

Sciences du Mouvement Humain UNIVERSITÉ CÔTE D'AZUR @r5.johan @lahti\_johan

## Hamstrings; cant we just get along?

A multifactorial and individualized approach for reducing hamstring muscle injuries in professional football players

Johan Lahti, PhD, CSCS

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### INTRODUCTION

Most popular sport

On a pro level:

- High skill requirements (Bradley et al., 2012; Haugen et al., 2014)
- High physical requirements (Cometti et al., 2001; Haugen, Tønnessen and Seiler, 2013; Tønnessen et al., 2013)

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### INJURIES IN MALE FOOTBALL

- ~14% of players regularly unavailable (Ekstrand et al., 2013)
- 1 month injury ~ € 500,000 (Ekstrand et al., 2013)
- Performance + psychological consequences (Borich et al., 2019)
- League standing (Arnason et al., 2004; Häggglund et al., 2013)

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### INJURIES IN FOOTBALL

How serious? Severity

How often? Incidence

- Concussion
- Quadriceps muscle injury
- ACL/MCL
- Tibia/Fibula fracture
- Ankle sprain
- Low back pain
- Hamstring muscle injury
- Groin muscle injury
- Calf muscle injury
- Achilles tendon

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### INJURIES IN FOOTBALL

Injury burden for top-10 injuries (Ekstrand et al., 2013)

Injury Type	Days lost per 1000 player hours
Thigh contusion	~1
Hamstring hypertonia	~1
Knee synovitis	~1
Achilles	~2
Calf	~3
Medial knee	~4
Lateral ankle	~5
Anterior thigh	~6
Groin	~10
Hamstring	~18

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### INJURIES IN FOOTBALL<sup>4-7</sup>

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### HAMSTRING INJURIES IN FOOTBALL

Most take place during sprinting (70-80%) (Woods et al., 2004; Ekstrand et al., 2012)



Other scenarios:

- Overstretch actions (5-10 %)
- Shooting (4 %)
- Change of direction (4 %)
- Passing & Jumping (4 %)

~80% of injuries to biceps femoris long head (Kulouris et al., 2007; Ekstrand et al., 2012; Wangensteen et al., 2016)

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### SCIENTIFIC BACKGROUND

WHY



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### TASK AND DEMANDS OF HAMSTRINGS IN FOOTBALL

EXTERNAL (TASK) → INTERNAL (DEMANDS)



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### TASK AND DEMANDS OF HAMSTRINGS IN FOOTBALL

EXTERNAL (TASK) → INTERNAL (DEMANDS)



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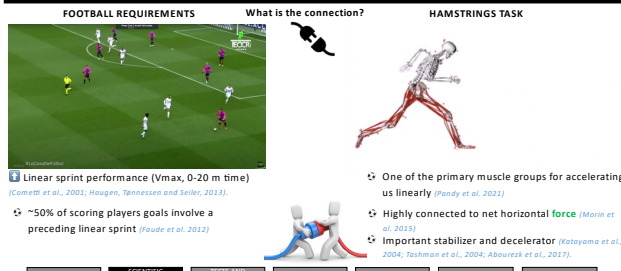
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### TASK OF HAMSTRING IN FOOTBALL

FOOTBALL REQUIREMENTS What is the connection? HAMSTRINGS TASK



Linear sprint performance ( $V_{max}$ , 0-20 m time) (Carmean et al., 2001; Haugen, Tønnessen and Seien, 2013)

~50% of scoring players goals involve a preceding linear sprint (Faude et al., 2012)

One of the primary muscle groups for accelerating us linearly (Pandy et al., 2021)

Highly connected to net horizontal force (Marin et al., 2015)

Important stabilizer and decelerator (Istayama et al., 2006; Toimann et al., 2006; Abouev et al., 2017)

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### TASK AND DEMANDS OF HAMSTRINGS IN FOOTBALL

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TASK AND DEMANDS OF HAMSTRINGS IN FOOTBALL

EXTERNAL (TASK) → INTERNAL (DEMANDS)

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BASIC ANATOMY AND FUNCTION

Lateral compartment Medial compartment

"Functional pairs" (Kellis, 2012)

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BASIC ANATOMY AND FUNCTION

Primary tasks

- Knee flexion
- Hip extension (Biarticular hamstrings)

Secondary tasks

- Knee rotation (lateral/medial)

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BASIC ANATOMY AND FUNCTION

free tendon length Muscle length Total tendon length

SM ST BFih

— Muscle length  
 ..... Free tendon length  
 - - - Total tendon length

Van der Made et al., (2015)

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INTERNAL DEMANDS DURING SPRINTING

HAMSTRING DEMANDS IN SPRINTING

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INTERNAL DEMANDS DURING SPRINTING


Left leg: Stance phase Left leg: Early swing Left leg: Mid-swing Left leg: Late swing

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### INTERNAL DEMANDS DURING SPRINTING



**Left leg: Stance phase**



**Left leg: Late swing**




**Two most commonly proposed injury time points**  
*(Kennedy-Dabrowski et al. 2019)*

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### INTERNAL DEMANDS DURING SPRINTING



Stance phase



Late swing phase

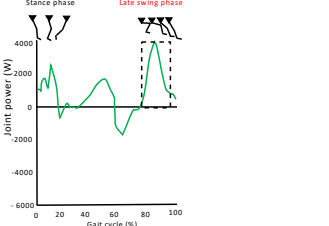


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### INTERNAL DEMANDS DURING SPRINTING

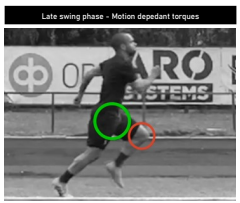


Joint power (W)

Gait cycle (%)

Hip power *Zhong et al., (2017)*

Late swing phase - Motion dependant torques



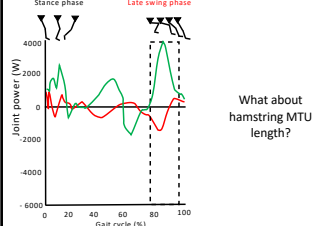
Hip: Thigh acceleration towards ground (concentric)

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### INTERNAL DEMANDS DURING SPRINTING



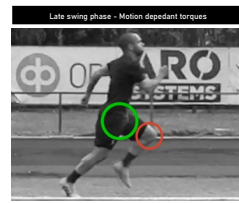
Joint power (W)

Gait cycle (%)

Hip power *Zhong et al., (2017)*

Knee power *Zhong et al., (2017)*

Late swing phase - Motion dependant torques



Hip: Thigh acceleration towards ground (concentric)

Knee: Absorption of energy (eccentric)

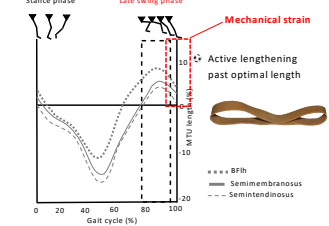
What about hamstring MTU length?

