Optimal Rehabilitation of Hamstring Injuries: Recent Developments In Sports Medicine

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Objectives:

- Develop a contemporary understanding of the research literature on the evaluation and treatment of hamstring injuries
- Understand Hamstring Activity During Gait and Running
- Develop an advanced understanding of recent developments in treatment approaches for hamstring injuries and recurrent posterior thigh pain
- Develop new treatment ideas for recurrent hamstring injuries
- Demonstrate understanding of advanced rehabilitation for return to sports activities

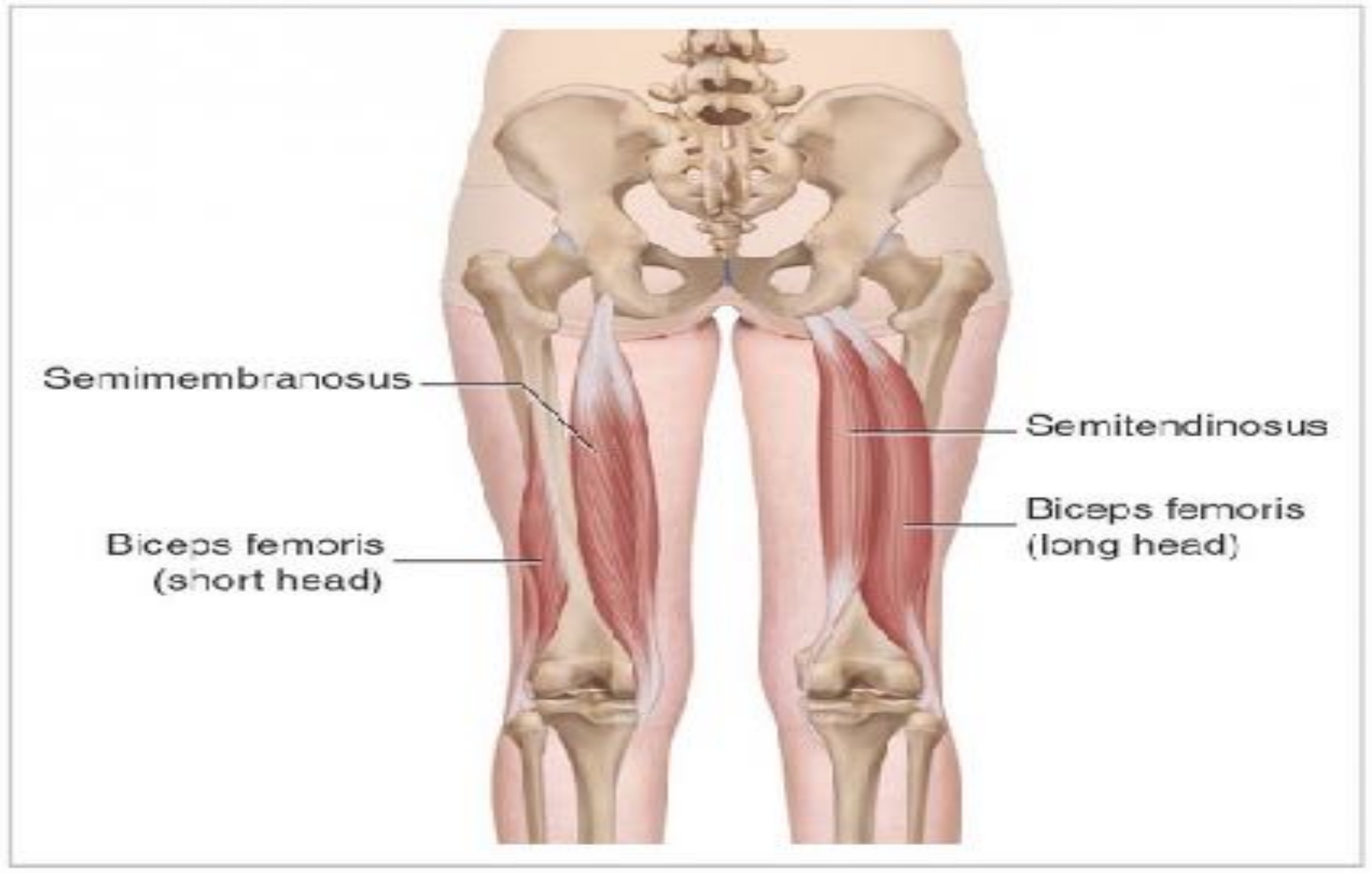
Why Hamstring Injuries?

- Very Common Muscular Strain
- New Data to Improve our outcomes and reduce recurrence
- Simple Rehab including RICE and Stretching is not comprehensive enough for optimal outcomes
- Many recent developments in research to guide contemporary management hamstring injuries

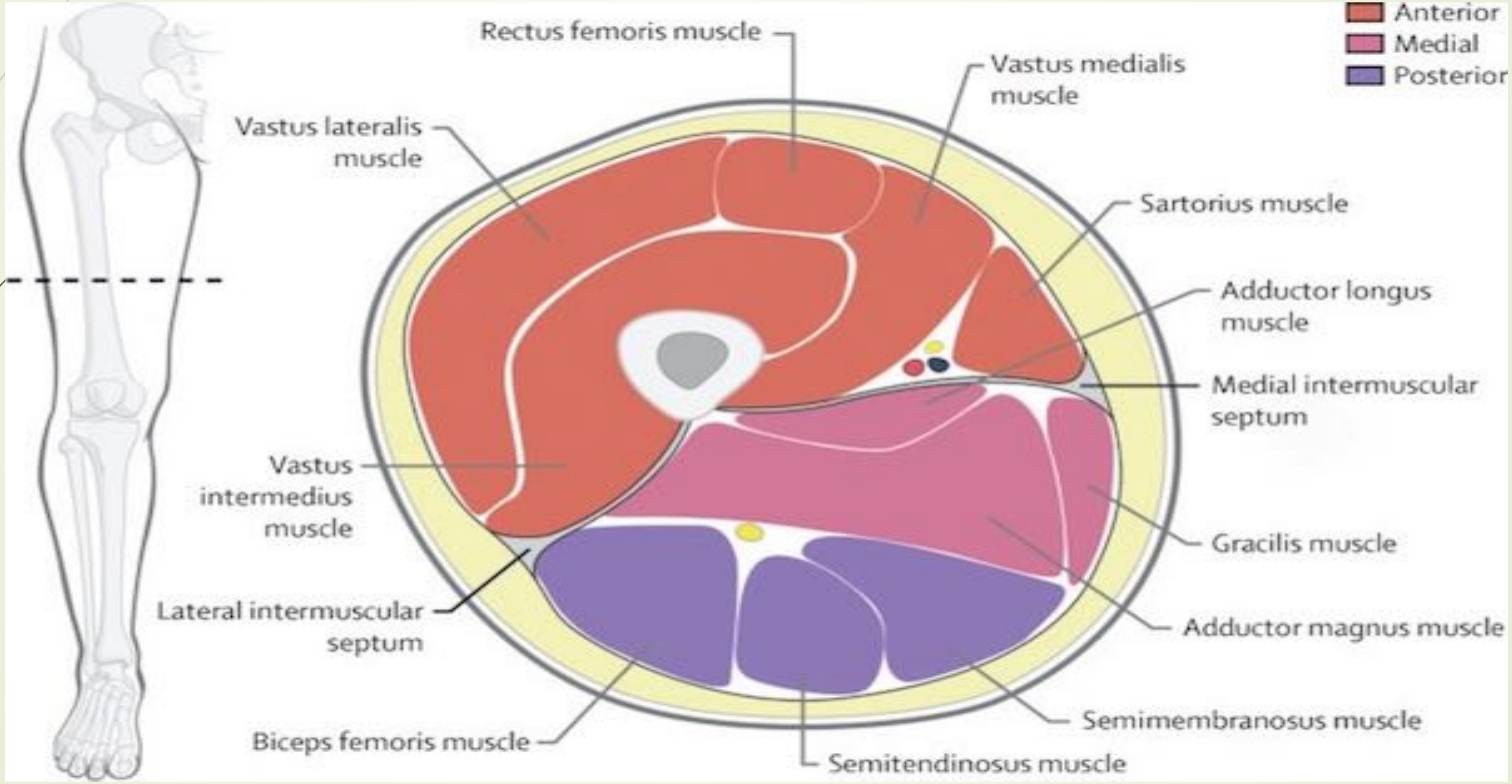
Why Hamstring Injuries?

- Traditional strengthening exercises alone have not been enough to reduce recurrence
- We are still commonly returning athletes too quickly with suboptimal rehabilitation as evidenced by high rate of recurrence (Erickson & Sherry 2017)

Anatomy

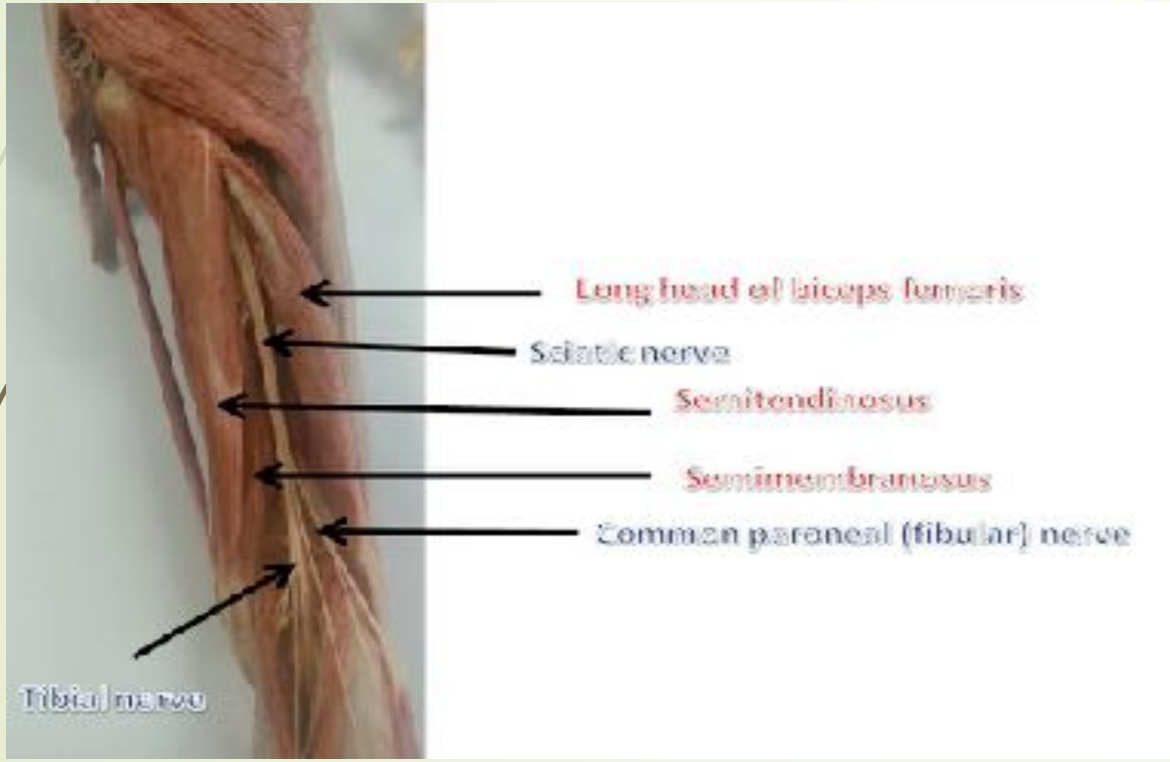

Semimembranosus
Semitendinosus
Biceps femoris
(long head)
Biceps femoris
(short head)

