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

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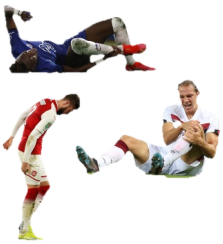
INJURIES IN MALE FOOTBALL

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



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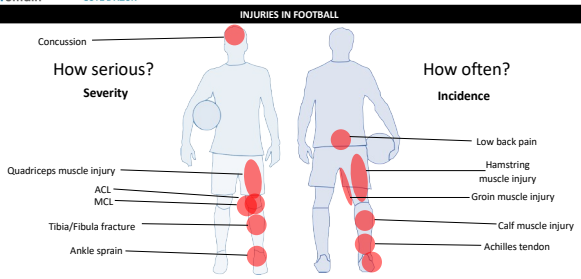
INJURIES IN FOOTBALL



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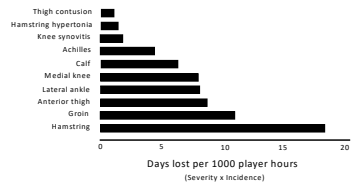
INJURIES IN FOOTBALL

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



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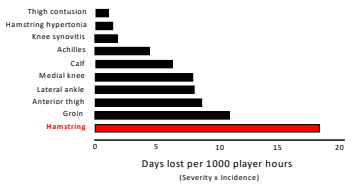
INJURIES IN FOOTBALL[4-7]

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



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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 (Koulouris et al., 2007; Ekstrand et al., 2012; Wangensteen et al., 2016)

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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

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TASK OF HAMSTRING IN FOOTBALL

FOOTBALL REQUIREMENTS | **What is the connection?** | **HAMSTRINGS TASK**

Linear sprint performance (Vmax, 0-20 m time) (Cometti et al., 2001; Haugen, Tønnessen and Seiler, 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** (Morin et al. 2015).

⚽ Important stabilizer and decelerator (Katayama et al., 2004; Tashman et al., 2004; Abourezk 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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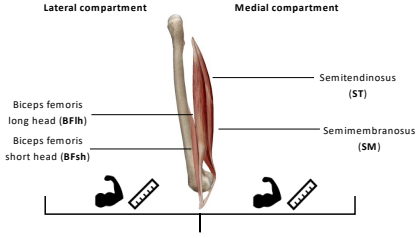
BASIC ANATOMY AND FUNCTION



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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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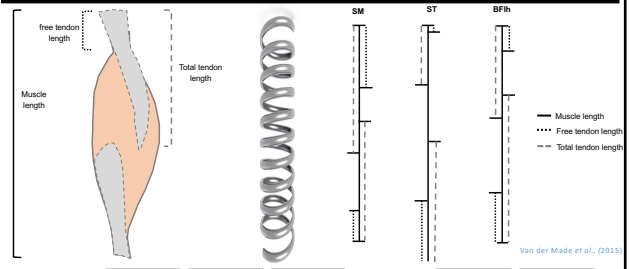
BASIC ANATOMY AND FUNCTION



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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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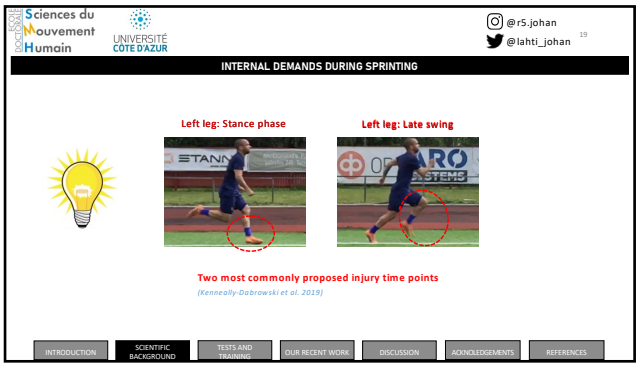

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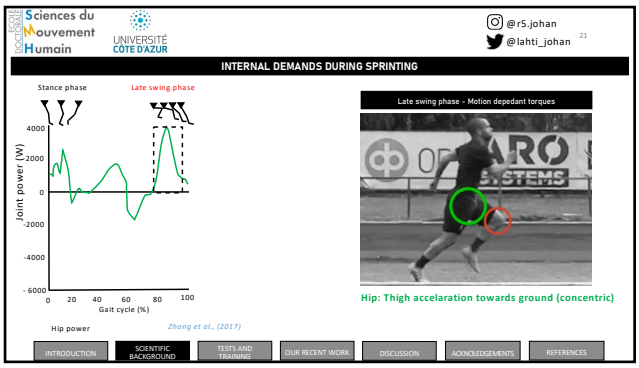

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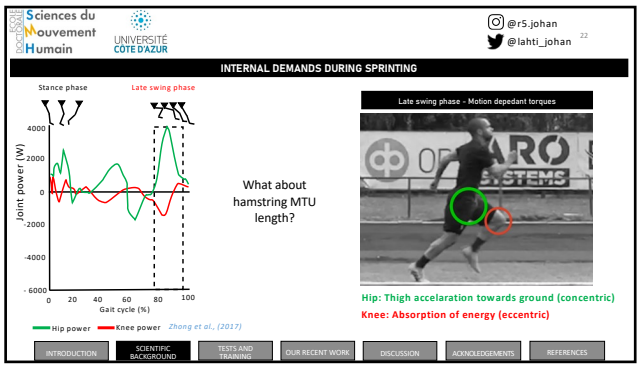

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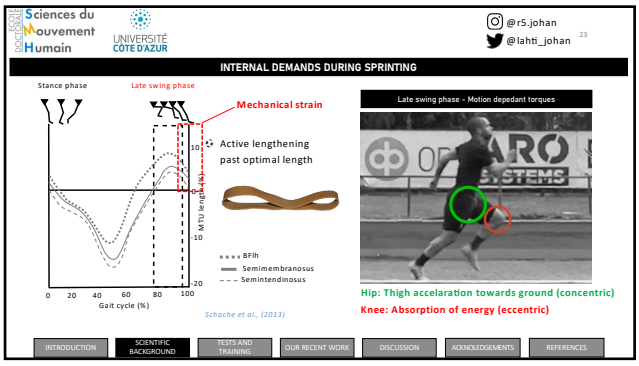

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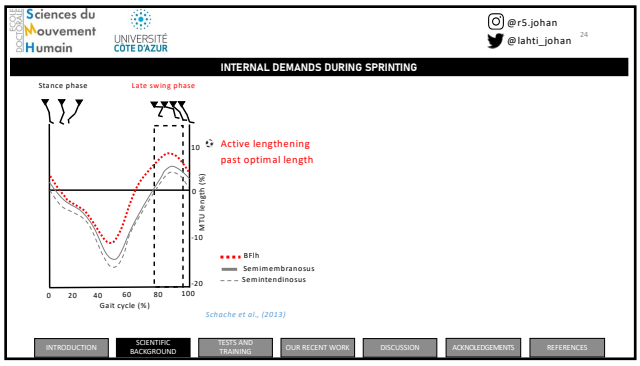

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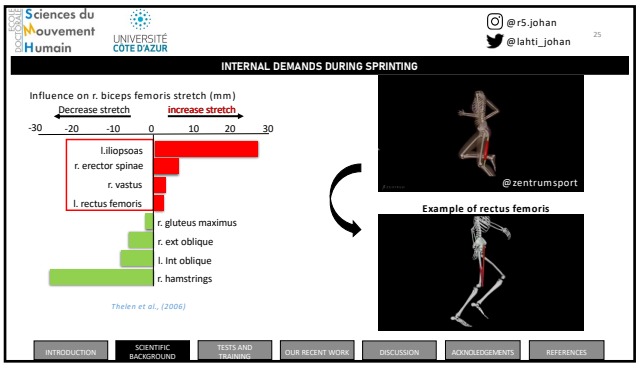

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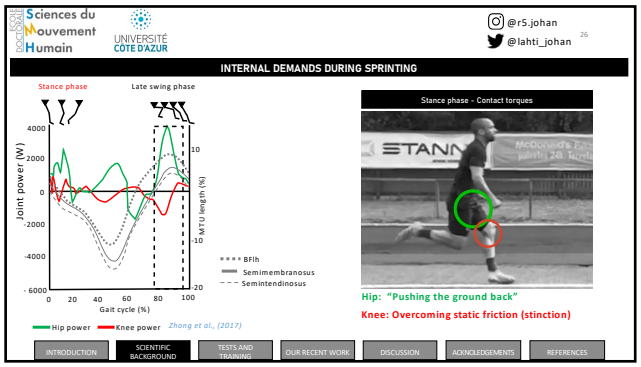

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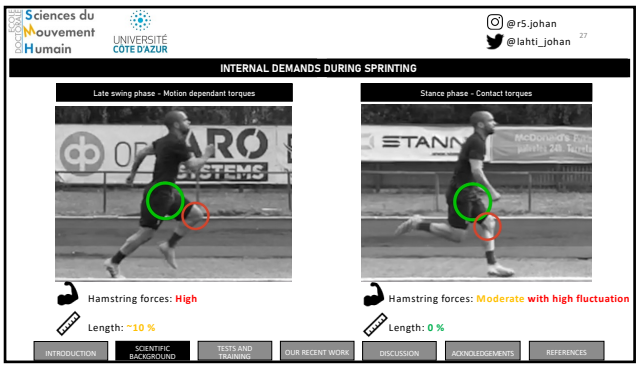

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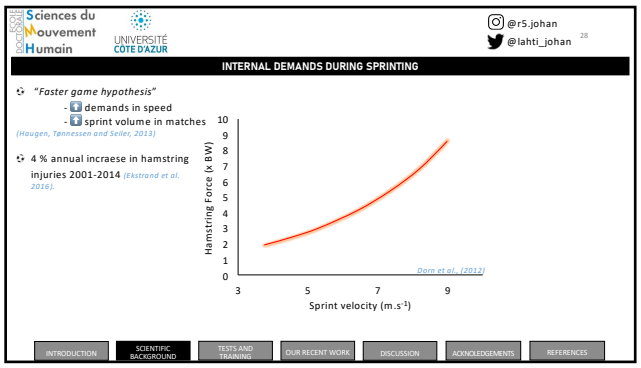

