La Tour SPORT MEDICINE
swiss olympic MEDICAL CENTER

Saas-Fee, March 9th 2016

The foot & the athlete

a sports physician's view

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How your document works for the curious minds

Click on references → opens relevant internet pages

PubMed *Van Mechelen W et al, BJSM 2015*

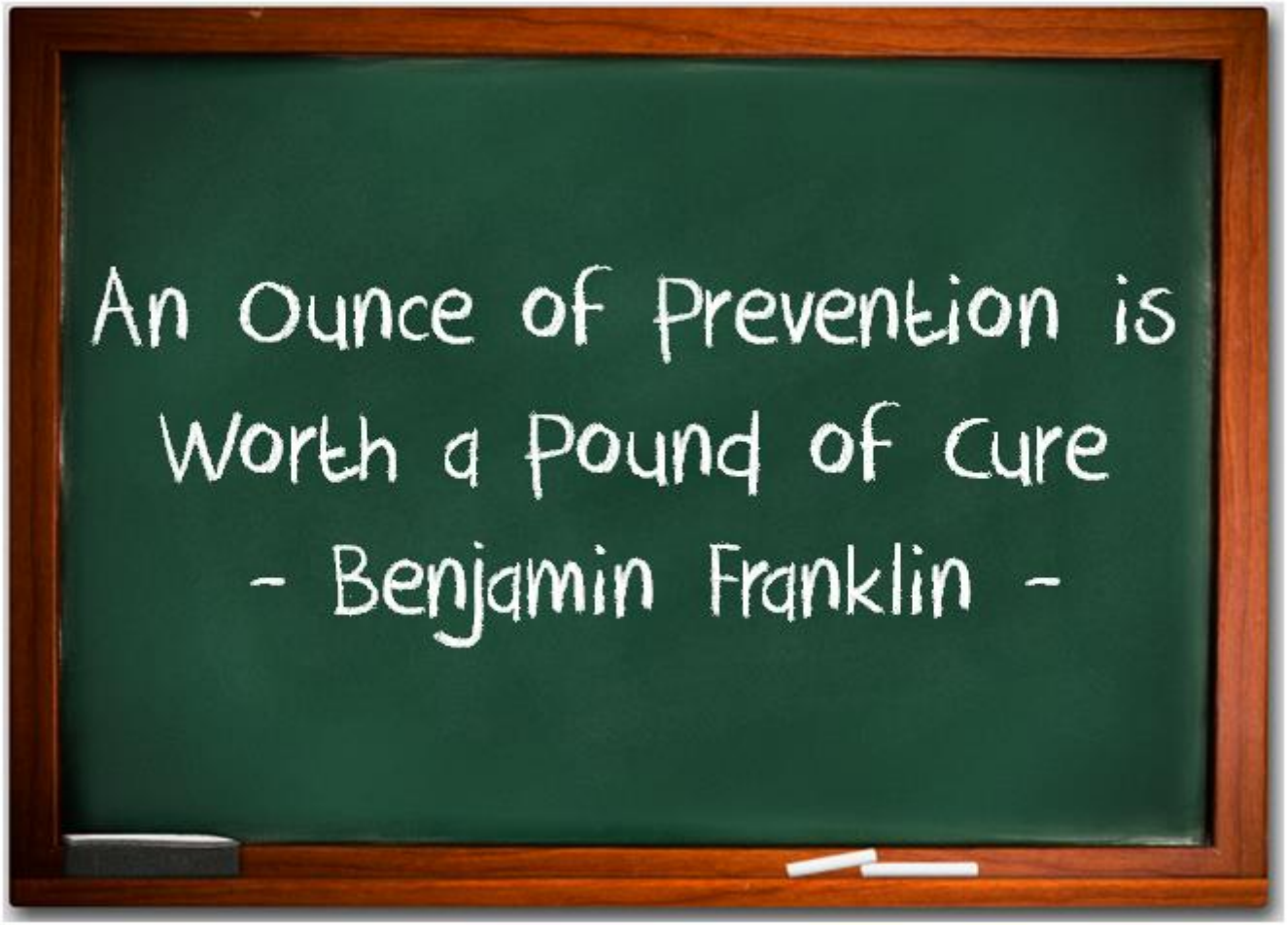
Or the complete pdf document will open if available

FREE

Images contain sometimes hyperlinks, explore your pdf to learn more…

Enjoy! Boris

Part I - Prevention

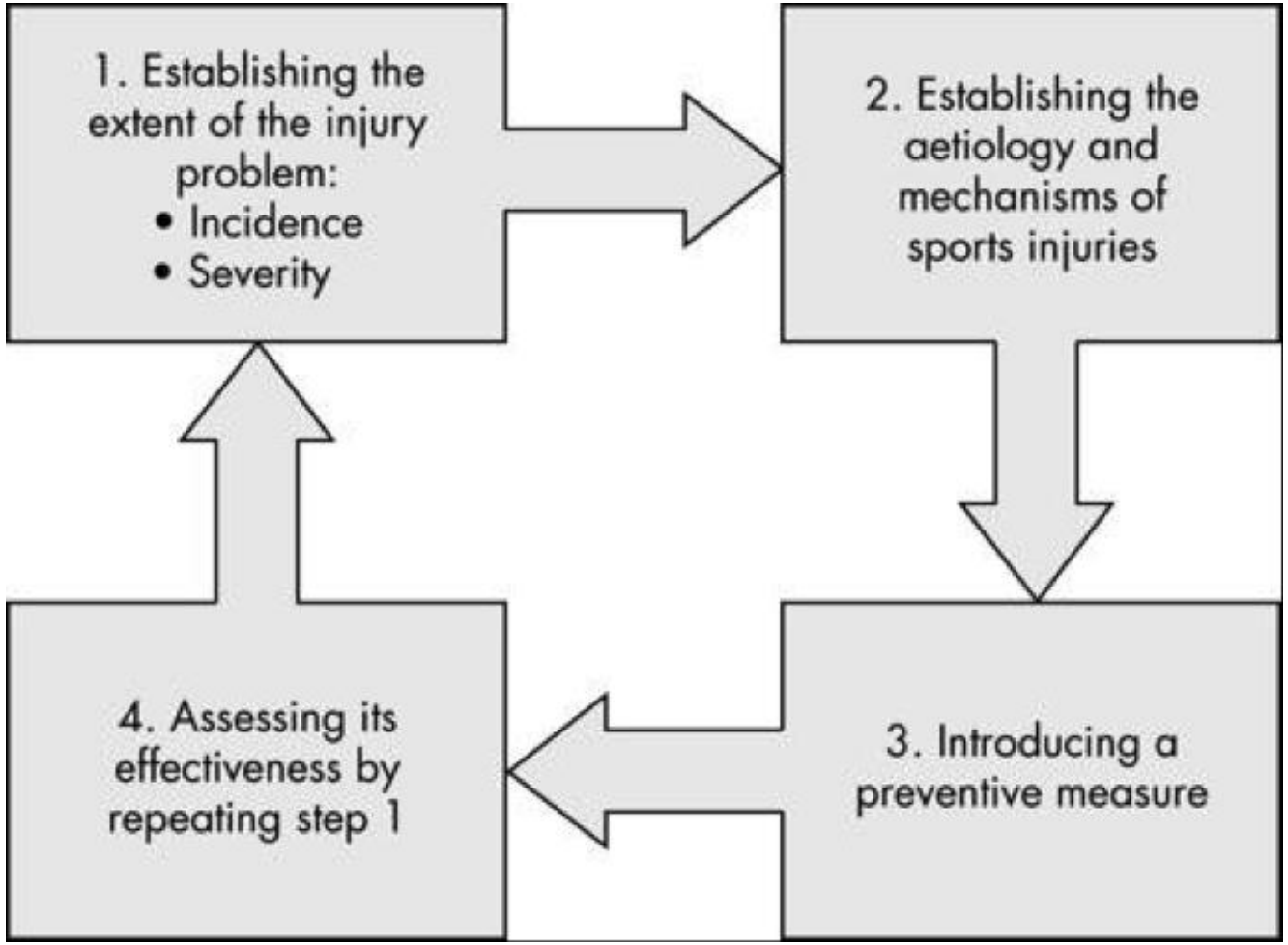


Target group ?

Important elements in prevention

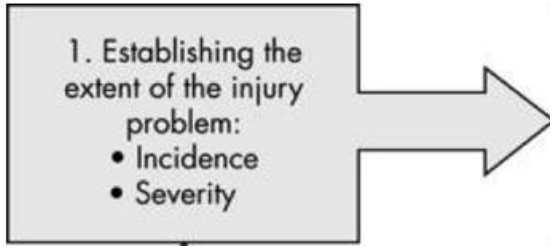
- Epidemiology of problems
- Causes
- Feasibility of interventions
- Effectiveness of prevention measures
- Cost-benefit/efficiency analyses

Willem van Mechelen



Sports Medicine 1992

1. Incidence



- **Incidence**
  Number of injuries per 100 athlees per season
  (= absolute injury rate)

- **Exposure**
  Number of injuries per hour of sports training
  (= relative injury rate, often reported /1'000h)

Cave! Numbers…

1. Establishing the extent of the injury problem:
   - Incidence
   - Severity

suva

Mieux qu'une assurance

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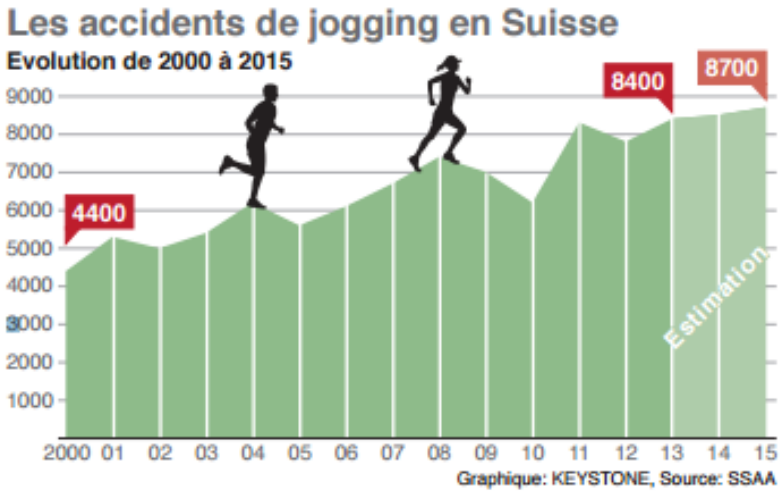
Prévention | Accident | Assurance | Service | La Suva



retour

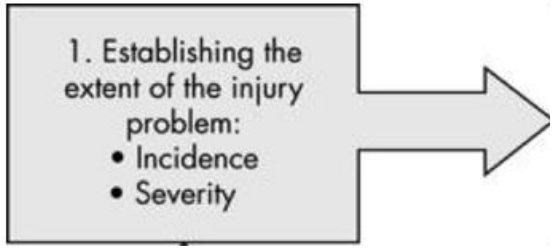
Les accidents de jogging en hausse de 90 %

Lucerne, le 14 avril 2015

Les accidents impliquant des joggeurs ont presque doublé par rapport à ceux enregistrés au tournant du siècle. Des études récentes réalisées par la Suva montrent à quel moment les coureurs tendent à se blesser et quelles sont les particularités du risque d'accident.

My response in the media FREE

1. Severity



Every injury must be categorized per severity

- Was medical assistance necessary or not
- Usually, the duration of absence from play (training or competition) is used

- Minimal: no absence
- Light : 1-3 days
- Moderate : 3-7 days
- Severe: 8-28 days
- Very severe: >28 days

Alpine skiing

World Cup skiing – injury study

Objective: To describe the risk of injury and the injury pattern among competitive World Cup alpine skiers during the competitive season.

Methods: Retrospective interviews were performed with all World Cup athletes from 10 nations at the end of the 2006–7 and 2007–8 winter seasons, and all acute injuries occurring during the 4.5-month competitive season were recorded. If the athlete was not present, their coaches or medical personnel were interviewed.

Interview retrospectively of athletes and coaches

Florenes et al, BJSM 2009

Absolute injury rates

1. Establishing the extent of the injury problem:
   - Incidence
   - Severity

Table 1 Absolute injury rates with 95% CIs for all recorded injuries (n = 191) among males and females related to injury severity

	Incidence (injuries/100 athletes per season)			Relative risk
Absence	**Male**	**Female**	**Total**	**Males versus females**
None	9.2 (5.8 to 12.7)	3.9 (1.4 to 6.5)	6.9 (4.7 to 9.2)	2.35 (1.11 to 5.00)
1–3 days	3.4 (1.3 to 5.5)	2.6 (0.5 to 4.7)	3.1 (1.6 to 4.6)	1.31 (0.48 to 3.60)
4–7 days	6.5 (3.6 to 9.4)	4.4 (1.7 to 7.1)	5.6 (3.5 to 7.6)	1.49 (0.69 to 3.21)
8–28 days	11.3 (7.4 to 15.2)	7.9 (4.2 to 11.5)	9.8 (7.1 to 12.5)	1.44 (0.81 to 2.55)
>28 days	11.6 (7.7 to 15.6)	10.9 (6.6 to 15.2)	11.3 (8.4 to 14.2)	1.07 (0.64 to 1.79)
Total	42.1 (34.7 to 49.6)	29.7 (22.6 to 36.8)	36.7 (31.5 to 41.9)	1.42 (1.06 to 1.91)

Many **severe** and **very severe** injuries

No real male/female differences

Florenes et al, BJSM 2009

Body part injured	8–28 days	>28 days	Total (%)
Head/face	4	5	16 (8.4)
Neck, cervical spine			
Shoulder, clavicula	4	2	13 (6.8)
Upper arm	1		1 (0.5)
Elbow		1	3 (1.6)
Forearm		1	1 (0.5)
Wrist	1	1	3 (1.6)
Hand, finger, thumb	1	1	17 (8.9)
Chest (sternum, ribs, upper back)	1		4 (2.1)
Abdomen			
Lower back, pelvis, sacrum	6	1	22 (11.5)
Hip, groin		2	4 (2.1)
Thigh	2		4 (2.1)
Knee	17	37	68 (35.6)
Lower leg, Achilles tendon	7	7	22 (11.5)
Ankle	4	1	10 (5.2)
Foot, heel, toe	3		3 (1.6)
Total (%)	51 (26.7)	59 (30.9)	191 (100)

Florenes et al, BJSM 2009


10
10

Football

Injuries among male and female elite football players

All 12 female football clubs (228 players) and 11 of 14 male clubs (239 players) in the Swedish premier league were followed prospectively during the 2005 season. Individual exposure (playing time), injuries (time loss), and injury severity (days lost due to injury) were recorded by the team medical staffs.