Anatomy

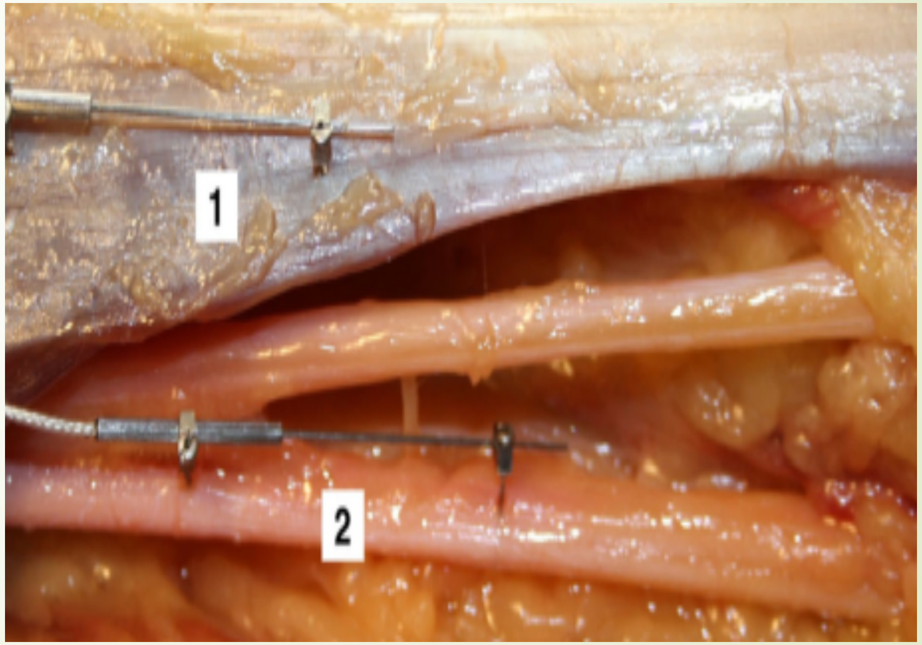

Rectus femoris muscle
Vastus medialis muscle
Anterior
Medial
Posterior
Vastus lateralis muscle
Sartorius muscle
Adductor longus muscle
Medial intermuscular septum
Vastus intermedius muscle
Gracilis muscle
Lateral intermuscular septum
Adductor magnus muscle
Semimembranosus muscle
Biceps femoris muscle
Semitendinosus muscle

Nerve anatomy review

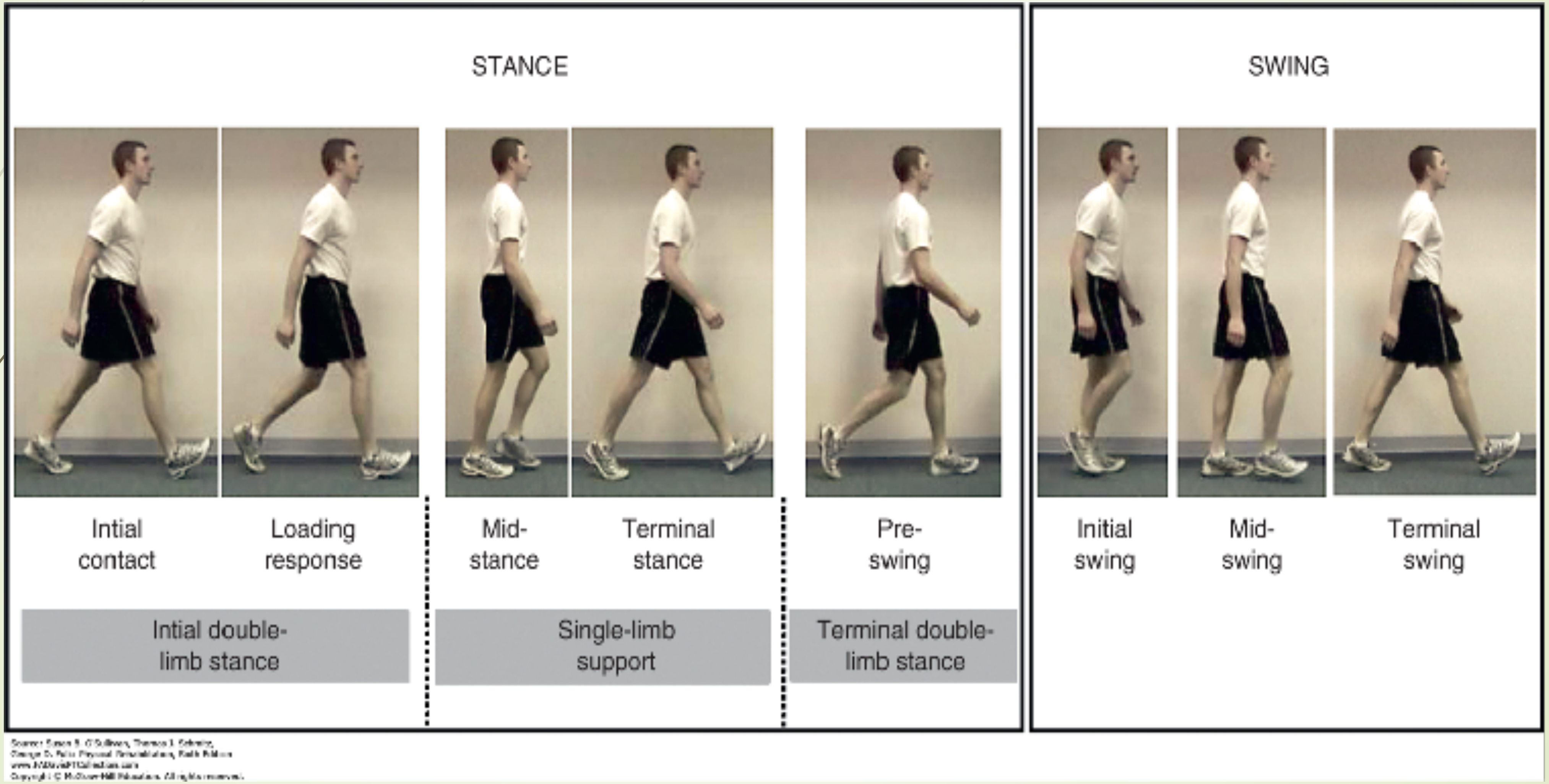
Sciatic nerve & Hamstrings



Tibial Nerve and Distal Biceps Femoris



Gait Cycle – Role of the Hamstrings



Initial Contact & Loading Response during Gait Cycle

Biceps Femoris (Long Head) Semitendinosus& Semimembranosus are Active as hip extensors