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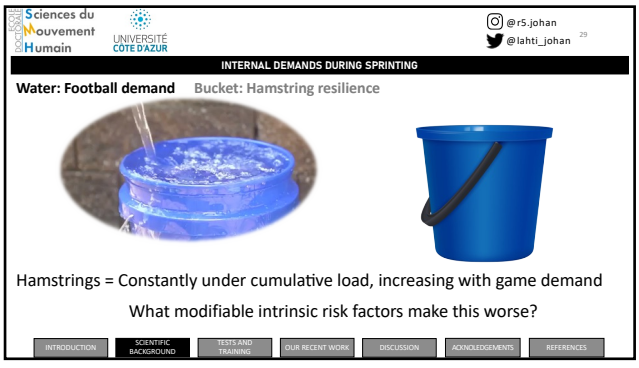

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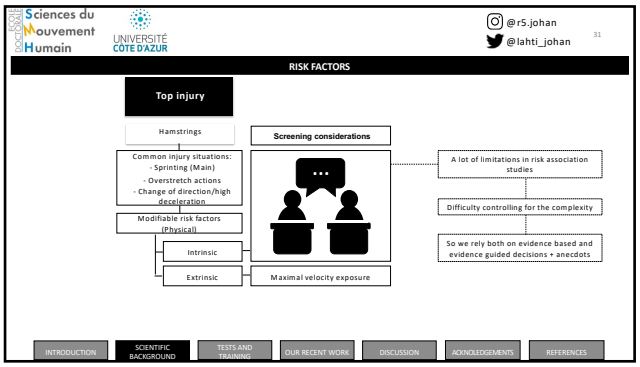

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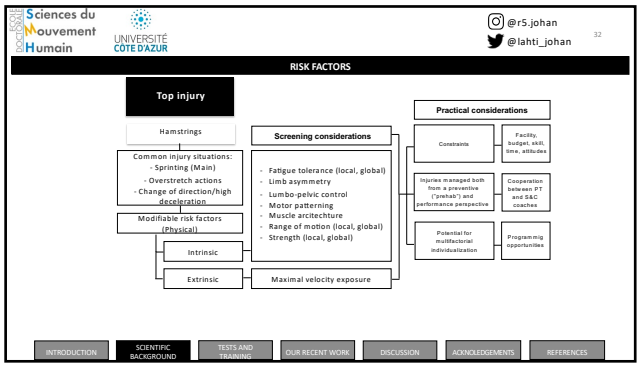

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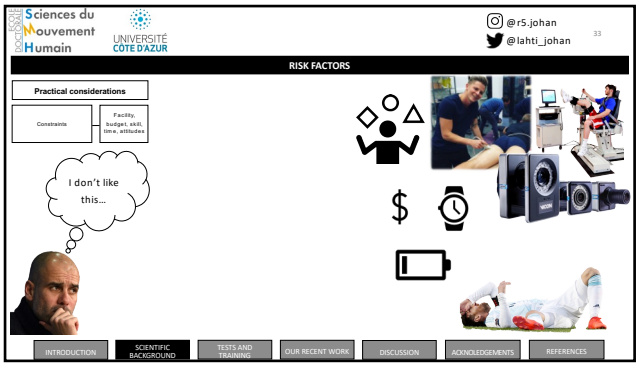

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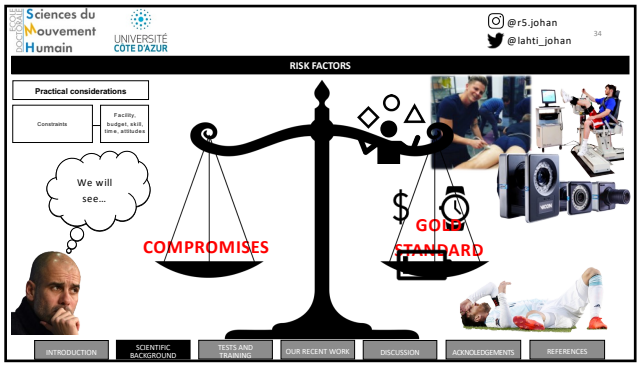

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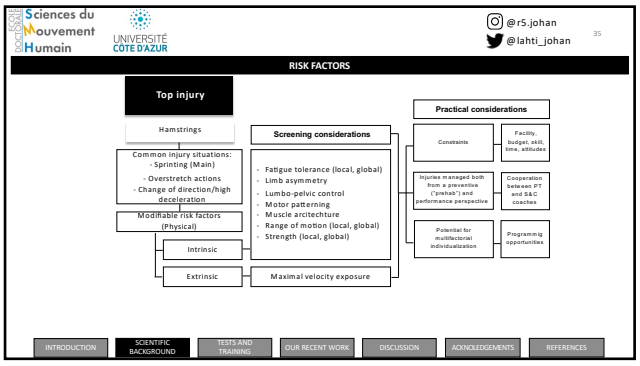

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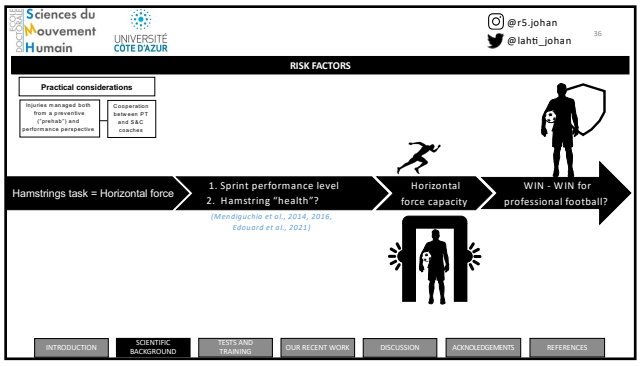

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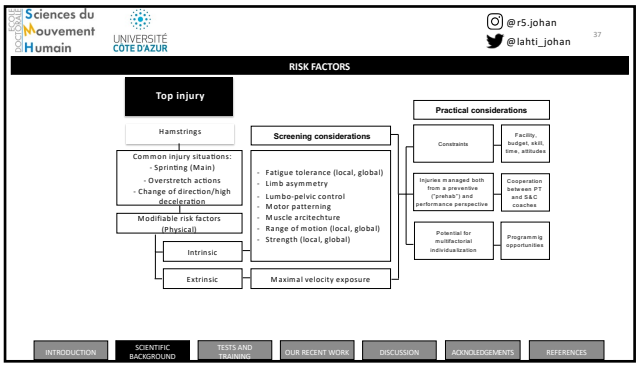

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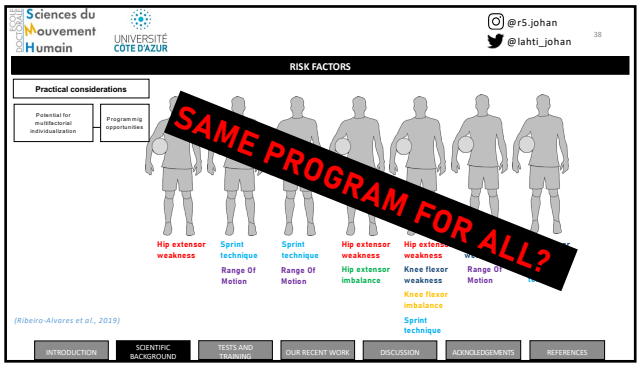

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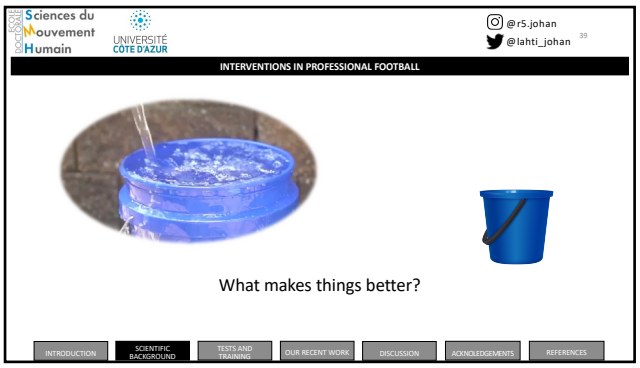

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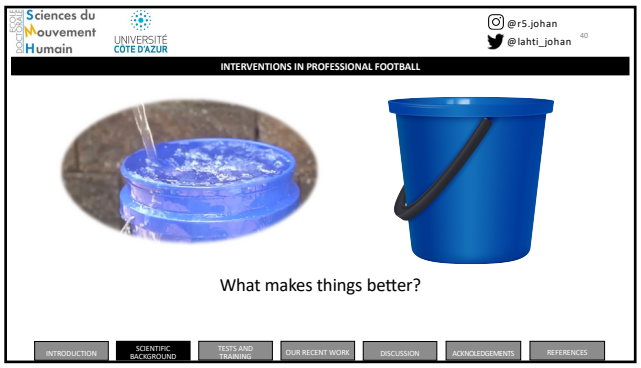

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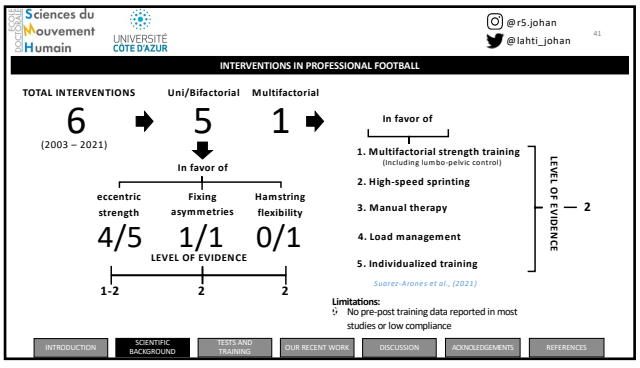