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### INTERNAL DEMANDS DURING SPRINTING



MTU length (cm)

Gait cycle (%)

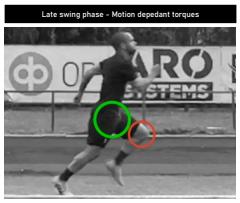
..... BfH  
— Semimembranosus  
- - - Semitendinosus

Mechanical strain

Active lengthening past optimal length

*Schache et al., (2013)*

Late swing phase - Motion dependant torques



Hip: Thigh acceleration towards ground (concentric)

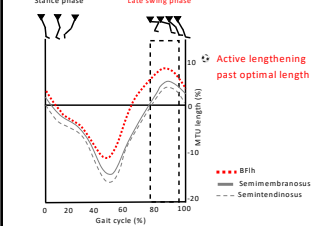
Knee: Absorption of energy (eccentric)

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### INTERNAL DEMANDS DURING SPRINTING



MTU length (cm)


Gait cycle (%)

..... BfH  
— Semimembranosus  
- - - Semitendinosus

Active lengthening past optimal length

*Schache et al., (2013)*

Late swing phase - Motion dependant torques



Hip: Thigh acceleration towards ground (concentric)

Knee: Absorption of energy (eccentric)

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### INTERNAL DEMANDS DURING SPRINTING

Influence on r. biceps femoris stretch (mm)

Example of rectus femoris

Thelen et al., (2006)

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### INTERNAL DEMANDS DURING SPRINTING

Stance phase - Contact torques

Hip: "Pushing the ground back"  
Knee: "Overcoming static friction (stiction)"

Zhang et al., (2017)

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### INTERNAL DEMANDS DURING SPRINTING

Late swing phase - Motion dependent torques

Hamstring forces: **High**  
Length: **-10%**

Stance phase - Contact torques

Hamstring forces: **Moderate with high fluctuation**  
Length: **0%**

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### INTERNAL DEMANDS DURING SPRINTING

- "Faster game hypothesis"
  - demands in speed
  - sprint volume in matches (Haugen, Tønnessen and Selnes, 2013)
- 4% annual increase in hamstring injuries 2001-2014 (Ekstrand et al., 2016)

Dorn et al., (2012)

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### INTERNAL DEMANDS DURING SPRINTING

Water: Football demand Bucket: Hamstring resilience

Hamstrings = Constantly under cumulative load, increasing with game demand  
What modifiable intrinsic risk factors make this worse?

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**RISK FACTORS**

**Top injury**

- Hamstrings
- Common injury situations:
  - Sprinting (Main)
  - Overstretch actions
  - Change of direction/high deceleration
- Modifiable risk factors (Physical)
  - Intrinsic
  - Extrinsic
- Maximal velocity exposure

**Screening considerations**

- A lot of limitations in risk association studies
- Difficulty controlling for the complexity
- So we rely both on evidence based and evidence guided decisions + anecdotes

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**RISK FACTORS**

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**Screening considerations**

- Fatigue tolerance (local, global)
- Limb asymmetry
- Lumbo-pelvic control
- Motor patterning
- Muscle architecture
- Range of motion (local, global)
- Strength (local, global)

**Practical considerations**

- Constraints
  - Facility, budget, skill, time, attitudes
- Injuries managed both from a preventive ("prehab") and performance perspective
  - Cooperation between PT and SAC coaches
- Potential for multifactorial individualisation
  - Programming opportunities

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**RISK FACTORS**

**Practical considerations**

- Constraints
  - Facility, budget, skill, time, attitudes

I don't like this...

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**RISK FACTORS**

**Practical considerations**

- Constraints
  - Facility, budget, skill, time, attitudes

We will see...

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**RISK FACTORS**

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**RISK FACTORS**

**Practical considerations**

- Injuries managed both from a preventive ("prehab") and performance perspective
  - Cooperation between PT and SAC coaches

Hamstrings task = Horizontal force

1. Sprint performance level

2. Hamstring "health"?

Horizontal force capacity

WIN - WIN for professional football?

(Ménaguchto et al., 2014, 2016, Esourd et al., 2022)

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### RISK FACTORS

**Top injury**

**Hamstrings**

**Common injury situations:**

- Sprinting (Main)
- Overstretch actions
- Change of direction/high deceleration

**Modifiable risk factors (Physical)**

- Intrinsic
- Extrinsic

**Screening considerations**

- Fatigue tolerance (local, global)
- Limb asymmetry
- Lumbo-pelvic control
- Motor patterning
- Muscle architecture
- Range of motion (local, global)
- Strength (local, global)
- Maximal velocity exposure

**Practical considerations**

- Constants: Facility, medical, skill, time, attitudes
- Injuries managed both from a preventive ("prehab") and performance perspective
- Potential for multifactorial interventions
- Programing opportunities: Cooperation between PT and S&C coaches

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### RISK FACTORS

**Practical considerations**

Potential for multifactorial individualization

**Programing opportunities**

**SAME PROGRAM FOR ALL?**

(Ribeiro-Alvares et al., 2019)

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### INTERVENTIONS IN PROFESSIONAL FOOTBALL

What makes things better?

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### INTERVENTIONS IN PROFESSIONAL FOOTBALL

What makes things better?

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### INTERVENTIONS IN PROFESSIONAL FOOTBALL

**TOTAL INTERVENTIONS (2003 – 2021): 6**

Uni/Bifactorial: 5

Multifactorial: 1

**In favor of:**

- eccentric strength: 4/5 (LEVEL OF EVIDENCE: 1-2)
- Fixing asymmetries: 1/1 (LEVEL OF EVIDENCE: 2)
- Hamstring flexibility: 0/1 (LEVEL OF EVIDENCE: 2)

**In favor of:**

1. Multifactorial strength training (including lumbo-pelvic control)
2. High-speed sprinting
3. Manual therapy
4. Load management
5. Individualized training

**LEVEL OF EVIDENCE: 2**

**Limitations:**

- ⚠ No pre-post training data reported in most studies or low compliance

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### PROBLEMS IN FOOTBALL AND GAPS IN LITERATURE

- Hamstring injuries are a large burden
- Lack of multifactorial approaches
- Lack of individualized approaches

**SAME PROGRAM FOR ALL?**

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PROBLEMS IN FOOTBALL AND GAPS IN LITERATURE

## How can we further reduce the risk of hamstring injuries in professional football?

- Hamstring injuries are a large burden
- Lack of multifactorial approaches
- Lack of individualized approaches

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HAMSTRING RISK REDUCTION EVOLUTION

**Top injury**

Hamstrings

Common injury situations:

- Sprinting (Main)
- Overstretch actions
- Change of direction/high deceleration

Modifiable risk factors (Physical):

- Intrinsic
- Extrinsic
- Maximal velocity exposure

**Screening and training considerations:**

- Fatigue tolerance (local, global)
- Limb asymmetry
- Lumbo-pelvic control
- Motor patterning
- Muscle architecture
- Range of motion (local, global)
- Strength (local, global)

**Practical considerations:**

- Constrains: Facility, budget, skill, time, attitudes
- Issues managed both from a prevention (coach's need) and performance perspective
- Cooperation between PT and SAC coaches
- Potential for multifactorial individualization
- Programing opportunities

Outcomes:

- Lumbo-pelvic control
- Posterior chain strength
- Sprint mechanical output
- Range of motion

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HAMSTRING RISK REDUCTION EVOLUTION

Lumbo-pelvic control

Posterior chain strength

Sprint mechanical output

Range of motion

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HAMSTRING RISK REDUCTION EVOLUTION

Max velocity sprinting

Post sport ROM

Manual Therapy

Triceps surae health

Lumbo-pelvic control

Posterior chain strength

Sprint mechanical output

Range of motion

Training for all

Individualized

Non-individualized

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HAMSTRING RISK REDUCTION EVOLUTION

Individualized approach

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HAMSTRING RISK REDUCTION EVOLUTION

Lumbo-pelvic control

Posterior chain strength

Sprint mechanical output

Range of motion

Individualized approach

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### HAMSTRING RISK REDUCTION EVOLUTION

Individualized approach

- Lumbo-pelvic control
- Posterior chain strength
- Sprint mechanical output
- Range of motion

Targeting feasibility:

- Multicomponent data
- Efficiency (ease)
- Mobility
- Relative low cost
- Low fatigue

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### HAMSTRING RISK REDUCTION EVOLUTION

Individualized approach

- Lumbo-pelvic control
- Posterior chain strength
- Sprint mechanical output
- Range of motion

Targeting feasibility:

- Multicomponent data
- Efficiency (ease)
- Mobility
- Relative low cost
- Low fatigue

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### TESTS

- Lumbo-pelvic control
- Kick back test
- Posterior chain strength
- Knee flexor force
- Knee flexor asymmetry
- Hip extensor force
- Hip extensor asymmetry
- Sprint mechanical output
- Theoretical maximal horizontal force
- Range of motion
- Jordan test
- Jordan test asymmetry
- ASLR
- ASLR asymmetry

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### LUMBOPELVIC CONTROL

Symmetry between "force coupler" at pelvis

**Gold standard approach**

Not just about how much you sprint, but how you sprint

LOWER CROSSED SYNDROME? (Pooni CA ↑ in football players vs. age-matched non-athletes (Hoshikawa et al., 2012))

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### LUMBOPELVIC CONTROL

**Gold standard approach**

3D pelvis kinematics during sprinting

↓

Indirect approaches

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### LUMBOPELVIC CONTROL

**Gold standard approach**

3D pelvis kinematics during sprinting

↓

Indirect approaches

2D thigh kinematics during sprinting

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LUMBOPELVIC CONTROL

Lumbo-pelvic control

### 2D thigh kinematics during sprinting

**A**

Kick-back mechanism

**B**

OPTIMAL BODY LINE DDD <br/> <small>KUROSPORT</small>

- ↳ Anecdotes from sprint coaches; "Kick back" mechanism (A) more risky than good front side mechanics (B)
- ↳ Defined or biased towards:
  - Increased hip flexion during swing
  - Straight leg during toe-off
  - Good posture
- ↳ Reduced hip flexion associated with static pelvic position in football players (Alizadeh et al., 2019)

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LUMBOPELVIC CONTROL

Lumbo-pelvic control

### Kick-Back test

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LUMBOPELVIC CONTROL

Lumbo-pelvic control

### Kick-Back test

Toe-off

Less optimal

Touchdown

Toe-off

More optimal

Touchdown

Kick-back score:  $57^\circ + 71^\circ = 128$

Kick-back score:  $69^\circ + 105^\circ = 174$

↳ Trunk inclination not included as we observed that "kick-back" can be present irrespective of it

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LUMBOPELVIC CONTROL TRAINING

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LUMBOPELVIC CONTROL TRAINING

Can We Modify Maximal Speed Running Posture? Implications for Performance and Hamstring Injury Management

Jordan Mendiguchia<sup>1</sup>, Angel Gonzalez De La Flor<sup>2</sup>, Alberto Mendez-Villaverde<sup>3</sup>, Juan-Benito Morin<sup>4</sup>, Pascal Esbaze<sup>5</sup>, T. Milan Aranzazu-Garnica<sup>6</sup>

> Int J Sports Physiol Perform. 2021 Nov;16(11):2021-2027. Online ahead of print.

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### LUMBOPELVIC CONTROL

Can We Modify Maximal Speed Running Posture? Implications for Performance and Hamstring Injury Management

**TESTING**

**TRAINING**

PHASE 1 PHASE 2

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### LUMBOPELVIC CONTROL

Reduced dynamic anterior pelvic tilt  
Increased max velocity

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### LUMBOPELVIC CONTROL

Anterior-posterior pelvic tilt and ant-extension  
Anti-lateral flexion, Rotational elements  
More dynamic  
Dynamic sport-specific positions

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### TESTS

- Lumbo-pelvic control: Kick back test
- Posterior chain strength: Knee flexor force, Knee flexor asymmetry, Hip extensor force, Hip extensor asymmetry
- Sprint mechanical output: Theoretical maximal horizontal force
- Range of motion: Jordan test, Jordan test asymmetry, ASLR, ASLR asymmetry

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### POSTERIOR CHAIN STRENGTH

Tissue load tolerance, and symmetry in the gluteus max and hamstrings

- Posterior chain strength: Knee flexor force, Knee flexor asymmetry, Hip extensor force, Hip extensor asymmetry

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### POSTERIOR CHAIN STRENGTH

#### HAMSTRING STRENGTH PROPERTIES RELATED

- Direct associations for increased risk:
  - ↓ Reduced eccentric force
  - ↓ Reduced fascicle length
  - ↓ limb force symmetry
  - BF picks up workload for ST
  - ↓ Proximal cooperation with other extensors
- Indirect associations for increased risk:
  - ↓ Muscle mass → increased muscle damage
  - ↓ Muscle mass → increased strength loss from repeated sprints → increased changes in sprint technique during fatigue

(Johansson et al. 2005, Williams et al. 2016, Schummons et al. 2016, 2017) (Barnett et al. 2005, Mao et al. 2021)

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### POSTERIOR CHAIN STRENGTH