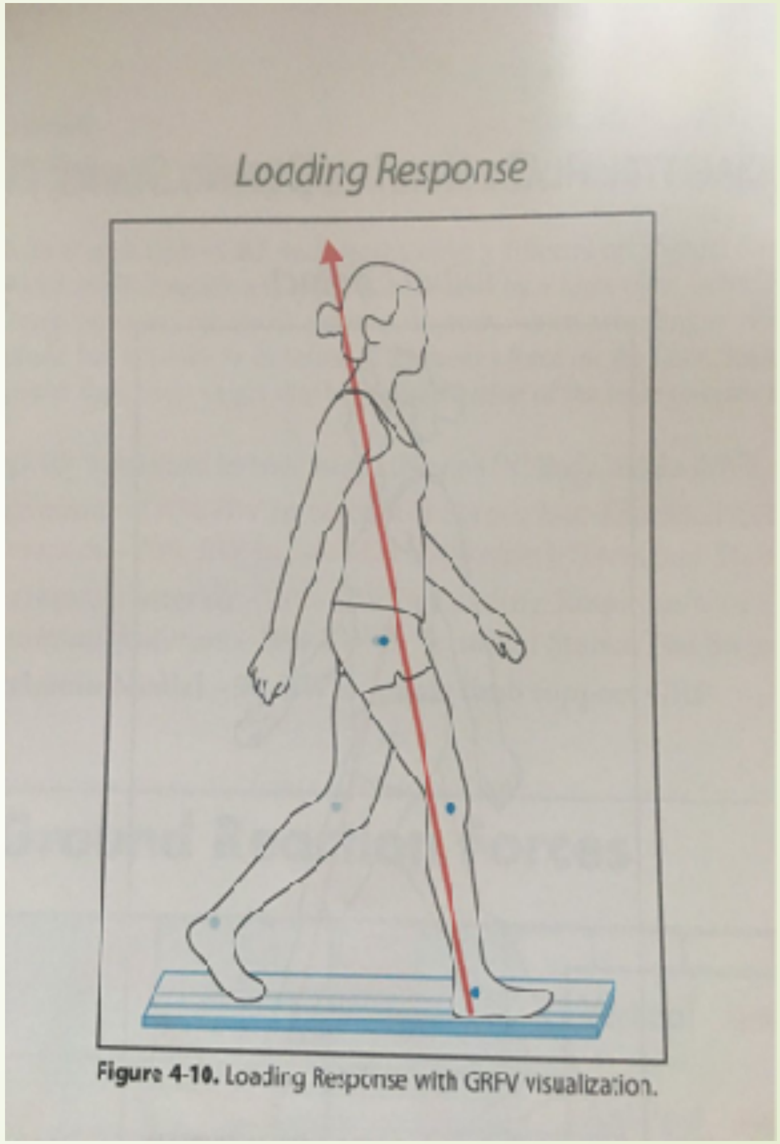
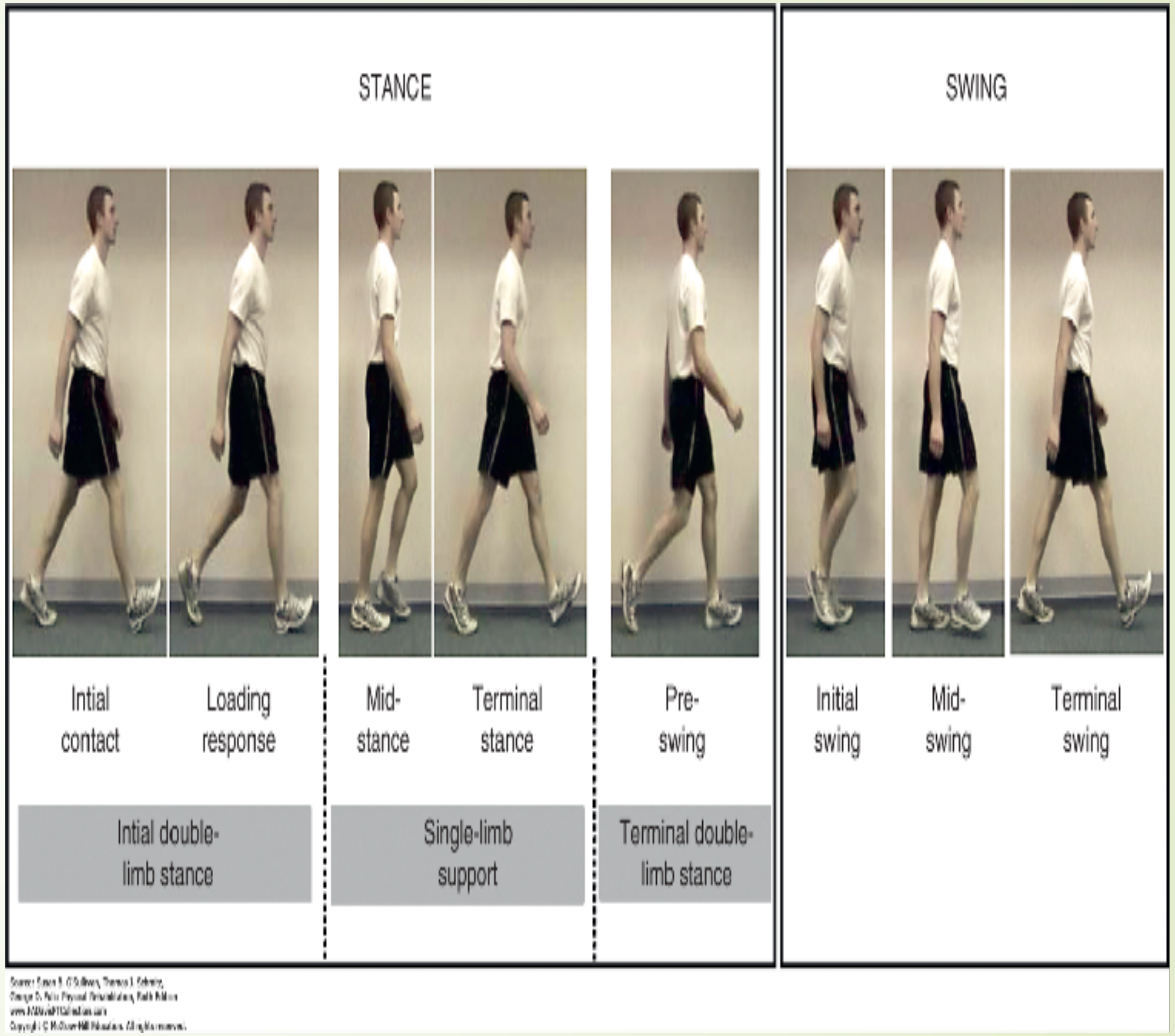


Figure 4-10. Loading Response with GRFV visualization.

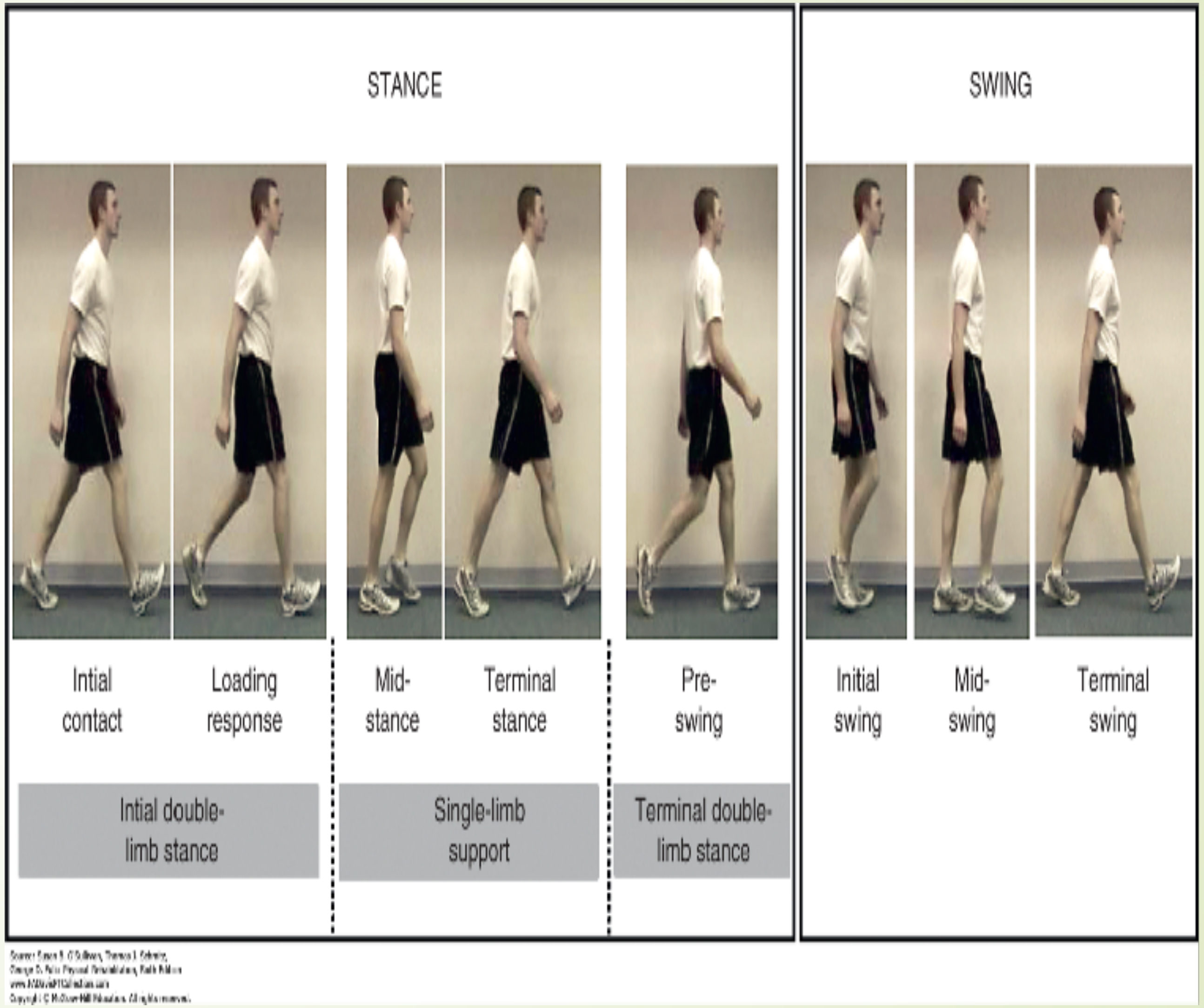
Terminal Stance

The Short Head of the Biceps Femoris has variable activity levels in different individuals to prevent knee hyperextension



Mid and Terminal Swing Phase of Gait

Hamstring muscle activation is an important part of Mid and Terminal Swing Phase during the gait cycle to Decelerate the Limb (Control hip flexion and knee extension) and prep for Initial Contact

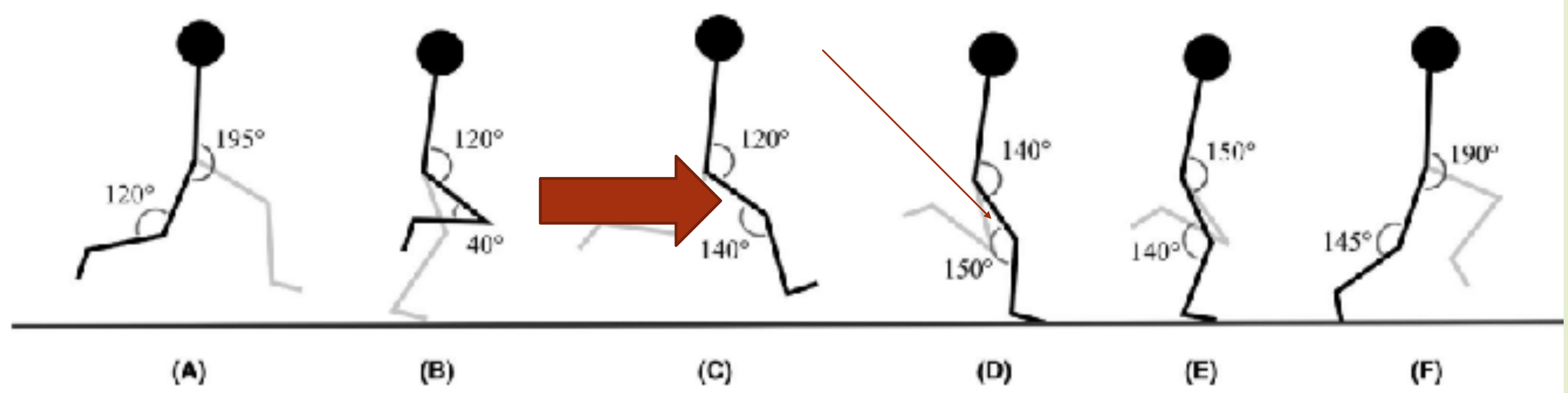


Muscle Activation Patterns

- Long head of the biceps
  Femoris and semimembranosus being
  more active during hip extension and
  the semitendinosus and short head of
  the biceps femoris preferentially assisting knee flexion

(Arner et al, J Am Acad Orthop Surg 2019;27:
868-877)

Hamstring Strains are most common during High-Speed Running


KENNEALLY-DABROWSKI ET AL.