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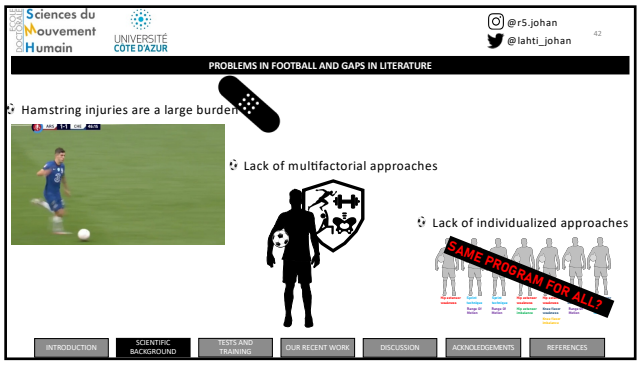

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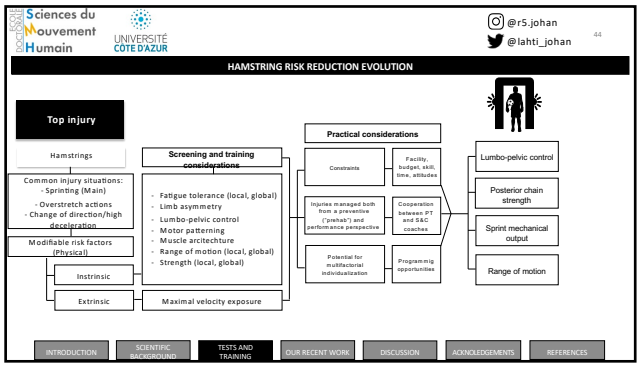

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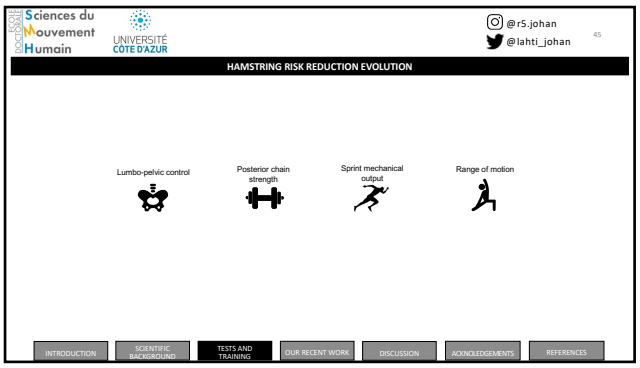

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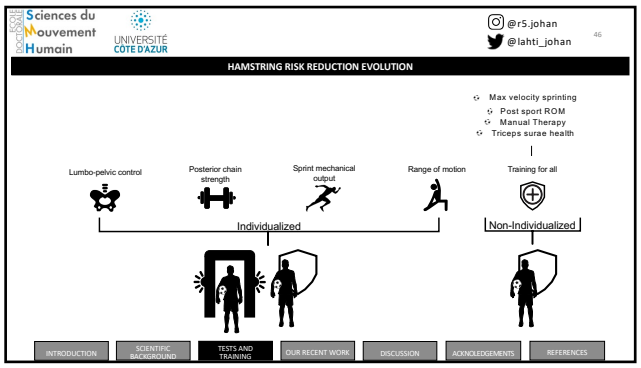

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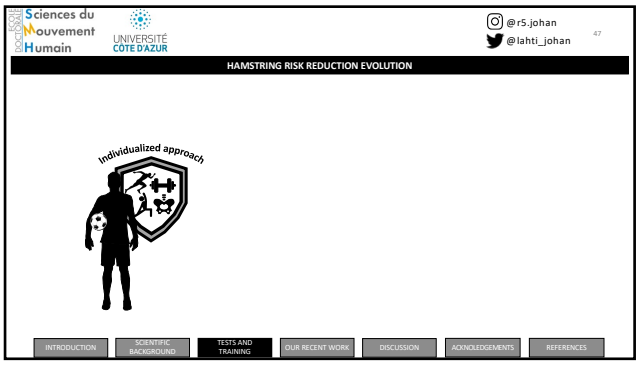

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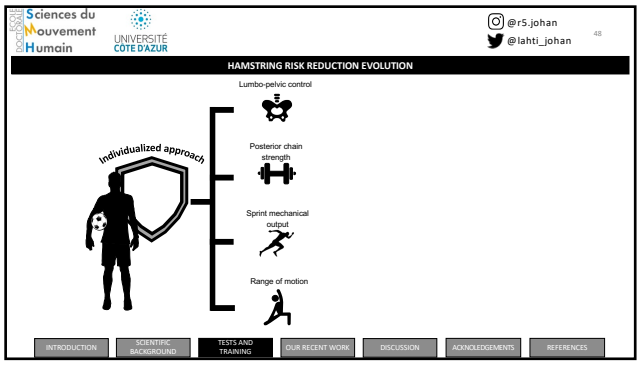

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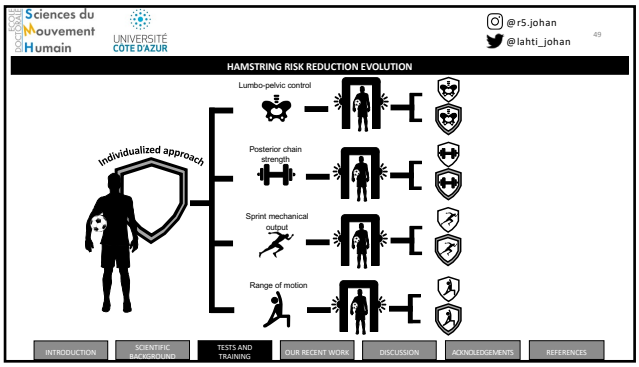

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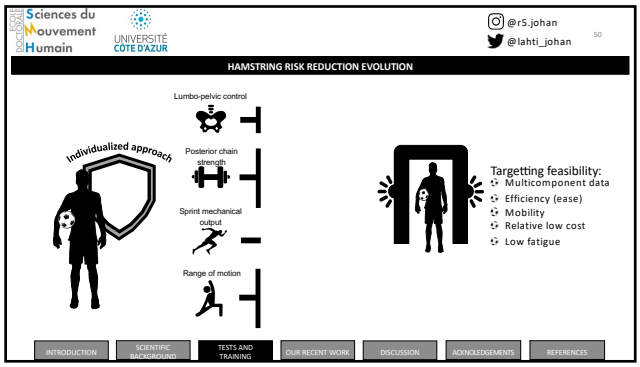

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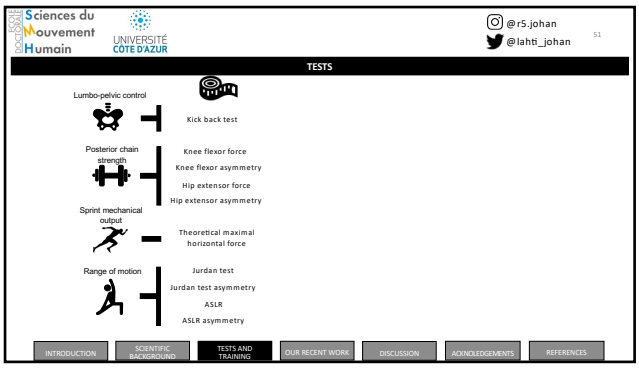

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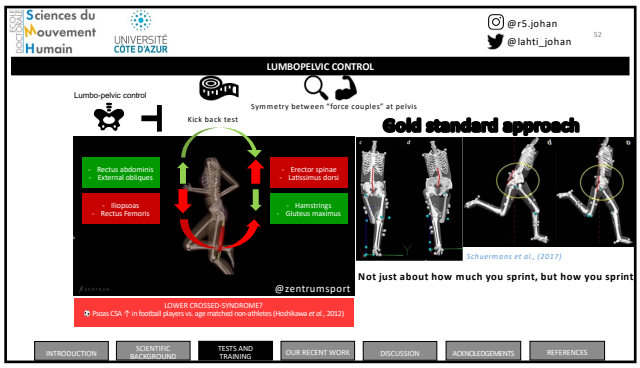

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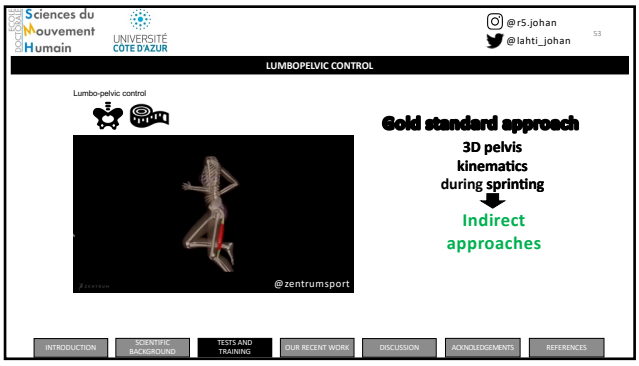

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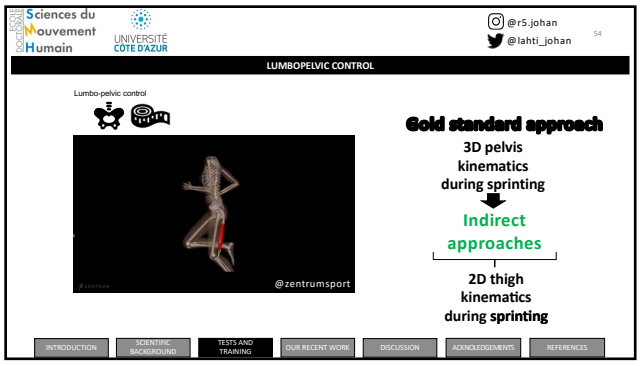

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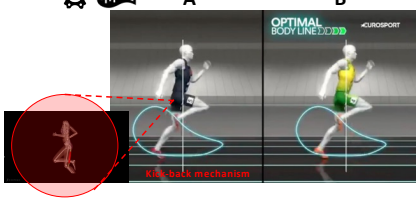
LUMBOPELVIC CONTROL

Lumbo-pelvic control

2D thigh kinematics during sprinting

A B



- 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

Kinovea

Kick-Back test

INNOVATIVE

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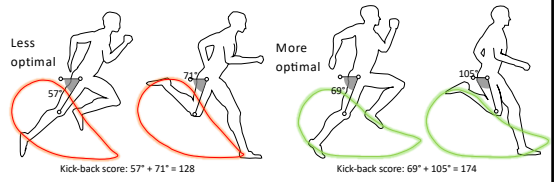
LUMBOPELVIC CONTROL

Lumbo-pelvic control

Kick-Back test

Kinovea



Kick-back score: 57° + 71° = 128

Kick-back score: 69° + 105° = 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

Controlled Clinical Trial > J Sports Sci. 2021 Apr;39(7):760-767. doi: 10.1080/02640414.2020.1845439. Epub 2020 Nov 10.