Prospective recording by medical staff, for all injuries

Hägglund et al, SJMSS 2009

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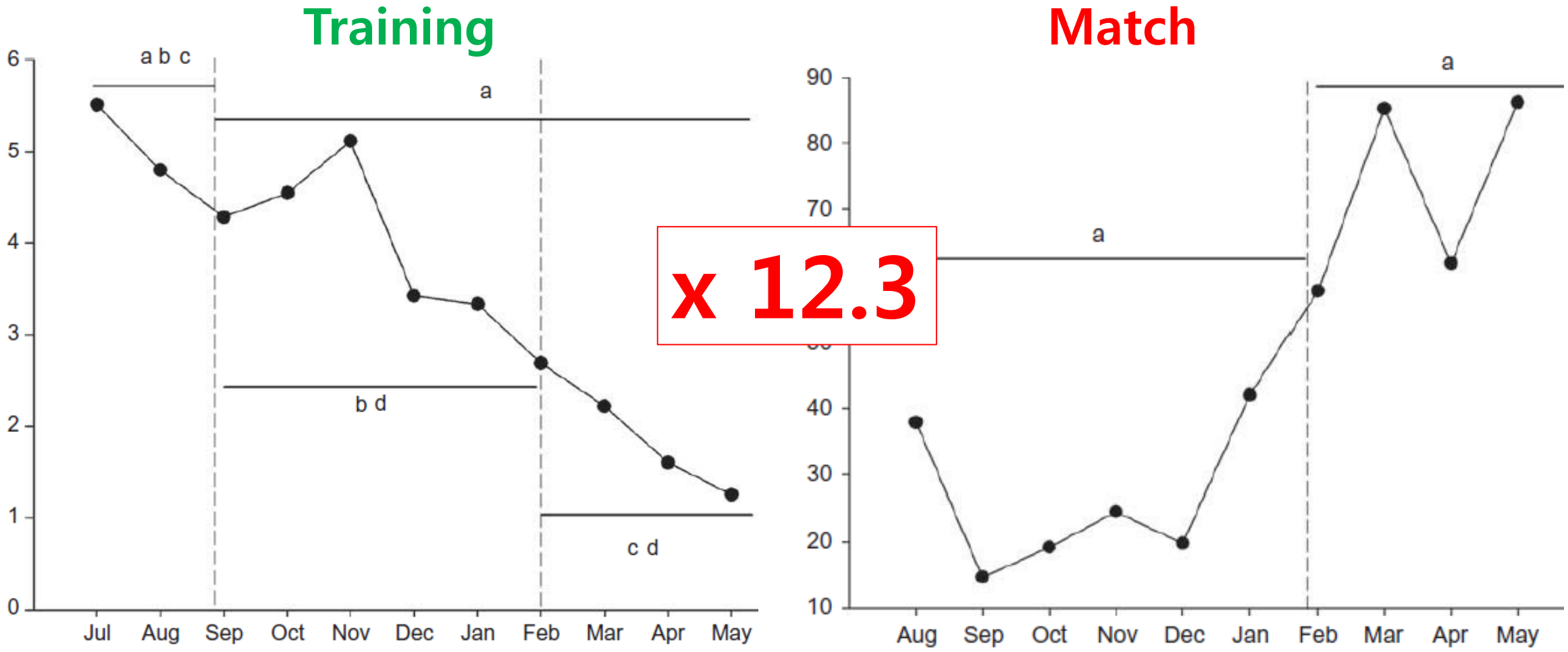
1. Establishing the extent of the injury problem:
- Incidence
- Severity

Injuries	Male ($n = 239$)	
	N (%)	Incidence (95% CI)
Total	548 (100)	7.7 (7.1–8.3)
Training	294 (54)	4.7 (4.2–5.3)
Match play	254 (46)	28.1 (24.8–31.8)
Severity		
Minimal	200 (36)	2.8 (2.4–3.2)
Mild	158 (29)	2.2 (1.9–2.6)
Moderate	142 (26)	2.0 (1.7–2.3)
Severe	48 (9)	0.7 (0.5–0.9)
Recurrence		
No	442 (81)	6.2 (5.6–6.8)
Yes	106 (19)	1.5 (1.2–1.8)
Early	83	1.2 (0.9–1.4)
Late	23	0.3 (0.2–0.5)
Injury type/diagnosis		
Ligament sprain	96 (18)	1.3 (1.1–1.6)
Ankle	57 (10)	0.8 (0.6–1.0)
Knee	38 (7)	0.5 (0.4–0.7)
Muscle strain	182 (33)	2.6 (2.0–2.9)
Hamstrings	68 (12)	1.0 (0.8–1.2)
Groin	73 (13)	1.0 (0.8–1.3)

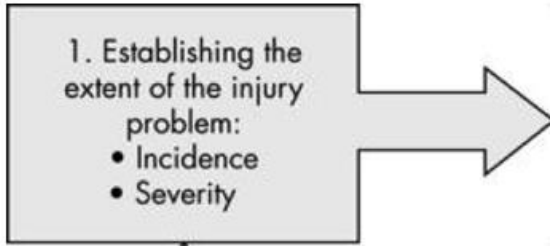
Hägglund et al, SJMSS 2009

When during the season?

Noya Salces J et al, JSS 2014



Track and field



Prevalence of Musculoskeletal Injuries in Swedish Elite Track and Field Athletes

Study Design: Descriptive epidemiology study.

Questionnaire retrospective

High incidence of lower limb injurie (knee, leg, ankle).

→ **overuse** mostly, few traumatic lesions

Jacobsson et al, AJSM 2011

Epidemiology foot and ankle overuse injury

1. Highest incidence 1000 athletes **per season**:

sports dance (ballet), running and gymnastics

2. Highest incidence 1000 athletes **per year**:

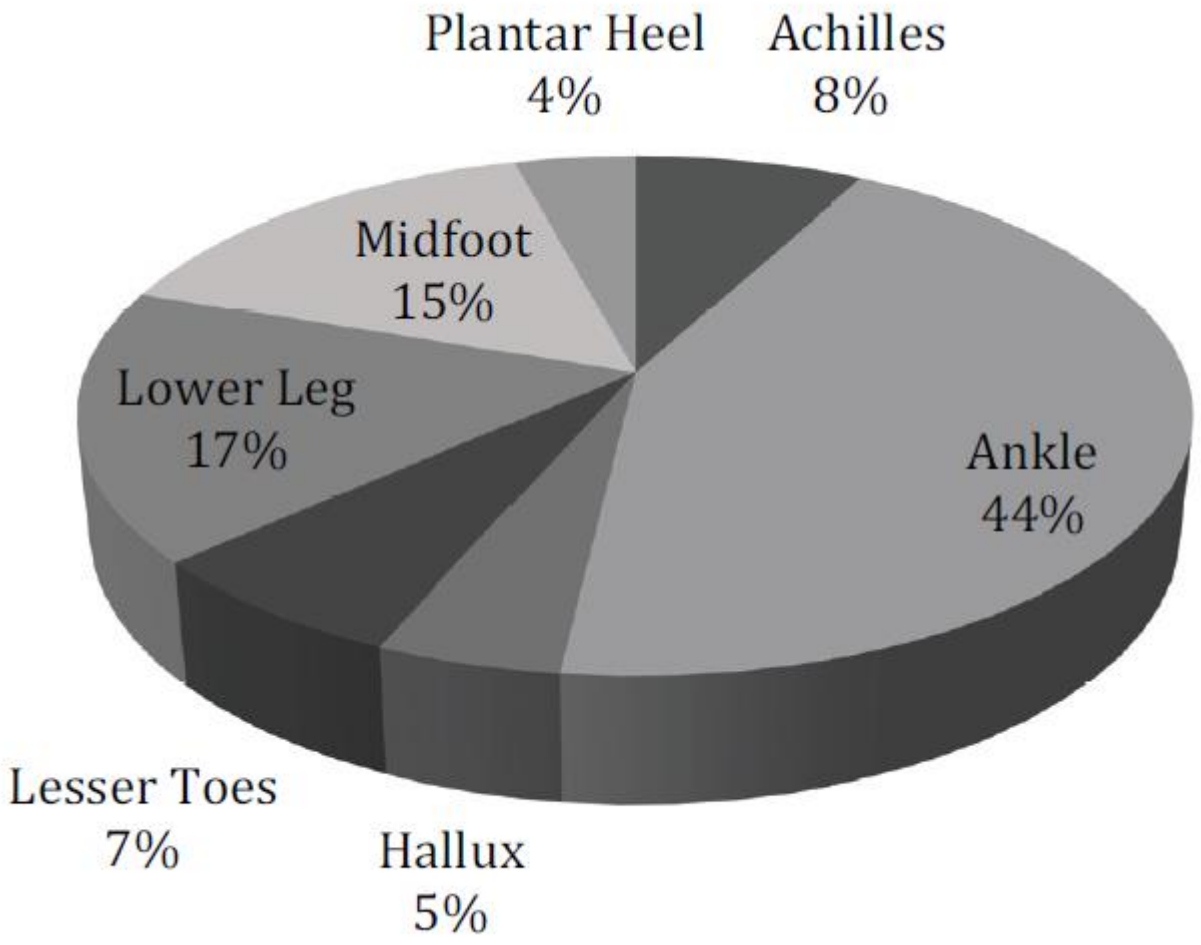
orienteering, gymnastics and dance

3. Highest incidence 1000 athlete **per hour exposure**:

Soccer and rugby.

Sobhani et al. Scand J Med Sci Sports 2012

Epidemiology foot and ankle overall



The top 4 types of injuries
- sprains/strains
- impingements
- contusions
- fractures

+ bone stress reaction & tendinopathy

Hunt et al. AJSM 2016

2. Causes & mechanisms

2. Establishing the aetiology and mechanisms of sports injuries

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Three distinct mechanisms predominate in non-contact anterior cruciate ligament injuries in male professional football players: a systematic video analysis of 39 cases

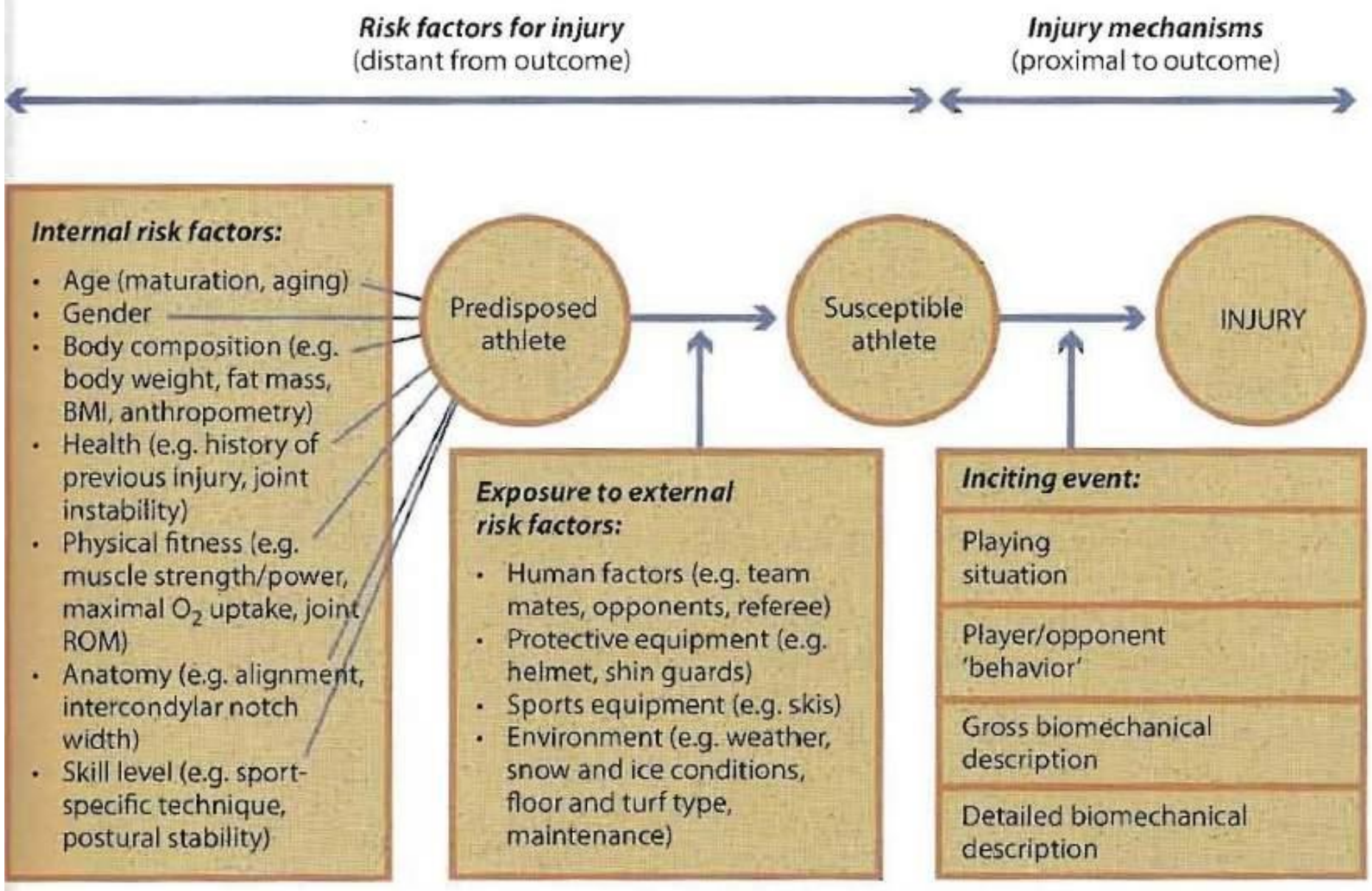
Markus Waldén,[1,2] Tron Krosshaug,[3] John Bjørneboe,[3] Thor Einar Andersen,[3] Oliver Faul,[3] Martin Hägglund[2,4]

Methods We assessed videos from 39 complete ACL tears recorded via prospective professional football injury surveillance between 2001 and 2011. Five analysts

Walden M, BJSM 2015 FREE

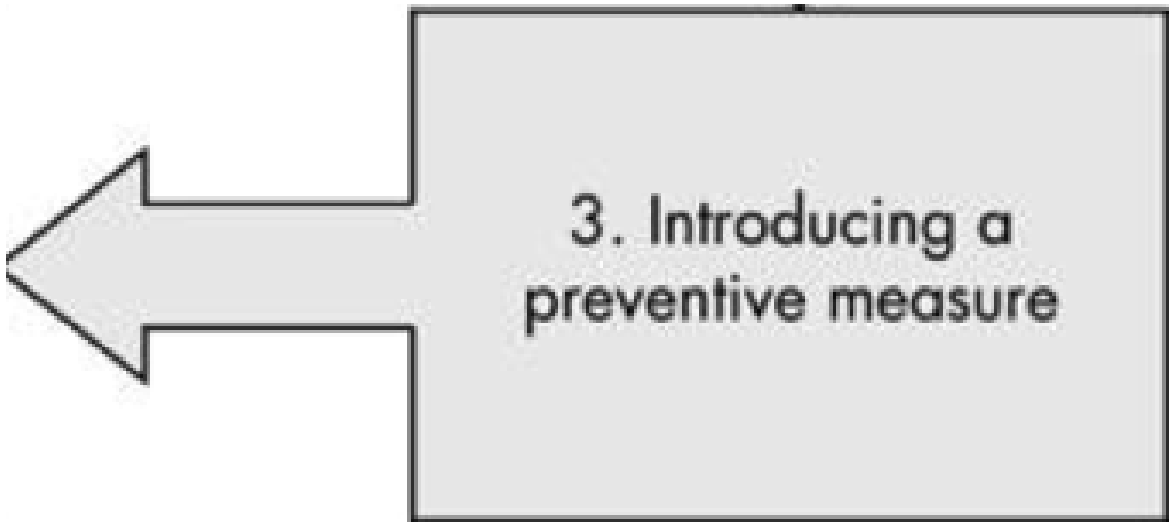
Lateral defensive play

Figure 2 Non-contact pressing mechanism (right knee). (A) At−160 ms, the defending player is running forward at high speed towards the opponent in possession of the ball. (B) At initial contact, he strikes the pitch with his right heel and makes a sidestep cut in an effort to reach the ball or to tackle the opponent, but no player contact. (C) At 80 ms, he rotates the trunk towards his left leg and puts the entire load on his right leg. (D) At 240 ms the right hip and knee joints are in abducted positions and the ankle joint is in eversion (dynamic valgus without collapse).