WILEY

FIGURE 1 The sprinting gait cycle. (A) Early swing (B) Mid-swing (C) Late swing (D) Early stance/ foot strike (E) Mid-stance (F) Late stance/ toe-off[25,26]

<u>Late Swing</u> and Early Stance Appear to Be the Most Common MOI

Injury Statistics
(Erickson & Sherry 2017)

- Common MOI: Sprinting, Kicking, or high-speed skilled movements, such as football, soccer, rugby, and track sports
- Other MOI: Extensive muscle lengthening-type maneuvers, such as dancing.
- Acute hamstring strains have been found to be more common in field sports (football, soccer, and field hockey)
- Less common in court sports (basketball, volleyball) but can occur with sprinting and/or quick deceleration

Injury Statistics

- More common in competition than in practice
- More common in preseason games than regular season and postseason games.
- Mostly non-contact injuries

Injury Statistics

- Most Common Primary Hamstring Strain is Biceps Femoris (Arner et al, Askling et al)

	Arner	Askling
Biceps Femoris:	84%	69%
Semimembranosus:	12%	21%
Semitendinosus:	4%	10%

- Commonly injured during eccentric contraction
- Believed to be at risk due to crossing 2 joints and demands associated with all of its roles

Injury Statistics Askling et al

- The MRI negative group had significantly shorter time to return, mean 6 days
- In 48% of the BFLH strains, there was a secondary hamstring muscle injury. Secondary injury was located in the semitendinosus in 80% of those cases.
- In 21%, the primary injury was located in semimembranosus and in 44% of those cases there was a secondary injury

Injury Statistics

- Previous Injury may increase risk of future injury by 2 – 6 times (Schmitt et al, 2012)
- Recurrence Rate 32% Football, 21% Rugby, and 16% in Soccer (Heer et al, 2019 JBJS)
- Quad Tightness can also be a factor (Gabbe et al, 2006)

Injury Prevention

- Include Factors that are clear in the research literature
- Include Individualized factors (sport specific when necessary)
- Flexibility if it is a problem
- Flexibility doesn't necessarily help if already flexible
- Look at player workload and fatigue levels
- Recovery and Nutrition

Injury prevention

- Address poor Aerobic fitness
- Address Abnormal mobility at proximal tib/fib joint
- Playing Surface
- Footwear
- Dynamic warm up
- Avoid weak hip extension strength
- Those with a previous injury had an average 30% asymmetry in eccentric strength of hamstring

Injury Prevention

- Eccentric Hamstring strength
- Hamstring fatigue resistance
- Lumbopelvic/Hip stability and motor control
- Functional strength
- Psychosocial Factors
- Time between games
- Overall Movement Quality

Askling's Program

Askling et al, Br J Sports Med

- Followed athletes for one year to monitor for re-injury
- Eccentric Training Group returned to sport quicker and without re-injury

Injury Grade on MRI

- Some mild strains may not show up on MRI (Grade 0)
- Grade I is increased signal of a tendon or muscle without disruption
- grade II is disruption of less than half of the width of the muscle
- grade III
  Ranging from being over half disrupted to completely ruptured

British Muscle Injury Classification System

Table 1 – British athletics muscle injury classification.

Grade	Description	MRI
Grade 0		
0a	Focal neuromuscular pain	Normal.
0b	Generalized muscle soreness after exercise	Normal or increased signal in one or more muscles.
Grade 1		
1a	Minor myofascial injury	Increased signal from the fascia involving <10% of the muscle belly, and craniocaudal length <5cm.
1b	Minor myotendinous injury	Signal increase <10% of the transverse section of muscle in the myotendinous area and craniocaudal length <5 cm.
Grade 2		
2a	Moderate myofascial injury	Increased signal from the fascia extending to the muscle, lesion cross sectional area of 10% and 50%, craniocaudal length >5 and <15 cm, structural fiber disruption <5 cm.
2b	Moderate myotendinous injury	Increased signal in the myotendinous region, lesion cross-sectional area ranging from 10% and 50%, craniocaudal length >5 and <15 cm, structural fiber disruption <5 cm.
2c	Moderate intratendinous injury	Increased signal in the tendon, with longitudinal length <5 cm and <50% of the cross-sectional area of the tendon is involved. No loss of tendon tension or discontinuity are observed.
Grade 3		
3a	Extensive myofascial injury	Increased signal from the fascia extending to the muscle, lesion cross sectional area >50%, craniocaudal length >15 cm, structural fiber disruption > 5 cm.
3b	Extensive myotendinous injury	Increased signal with lesion cross-sectional area >50%, craniocaudal length >15 cm, and structural fiber disruption >5 cm.
3c	Extensive intratendinous injury	Increased signal in the tendon, with longitudinal length >5 cm and >50% of the cross sectional area of the tendon is involved. Loss of tendon tension may be observed, but there is no apparent discontinuity.
Grade 4		
4	Complete muscle injury	Complete muscle discontinuity with retraction.
4c	Complete tendon injury	Complete discontinuation of tendon with retraction.

Surgical Recommendations

Heer et al, 2019 *JBJS*

Physical therapy should be used to rehabilitate both operatively and nonoperatively treated injuries, with exercises focusing on strengthening tendons to withstand high levels of eccentric forces[19,24,65,66,71,72].	B
Surgical treatment of acute hamstring avulsions with retraction exceeding 2.5 to 3 cm with symptomatic involvement should be managed with open or endoscopic surgical repair using suture anchors, with early intervention yielding better results[7,56,57].	B
Physicians should treat ischial tuberosity avulsion fractures with displacement of >1 cm surgically and use conservative measures for displacement of ≤1 cm[18,60-62].	C

Ischial Tuberosity Avulsion Fractures are Relatively Rare: 1.4-4% of Hamstring Injuries (Heer et al, 2019)

FASH (Functional Assessment Scale for Acute Hamstring Injuries) Malliaropoulos et al, 2014 and Lohrer et al, 2016

Table 5 Principal component factor analysis suggesting the one-factor solution and the total variance explained

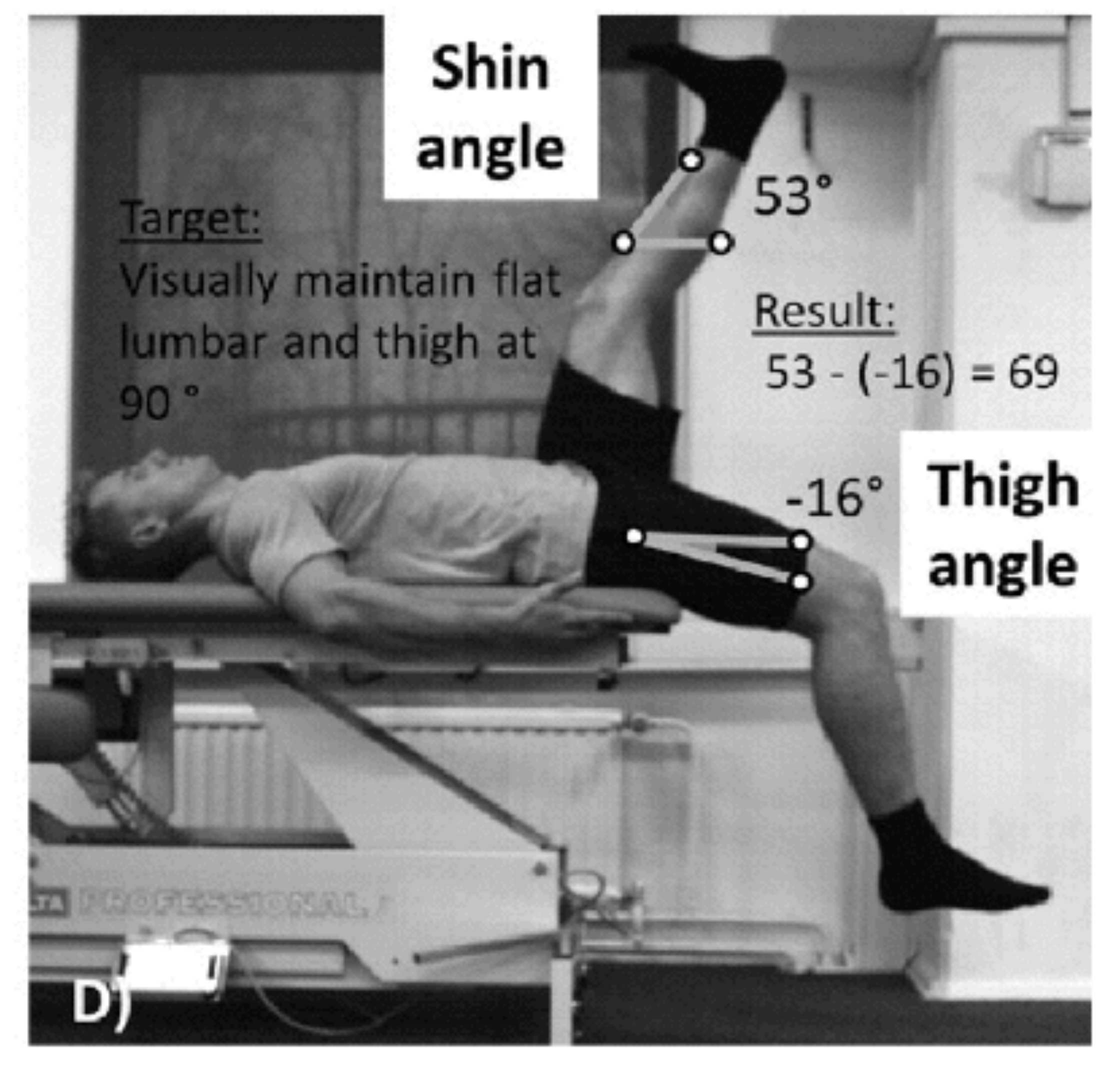
Questions	Loadings
Q1: If you have had an acute hamstring injury, please rate your current level of pain or discomfort	0.966
Q2: Are you currently taking part in your sport, training or other physical activity?	0.990
Q3: How much pain do you have during walking?	0.976
Q4: How much pain do you have during jogging or slow pace running?	0.988
Q5: How much pain do you have during accelerating or sprinting for 30 m?	0.970
Q6: How much pain do you have during static stretching of your hamstrings (toe touch while standing)?	0.986
Q7: How much pain do you have during functional stretching of your hamstrings (straight leg kick)?	0.988
Q8: Do you have pain/or discomfort when performing a full weight-bearing lunge?	0.997
Q9: Can you perform one Nordic exercise (partner exercise where you attempt to resist a forward-falling motion using your hamstrings throughout the whole range of motion to the ground)?	0.948
Q10: Can you perform 3 one-legged jumps for a distance?	0.978
Total variance explained	95.83%