Training-induced changes in anterior pelvic tilt: potential implications for hamstring strain injuries management

Jurdan Mendiguchia [1], Angel Gonzalez De la Flor [2 3], Alberto Mendez-Villanueva [4], Jean-Benoît Morin [5], Pascal Edouard [6 7], Mirian Aranzazu Garrues [8]

> Int J Sports Physiol Perform. 2021 Nov 18;1-10. doi: 10.1123/ijspp.2021-0107. Online ahead of print.

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

Jurdan Mendiguchia, Adrián Castaño-Zambudio, Pedro Jiménez-Reyes, Jean-Benoît Morin, Pascal Edouard, Filipe Conceição, Jonas Tawiah-Dodoo, Steffi L Colyer

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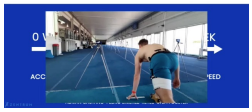
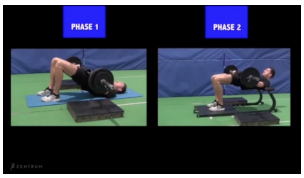
LUMBOPELVIC CONTROL

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

TESTING



TRAINING



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LUMBOPELVIC CONTROL

- Reduced dynamic anterior pelvic tilt
- Increased max velocity

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

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LUMBOPELVIC CONTROL

Anterior-posterior pelvic tilt and ant-extension

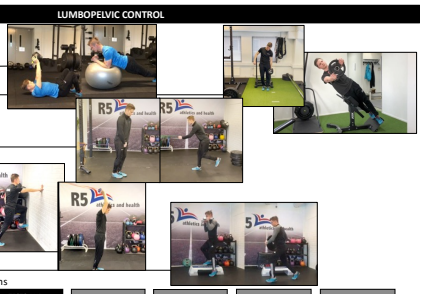
Simple

Anti-lateral flexion, Rotational elements

More dynamic

Complex

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
  - Jurdan test
  - Jurdan 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

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

(Croisier et al. 2008, Bourne et al. 2016, Schuermanse et al. 2016, 2017)

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

(Baumert et al. 2020, Maeo 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

Med Sci Sports Exerc. 2021 Apr; 53(4): 825–837.
Published online 2020 Oct 2. doi: 10.1249/MSS.0000000000002523
PMCID: PMC7969179
PMID: 33009197

Greater Hamstrings Muscle Hypertrophy but Similar Damage Protection after Training at Long versus Short Muscle Lengths

Sumiaki Maeo,[1] Meng Huang,[2] Yuhang Wu,[2] Hikaru Sakurai,[2] Yuki Kusagawa,[2] Takashi Sugiyama,[3] Hiroaki Kanehisa,[2] and Tadao Isaka[2]

Randomized Controlled Trial > Br J Sports Med. 2017 Mar;51(5):469–477.
doi: 10.1136/bjsports-2016-096130. Epub 2016 Sep 22.

Impact of the Nordic hamstring and hip extension exercises on hamstring architecture and morphology: implications for injury prevention

Matthew N Bourne [1 2 3], Steven J Duhig [2 4], Ryan G Timmins [5], Morgan D Williams [6], David A Opar [5], Aiman Al Najjar [7], Graham K Kerr [2 4], Anthony J Shield [2 4]

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POSTERIOR CHAIN STRENGTH

KNEE OVER HIP MOVEMENT

HIP OVER KNEE MOVEMENT

Follow @BasVanHooren
PhD work

Impact of the Nordic hamstring and hip extension exercises on hamstring architecture and morphology: implications for injury prevention

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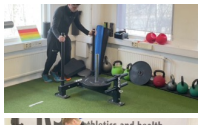
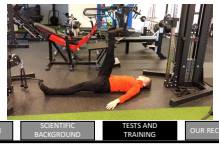
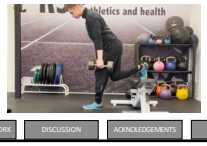
POSTERIOR CHAIN STRENGTH

LENGTHENED TRAINING OPTIONS







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POSTERIOR CHAIN STRENGTH

PETURBATIONS

STIFFNESS
(Open to closed chain)

COCONTRACTION REDUCTION

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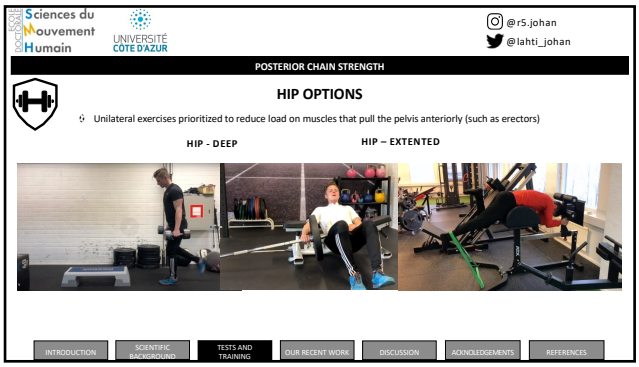

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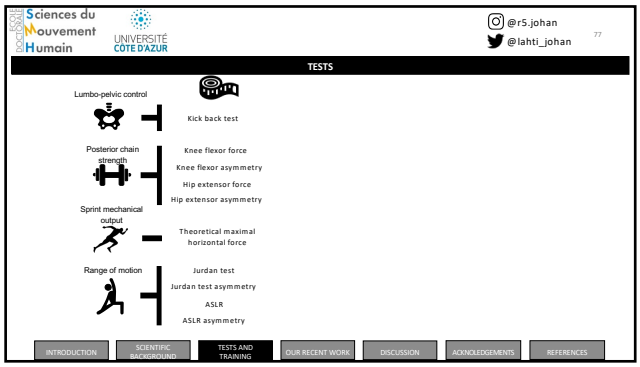

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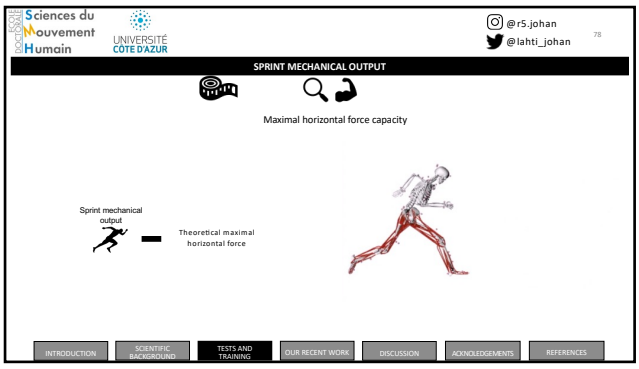

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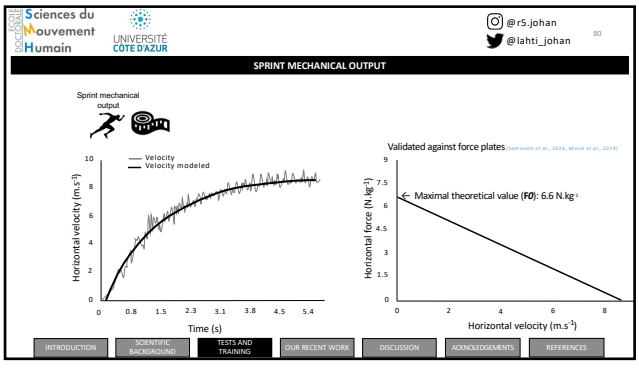

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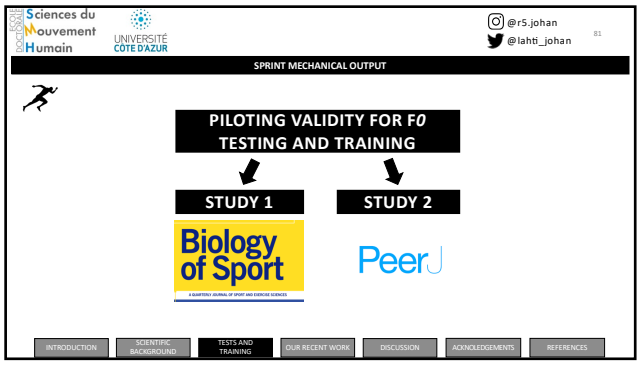

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SPRINT MECHANICAL OUTPUT

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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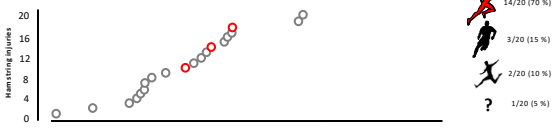
SPRINT MECHANICAL OUTPUT