Posterior chain strength

Hip extensor force  
Hip extensor asymmetry

Knee flexor force  
Knee flexor asymmetry

Thorborg et al., (2009), van der Made et al., (2019)

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### POSTERIOR CHAIN STRENGTH TRAINING

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### POSTERIOR CHAIN STRENGTH TRAINING

Randomized Controlled Trial | Br J Sports Med. 2017 Mar;51(10):469-477. doi: 10.1136/bjsports-2016-096130. Epub 2016 Sep 22. PMID: 27661979

Med Sci Sports Exerc. 2021 Apr; 53(4):808-837. Published online 2021 Oct 15. doi: 10.1249/00000000000002327

Greater Hamstring Muscle Hypertrophy but Similar Damage Protection after Training at Long Versus Short Muscle Lengths

Suzuki Mena<sup>1</sup>, Mero Hattori<sup>2</sup>, Takano Yu<sup>2</sup>, Takano Seitaro<sup>2</sup>, Takai Kazuyuki<sup>2</sup>, Takami Daisuke<sup>2</sup>, Takasaki Kazuhisa<sup>2</sup>, and Takao Isobe<sup>2</sup>

Matthew N Bourne<sup>1, 2, 3</sup>, Steven J Duhaig<sup>2, 4</sup>, Ryan G Timmins<sup>5</sup>, Morgan D Williams<sup>6</sup>, David A Opar<sup>7</sup>, Arman Ali Najjar<sup>8</sup>, Graham K Kerr<sup>4, 8</sup>, Anthony J Shield<sup>2, 4</sup>

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### POSTERIOR CHAIN STRENGTH

KNEE OVER HIP MOVEMENT HIP OVER KNEE MOVEMENT

**OTHER EXERCISE OPTIONS AVAILABLE (evidence guided)**

Follow @BasVanHooren PhD work

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### POSTERIOR CHAIN STRENGTH

#### LENGTHENED TRAINING OPTIONS

athletics and health

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### POSTERIOR CHAIN STRENGTH

PETURBATIONS STIFFNESS (Open to closed chain) COCONTRACTION REDUCTION

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POSTERIOR CHAIN STRENGTH

### HIP OPTIONS

Unilateral exercises prioritized to reduce load on muscles that pull the pelvis anteriorly (such as erectors)

HIP - DEEP      HIP - EXTENDED

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- Sprint mechanical output: Theoretical maximal horizontal force
- Range of motion: Jordan test, Jordan test asymmetry, ASLR, ASLR asymmetry

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SPRINT MECHANICAL OUTPUT

Maximal horizontal force capacity

Sprint mechanical output      Theoretical maximal horizontal force

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SPRINT MECHANICAL OUTPUT

Sprint mechanical output

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SPRINT MECHANICAL OUTPUT

Sprint mechanical output

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SPRINT MECHANICAL OUTPUT

PILOTING VALIDITY FOR F0 TESTING AND TRAINING

STUDY 1      STUDY 2

Biology of Sport      PeerJ

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**SPRINT MECHANICAL OUTPUT**

**A novel multifactorial musculoskeletal hamstring screening protocol: association with hamstring muscle injuries in professional football (soccer) – a prospective cohort study**

Lahti J, Mendiguchia J, Edouard P, Morin JB.

Biology of Sport

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**SPRINT MECHANICAL OUTPUT**

6 pro teams, N = 95 ○ = Index injury ● = Re-injury 17 index injuries

Hamstring injuries

Pre-season end Mid-season Season end

Knee flexor force ↑ 3.77 vs 3.99 N.kg<sup>-1</sup>, p < 0.0001, Effect Size: 0.35  
 Theoretical maximal horizontal force (F0) ↑ 7.63 vs 7.84 N.kg<sup>-1</sup>, p = 0.004, Effect Size: 0.35  
 ASLR asymmetry ↓ 6.75 vs 4.36 %, p = 0.001, Effect Size: -0.60

Injury scenario  
 14/20 (70 %) 3/20 (15 %) 2/20 (10 %) 1/20 (5 %)

Jimenez-Reyes et al., (2020) Moreno-Perez et al., (2020, 2021)

Biology of Sport PeerJ

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**SPRINT MECHANICAL OUTPUT**

○ = Index injury

Hamstring injuries

Theoretical maximal horizontal force (F0)  
 Hazard ratio: 4.02 (CI95% 1.08 - 15.0), p = 0.04

Pre-season end Mid-season Season end

○ No other associations  
 ○ Interesting trends  
 ○ More data needed to make clearer inferences (also for F0)

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**SPRINT MECHANICAL OUTPUT**

**PILOTING VALIDITY FOR F0 TESTING AND TRAINING**

STUDY 1 STUDY 2

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**SPRINT MECHANICAL OUTPUT TRAINING**

**STUDY 2**

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**SPRINT MECHANICAL OUTPUT TRAINING**

**Changes in sprint performance and sagittal plane kinematics after heavy resisted sprint training in professional soccer players**

Lahti J, Huuhka T, Romero V, Bezodis I, Morin JB, Häkkinen K. 2020.

PeerJ

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SPRINT MECHANICAL OUTPUT TRAINING

Training approaches to improve  $F_0$

Intramuscular Intermuscular

$F_0$  (Maximal theoretical horizontal force)  
Direction of force output from a system of muscles

GOO  
Which the hamstrings are an essential part of

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SPRINT MECHANICAL OUTPUT TRAINING

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SPRINT MECHANICAL OUTPUT

Pro football team 1 (Intervention team)

Horizontally oriented training

Pre-season start Season start

Pro football team 2 (Control)

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SPRINT MECHANICAL OUTPUT

Intervention team

Highly similar initial sprint performance ( $p = 0.88$ )

Control team

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SPRINT MECHANICAL OUTPUT

Intervention team

Horizontally oriented training

Pre-season start Season start

Control team

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SPRINT MECHANICAL OUTPUT

Pro football team 1 (Intervention team)

Horizontally oriented training

Pre-season start Season start

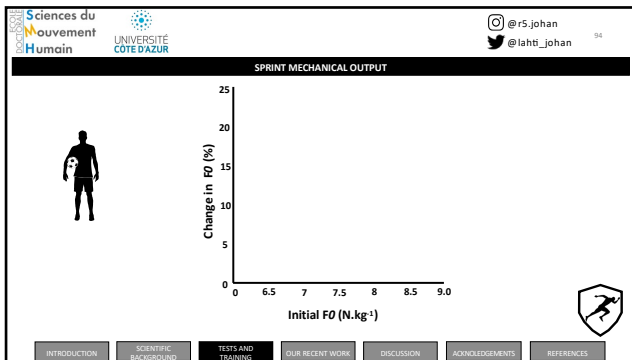
Pro football team 2 (Control)