Schmitt et al, 2012

The International Journal of Sports Physical Therapy | Volume 7, Number 3 | June 2012

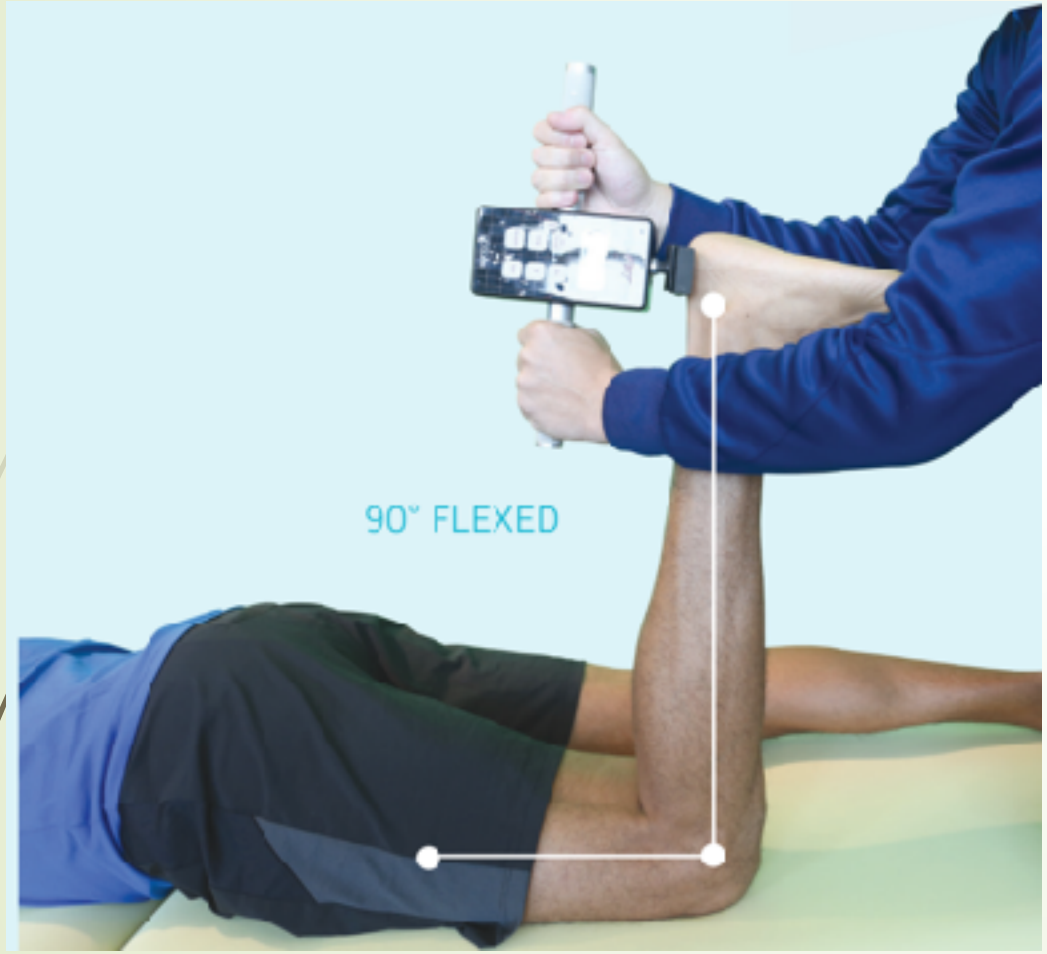
Figure 7. *Lengthened state manual muscle hamstring test.*

Jurdan Test (Jurdan Mendiguchia)



- Quantify the Interaction of Flexibility Between the Limbs during sprinting (Hamstrings and Contralateral Hip Flexors)
- Hybrid Version of **Thomas** Test and **Active Knee Extension** Test (Lahti et al, 2020)
- Utilized in Professional European Football **(Soccer)**

Aspetar Hamstring Protocol



Aspetar Hamstring Protocol

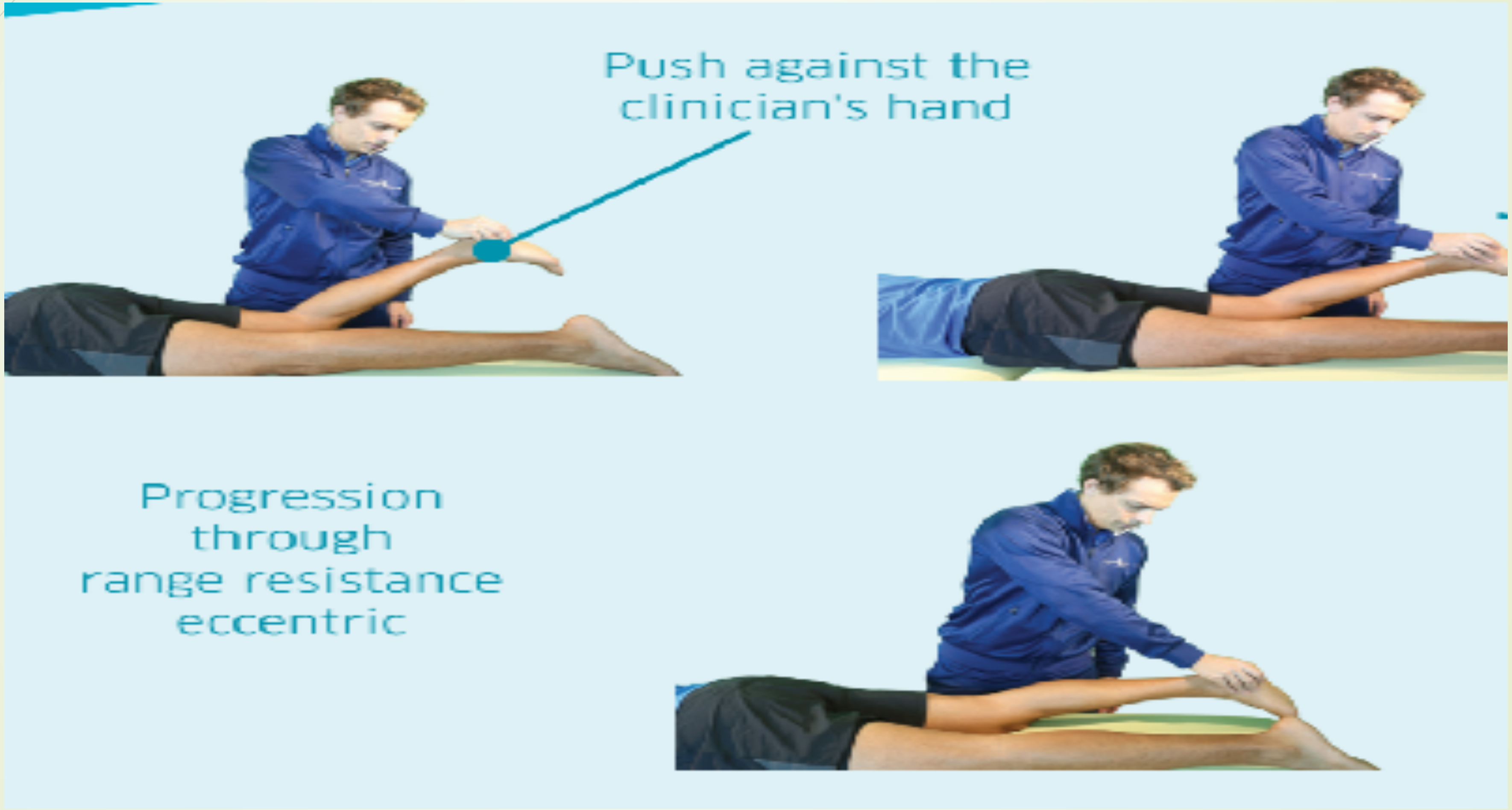
Aspetar Protocol Exercises

Strengthening in varied positions including lengthened positions

Eccentrics During Treatment

- Eccentrics aid in muscular remodeling (Heiderscheit et al, 2010 JOSPT)
- Increase Fascicle length of Biceps Femoris- Long Head (BFLH) after 5-10 weeks of eccentric training
- Increased Fascicle Length reduces hamstring injury risk
- Bourne et al, 2017 Br J Sports Med. Potier et al, 2009 Eur J Applied Physiol. Timmins et al, 2016 Br J Sports Med.

Manual Eccentrics



Muscular Adaptations and Injury Risk

- Athletes with a BFLH fascicle length less than 10.6 cm were at 4x the risk of hamstring injury

- Sprint training and Nordic Hamstring Exercises induced increased fascicle length of the BFLH, while regular Soccer practice did not

- Bourne et al, 2017 Br J Sports Med. Potier et al, 2009 Eur J Applied Physiol. Timmins et al, 2016 Br J Sports Med. Mendiguchia et al, 2020

Nordic Hamstring Strength Training

- Hypertrophy with Nordic Hamstring Training
- Increased Volume and Cross-sectional area of hamstrings
- Seymore et al, 2017. Eur J Appl Physiol.

Nordic Hamstring Exercise Effects

- Chronic NHE programs have been shown to reduce hamstring injuries by 57%-72% in both amateur and professional soccer players
- likely mediated by NHE-induced eccentric hamstring strength gains
- Favorable increases in fascicle length of the biceps femoris long head.

Hamstring injury prevention in soccer: Before or after training?

