles → potential repercussions for tibial translation in women  
(Soderman 2001, Behrens 2013)
- **Muscular fatigue** of the hamstrings and a **weak** of **hamstring/quadriceps ratio** → could increase the instability of the knee (Solomonow 1987)

→ Interest of **isokinetic evaluation** and **specific reeducation/strengthening programs**



# Knee laxity



- **Women: reduced muscular and capsuloligamentous stiffness** → increased risk of ACL rupture (Alentorn-Geli 2009)
- Women show **less stiffness** of the knee in response to weak varus/valgus force and internal/external torsion (Schmitz 2008)
- This **stiffness** tends to **increase with the applied constraints** (Schmitz 2008)
  - ***ACL injury risk during low energy activity in women***

# Assessment methods

- **Biomechanical analyses in laboratories**

- limiting possibility of targeting athletes with high risk of ACL injury (Myer 2010, Smith 2012)

- **Clinical assessment**

- validated in laboratory (Myer 2010)

- parameters

- weight
- length of the tibia
- knee valgus
- amplitude of knee flexion
- isokinetic ratio between hamstring and quadriceps

- greater population



# Conclusion

- Hypothetical neuromuscular factors (proprioceptive and muscular control, knee laxity) do not offer a complete understanding of this risk
- **Prospective studies** on bigger populations and for longer periods **are needed**
- **Other** potential neuromuscular risk factors could be demonstrated
- **Multiple risk factors** could act in **combination** to cause ACL rupture
- These factors could be **specific to certain groups**: young women, depending on the sport practiced...
- Identification subjects at risk by **functional analysis**
- ***Preventive protocols***



# Thank you for your attention...







[jfkaux@chu.ulg.ac.be](mailto:jfkaux@chu.ulg.ac.be)

Link ORBI: <http://hdl.handle.net/2268/155461>