Risk factors for injury
(distant from outcome)
Injury mechanisms
(proximal to outcome)
Internal risk factors:
Age (maturation, aging)
Gender
Body composition (e.g. body weight, fat mass, BMI, anthropometry)
Health (e.g. history of previous injury, joint instability)
Physical fitness (e.g. muscle strength/power, maximal O_2 uptake, joint ROM)
Anatomy (e.g. alignment, intercondylar notch width)
Skill level (e.g. sport-specific technique, postural stability)
Predisposed athlete
Susceptible athlete
INJURY
Exposure to external risk factors:
Human factors (e.g. team mates, opponents, referee)
Protective equipment (e.g. helmet, shin guards)
Sports equipment (e.g. skis)
Environment (e.g. weather, snow and ice conditions, floor and turf type, maintenance)
Inciting event:
Playing situation
Player/opponent 'behavior'
Gross biomechanical description
Detailed biomechanical description

3. Introduce a preventative measure

«The mission»



3. Prevention measure - Intervention

Knee brace

Taping

Supplements

Stretching

Warm-up

Strengthening

Rules of the game

Equipment
(boots/shoes and floor/turf)

Knee braces & injuries

Systematic reviews show **unconclusive** results in athletes without pre-existing injuries

Rishiraj N et al, Sports Medicine 2009

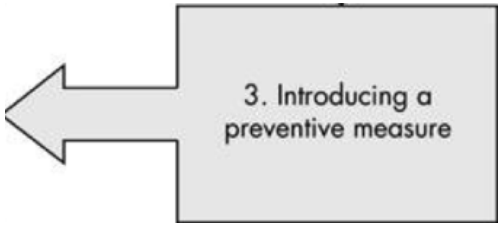
Pietrosimone BG et al, JAT 2008 FREE

The «11»

3. Introducing a preventive measure

Complete warm-up program aiming to prepare players for training, whilst executing prevention-oriented drills

Switzerland from 2003



5000+ coaches of **youth football** instructed for the «11»

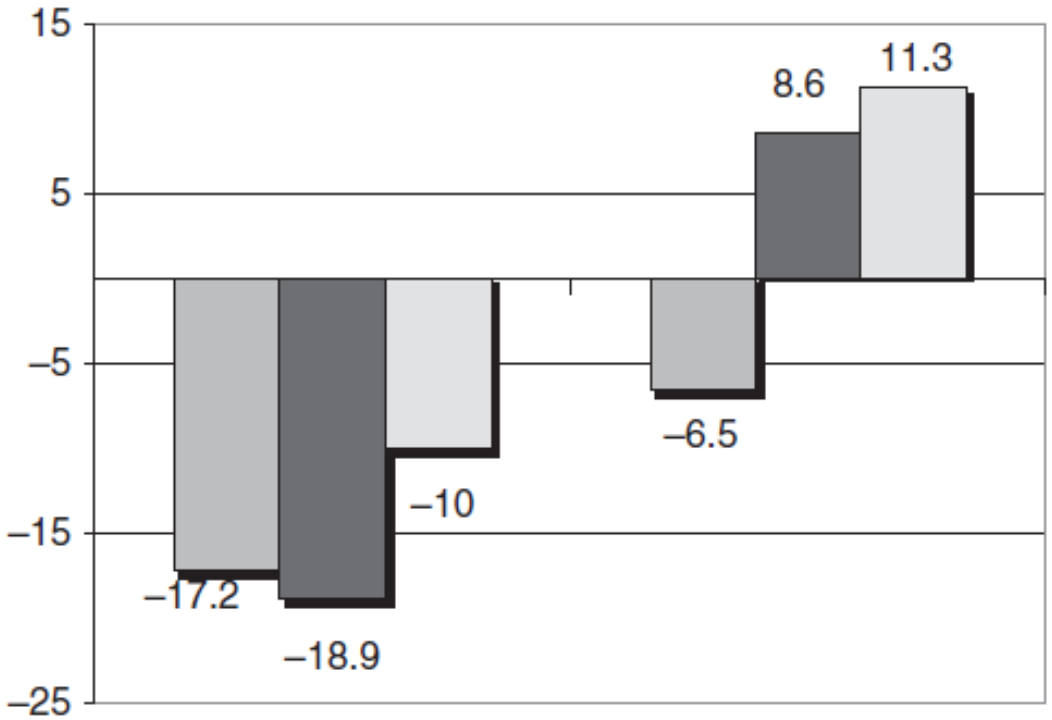
Teams integrating the 11 showed after 4 years (2008):

- **12%** reduction in **match** injuries
- **25%** reduction in **training** injuries

Coaches were **interviewed by telephone** and had to **remember** the injuries of the past 4 weeks…

Junge A et al, AJSM 2010 FREE

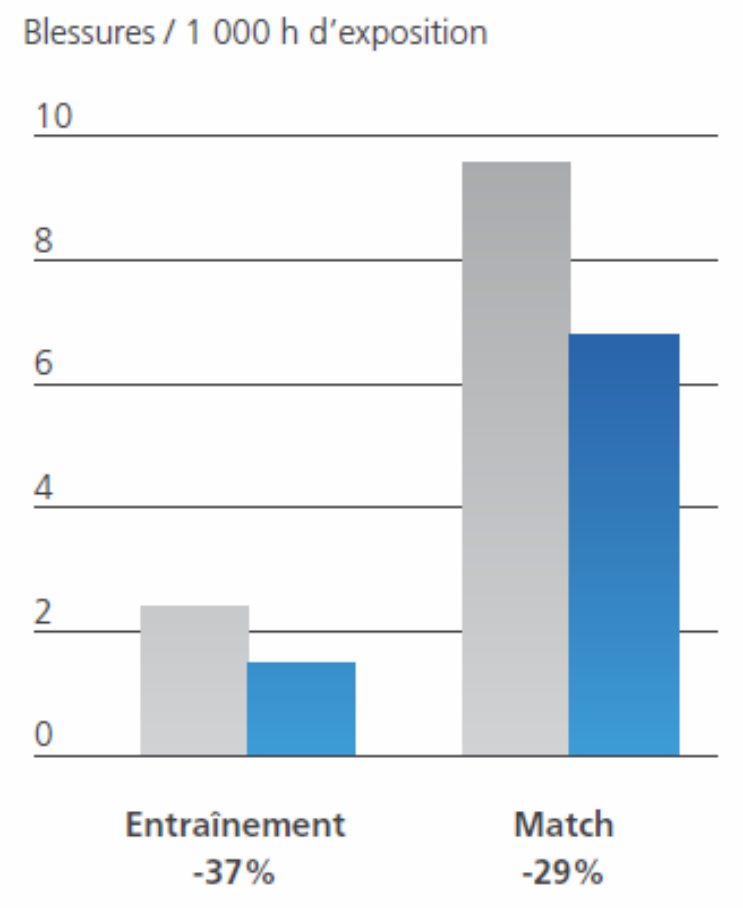
The 11 in Switzerland 2004-2008



"The 11" was successfully implemented in a countrywide campaign and proved effective in reducing soccer injuries in amateur players.

The 11 – RCT 125 clubs Norway

3. Introducing a preventive measure



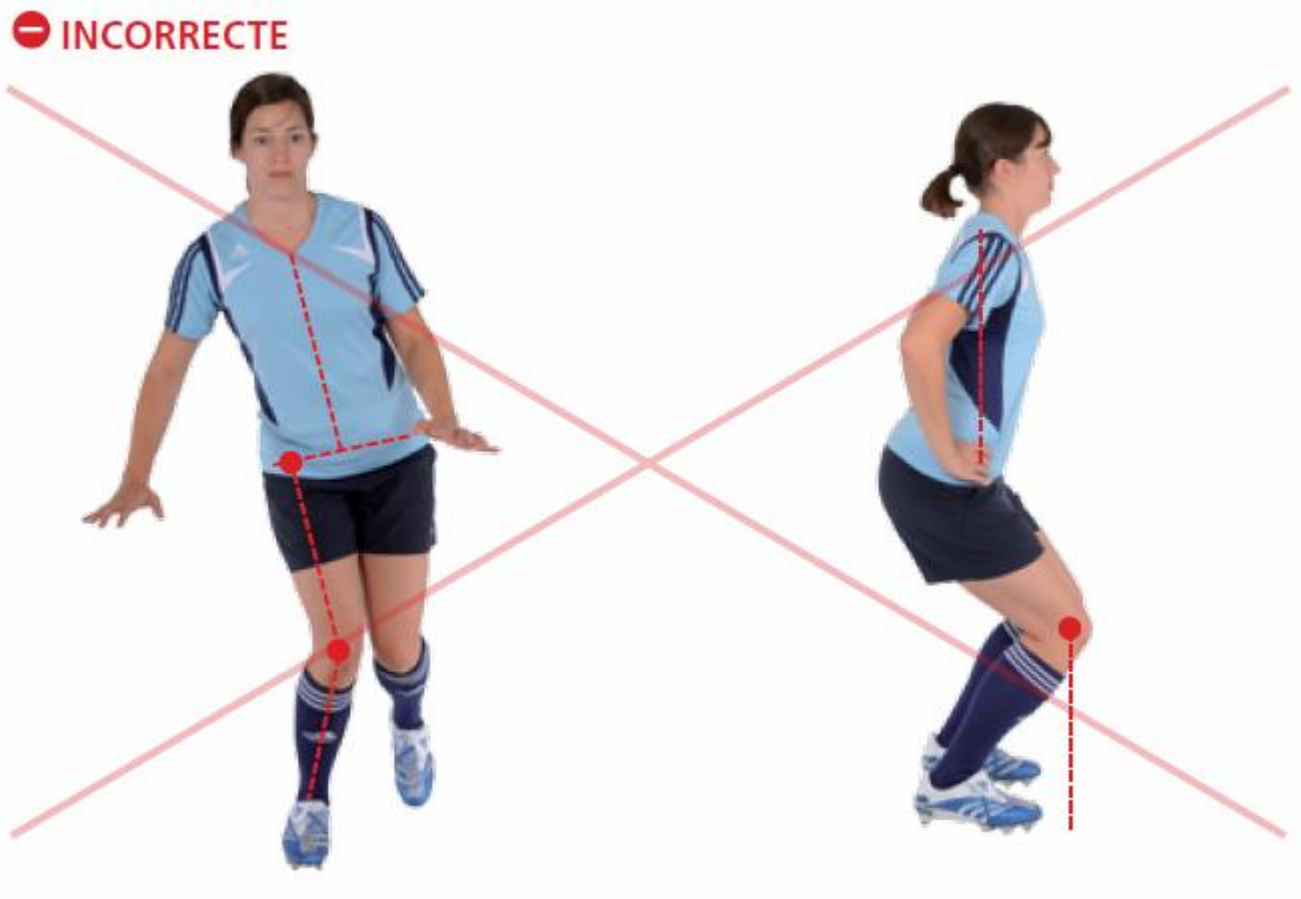
The «11» manages to reduce:

- Injuries to **knee ligaments**
- **Overuse** injuries in lower limbs

In girls aged 13 to 17 yo

Soligard T, BMJ 2008

Jump landing, single leg squat SLS



Jump landing, single leg squat SLS

Cutting manoeuver

Soligard T, BMJ 2008

Single Leg Squat - SLS

RCT 230 clubs football Sweden

3. Introducing a preventive measure

64% reduction in ACL risk (IC 95% 0.15 à 0.85)

21 total injuries (14 control, 7 intervention)

83% (IC 95% 0.05 à 0.57)
when high **compliance**

Walden M, BMJ 2012

The program

15 minutes, 2x/week

Exercises

- SLS
- Squats
- Pelvic lift
- Bridge (variations)
- Lunges
- Jump/landing technique

Table 1| **Details of neuromuscular warm-up programme used in intervention group**