R. Lovell[1] | M. Knox[1] | M. Weston[2] | J. C. Siegler[1] | S. Brennan[1] | P. W. M. Marshall[1]

Nordic Hamstring Exercise (NHE)

- Multiple studies showing substantial benefit of Nordic Hamstring Exercise (NHE)
- NHE Program can lead to a threefold to fourfold reduction of hamstring injury risk (Van der Horst et al 2016, American Journal of Sports Med.)
- NHE program reduced hamstring injuries by 65-70% (Goode et al, Br J Sports Med 2015 & Petersen et al, Am J Sports Med 2011)
- Lack of Implementation of NHE despite significant data to suggest efficacy (Buckthorpe et al)
- Unclear why this isn't being regularly implemented for sports

Nordic Hamstring Exercise (Eccentric Lowering)

Eccentric Lowering

Lenghthened State Eccentrics

(Schmitt et al, 2012- IJSPT)

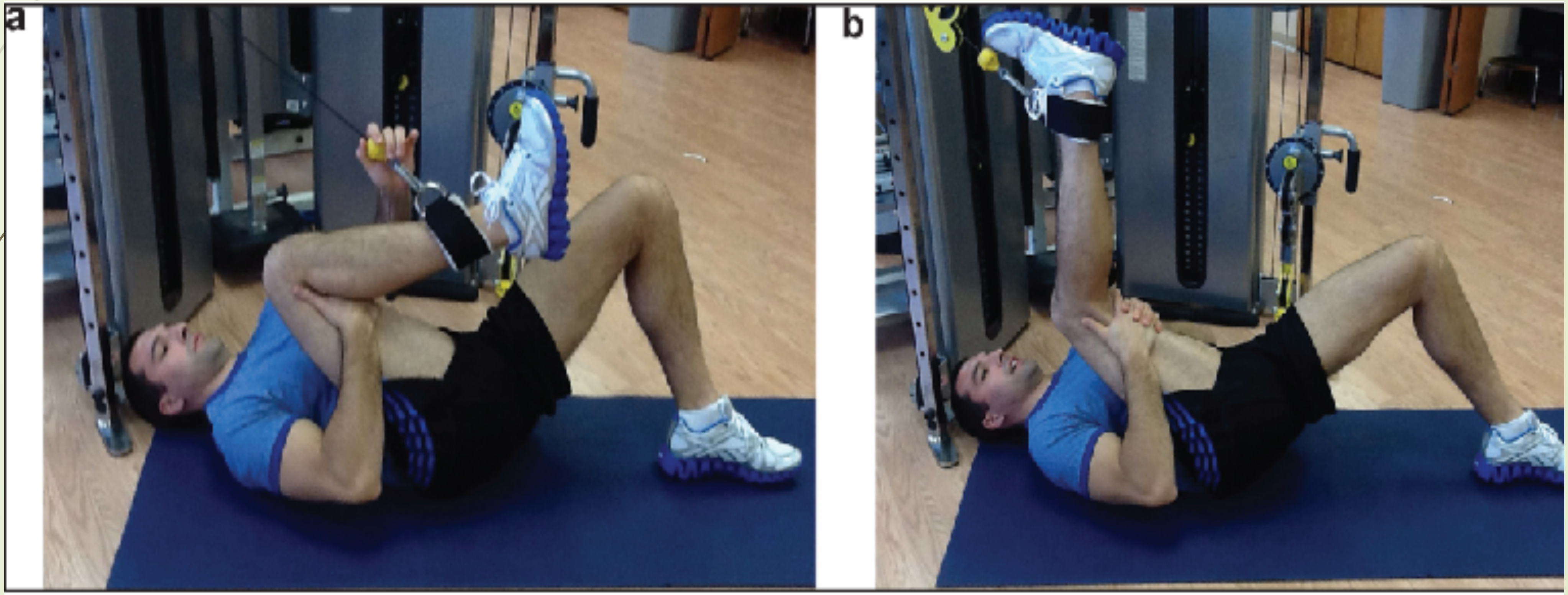


Figure 5 a,b. *Lengthened state eccentric training on cable column.*

Kettlebell Training

Single Leg Bridge on Plyo Box

Dynamic Exercises

Acute Effects of Different Dynamic Exercises on Hamstring Strain Risk Factors

Chen et al, 2018

Dynamic closed chain

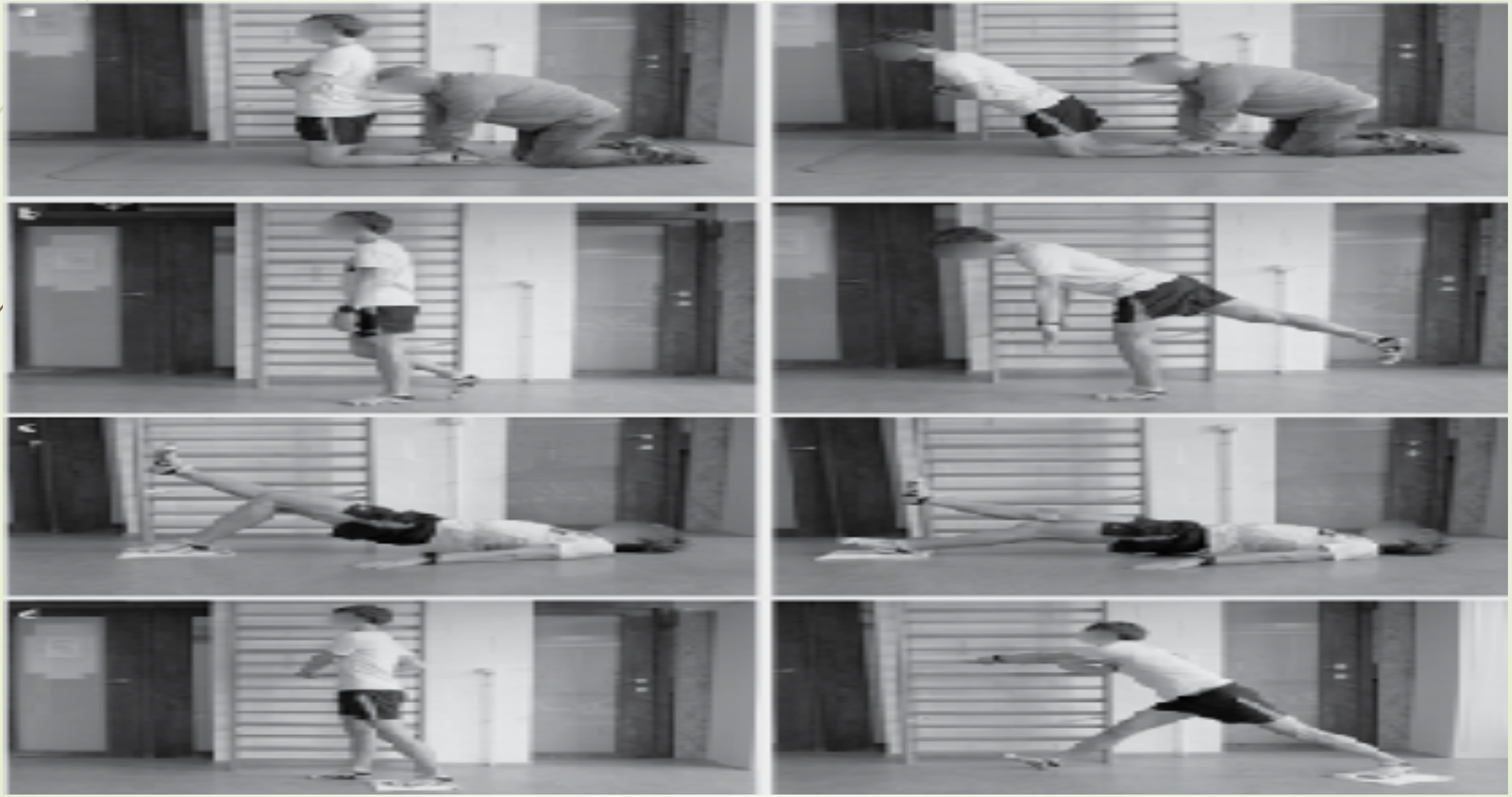
Dynamic open chain

Chen et al, 2018

- Passive SLR ROM improved with Dynamic stretching and Closed Kinetic Chain Stretch
- Closed Chain stretch had less joint position errors (better proprioception)
- Dynamic stretching decreases muscle stiffness and improves stretch tolerance
- Closed Chain stretch did not improve muscle stiffness
- Closed Chain stretch improved eccentric muscle performance
- Stretches longer than 60 second holds immediately prior to sports can have negative effects on muscle performance (Behm et al, 2016)

Reverse Plank/Modified Bridge

Delvaux et al, 2020 (4 exercises)



Oliver & Dougherty, 2009: JSCR
Razor Curl Exercise for Hamstring Rehabilitation

Figure 1. Starting position of the razor curl.

Figure 3. End position: hips should maintain 90° flexion and knees should be maximally flexed by full contraction of the hamstring.

Modified Walking Lunge Into Single-Limb Deadlift

Sherry, Johnston, Heiderscheit: 2015

Askling Glider – Advanced return to sport or prevention exercise

Weighted Extension- Posterior Chain Exercise

Bourne et al, 2017

Lumbopelvic/Hip Stability & Motor Control Considerations for Treatment

- Avoid aberrant pelvic motion during sprinting *(Buckthorpe et al, 2019 Br J Sports Med)*
- Avoid excessive anterior pelvic tilt during sprinting
- Excessive hip flexor tightness can be a risk factor
- Hip extension torques can double knee flexion torques during sprinting *(Higashihara et al 2018, J Sports Sci)*
- Decreased gluteus maximus strength is a risk factor for hamstring injury (believed to be due to the hamstring providing more of the hip extension force output)

Lumbopelvic/Hip stability

- Lumbopelvic/Core/Hip Stability was effective at decreasing recurrence (*Sherry and Best, 2004 JOSPT*)
- Side planks and planks with rotations
- Chops
- Lifts
- Walking lunges

Sherry et al 2015, Clin Sports Med

- Agility work
- Proprioceptive (SLS)