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



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

Pre-season end | Mid-season | Season end

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

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

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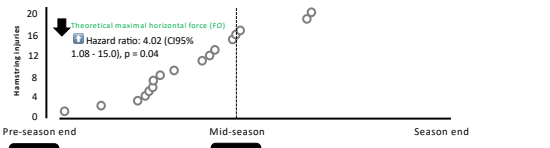
SPRINT MECHANICAL OUTPUT

= Index injury



Pre-season end | Mid-season | Season end

- No other assocations
- 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

Biology of Sport | PeerJ

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SPRINT MECHANICAL OUTPUT TRAINING

STUDY 2

PeerJ

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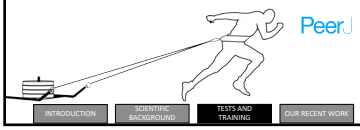
SPRINT MECHANICAL OUTPUT TRAINING

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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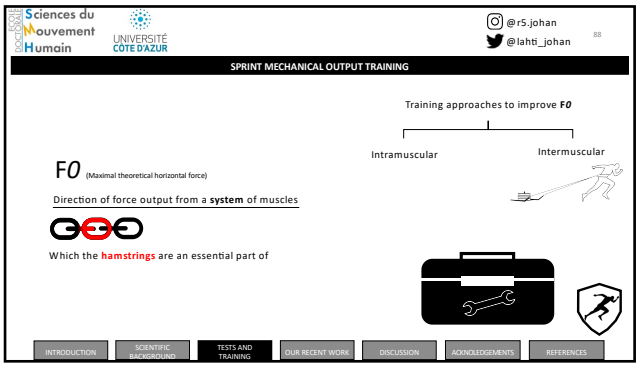

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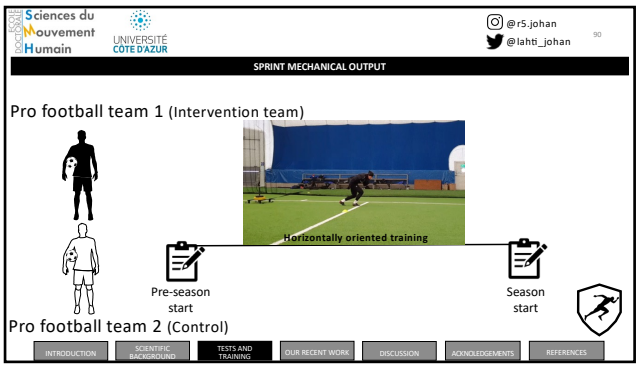

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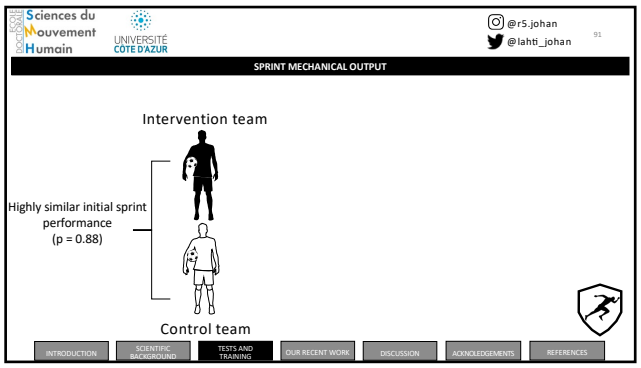

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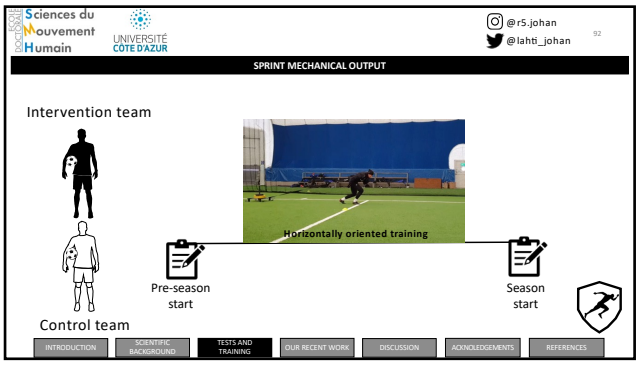

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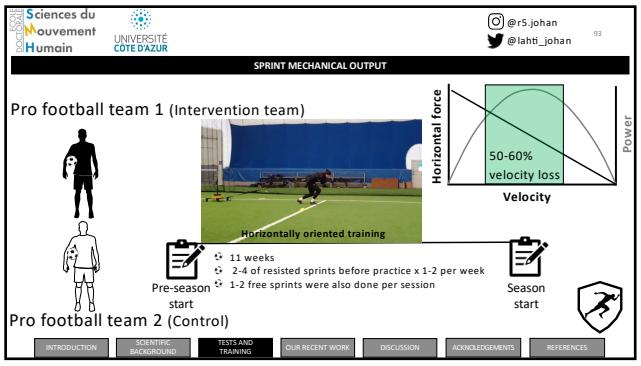

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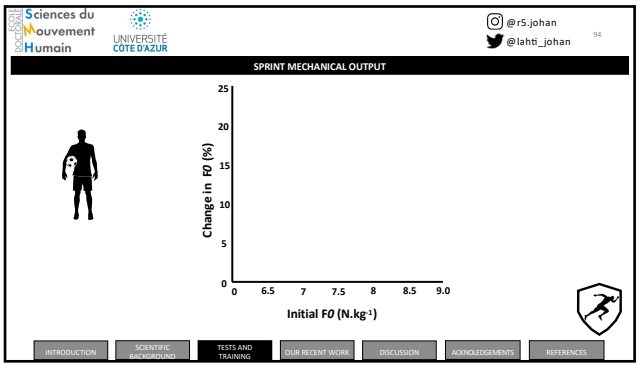

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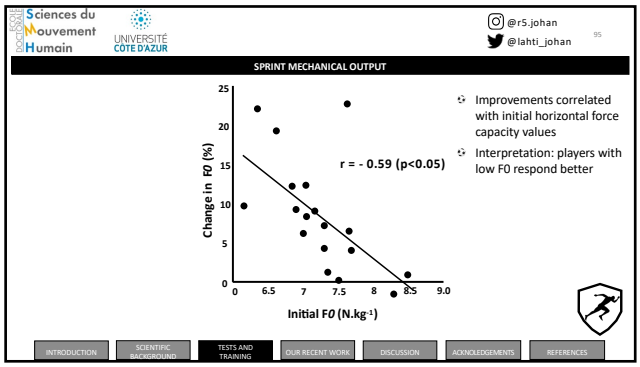

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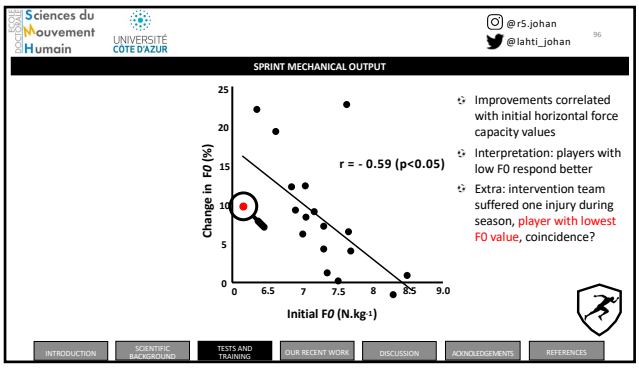

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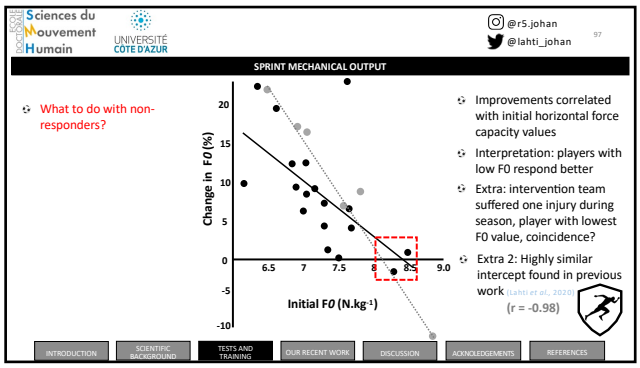

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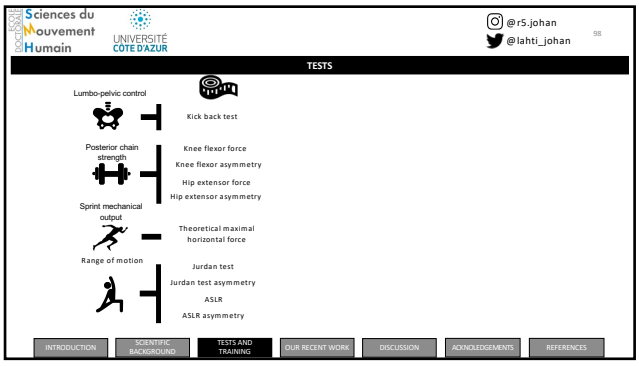

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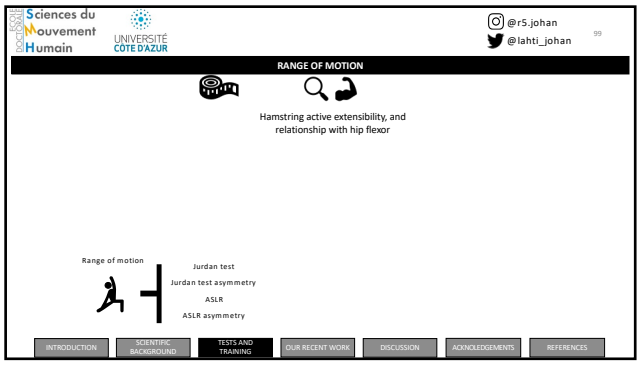