11 weeks  
2-4 of resisted sprints before practice x 1-2 per week  
1-2 free sprints were also done per session

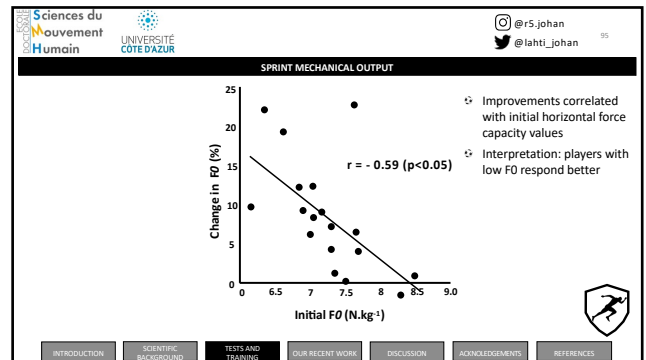
Horizontal force Velocity  
50-60% velocity loss  
Power

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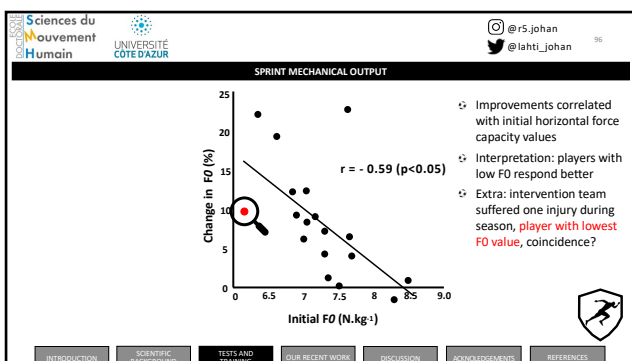
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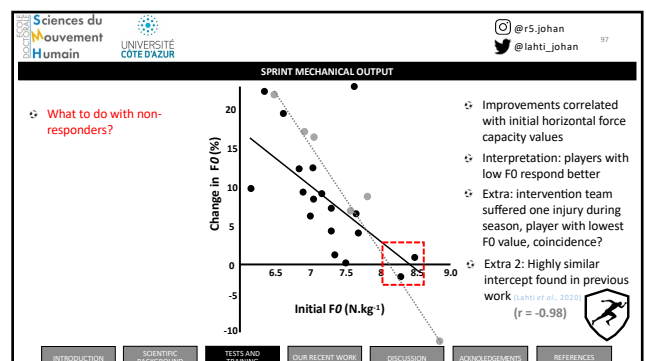
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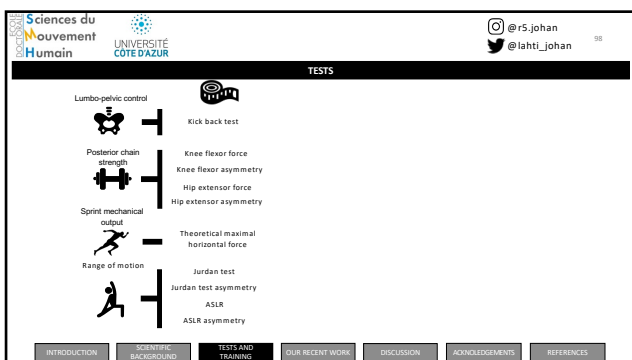
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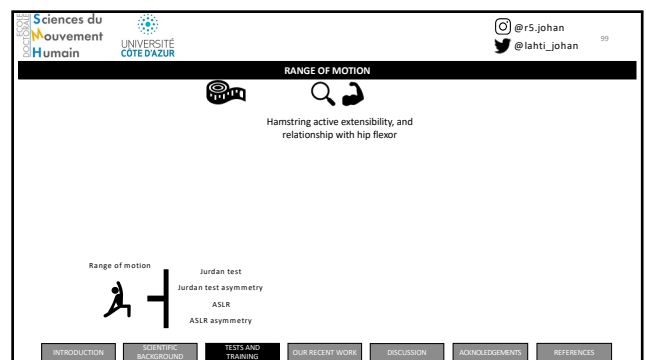
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**RANGE OF MOTION**

Isokinetic knee flexion (15°/sec)

TEST A  
Peak torque: 68 Nm  
Angle of peak torque: 52°

Peak torque

Optimal length

Mechanical strain

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**RANGE OF MOTION**

Isokinetic knee flexion (15°/sec)

TEST A  
Peak torque: 68 Nm  
Angle of peak torque: 52°

TEST B  
Peak torque: 68 Nm  
Angle of peak torque: 38°

Peak torque

Optimal length

Mechanical strain

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**RANGE OF MOTION**

Athletes ROM connected to likelihood of mechanical strain during sprinting?

Range of motion in straight leg raise (°)

Wan et al., (2017)

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**RANGE OF MOTION**

Athletes ROM connected to likelihood of mechanical strain during sprinting?

Range of motion in straight leg raise (°)

To conclude:  
"Tight" athletes may experience more mechanical strain during sprinting

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**RANGE OF MOTION**

ASLR  
ASLR asymmetry (>=15%)

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**RANGE OF MOTION**

ASLR  
ASLR asymmetry (>=15%)

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RANGE OF MOTION

Range of motion Jordan test Jordan test asymmetry ASLR ASLR asymmetry



Thelen et al., (2006)

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RANGE OF MOTION

Range of motion Jordan test Jordan test asymmetry (>15%)



INNOVATIVE

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RANGE OF MOTION TRAINING

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RANGE OF MOTION TRAINING

Effects of flexibility and strength training on peak hamstring musculotendinous strains during sprinting (2020)

Xianglin Wan <sup>1</sup>, Shangxiao Li <sup>1</sup>, Thomas M Best <sup>2</sup>, Hui Liu <sup>1</sup>, Hanjun Li <sup>3</sup>, Bing Yu <sup>4</sup>

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RANGE OF MOTION TRAINING

Stance phase Late swing phase

Optimal length (%)

8 weeks of flexibility training



Effects of flexibility and strength training on peak hamstring musculotendinous strains during sprinting

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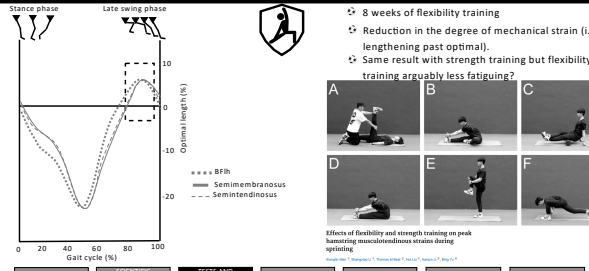
RANGE OF MOTION TRAINING

Stance phase Late swing phase

Optimal length (%)

8 weeks of flexibility training

- Reduction in the degree of mechanical strain (i.e., lengthening past optimal).
- Same result with strength training but flexibility training arguably less fatiguing?



