

HAZARD FACTORS OF ACL RUPTURE: NEUROMUSCULAR FACTORS

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8th
European Sport Medicine
CONGRESS OF EFSMA

et **6^{ème}** congrès commun
SFMES & SFTS



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

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



Introduction

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

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)

Proprioceptive control

- 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***



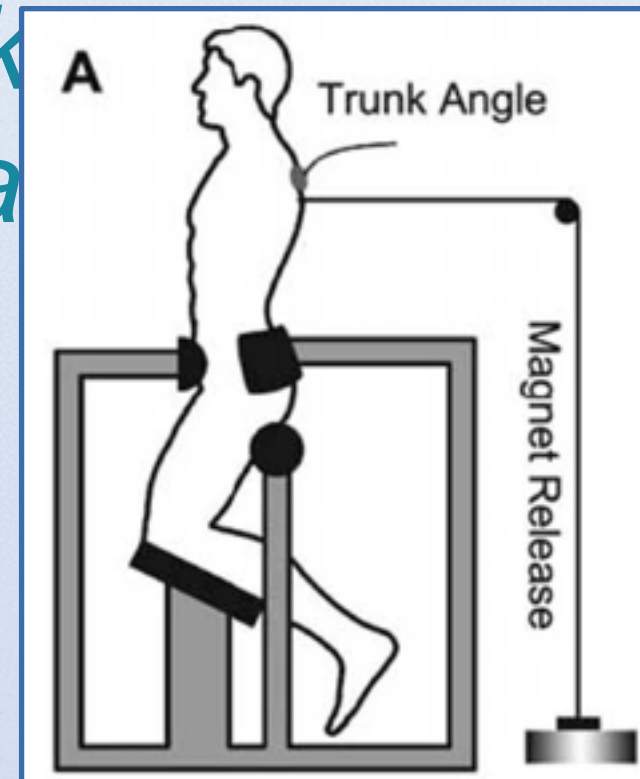
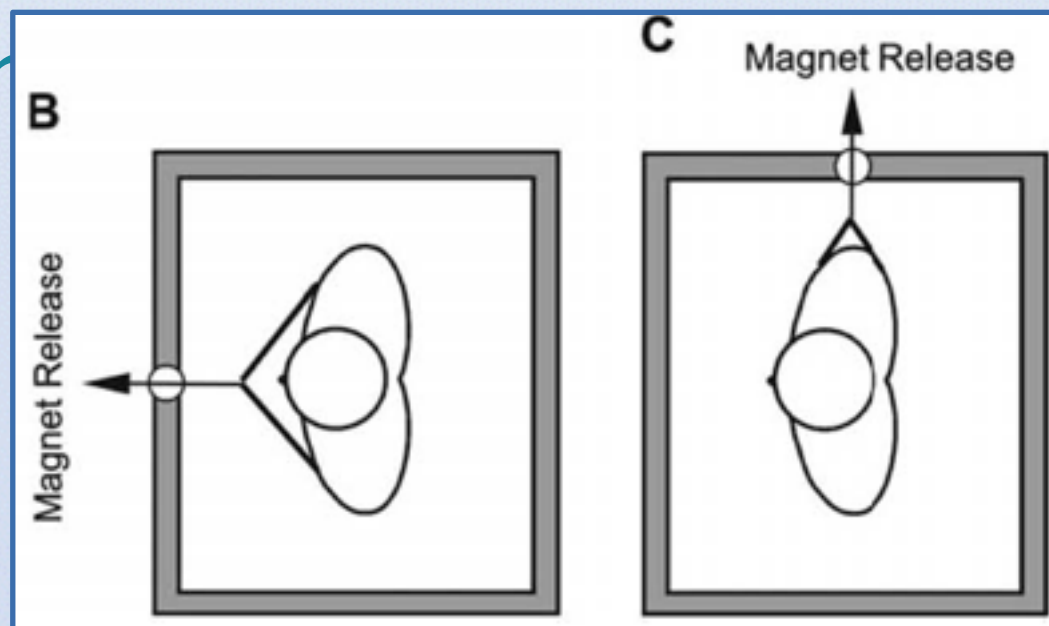
Proprioceptive control

- 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 front



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



Proprioceptive control



- 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**



Proprioceptive control

→ 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 constraints 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...





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