Exercise	Instructions	Repetitions/duration
One legged knee squat:	Slow movement with smooth turn, horizontal pelvis and non-supporting foot in front of body with slightly flexed hip and knee	
Level A	Hands on hips	3×8-15 reps
Level B	Hold ball over head with straight arms	3×8-15 reps
Level C	Hands on hips; mark with non-supporting foot just above ground at 12-02-04-06 o'clock positions	3×5 reps
Level D	Bend down while holding ball and let ball touch ground outside supporting foot; make diagonal movement upwards and raise ball over head with straight arms on contralateral side	3×8-15 reps
Pair exercise	Teammate stands slightly oblique in front of you and ball is pressed between lateral sides of feet of non-supporting legs	3×5-10 reps
Pelvic lift:	Supine position; lift pelvis from ground while keeping back straight	
Level A	Both feet on ground and hands across chest	3×8-15 reps
Level B	One foot on ground and contralateral leg flexed in hip and knee 90° with both hands on knee	3×8-15 reps
Level C	One foot on football and contralateral leg flexed in hip and knee 90° with arms on ground alongside body	3×8-15 reps
Level D	One foot on ground and other in air; keep upper arms on ground with elbows flexed 90°; push away supporting foot and land on contralateral foot	3×8-15 reps
Pair exercise	Teammate stands with flexed knees and supports heel of one of your feet in her hands; hands across chest and lift pelvis	3×8-15 reps
Two legged knee squat:	Slow movement with smooth turn, back in straight position and feet shoulder-wide apart with soles in contact with ground	
Level A	Hold ball in front of body with straight arms	3×8-15 reps
Level B	Hands on hips	3×8-15 reps
Level C	Hold ball over head with straight arms	3×8-15 reps
Level D	Same as level C but continue movement and rise up on toes after returning to starting position and stay briefly in that position	3×8-15 reps
Pair exercise	Teammate stands next to you approximately 1 m away, facing opposite directions; hold ball between you with one hand and other hand on hip; apply slight pressure on ball while performing knee squat	3×8-15 reps
The bench:	Lift body and keep it in straight line	
Level A	Prone position; support on knees and on lower arms with elbows kept under shoulders	15-30 sec
Level B	Same as level A but with support on tip of feet	15-30 sec
Level C	Same as level B, but move foot to side and back to starting position; alternate sides	15-30 sec
Level D	Lie sideways with support on foot and lower arm with elbow kept under shoulder and other hand on hip; lift hip off ground and stay briefly in that position with good control before slowly returning to starting position	5-10 reps
Pair exercise	Teammate stands behind you and holds your feet or lower legs; lift the body and walk forward by using hands on ground	15-30 sec
The lunge:	Take deep step with marked knee lift and soft landing; rear knee should not touch ground	
Level A	Hands on hips; move forward with each step	3×8-15 reps
Level B	Hold ball in front of body with straight arms; rotate upper body while stepping forward and position ball laterally of front leg; move forward with each step and alternate sides	3×8-15 reps
Level C	Hold ball over head with straight arms; perform forward lunge and push back with front leg and return to starting position	3×8-15 reps
Level D	Hold ball in front of body with straight arms; perform sideways lunge and return to starting position	3×8-15 reps
Pair-exercise	Teammate stands in front of you 5-10 m away; perform forward lunge while making throw-in with ball	3×8-15 reps
Jump/landing:	Make jump with soft landing; stay briefly in landing position	
Level A	Stand on one leg with knee slightly bent and hands on hips; make short forward jump and land on same foot; jump backwards to starting position	3×8-15 reps
Level B	Stand on two legs shoulder-wide apart with hands on back; make sideways jump and land on one foot; alternate sides	3×8-15 reps
Level C	Take a few quick steps on same spot and make short jump straight forward landing on one foot	3×5 reps
Level D	Same as level C, but change direction and jump to one side (90° turn); alternate sides	3×5 reps
Pair exercise	Teammate stands in front of you approximately 5 m away; make two legged jump while heading football and land on two legs	3×8-15 reps

Football adult male - RCT
«high-level amateur soccer»

3. Introducing a preventive measure

23 teams. **The 11** for each training session

Compliance 70%

Injury rate unchanged 9.6/1'000h

Less **knee** injuries

van Beijsterveldt AMC, BJSM 2012 FREE

Comparing 2 decades in Belgium

Elite men

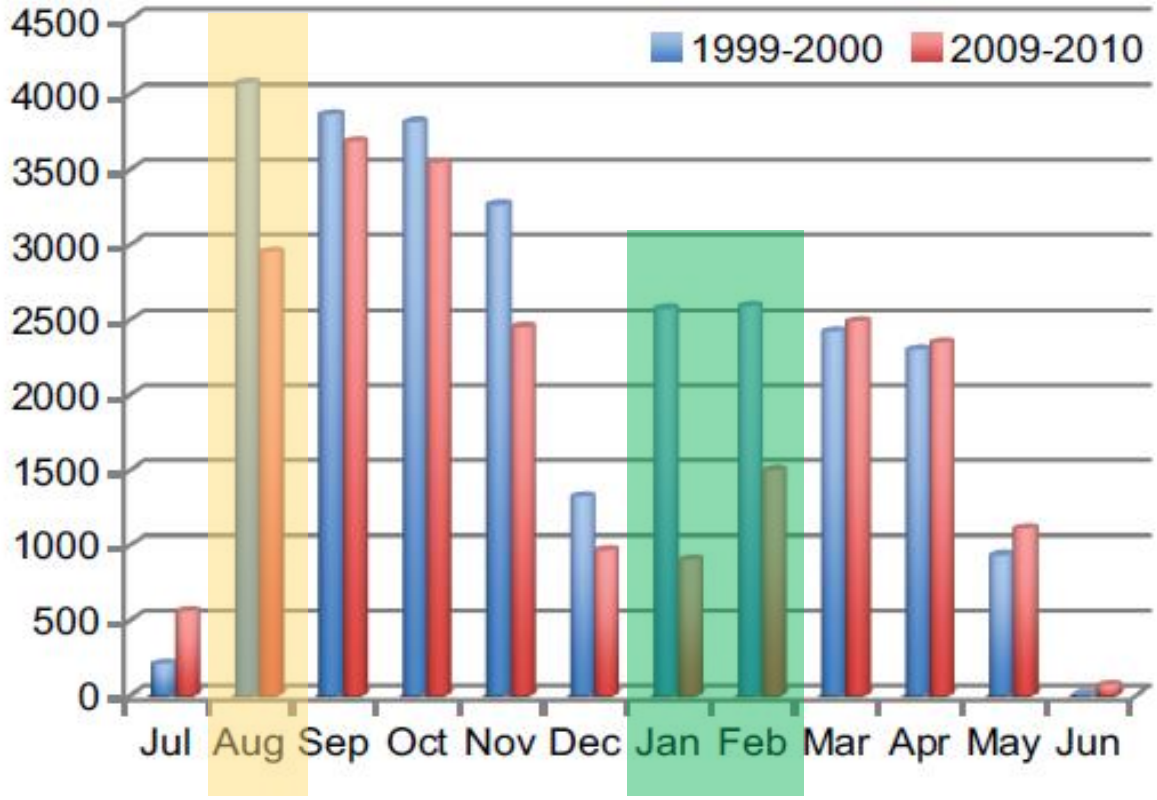


Figure 1. Distribution of the amount of injuries during both seasons.

Before« 11 » - **After**

Massive injury reduction in Jan-Feb

Rules regarding pitch state & temperature changed

Bollars P et al, AJSM 2014

Prevent – really, and for whom?

The more prevalent the problem, the better chance there will be an impact of the preventative intervention

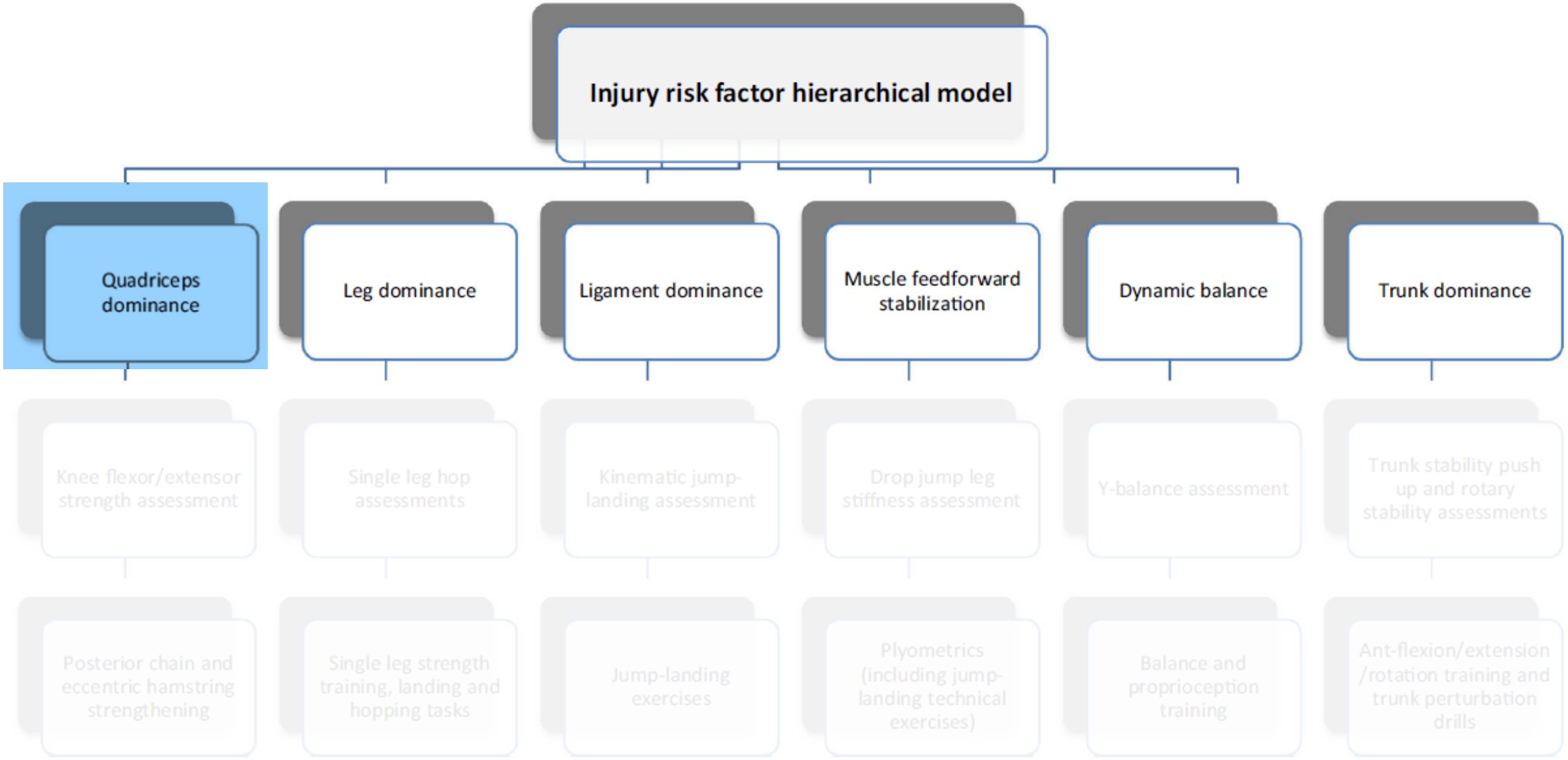
<18 yo 2-4x more chances of effectiveness

Women 4-8x > ACL than men

Weak core	Thin ACL	Tight notch	Hormones	Dynamic valgus

Myer GD, AJSM 2013
Harmon KG, Ireland ML, CJSM 2010

Factors thast cause knee and ankle injuries in young athletes

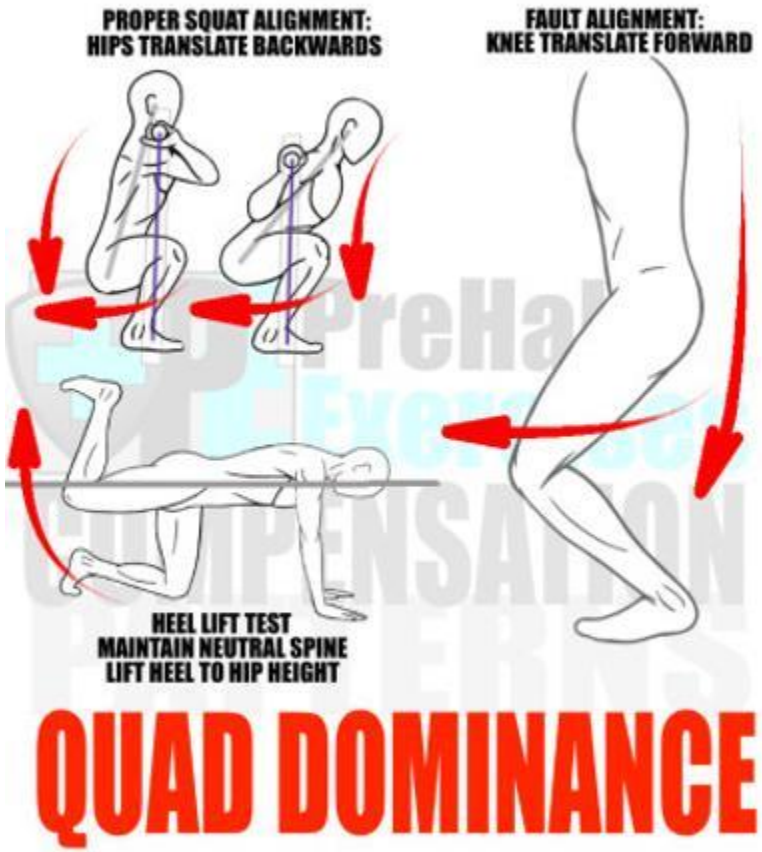

Injury risk factor hierarchical model
Quadriceps dominance
Leg dominance
Ligament dominance
Muscle feedforward stabilization
Dynamic balance
Trunk dominance
Knee flexor/extensor strength assessment
Single leg hop assessments
Kinematic jump-landing assessment
Drop jump leg stiffness assessment
Y-balance assessment
Trunk stability push up and rotary stability assessments
Posterior chain and eccentric hamstring strengthening
Single leg strength training, landing and hopping tasks
Jump-landing exercises
Plyometrics (including jump-landing technical exercises)
Balance and proprioception training
Ant-flexion/extension /rotation training and trunk perturbation drills

