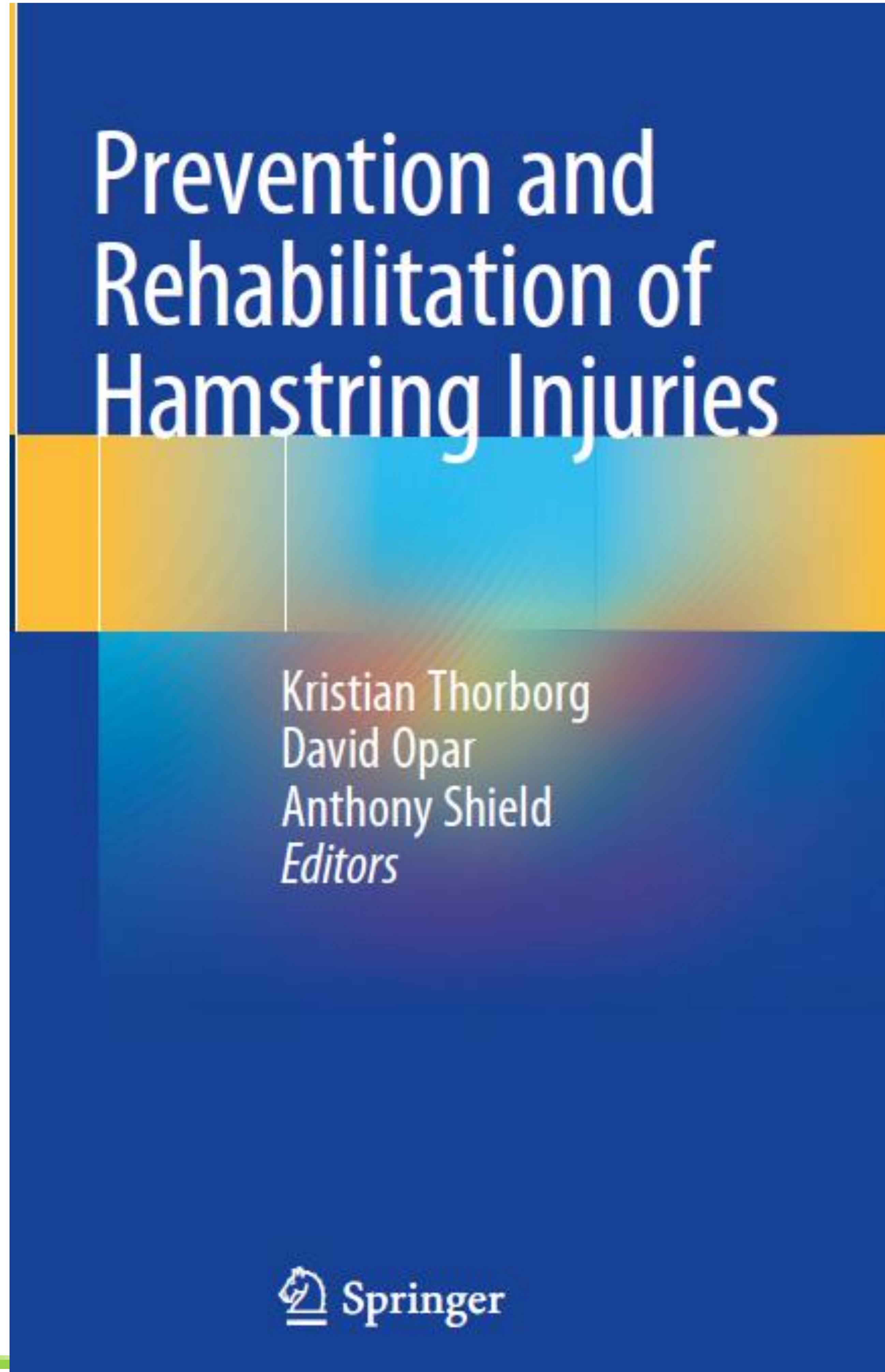
HAMSTRING INJURIES PREVENTION

Mostafa Zarei


Prevention and Rehabilitation of Hamstring Injuries
Kristian Thorborg
David Opar
Anthony Shield
Editors
Springer

- Hamstring strain injuries are among the most common sport injuries. Previous studies reported high hamstring injury incidence in track and field, soccer, American, rugby and Australian football.

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Exercise Interventions to Prevent Hamstring Injuries in Athletes: A Systematic Review and Meta-Analysis.

Rok Vatovec, Žiga Kozinc & Nejc Šarabon

Injuries in sport are problematic

- **Financial impact**

Open access | Original research

BMJ Open Sport & Exercise Medicine

Estimation of injury costs: financial damage of English Premier League teams' underachievement due to injuries

Eyal Eliakim,[1] Elia Morgulev,[2] Ronnie Lidor,[1] Yoav Meckel[1]

- **Team performance impact**

> Br J Sports Med. 2013 Aug;47(12):738-42. doi: 10.1136/bjsports-2013-092215. Epub 2013 May 3.