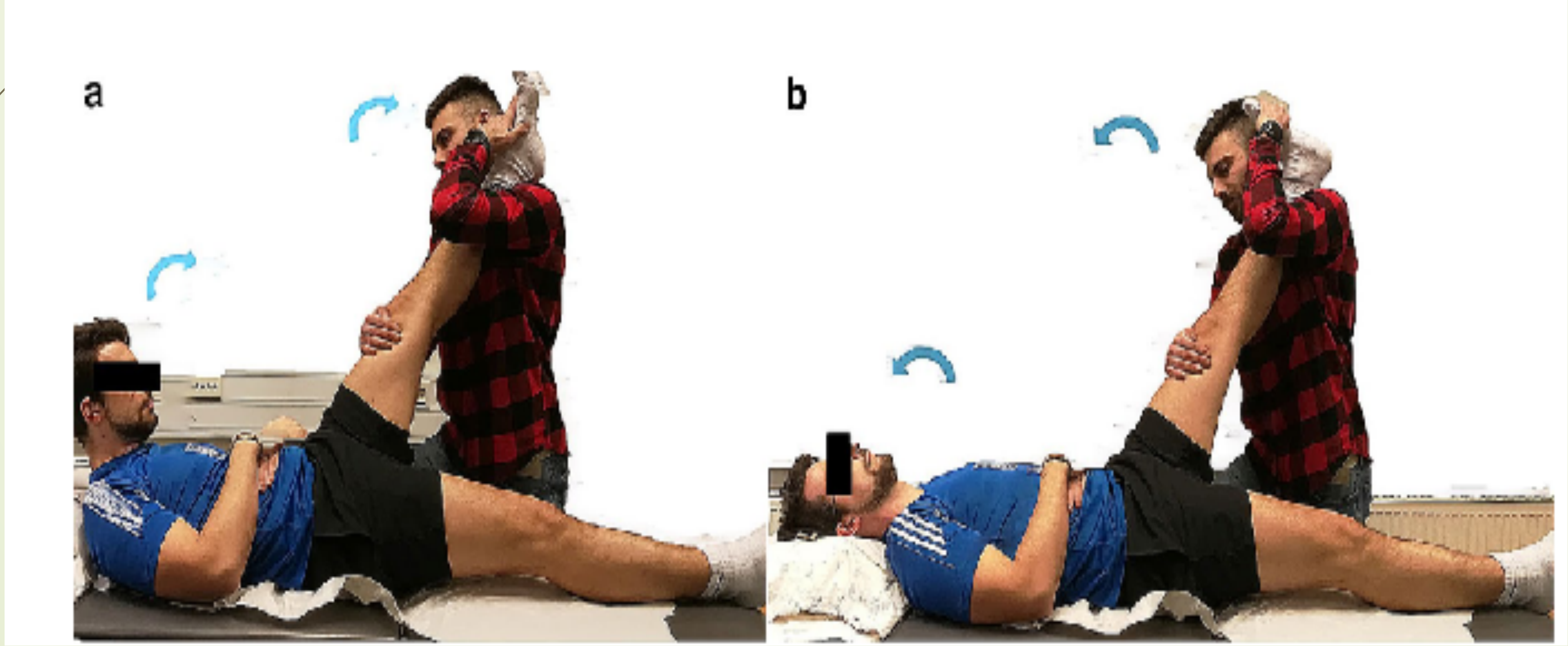
Neurodynamics

- Ankle Dorsiflexion during various angles of SLR affects the sciatic nerve, but not the hamstrings (Bueno-Garcia et al, 2019)
- Tibial nerve also glides without tensioning Hamstrings (Bueno-Garcia et al, 2020)
- Utilize Ankle DF to help determine if altered Neurodynamics (neural tension) is present
- Sciatic Nerve tension can increase recurrence rate of hamstring injury and lingering posterior thigh pain
- Altered neurodynamics of Sciatic nerve can cause earlier activation of Hamstring muscle during athletic activities

Neurodynamics

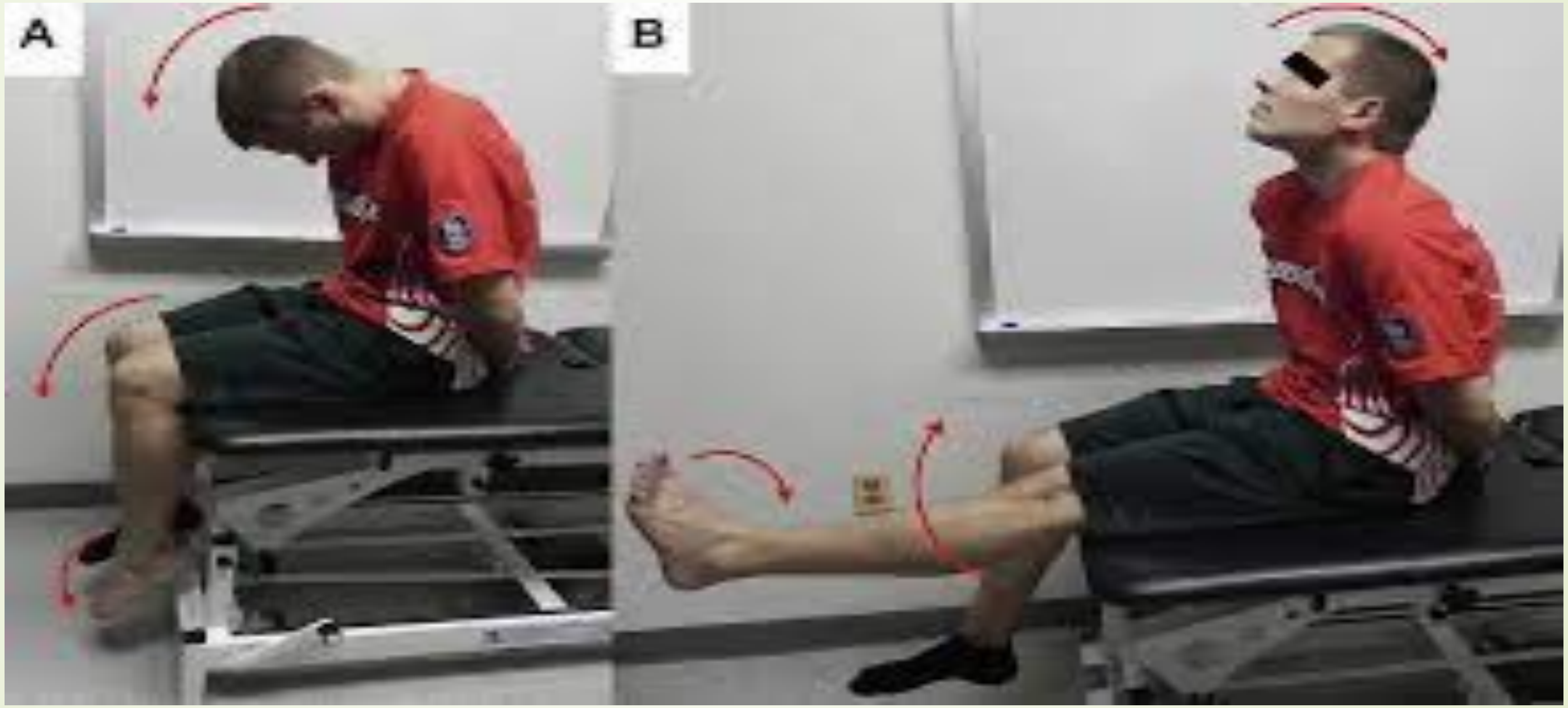
- Neural mobilization (Glides/Slides/Flossing)
  Ensuring neural mobility through different postures and multi-joint movements
  (Shacklock, Coppieters, Butler et al)
- Seated Slump glides (deRidder et al)
- Side-lying neural mobilization incorporating lumbar spine opening/gapping mobilization (Stagge, J.)
- Found 6 high quality studies demonstrating efficacy of neural mobilizations Lopez et al: Meta Analysis (2019)

Neurodynamic interventions with static stretching improved knee extension angle significantly more than stretching alone (Sharma et al, 2016 *Phys Ther in Sport*)



Neurodynamic Glides in Slump Position

De Ridder et al, 2020: Eur J Sport Sci



Return To Play Criteria

- Absence of Pain on Palpation
- Absence of Pain during strength and flexibility work
- Absence of Pain during Functional Testing
- Similar Hamstring Flexibility (Passive & ASLR within 5-10%)
- Psychologic Readiness – Fear Avoidance
- Performance Tests on the Field/Court
- Deceleration drills
- Single Limb Bridging

Return to Play Criteria

- Need Similar Concentric and Eccentric Strength prior to return to play (less than 5% deficit)

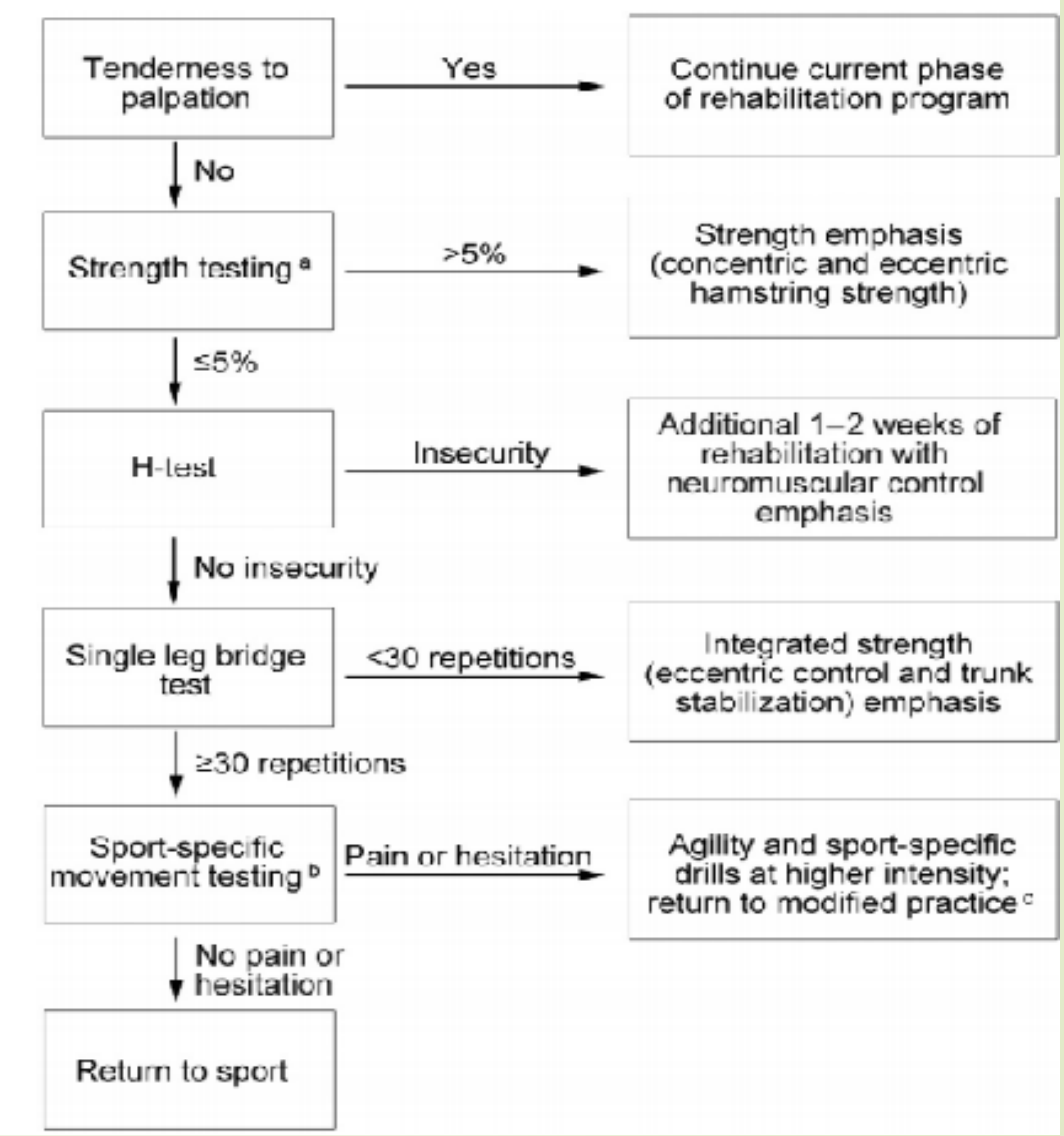
- High recurrence rate (12-33%) Van Beijsterveldt et al 2014, Ekstrand et al 2011, Woods et al 2004, Hagglund et al 2004)