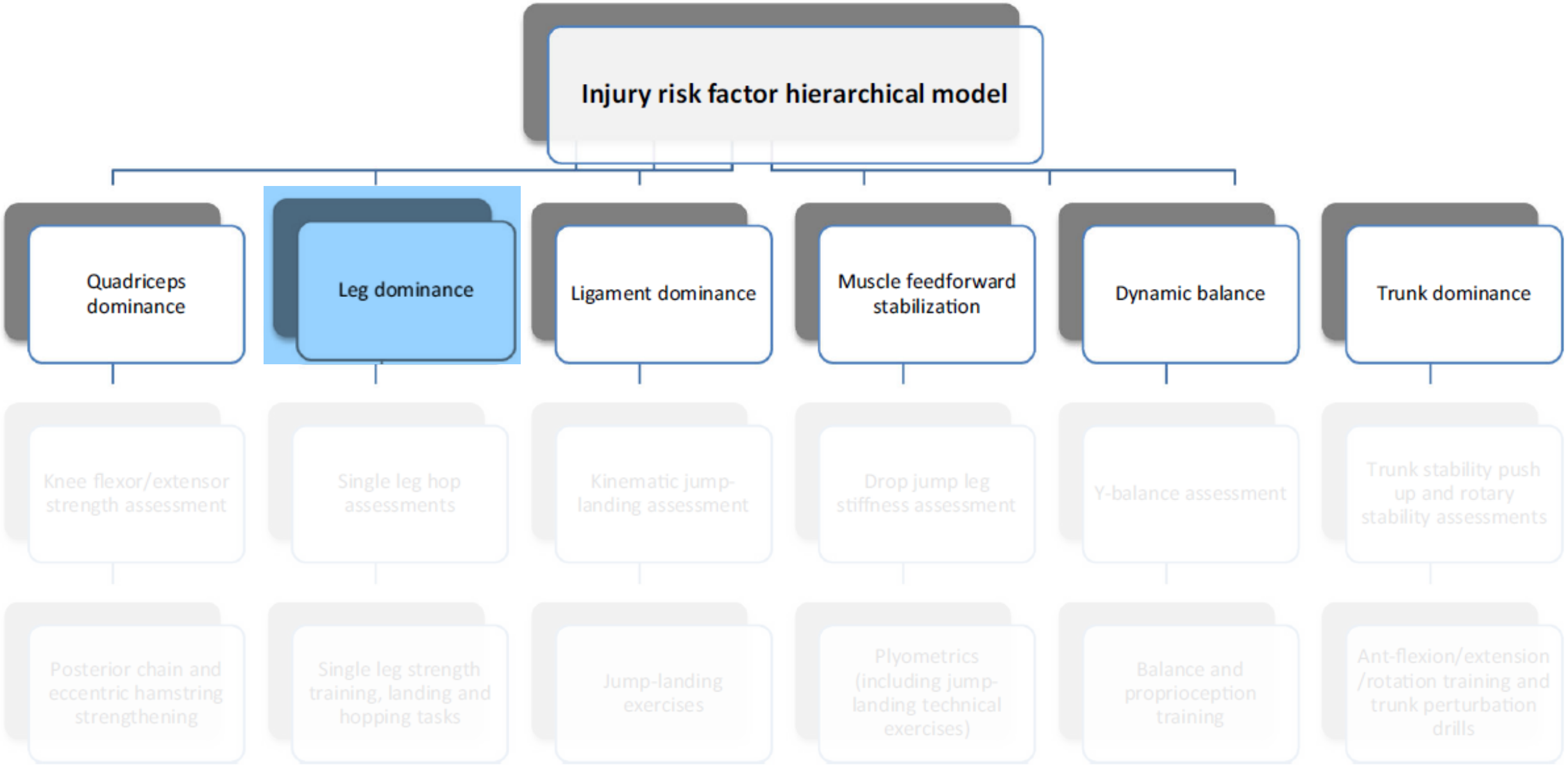
Quadriceps dominance

Dysbalance between front & back thigh muscles

hamstrings / quadriceps

$$H_{ecc} / Q_{conc}$$

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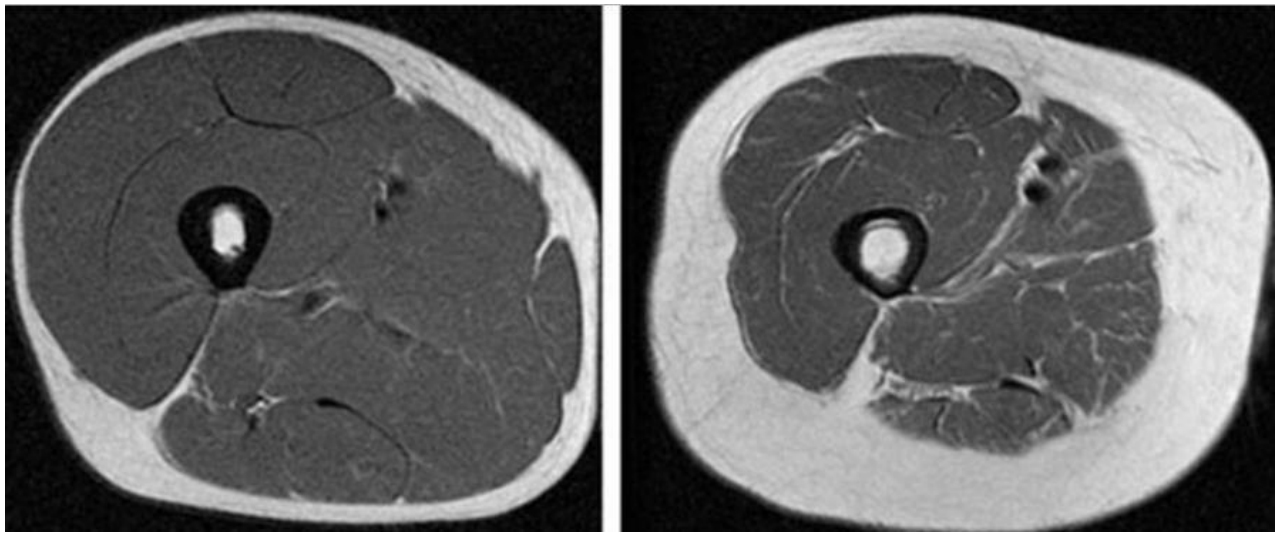
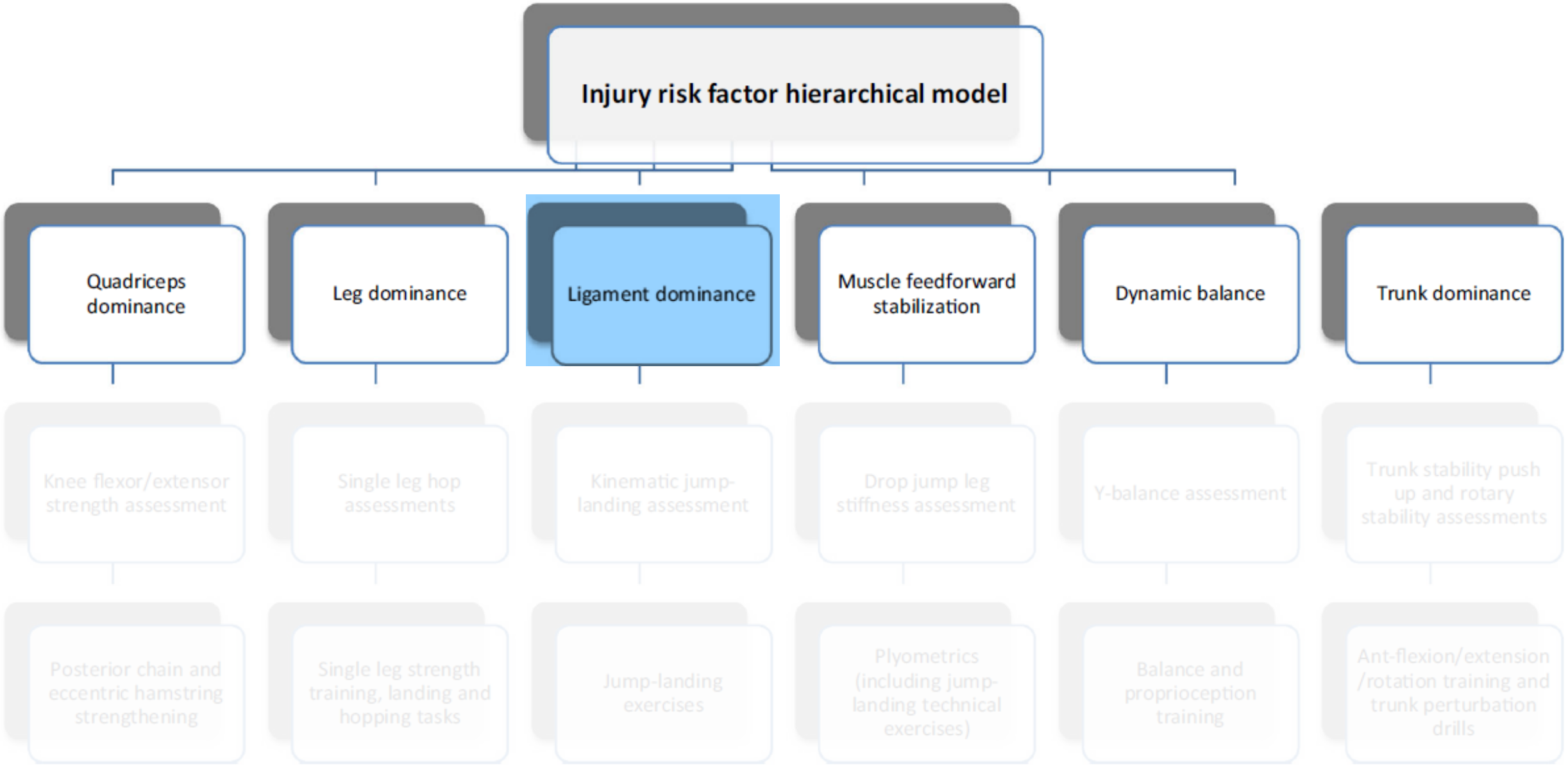
Muscle lateral dominance

Assymetry in strength L / R

Dominant leg develops more strength → loading upion landing and running is assymterical → higher risk

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Ligament dominance - valgus

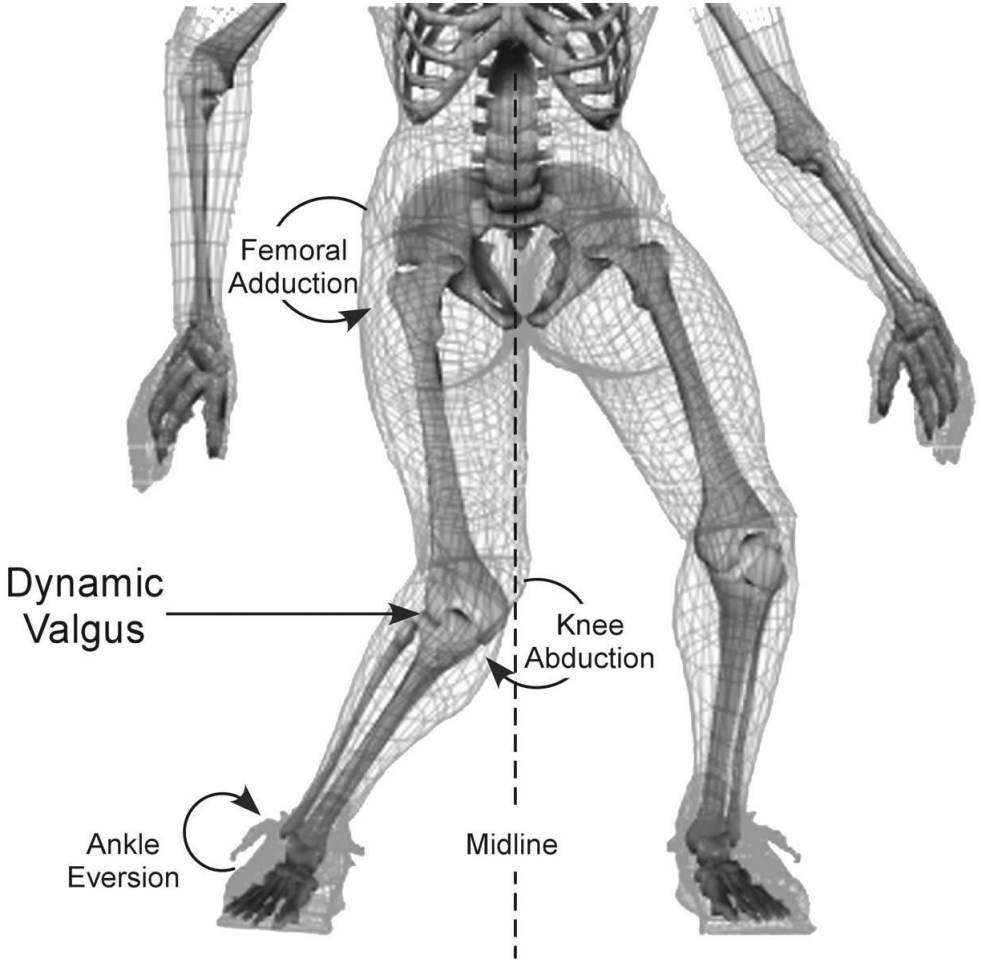
Lack of **proximal control** and anatomical peculiarities