Injuries affect team performance negatively in professional football: an 11-year follow-up of the UEFA Champions League injury study

Martin Hägglund [1], Markus Waldén, Henrik Magnusson, Karolina Kristenson, Håkan Bengtsson, Jan Ekstrand

- **Player performance impact**

The Cost to Sports Teams

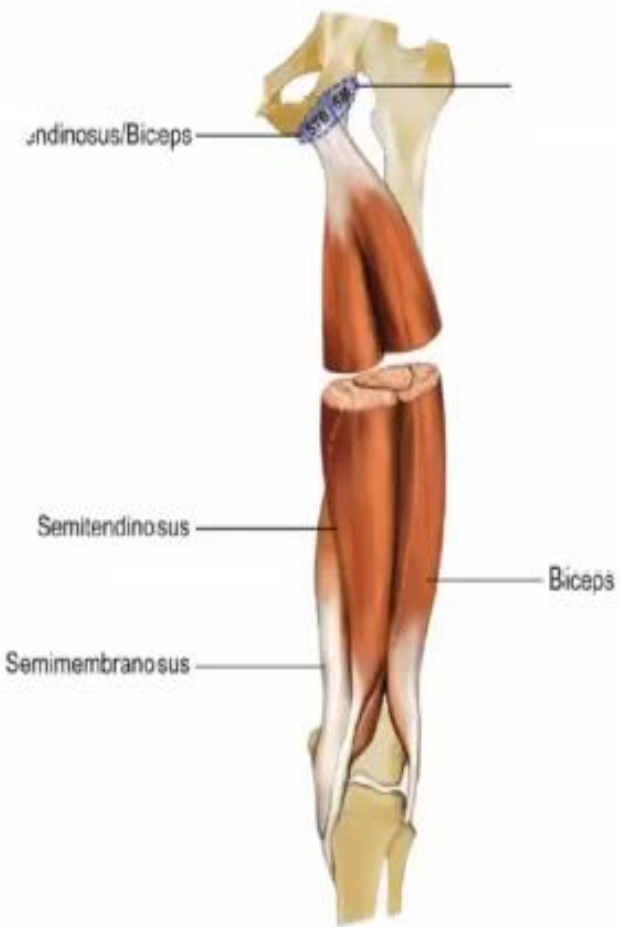
– In today's ultra-competitive culture, pro athletes are pushed to train and perform throughout the year more than ever. This is generating an on-going tsunami of injuries. To take the English Premier League as an example, Manchester United's squad have suffered a massive 187 injuries during the last three seasons, costing them at least 74 million US dollars in wages. In the 2017 season alone, just 6 of the top EPL clubs accrued 15,268 days of player injuries.

Club	Injury days	Injuries accrued	Most common injury
Liverpool	4,153	162	Knee injury (607 days)
Arsenal	4,131	147	Knee injury (483)
Manchester United	4,096	187	Ankle injury (492)
Manchester City	2,795	146	Hamstring injury (571)
Tottenham	2,751	124	Ankle injury (710)
Chelsea	1,499	98	Knee injury (289)

Table 1 Injuries' impact on team achievements in the 2016–2017 season of the EPL

Club	No of injuries	Days lost	Team worth (in millions of Pounds Sterling)	Expected rank	Actual rank	Rank difference	Expected points	Actual points	League points lost
Man United	75	1262	481	1	6	-5	93	69	–24
Chelsea	46	877	466	2	1	1	86	93	7
Man City	51	1153	466	3	3	0	78	78	–8
Arsenal	71	1573	422	4	5	-1	76	75	–1
Liverpool	81	1840	348	5	4	1	75	76	1
Tottenham	55	1029	329	6	2	4	69	86	17
West Ham	82	2191	217	7	11	-4	61	45	–16
Everton	41	1618	215	8	7	1	46	61	15
Leicester	44	885	189	9	12	-3	46	44	–2
Southampton	52	1655	179	10	8	2	45	46	1
Stoke	60	1624	155	11	13	-2	45	44	–1
Crystal Palace	67	1857	142	12	14	-2	44	41	–3
Watford	77	1852	117	13	17	-4	44	40	–4
Bournemouth	52	1163	110	14	9	5	41	46	5
West Brom	36	203	97	15	10	5	41	45	4
Swansea	44	991	95	16	15	1	40	41	1
Middlesborough	48	1055	95	17	19	-2	40	28	–12
Sunderland	85	2265	83	18	20	-2	34	24	–10
Hull City	49	2289	70	19	18	1	28	34	6
Burnley	35	822	60	20	16	4	26	40	16