Effects of flexibility and strength training on peak hamstring musculotendinous strains during sprinting

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RANGE OF MOTION TRAINING

**ACTIVE MOVEMENT**

**INCLUSION OF HIP FLEXOR (hip extension reserve)**

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NON-INDIVIDUALIZED

Individualized

Lumbo-pelvic control

Posterior chain strength

Sprint mechanical output

Range of motion

Non-Individualized

- Max velocity sprinting
- Post sport ROM
- Manual Therapy
- Triceps surae health

Training for all

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NON-INDIVIDUALIZED

Training for all

Max velocity sprinting

Mohr et al. (2016, 2018)

Post sport ROM

Panayy S et al., (2010), Sotkunskene et al., (2020)

Manual Therapy

Mendiguchia et al., (2021A,B)

Triceps surae health

Malliaropoulos et al., (2018)

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SUMMARY

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SUMMARY

Neuromuscular load

Injury scenarios

High Medium Low

Intramuscular (local - global) Mix Intermuscular (global)

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SUMMARY

Neuromuscular load

Injury scenarios

High Medium Low

Intramuscular (local - global) Mix Intermuscular (global)

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SUMMARY

High Neuromuscular load  
Medium  
Low

Intramuscular (local - global) Level of specificity Mix Intermuscular (global)

Injury scenarios

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PUTTING IT ALL TOGETHER

Multifactorial individualised programme for hamstring muscle injury risk reduction in professional football: protocol for a prospective cohort study

Lahti J, Mendiguchia J, Ahtiainen J, Anula L, Kononen T, Kujala M, Matinlauri A, Peltonen V, Thibault M, Toivonen RM, Edouard P, Morin JB. 2020.

**BMJ Open Sport & Exercise Medicine**

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INTERVENTION DESIGN

- 6 pro teams in Finnish premier league recruited
- Goalkeepers excluded due to low risk

	Pre-season		In-season				End of season
	Week 0 - 1	Week 2	Weeks 3-11	Week 12	Week 13	Week 27	Week 28
Control season 2019	Injury data and sport exposure collection						
	Feedback questionnaire for coaches: 2019 season						
	Season break: Physical coach staff education						
Intervention season 2021	Injury data, sport exposure collection and weekly compliance						
	Familiarization (Measurements, exercises)	Pre-measurements	New programmes initiated	First post-measurements	Programmes updated	Second post-measurements (Mid-season)	Programmes updated
	Feedback questionnaire for coaches: 2021 season						

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INTERVENTION DESIGN

Multifactorial approach

- Lumbo-pelvic control
- Posterior chain strength
- Sprint mechanical output
- Range of motion

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INTERVENTION DESIGN

Multifactorial approach

- Lumbo-pelvic control: Kick back test  $\leq 33\%$
- Posterior chain strength: Knee flexor force  $\leq 66\%$ , Knee flexor asymmetry  $\geq 15\%$ , Hip extensor force  $\leq 66\%$ , Hip extensor asymmetry  $\geq 15\%$
- Sprint mechanical output: Theoretical maximal horizontal force  $\leq 66\%$
- Range of motion: Jordan test  $\leq 33\%$ , Jordan test asymmetry  $\geq 15\%$ , ASLR  $\leq 33\%$ , ASLR asymmetry  $\geq 15\%$

Negative Positive

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INTERVENTION DESIGN

Lumbo-pelvic control Range of motion  $\leq 33\%$

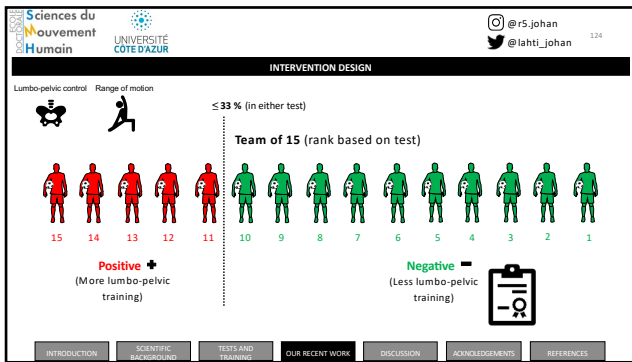
Team of 15 (rank based on test)

15 14 13 12 11 10 9 8 7 6 5 4 3 2 1

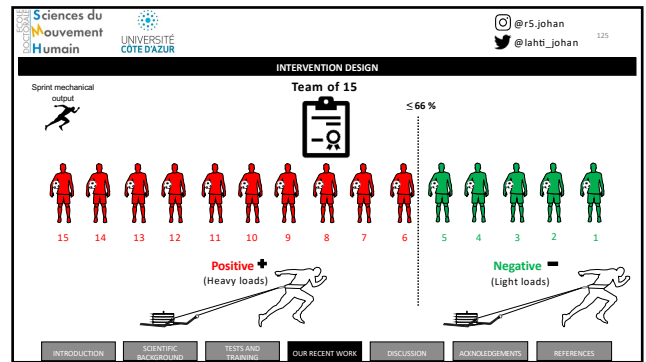
Negative Positive

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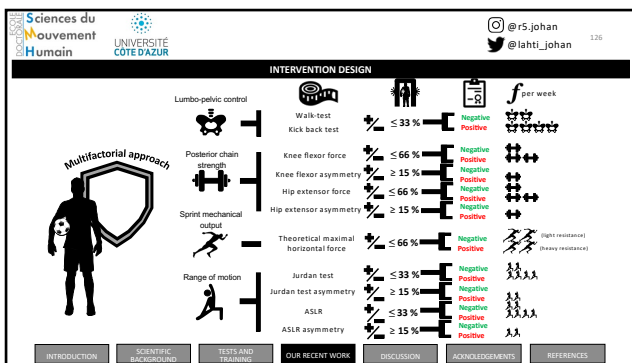
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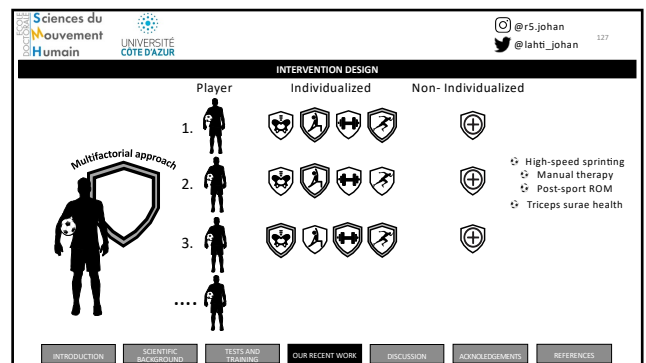
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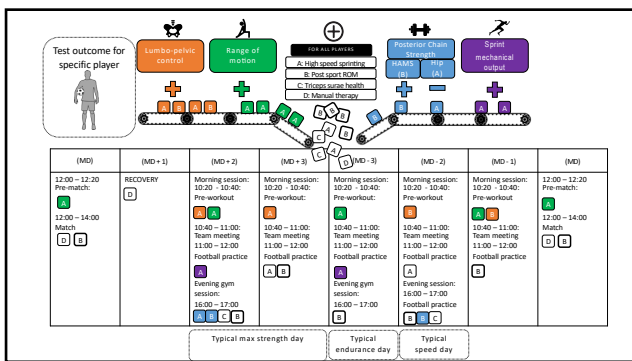
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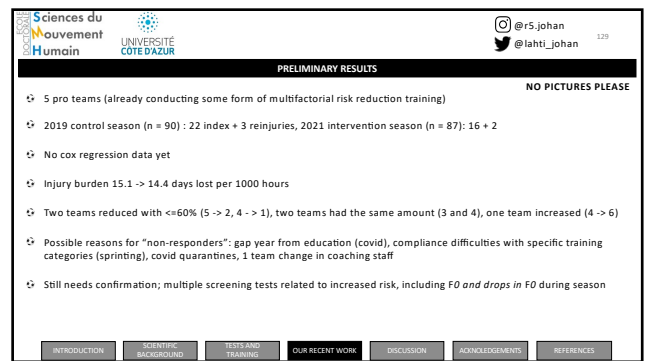
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DISCUSSION