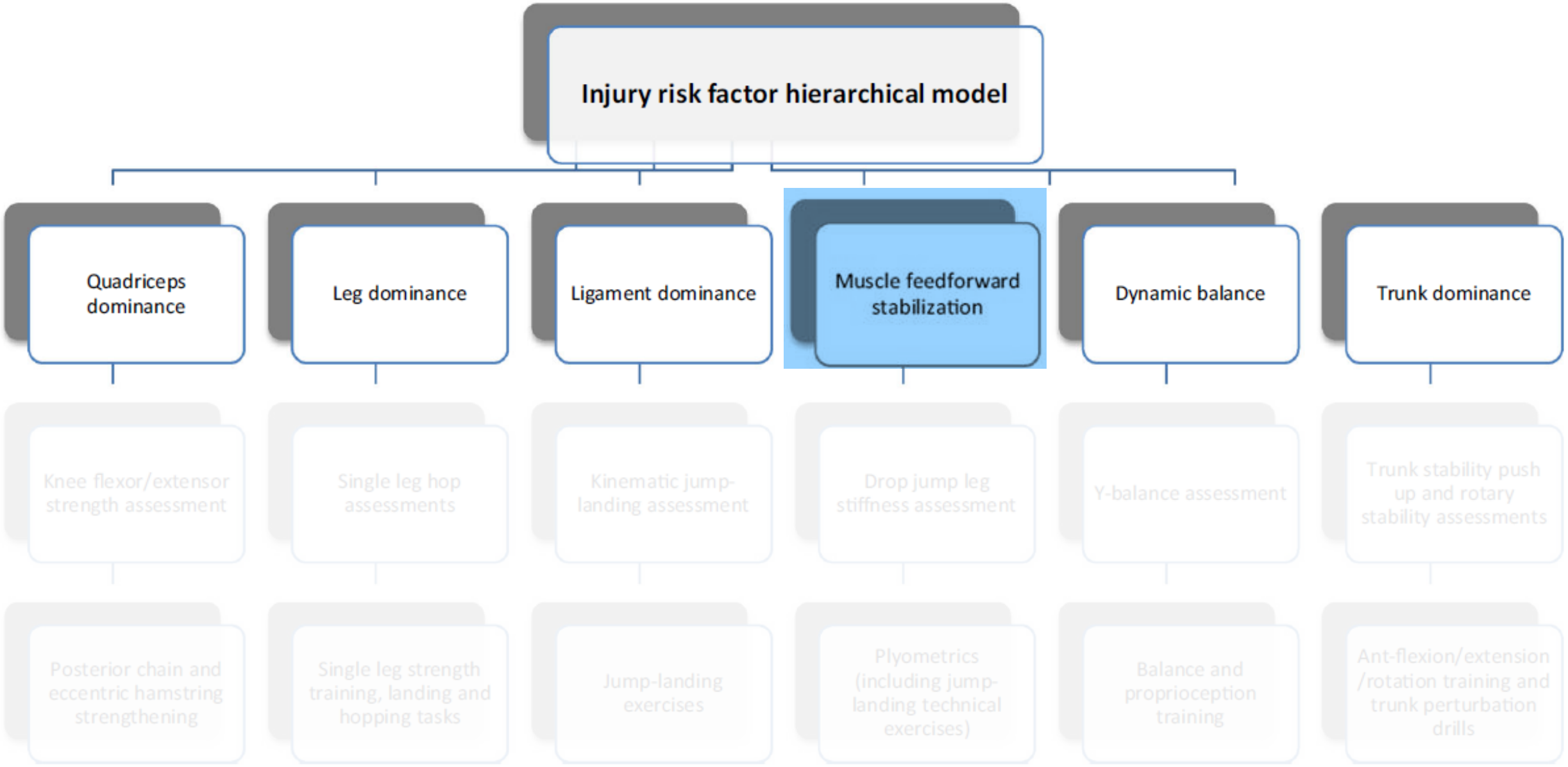
→ Valgus knee

→ Adduction/internal rotation of the femur

→ External tibia rotation

→ Ankle pronation

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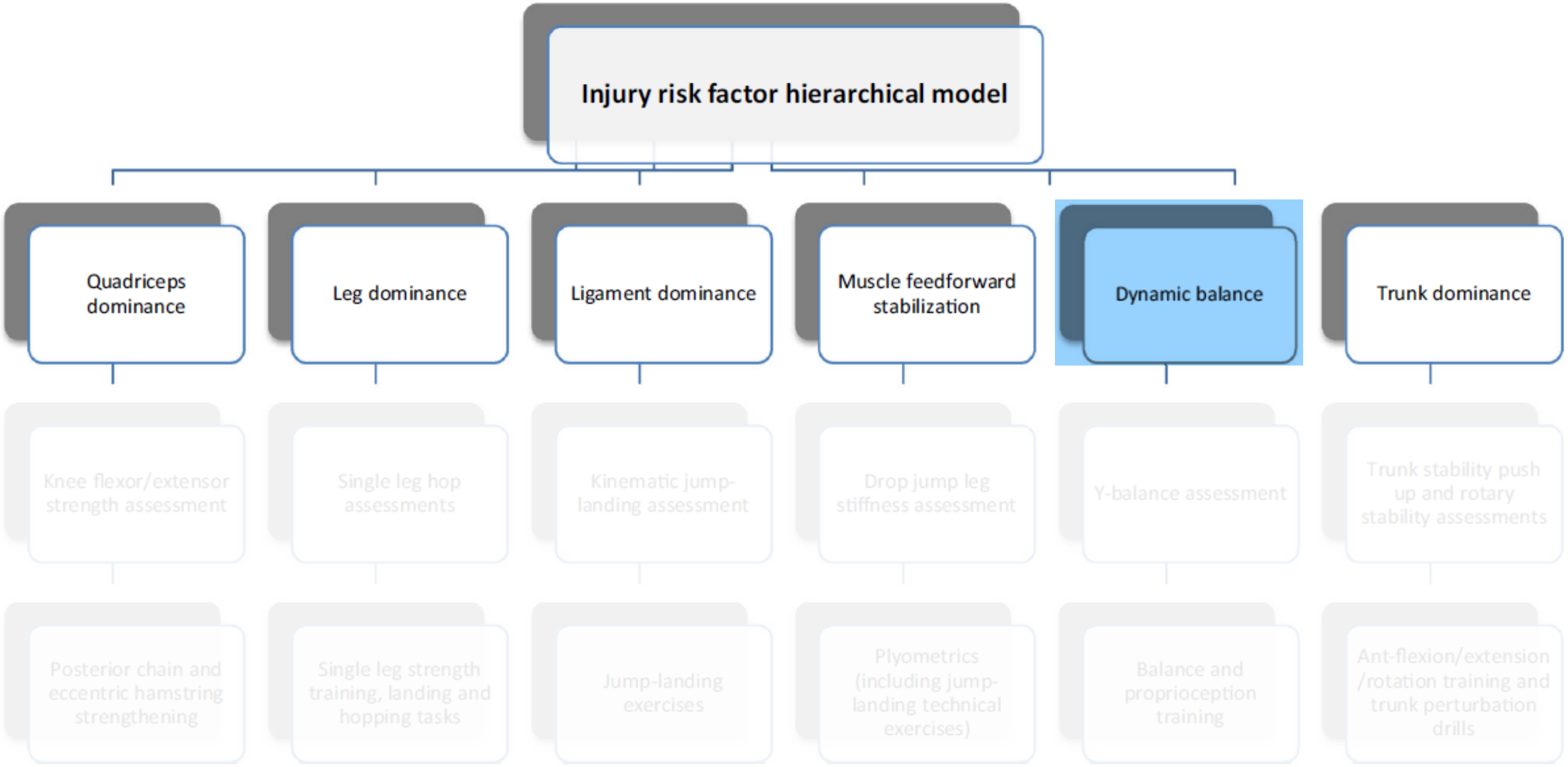
Muscular pre-activation

Anticipatory (feed-forward) actions at landing phase, rather than **neuromuscular feedback reflex.**

Young prepubertal adolescents anticipate impacts less and have less pre-activation.

→ They develop it with maturation (and training).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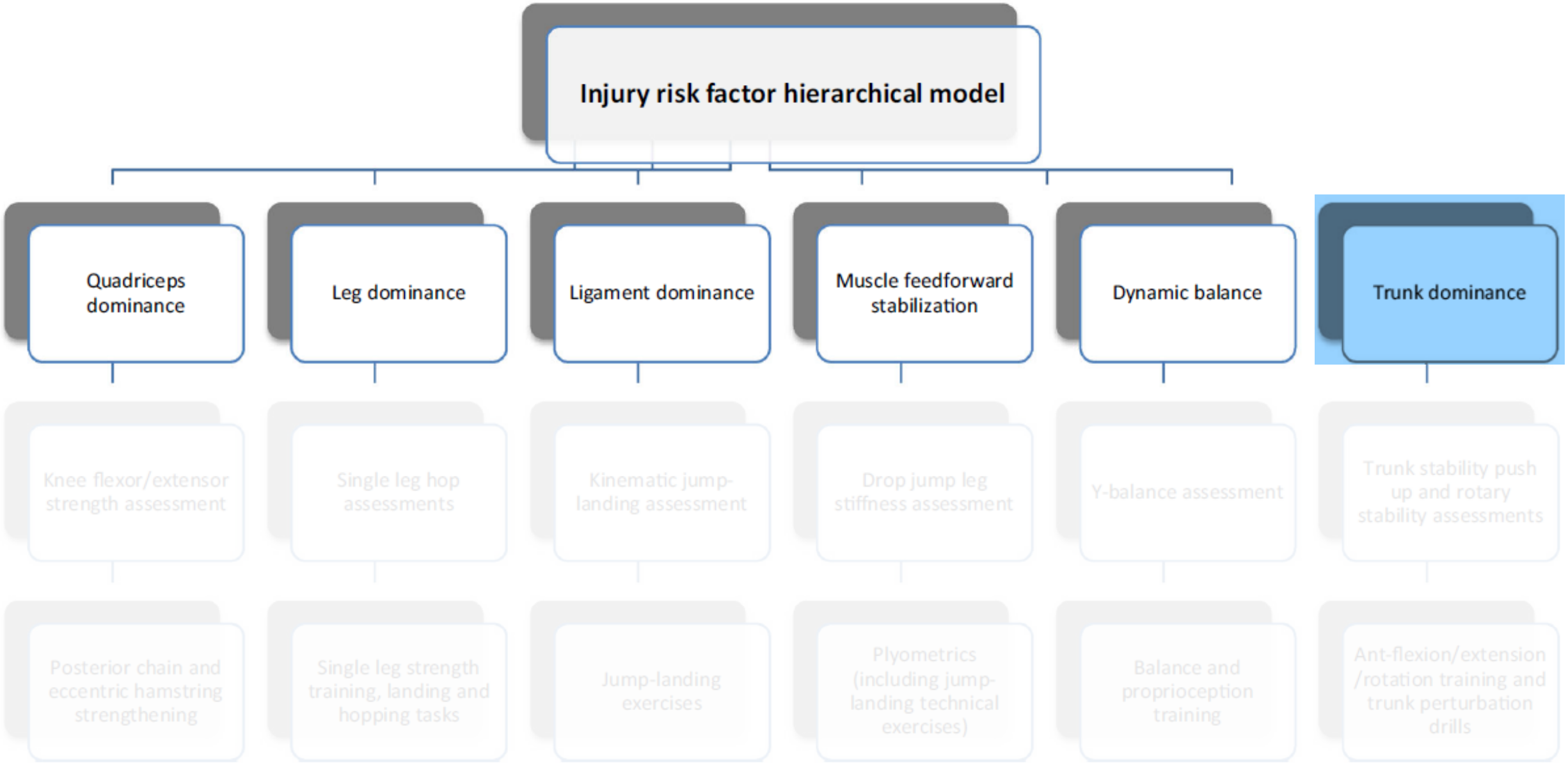
Dynamique balance

Necessitates visual, vestibular and proprioceptive inputs.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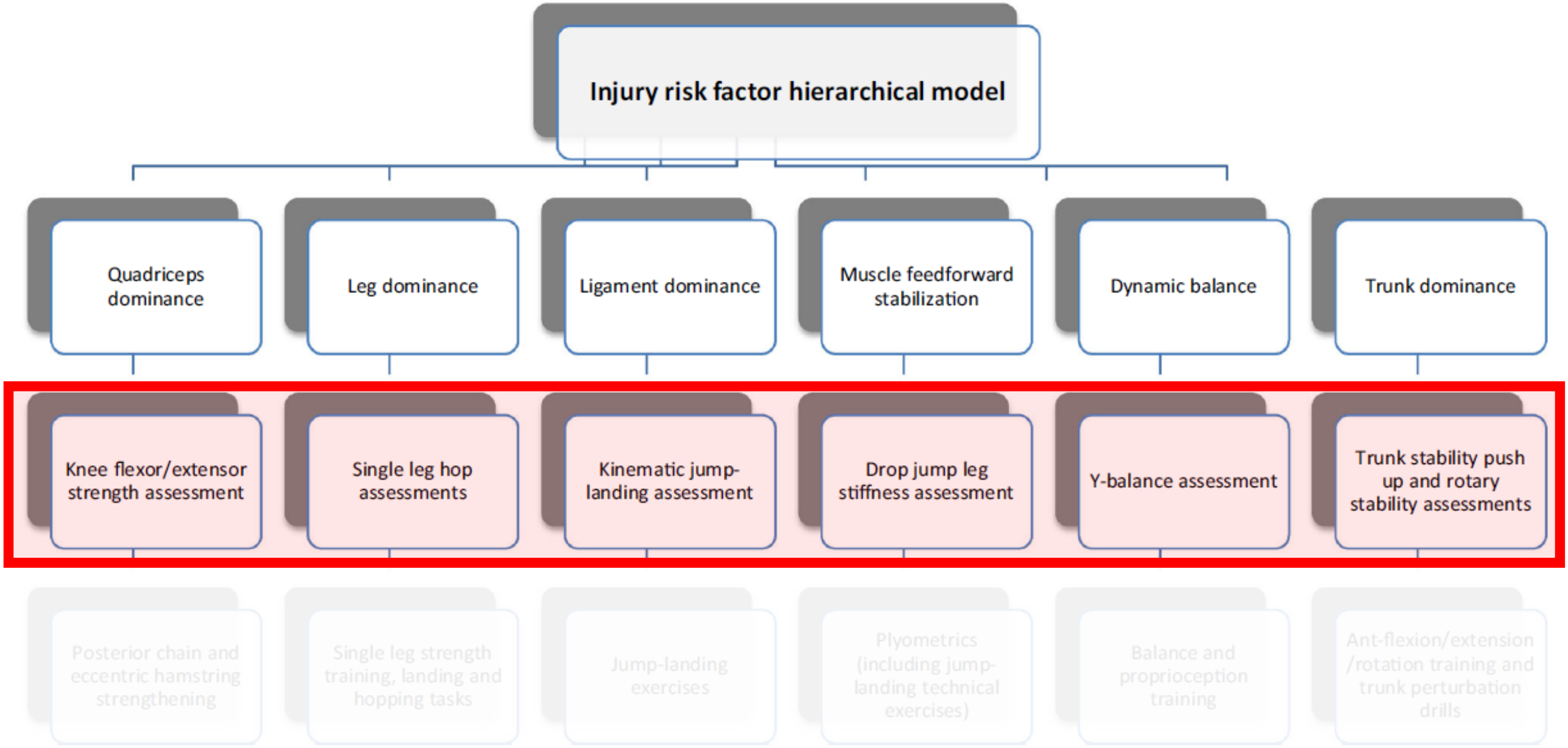
Trunk dominance

Insufficient trunk control

→ Large/wide movements which generate important torque on the lower elements of the closed kinetic chain.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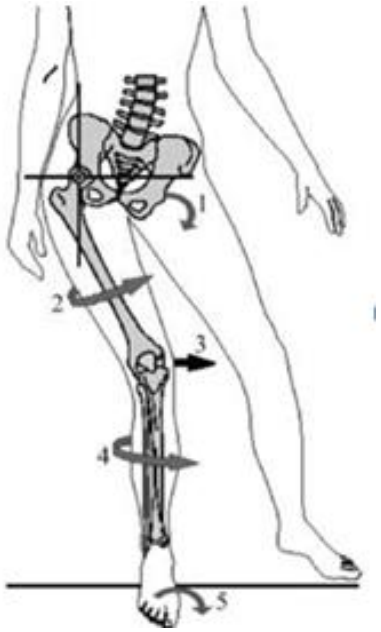
Performance Matrix
Weak links & uncontrolled movement