- ➢ Muscle injury/strains account for around a third of all injuries



BJSM

Injury incidence and injury patterns in professional football: the UEFA injury study

J Ekstrand,[1,2] M Hägglund,[1] M Waldén[1]

Table 3 Injury pattern by severity of injuries

	Total	1–3 Days	4–7 Days	8–28 Days	>28 days
Injury location					
Head and neck	77 (2)	19 (2)	23 (2)	29 (2)	6
Neck/cervical spine	23	11 (1)	8	3	1
Shoulder/clavicule	80 (2)	12 (1)	16 (1)	30 (2)	22 (3)
Upper arm	3	1	2	0	0
Elbow	24	3	10	8	3
Forearm	5	1	0	2	2
Wrist	8	1	1	4	2
Hand/finger/thumb	38	8	6	16	8
Sternum/ribs/upper back	47 (1)	9	16 (1)	19 (1)	3
Abdomen	31	3	7	17 (1)	4
Lower back/pelvis	237 (5)	74 (8)	78 (7)	66 (4)	19 (3)
Hip/groin	616 (14)	119 (12)	169 (15)	256 (16)	72 (10)
Thigh	1064 (23)	184 (19)	272 (23)	469 (28)	139 (20)
Knee	818 (18)	183 (19)	155 (13)	268 (16)	212 (30)
Lower leg/Achilles tendon	511 (11)	116 (12)	132 (11)	178 (11)	85 (12)
Ankle	625 (14)	150 (15)	185 (16)	220 (13)	70 (10)
Foot/toe	268 (6)	75 (8)	81 (7)	63 (4)	49 (7)
Unknown	8	2	3	3	0
Injury type					
Fracture	160 (4)	7	9	59 (4)	85 (12)
Other bone injury	26	5	1	6	14 (2)
Dislocation/subluxation	50 (1)	5	4	24 (1)	17 (2)
Sprain/ligament injury	828 (18)	123 (13)	197 (17)	334 (20)	174 (25)
Meniscus/cartilage	124 (3)	3	7	41 (2)	73 (10)
Muscle injury/strain	1581 (35)	212 (22)	397 (34)	765 (46)	207 (30)
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Haematoma/contusion	744 (17)	306 (32)	282 (24)	141 (9)	15 (2)
Abrasion	7	3	3	1	0
Laceration	31	10 (1)	11	10	0
Concussion	34	5	14 (1)	14	1
Nerve injury	29	7	3	14	5
Synovitis/effusion	158 (4)	55 (6)	36 (3)	55 (3)	12 (2)
Overuse complaints	285 (6)	110 (11)	99 (9)	59 (4)	17 (2)
Other type	91 (2)	23 (2)	27 (2)	24 (1)	17 (2)
Total injuries	4483	971	1164	1651	697

Values within brackets show percentage of total (values below 1% not shown).

- Hamstring injuries are the most common of <u>ALL</u> injuries in football

12%

Epidemiology of Muscle Injuries in Professional Football (Soccer)

Jan Ekstrand,*† MD, PhD, Martin Hägglund,† PT, PhD, and Markus Waldén,† MD, PhD
Investigation performed at Linköping University, Linköping, Sweden

TABLE 2
Incidence, Prevalence, and Nature of 4 Most Common Muscle Injuries

	Hamstrings	Quadriceps	Adductors	Calf Muscles
n (% of total no. of injuries)	1084 (12)	485 (5)	672 (7)	368 (4)
Season prevalence, %	17	8	14	6
Total injury incidence (95% confidence interval)	0.92 (0.87-0.98)	0.41 (0.38-0.45)	0.57 (0.53-0.62)	0.31 (0.28-0.35)
Injury incidence, training[a]	0.43 (0.39-0.47)	0.28 (0.25-0.32)	0.32 (0.29-0.36)	0.18 (0.16-0.21)
Injury incidence, match[a]	3.70 (3.43-3.99)	1.15 (1.00-1.32)	2.00 (1.80-2.22)	1.04 (0.90-1.20)
Injury severity (%)				
Minimal (1-3 days)	140 (13)	60 (12)	119 (18)	50 (14)
Mild (4-7 days)	272 (25)	120 (25)	210 (31)	93 (25)
Moderate (8-28 days)	556 (51)	233 (48)	275 (41)	177 (48)
Severe (>28 days)	116 (11)	72 (15)	68 (10)	48 (13)
Days of absence/injury, mean ± SD	14.3 ± 14.9	16.9 ± 19.2	14.0 ± 24.3	14.7 ± 14.4
Injury burden[b]	13.2 (13.0-13.4)	7.0 (6.8-7.1)	8.0 (7.8-8.2)	4.6 (4.5-4.7)
Reinjuries (%)	174 (16)	81 (17)	124 (18)	48 (13)

[a]Injury incidence for muscle injuries expressed as number of injuries/1000 hours of total exposure (95% confidence interval).
[b]Injury burden expressed as number of days' absence/1000 hours of total exposure (incidence × mean absence) (95% confidence interval).