- Is too early return to sport or inadequate rehabilitation to blame?

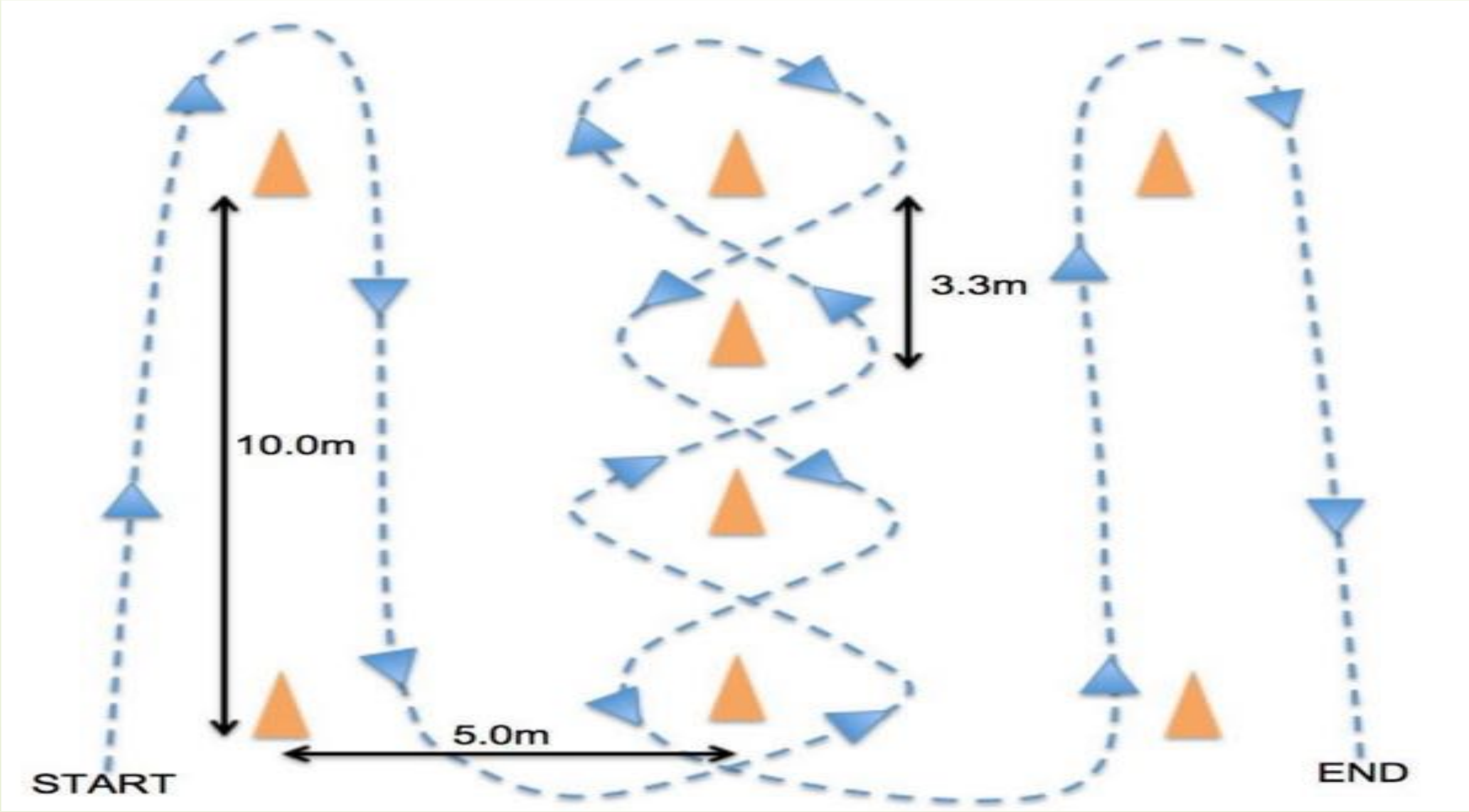
- More than half (59%) of the recurrent hamstring injuries occur within the first month after return-to-play (Van Der Horst et al, 2016 Sports Med)

Erickson & Sherry, 2017
J Sports Health Sci

Return to Sport Algorithm Following Hamstring Strain



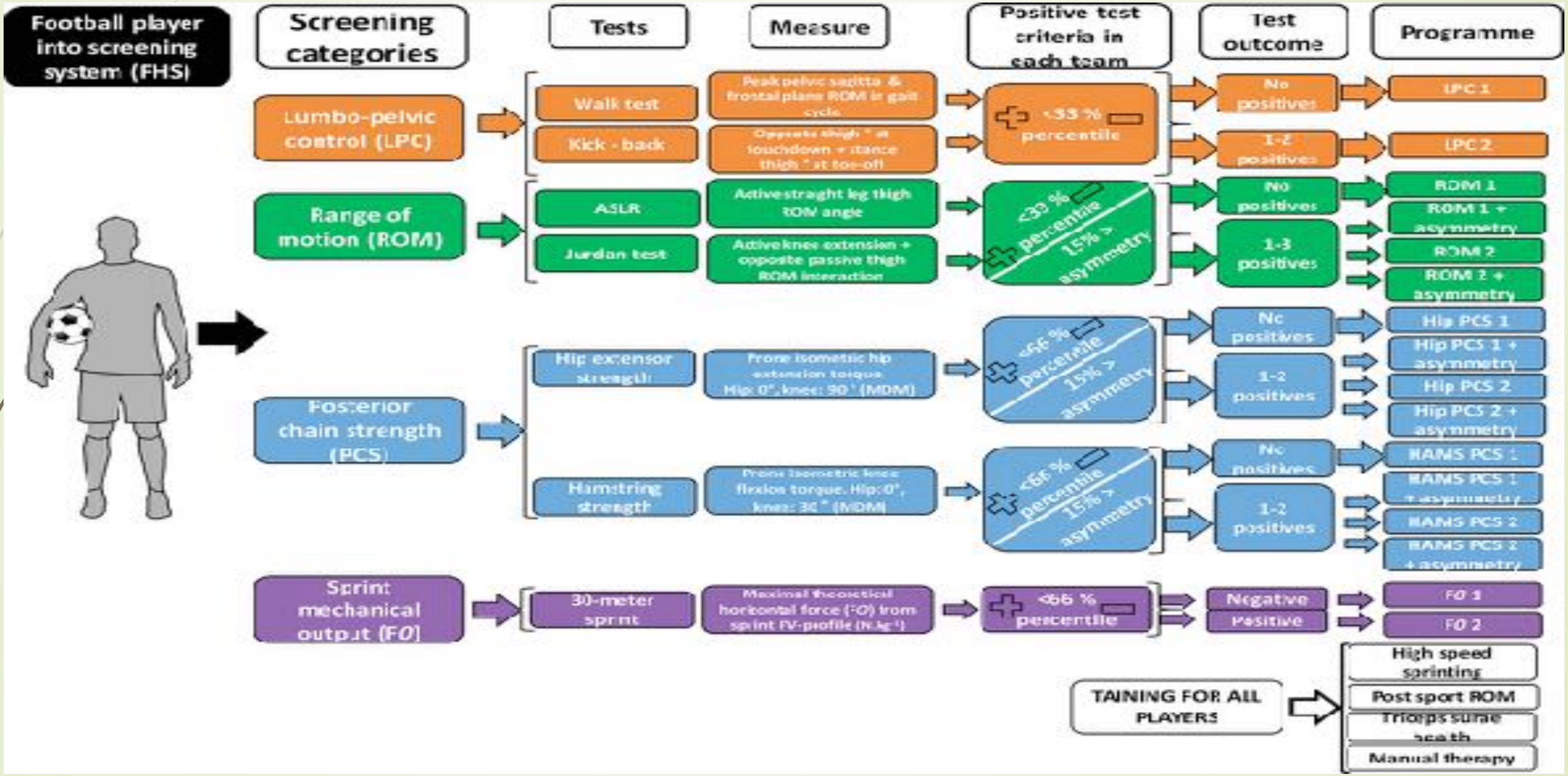
Illinois Agility Test for Return to Play
(Dembowski et al, 2013)



Illinois Agility Test Norms (Athletes Age 16-19 years)

Rating	Males (seconds)	Females (seconds)
Excellent	< 15.2	< 17.0
Above Average	15.2 - 16.1	17.0 - 17.9
Average	16.2 - 18.1	18.0 - 21.7
Below Average	18.2 - 19.3	21.8 - 23.0
Poor	> 19.3	> 23.0

Screening System (Lahti et al, BMJ)



Questions

Thank You!

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