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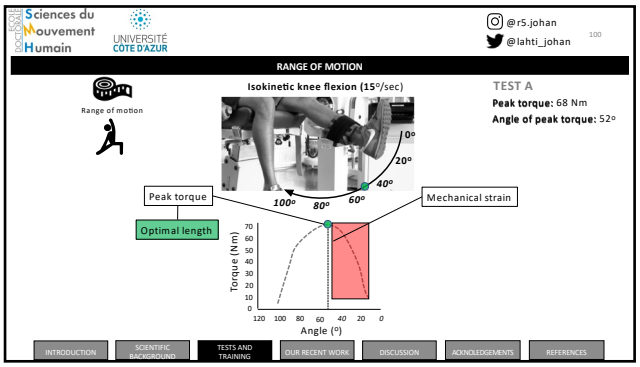

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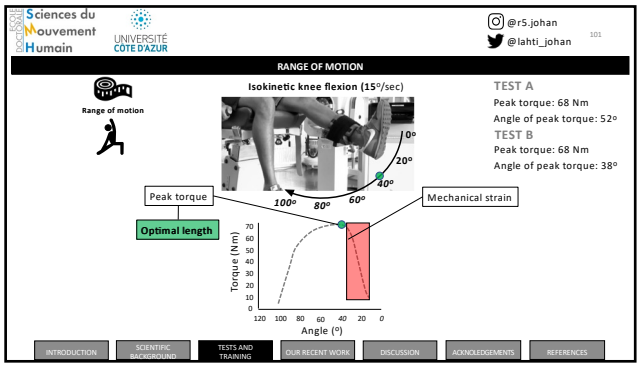

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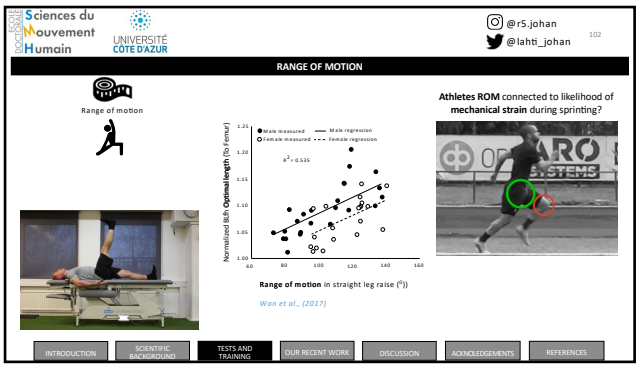

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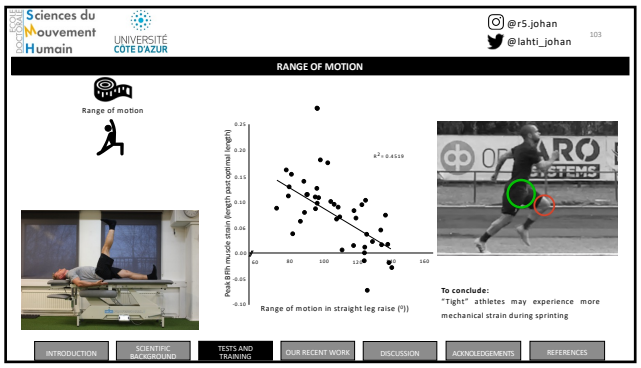

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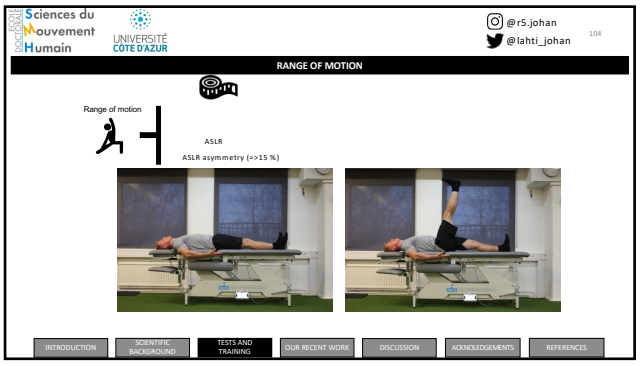

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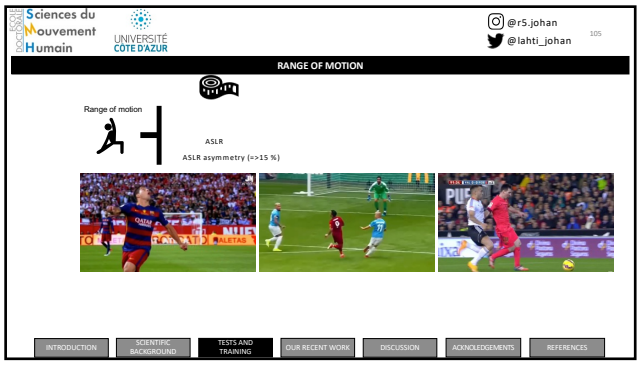

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RANGE OF MOTION

Range of motion
Jurdan test
Jurdan test asymmetry
ASLR
ASLR asymmetry

Thelen et al., (2006)

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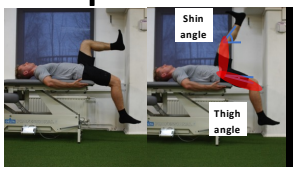
RANGE OF MOTION

Range of motion
Jurdan test
Jurdan 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 [1], Shangxiao Li [1], Thomas M Best [2], Hui Liu [1], Hanjun Li [3], Bing Yu [4]

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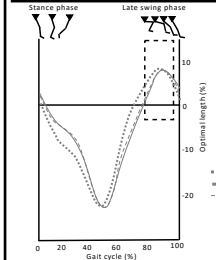
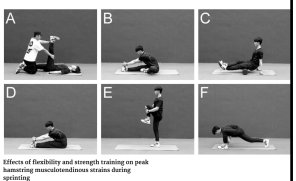
RANGE OF MOTION TRAINING



- 8 weeks of flexibility training



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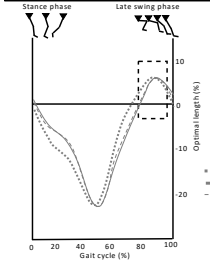
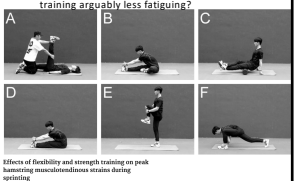


- 8 weeks of flexibility training
- Reduction in the degree of mechanical strain (i.e., lengthening past optimal).
- Same result with strength training but flexibility training arguably less fatiguing?



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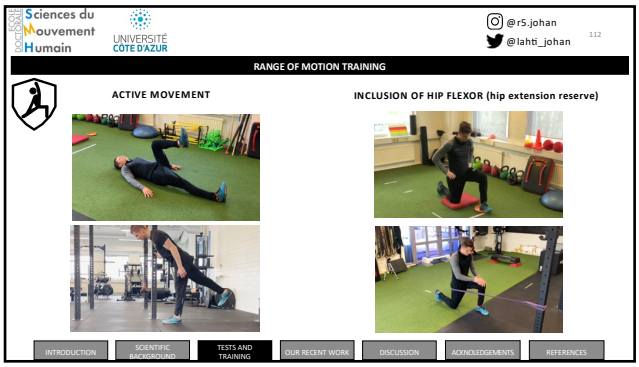

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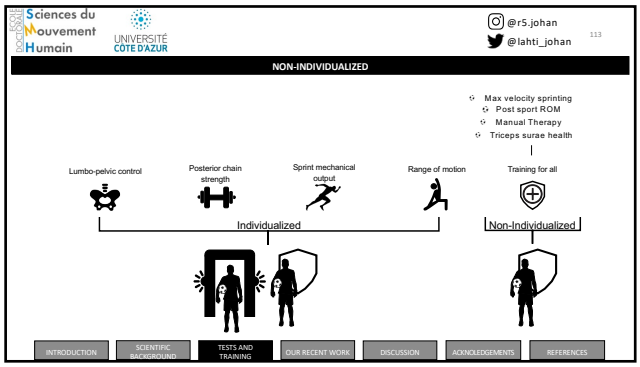

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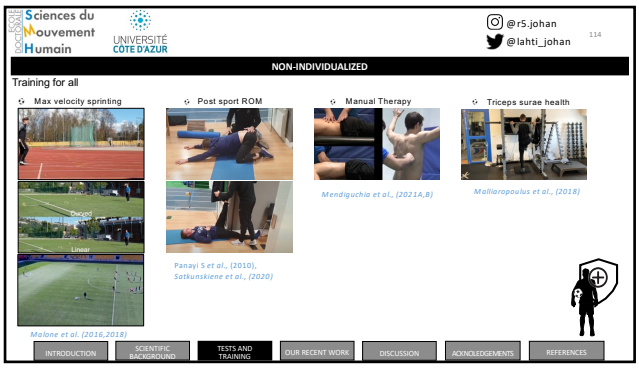

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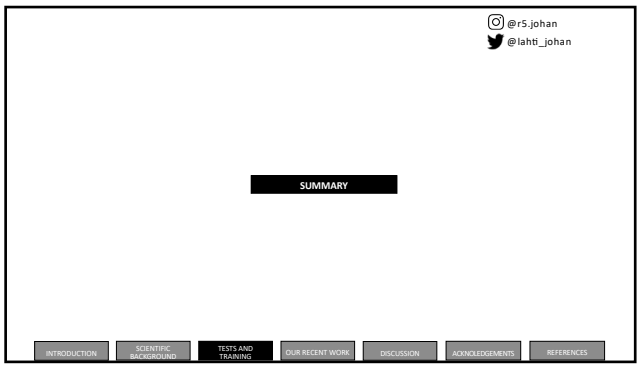