Hip, Direction = valgus (dynamic) ⇔ medial rotation & adduction
Threshold = low



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Masterclass

A new perspective on risk assessment

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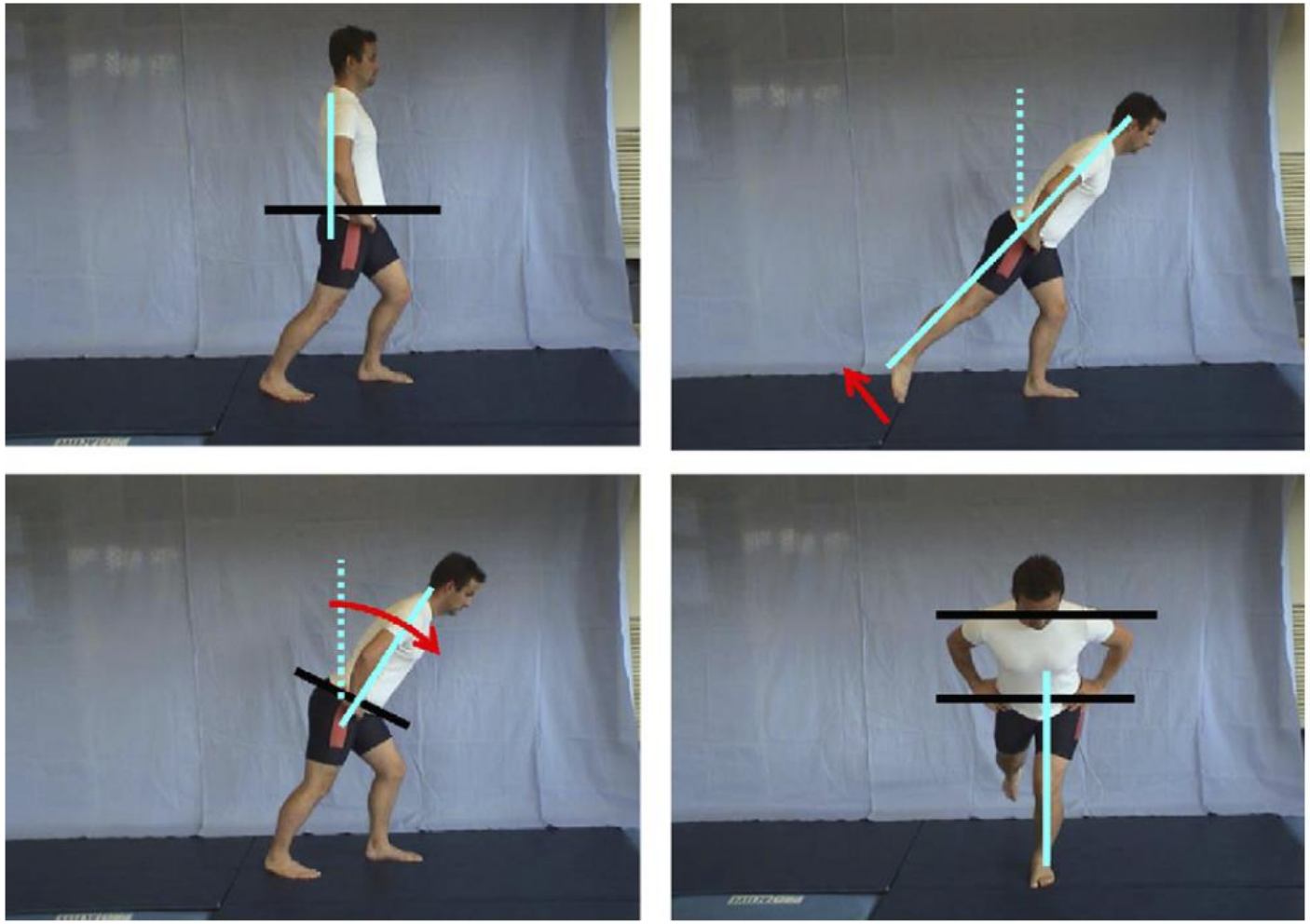
Abstract

Pre-season screening is routinely promoted as part of either an injury risk management strategy or as a performance enhancement strategy. Many of these processes focus on testing joint range, muscle strength (both power and endurance) and testing muscle extensibility. Although some functional tests based on work specific tasks and sport specific skills are applied they are specific to one task or a sport specific skill. It seems that the clinical outcomes of asymptomatic function, normal range of joint motion (isolated testing) and normal muscle strength (isolated testing) are not adequate rehabilitation end points to prevent recurrence. This Masterclass explores assessment and retraining from a new perspective in an attempt to address multiple muscle interactions acting on multiple joints in functionally orientated tasks. The assessment is based on the specific assessment of the site and direction of uncontrolled movement, under low and high threshold loading at different joint systems within functionally orientated tasks. From this assessment, a specific retraining programme can be developed and implemented.

Keywords: Risk assessment; Performance; Core Stability

Mottram & Comerford, Phys Therapy in Sport 2008

Single knee bend lunge & lean



Performance matrix

Performance Matrix analysis			Weak link		
	L	R	Load	Site	Direction
Can you prevent rotation of the pelvis? (pelvis staysfacing straight ahead)	Yes ☐ No ☐→	Yes ☐ No ☐→	Low	Low back (lumbo-pelvic)	Rotation
Can you prevent turning in of the weight-bearing (WB) front knee or rolling down of the arch?	Yes ☐ No ☐→	Yes ☐ No ☐→	Low	Hip (WB)	Rotation (medial)
Can you prevent the foot turning out or heel pulling in? (arch rolling down ± toe clawing)	Yes ☐ No ☐→	Yes ☐ No ☐→	Low	Low back (WB) (knee)	Rotation (lateral)
Can you prevent the back from rounding out (flexing)?	Yes ☐ No ☐→	Yes ☐ No ☐→	Low	Low back (lumbo-pelvic)	Flexion
Can you prevent the back from over arching (extending)?	Yes ☐ No ☐→	Yes ☐ No ☐→	Low	Low back (lumbo-pelvic)	Extension
Can you prevent sidebending of the trunk or tilting or side shifting of the pelvis?	Yes ☐ No ☐→	Yes ☐ No ☐→	Low	(lumbo-pelvic)	Sidebend
Can you prevent the non weight-bearing (NWB) rear leg dropping from the straight line?	Yes ☐ No ☐→	Yes ☐ No ☐→	Low	Hip (NWB)	Flexion

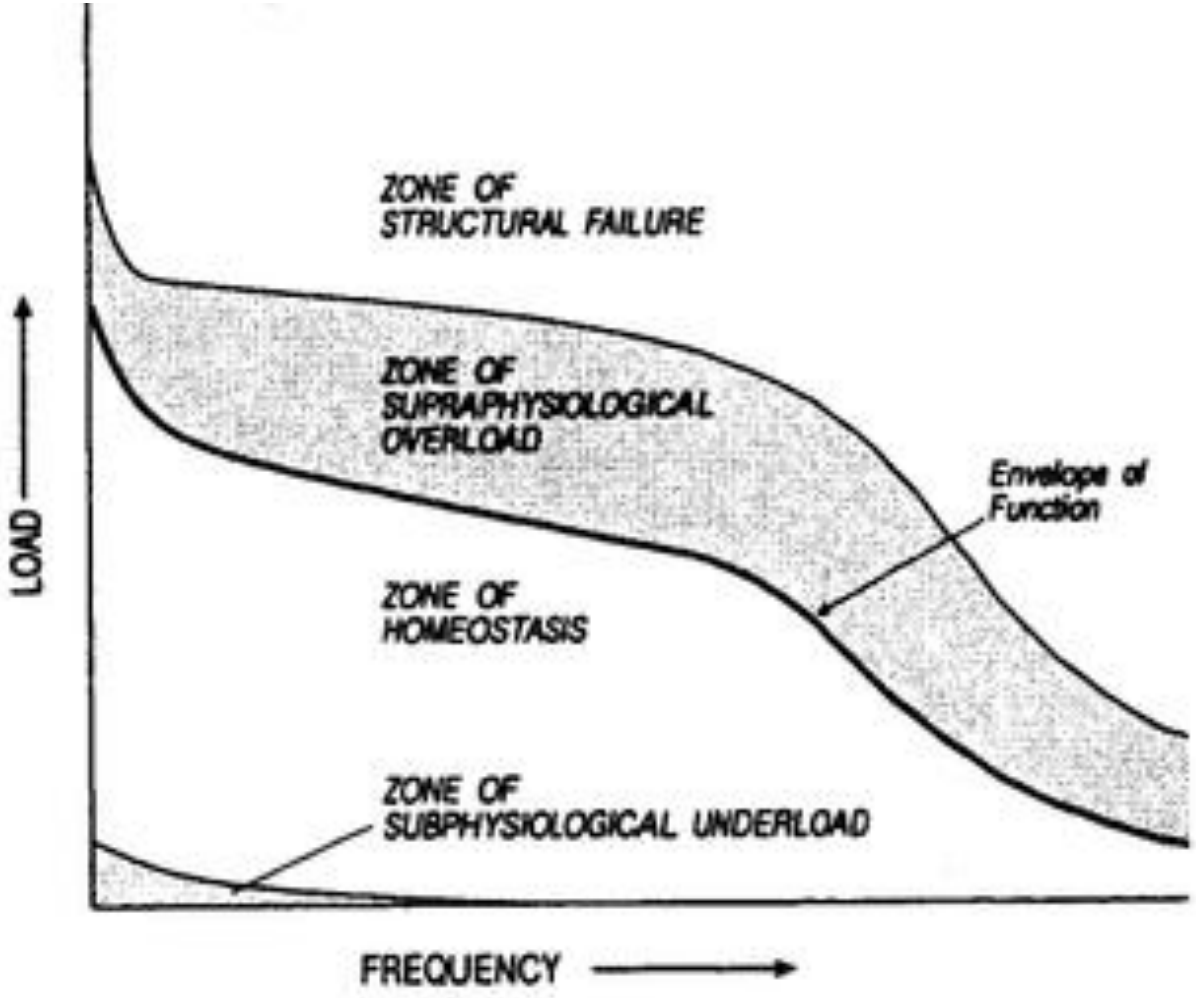
Mottram & Comerford, Phys Therapy in Sport 2008