### OVERVIEW (approach)

- ❖ **Sprint oriented approach**
  - Hamstring injuries mostly take place during sprinting -> zoom in on sprint properties
  - Kinetics: Horizontal force capacity, posterior chain strength
  - Kinematics: lumbo-pelvic control, range of motion
- ❖ **Concurrent injury risk reduction and performance approach**
  - Variables may be of interest for both physiotherapists and strength & conditioning coaches
- ❖ **Multifactorial approach**
  - Injuries can take place during different scenarios for different reasons
  - Protocol proposal aims to provide "safety net" for all for most common injury scenarios
- ❖ **Individualized approach**
  - Supports frequent testing = player ↔ coach interaction
  - May further support performance improvement
  - Can be feasible in club settings

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DISCUSSION

### LIMITATIONS

- ❖ Sample size
- ❖ Lack of randomization
- ❖ Percentile method
- ❖ Screening technology

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DISCUSSION

### PERSPECTIVES

- ❖ **Developments in testing technology**
  - May allow for higher testing frequency (screening -> monitoring)
  - More precise testing to the context of injury
  - Advanced statistical analysis more user friendly



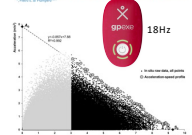
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DISCUSSION

### PERSPECTIVES

- ❖ **Developments in testing technology**
  - May allow for higher testing frequency (screening -> monitoring)
  - Advanced statistical analysis more user friendly
- ❖ **More precise testing to the context of injury**
  - 
  - 
  - 

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DISCUSSION

### PERSPECTIVES

- ❖ **Developments in testing technology**
  - May allow for higher testing frequency (screening -> monitoring)
  - More precise testing to the context of injury
  - Advanced statistical analysis more user friendly
- ❖ **Not just about technology developments**
  - Staff development
  - Using testing as part of training "testing without testing"



target: Dumbbell: 0.5 x BM    target: Barbell: 0.75 x BM    target: low breakpoint angle

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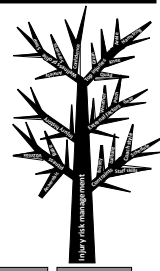
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DISCUSSION

### PERSPECTIVES

- ❖ **Developments in testing technology**
  - May allow for higher testing frequency (screening -> monitoring)
  - More precise testing to the context of injury
  - Advanced statistical analysis more user friendly
- ❖ **Not just about technology developments**
  - Staff development
  - Using testing as part of training "testing without testing"
- ❖ **Injury risk management**
  - Big picture thinking



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DISCUSSION

### CONCLUSION

- Novel tests
- Initial association ↔ hamstring injury
- Longitudinal findings in training F0
- Proposed and conducted a novel multifactorial and individualized approach for risk reduction
- All extensively rationalized, visualized, and discussed

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Jurdan Mendiguchia @zentrumsport @zentrumsport

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SCREENING

ALTERNATIVE TESTS

Novel biomechanical injury risk score demonstrates correlation with lower limb posterior chain injury in 50 elite-level rugby union athletes

Figure 1 Still image views of longitudinal (left) and transverse (right) views of biomechanical deficit and limb asymmetry when using the RIS system starting position (A), testing left limb (B) and testing right limb (C).

Injury Risk Score System Criteria		Lower Limb	
		LEFT	RIGHT
Loss of Pelvic-Clav-Cor-Activation			
Lumbar Spine Extension			
LRI of the Anterior Superior Iliac Spine from plumb			
Increase in Hip External Rotation from starting position			
Increase in Hip Abduction from starting position			
Unilateral Risk Score		1/4	1/4
Total Risk Score		1/8	

Instructions:  
Tense both buttock muscles and maintain this contraction for the duration of the movement, until the test is over. Niss bend your left knee to 90 degrees and lift that knee off the foot.

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STUDY I - METHODS

ALTERNATIVE PRAGMATIC TESTS

Lateral bias Target: Dumbbell: ~ 0.5 x BM Barbell: ~ 0.75 x BM

Medial bias Target: Low breakpoint angle

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Text here

Details of output (How) → Output (what)

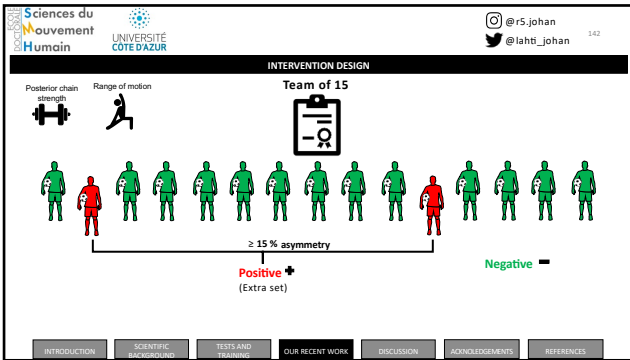
Sprint force asymmetry → Sprint kinematics → Angle of peak torque → Interaction with contralateral limb → ROM