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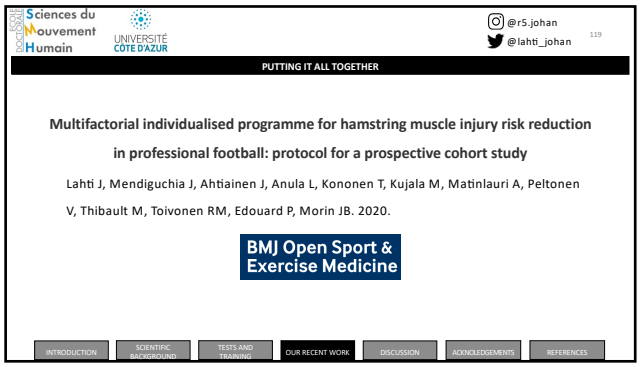

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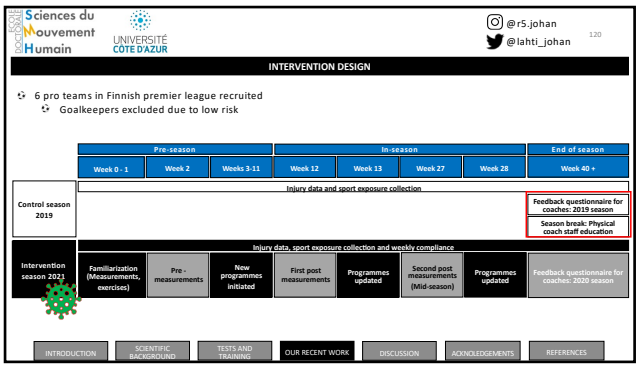

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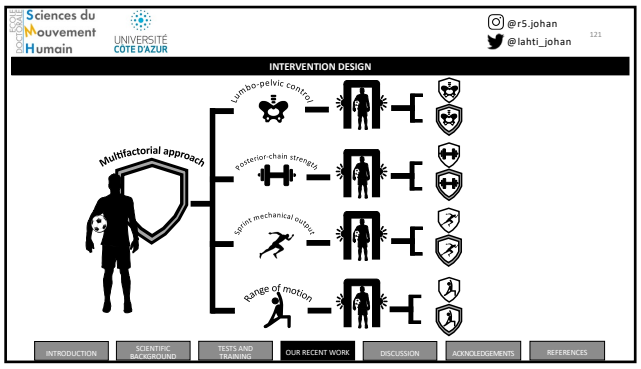

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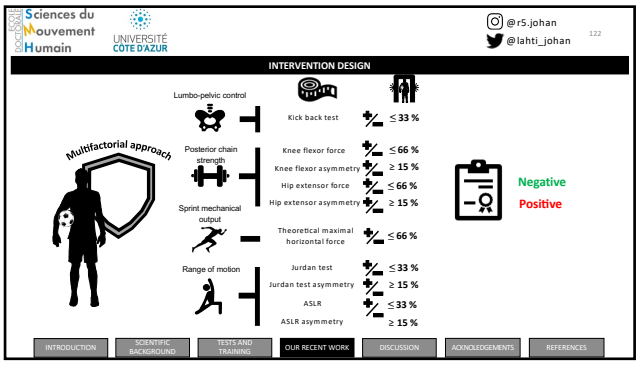

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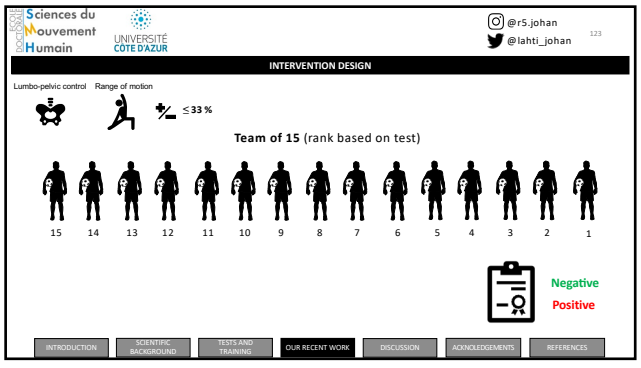

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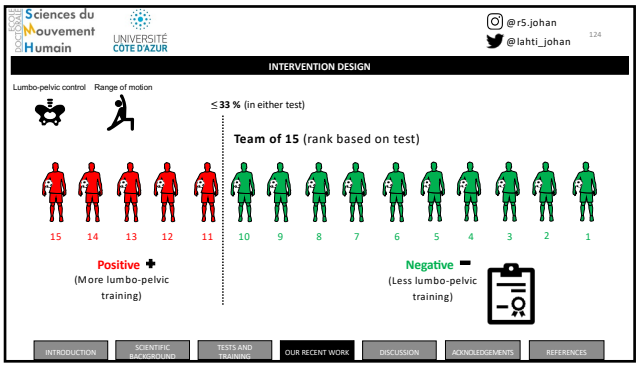

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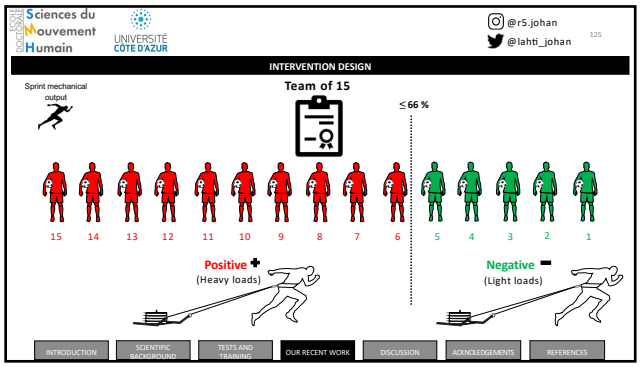

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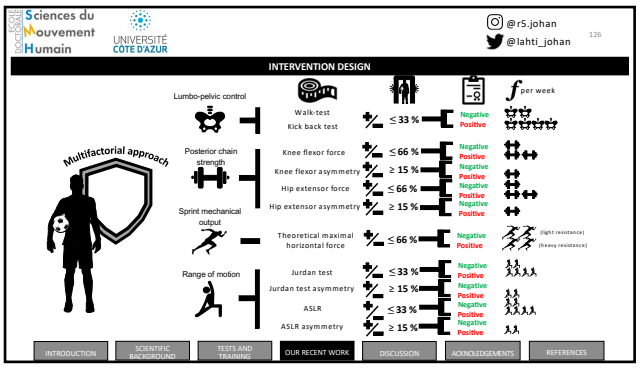

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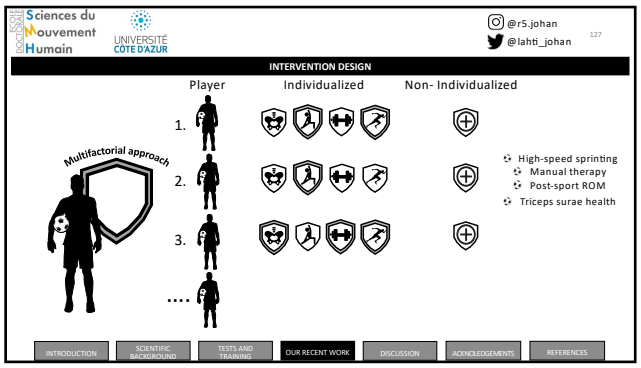

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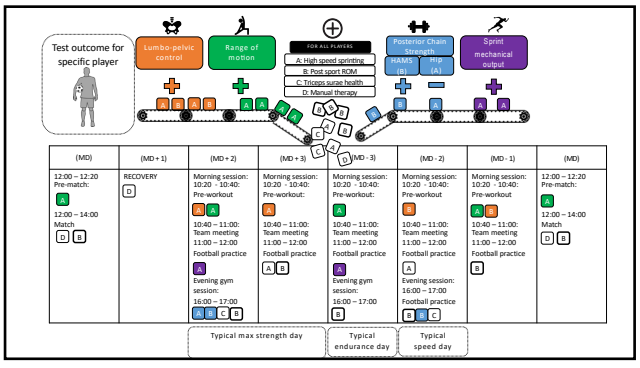

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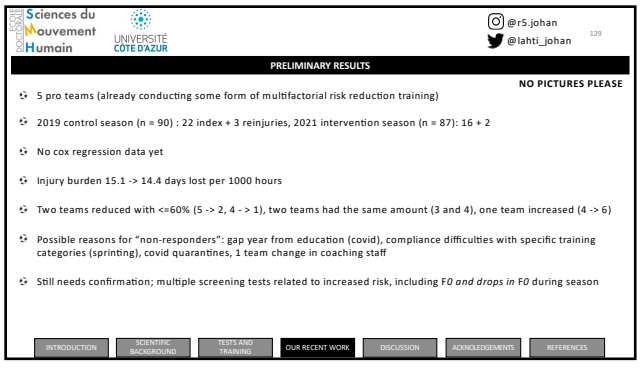

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DISCUSSION

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

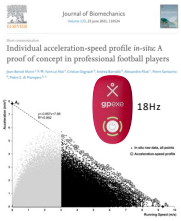
PERSPECTIVES

- Developments in testing technology
  - Advanced statistical analysis more user friendly
  - More precise testing to the context of injury

HOW force is produced

Hip extension + knee flexion

- May allow for higher testing frequency (screening -> monitoring)



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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"

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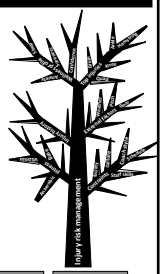
PERSPECTIVES

- 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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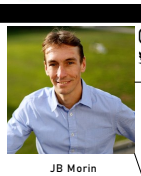

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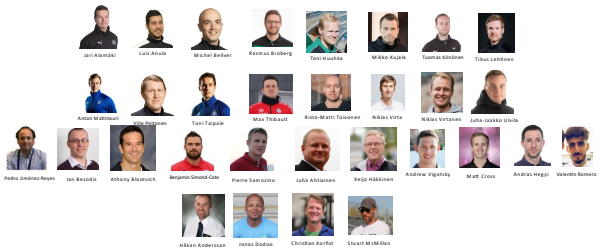

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SCREENING

ALTERNATIVE TESTS

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

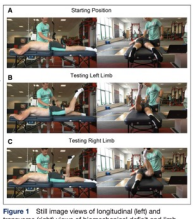

Figure 1 Still image views of longitudinal (left) and transverse (right) views of biomechanical deficit and limb asymmetry when using the IRS system: starting position (A), testing left limb (B) and testing right limb (C).