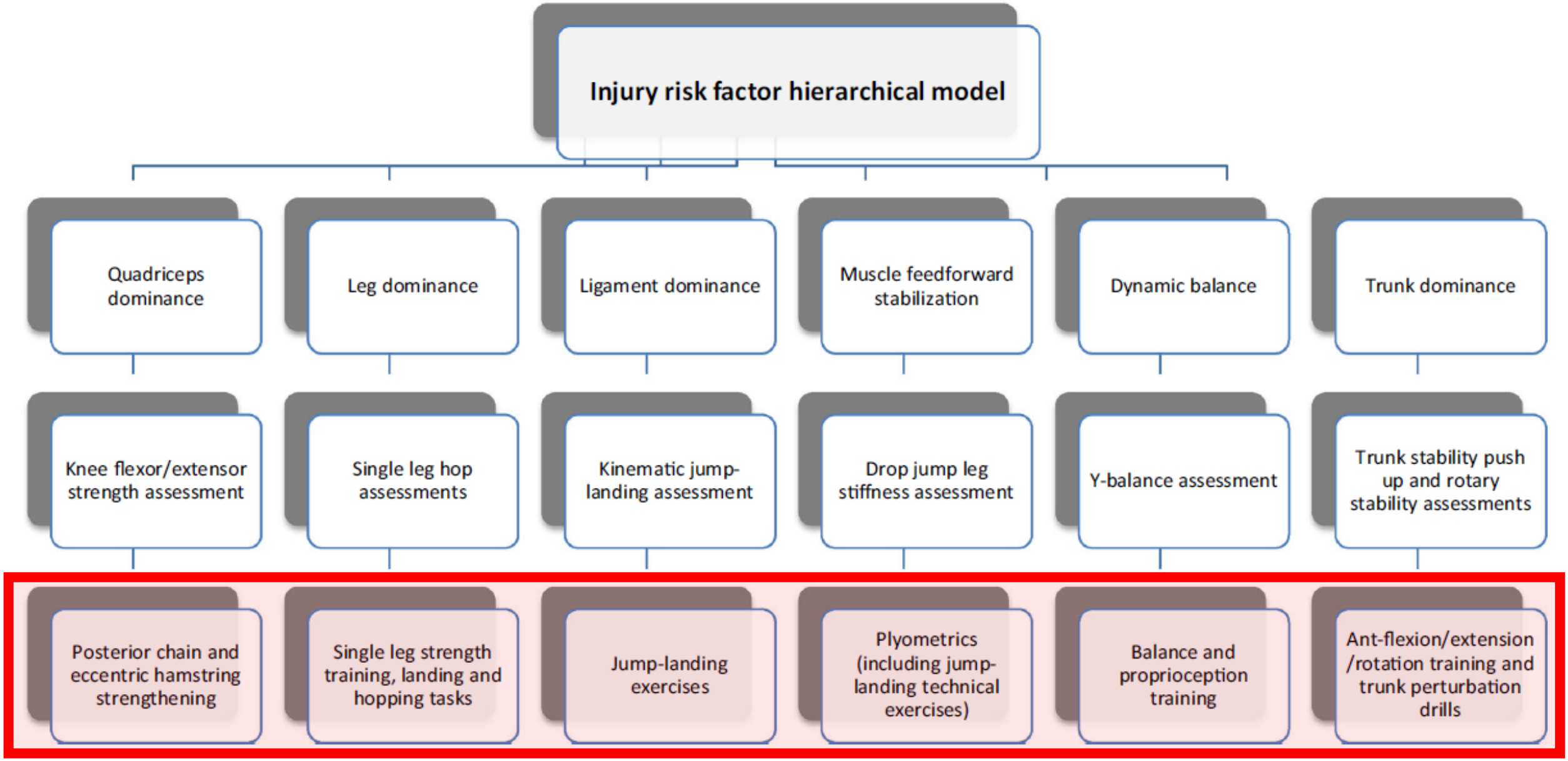
Risk factors for injuries

1. **Intrinsic factors**
2. **Extrinsic factors**
3. **Load management**

3 domains

1. Tissue capacity/tolerance
2. Actual Load
3. Frequencey/exposure

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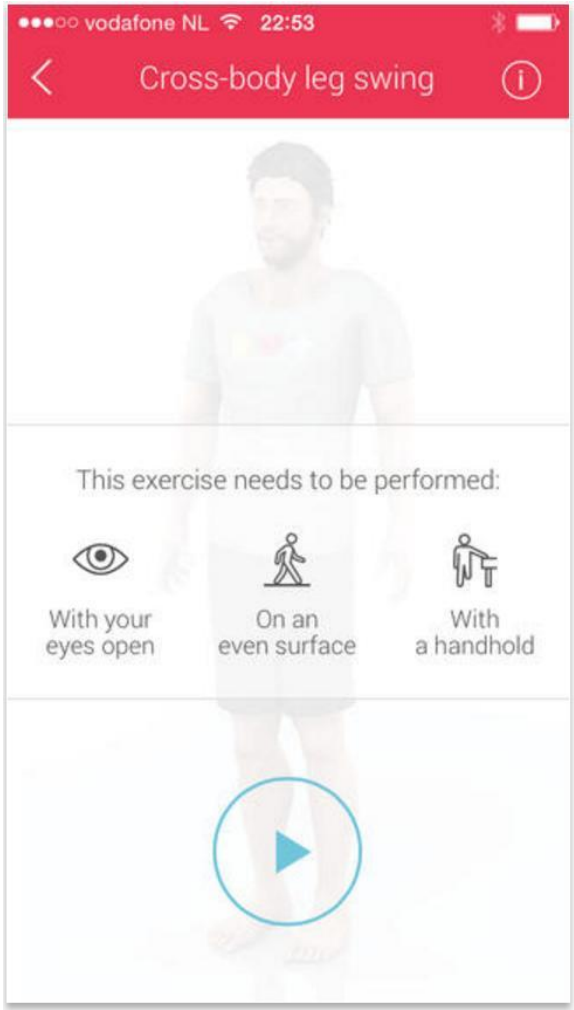
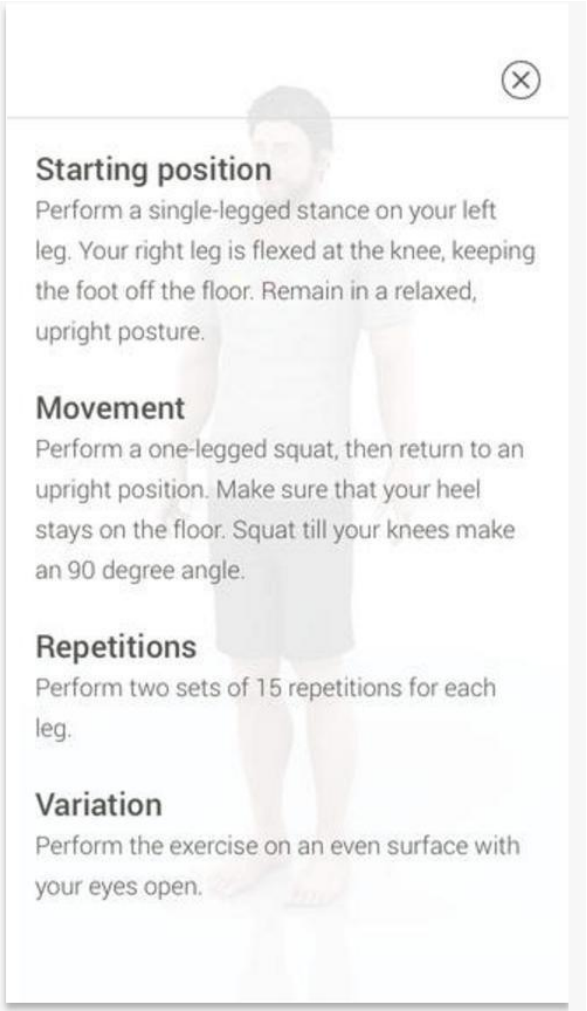
Ankle injuries – important elements

- Balance/proprioception
- Strength of ankle/foot evertor muscles
- Trunk control

Ankle injuries - APP



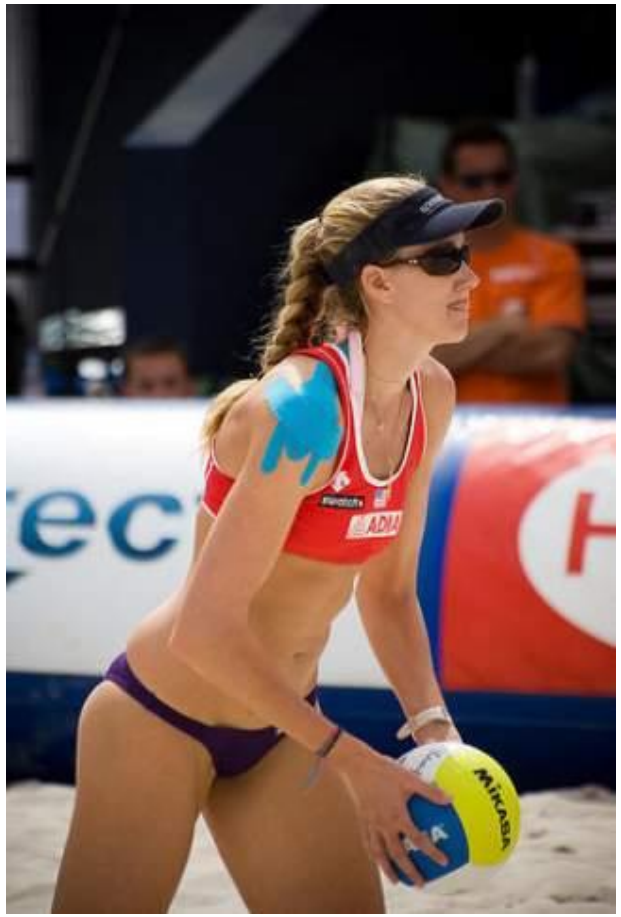


Taping and bracing

Useful ?

- Taping seems to be useful to prevent re-injury in the rehabilitation/return to sports phase.
- It is not known for how long one should wear a tape.
- Braces have not been evaluated adequately…but recent research supports their use for ankle sprains.

Kinesiotaping



K-tape

Kenzo Kase, chiropractor, Japan, 1980s

Stretches the skin and activates subcutaneous sensor/receptor, activate blood flow, stimulate or inhibit muscle contractions (depending on how it is applied)

Colours: **red → activates**, **blue → relaxes**

Preventive Interventions ANKLE

Braces 

Taping 

Supplements 

Stretching 

Warm-up 

Strengthening 

Rules of sport 

Equipment/ environment 

Jan Ekstrand

research leader in soccer injury prevention/management.

*« internal **communication** is essential, medical staffs must learn to communicate strategically about **performance** outcomes and **economic** outcomes. »*

Prevention training, anyone?

What does 'preventive training' prevent in competitive sport?

Per Bo Mahler,[1,2] Boris Gojanovic,[2] François Fourchet,[2] Finn Mahler[2]

So-called «prevention» exercises should not be labelled as such, but should be integrated as a regular part of training → **it will improve compliance**

Mahler PB et al, BJSM 2016

Prevention = performance

The Effects of Injury Preventive Warm-Up Programs on Knee Strength Ratio in Young Male Professional Soccer Players

36 male pro players 17-20 yrs

11+ for 2 months (3x/wk = 24 sessions)

Improvement hamstrg/quads ratio +8%

Daneshjoo A et al, PLOS one 2012 FREE

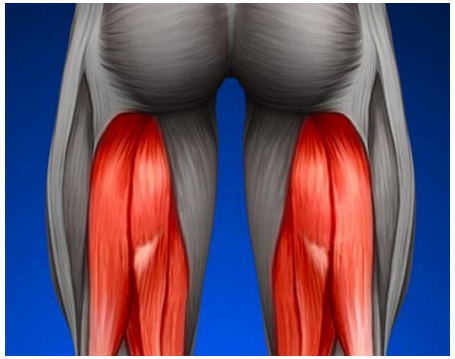
Performance

Inverse correlation between health status / number of **missed playing days** on soccer team and **performance** (standings Premier League)

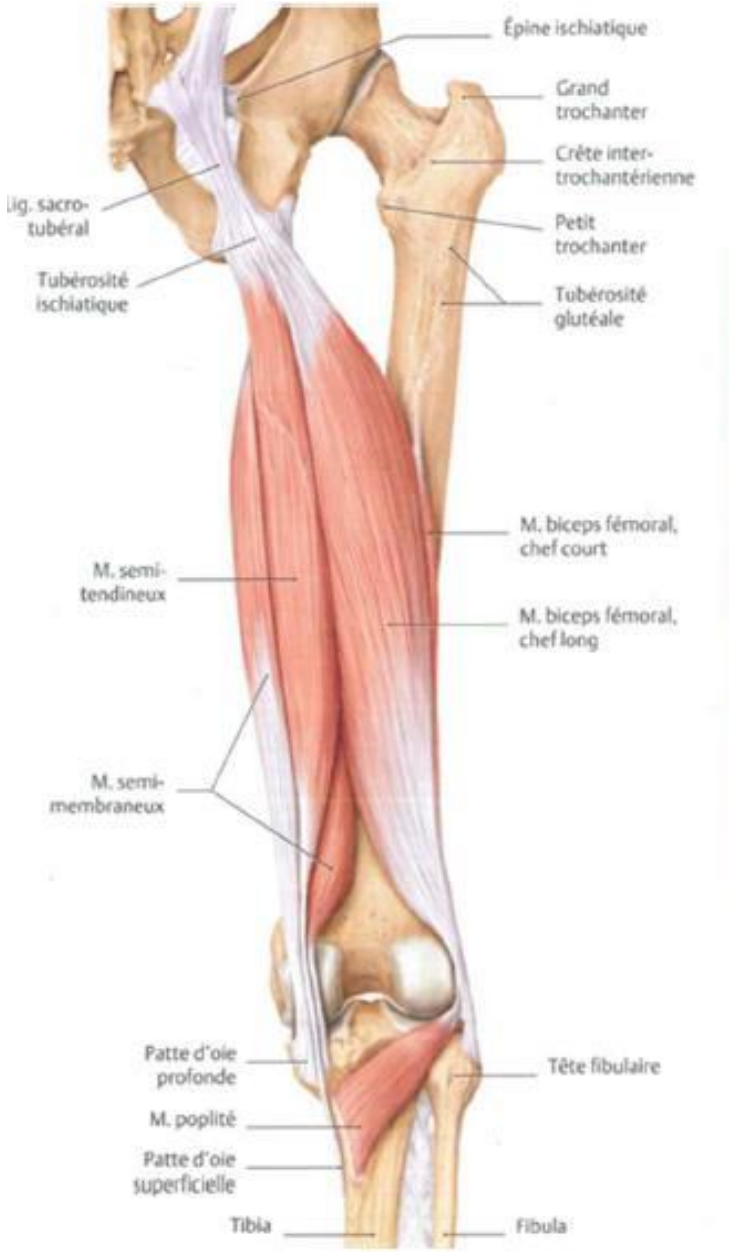
Costs

A Premier League's player absence for a month (severe injury) costs an estimated:

Euros 600'000.-



Ischial tuberosity



long

½ tendinosus (ST)
½ membr. (SM)

Biceps femoris (BF)
short

MEDIAL

LATERAL

Pes anserina

peronel head

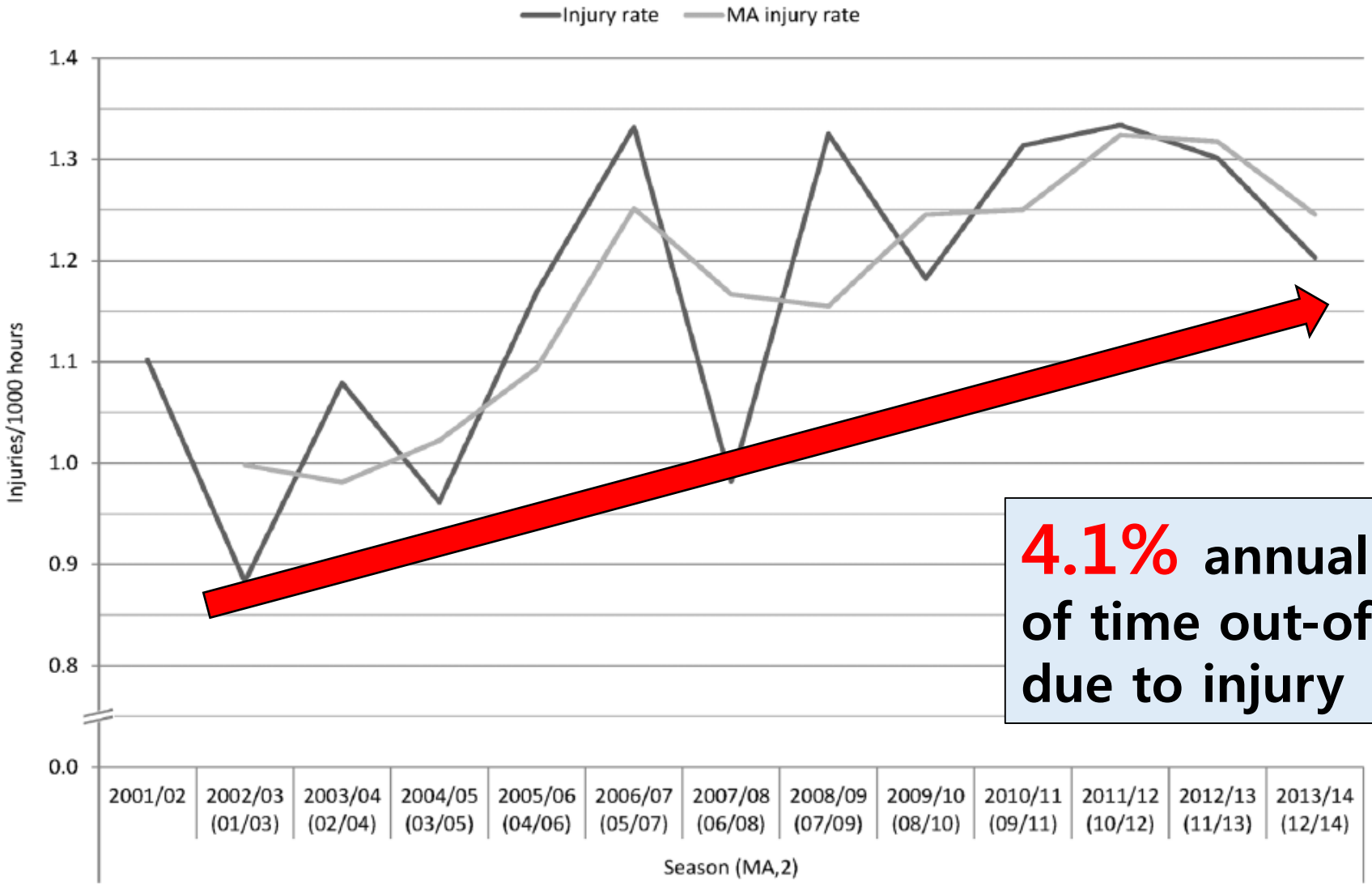
Epidemiology – hammies in pro foot

36 clubs, 12 countries, 14 yrs
(=5216 player-seasons)

- 50.5% of injuries to right side
- 5-6 injuries per season and per team
- 66% acute, 34% progressive onset

Ekstrand J et al, BJSM 2016

Incidence – evolution over 13 yrs



4.1% annual increase of time out-of-play due to injury

Incidence – hamstring 1.2/1000h

Training
0.51/1000h

x9

Match
4.77/1000h

Ekstrand J et al, BJSM 2016

Why such an evolution?

- **Match actions** have changed
  Between 2006 and 2012: 30% increase in high intensity running (distance and nb of repetitions)
- **More intense training** to simulate game situations (more sprints accel/deccel) → training stress is more important
- **Training < match** ? **survivors** are stronger (natural selection of those injured in training)

Barnes C et al, IJSM 2014;35:1095

Citius, altius, fortius

Sports are changing and the pattern of injuries can also be modified

Barnes C et al, IJSM 2014;35:1095

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Neeru Jayanthi…

Thank you

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