Isolated maximal strength → Isolated maximal speed → Different strength ratios

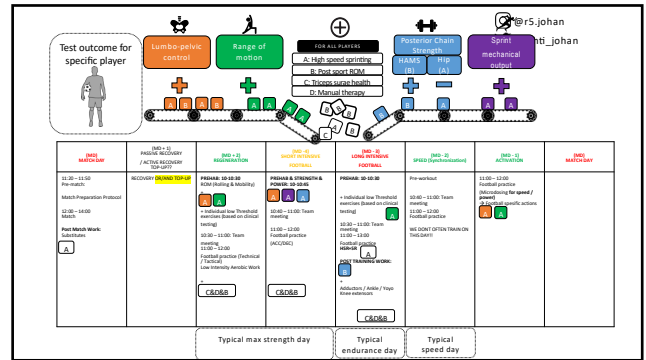
Multifactorial approach

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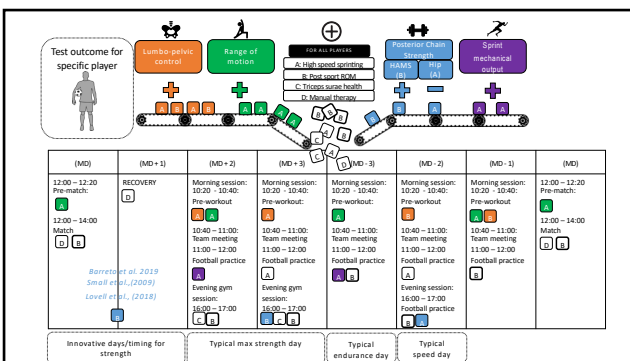
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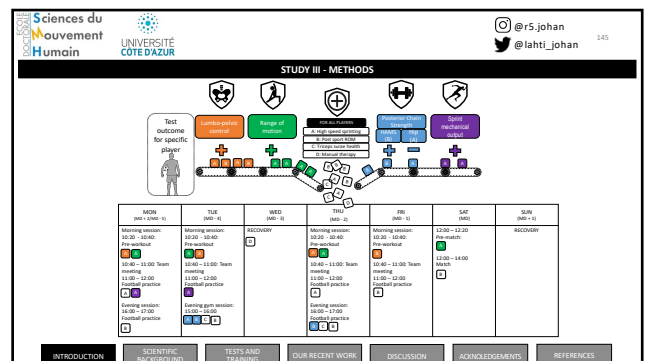
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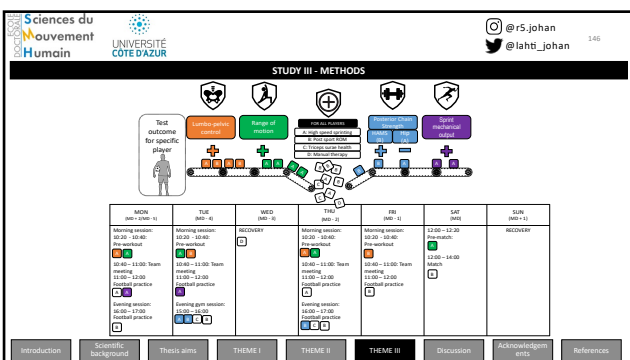
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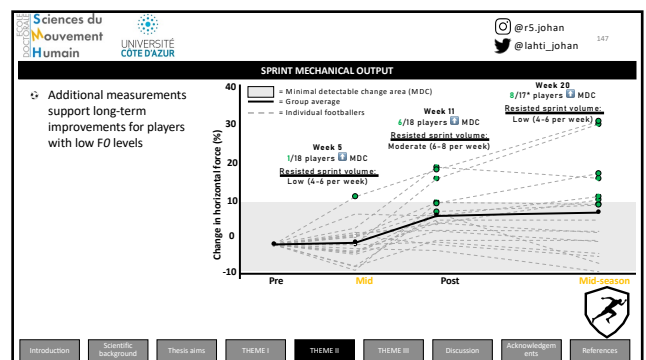
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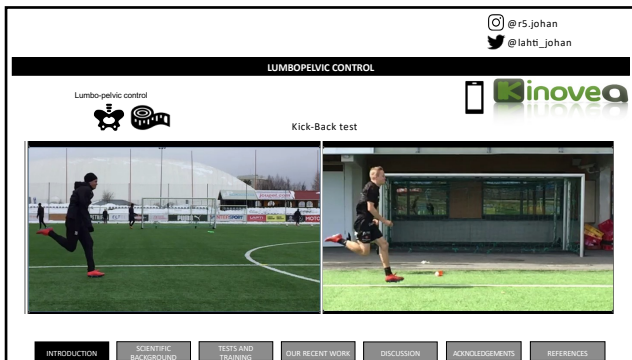


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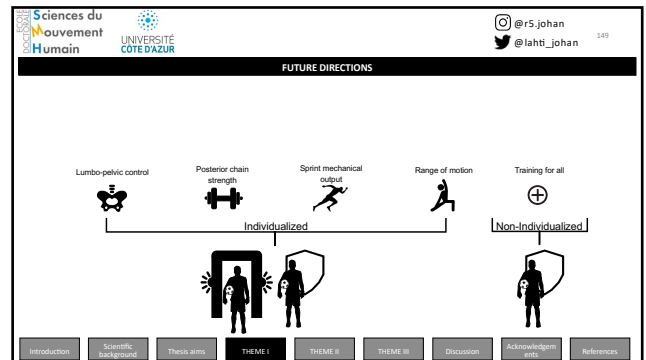


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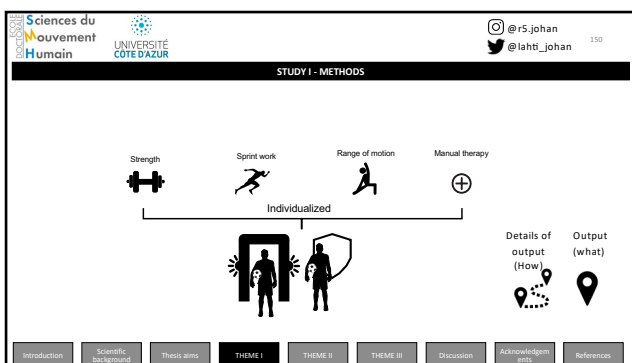




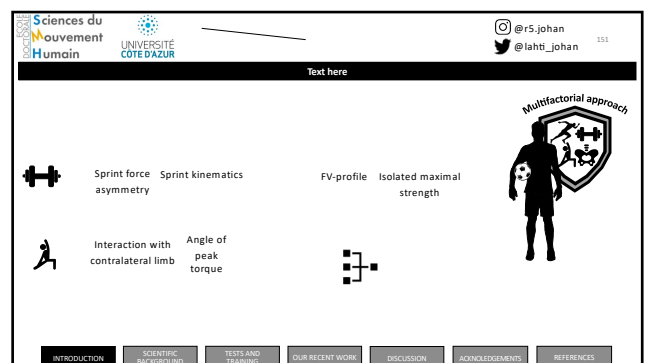
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