Injury Risk Score System Criteria	Lower Limb	
	Left	Right
Loss of Palpable Glute Co-activation		
Lumbar Spine Extension		
Lift off of the Anterior Superior Iliac Spine from plinth		
Increase in Hip External Rotation from starting position		
Increase in Hip Abduction from starting position		
Unilateral Risk Score	/ 5	/ 5
Total Risk Score	/ 10	

Instructions:

Tense both buttock muscles and maintain this contraction for the duration of the movement, until told the test is over. Now bend your left knee to 90 degrees and lift that knee off the bed. The

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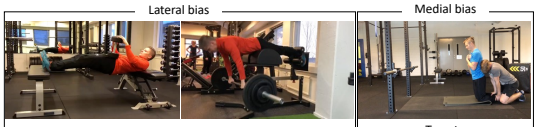
STUDY I - METHODS

ALTERNATIVE PRAGMATIC TESTS

Lateral bias | Medial bias



Target: Dumbbell: ~ 0.5 x BM

Target: Barbell: ~ 0.75 x BM

Target: Low breakpoint angle

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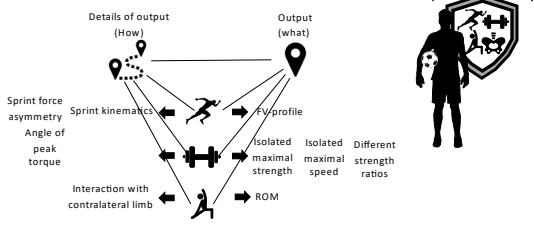

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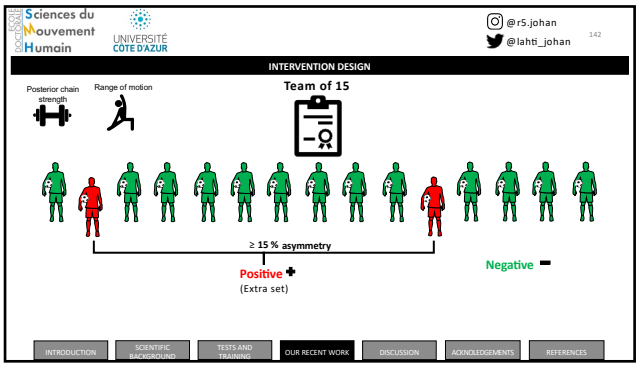

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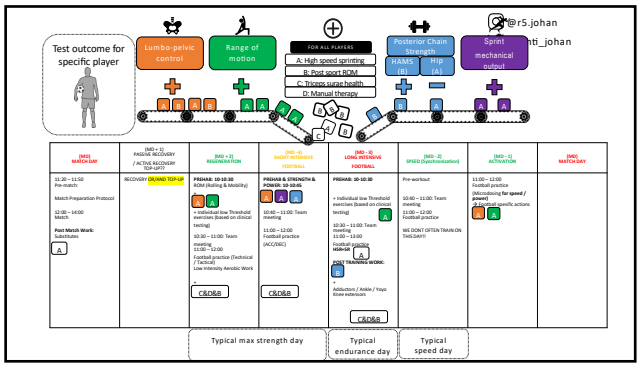

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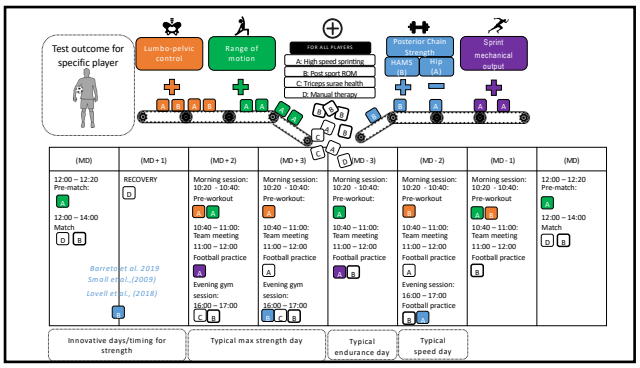

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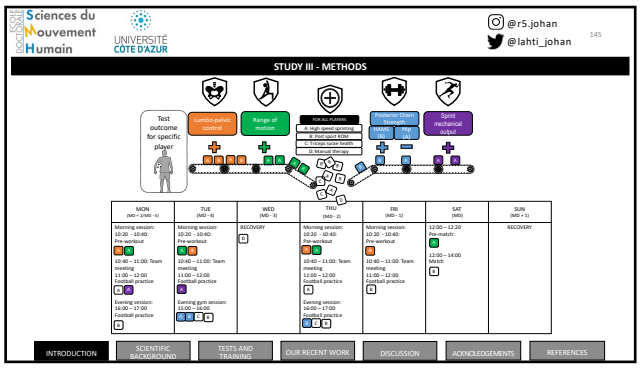

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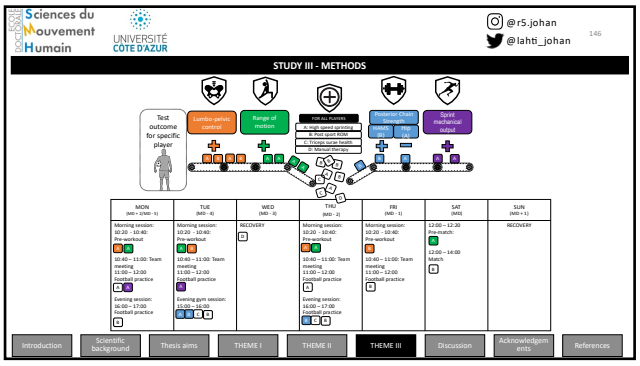

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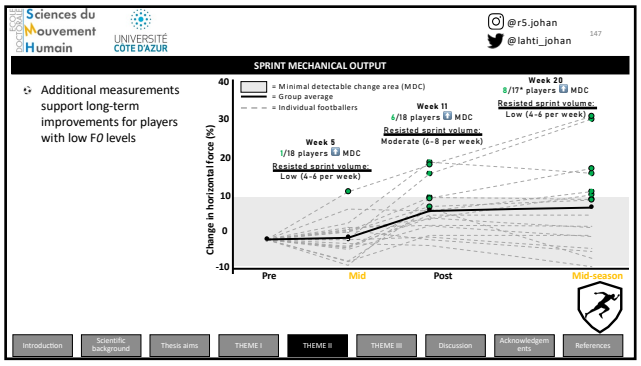

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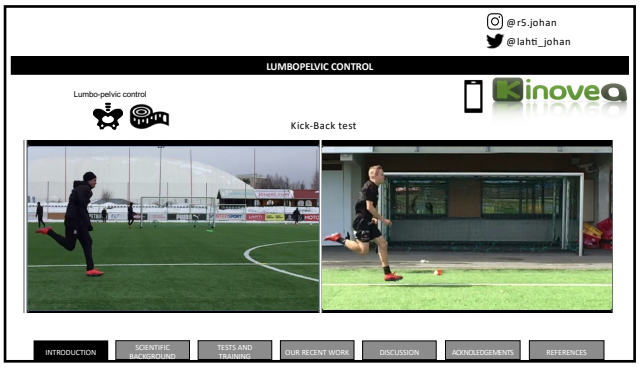

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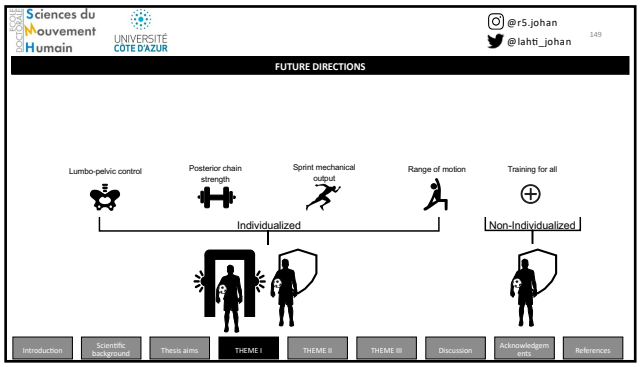

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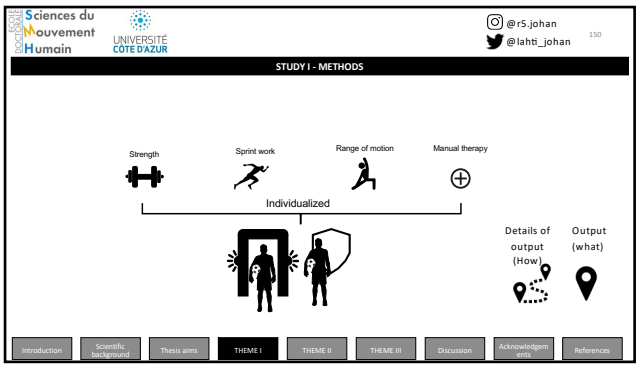

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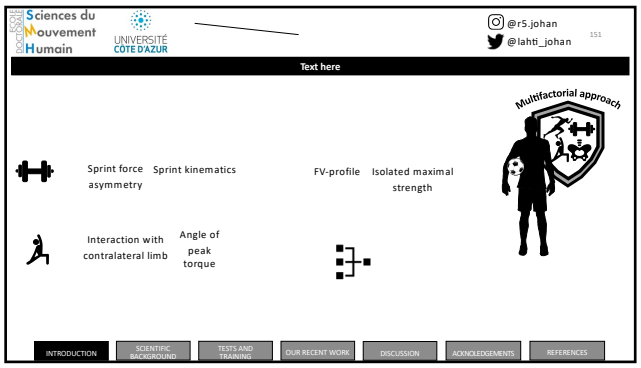

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