THEY CAN BE FRUSTRATING INJURIES

Frustration with hamstring injuries includes:

- prolonged on-going symptoms,
- poor healing and;
- high risk of re-injury of 12-31%

Woods et al., 2004; Orchard & Stewart, 2002; Ekstrand et al., 2011

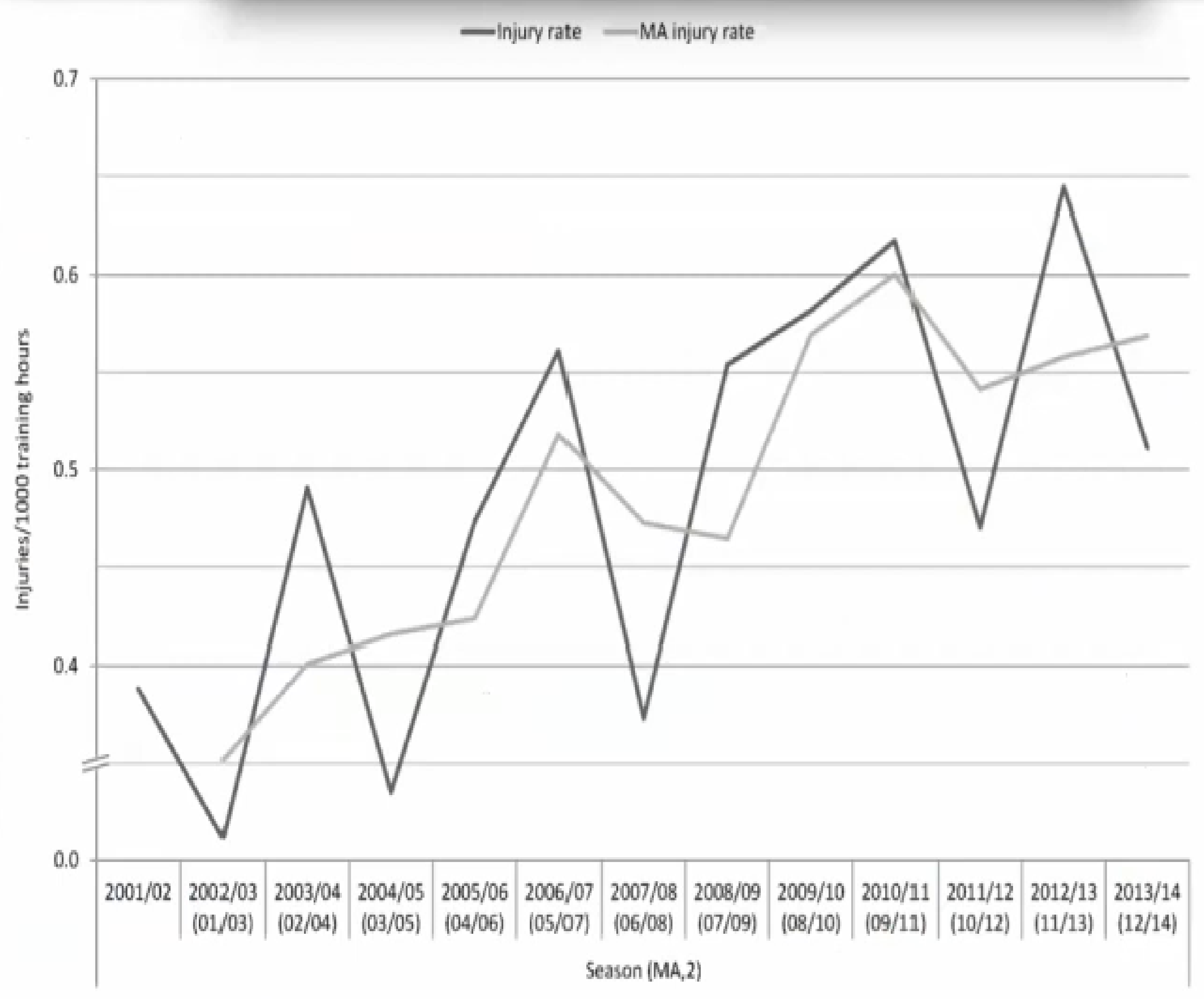
their incidence is also continuing to rise yearly

BJSM

Hamstring injuries have increased by 4% annually in men's professional football, since 2001: a 13-year longitudinal analysis of the UEFA Elite Club injury study

Jan Ekstrand,[1,2,3] Markus Waldén,[1,2] Martin Hägglund[2,4]

A 4% annual increase in hamstring injury incidence despite increased understanding of injury mechanisms and prevention



Anatomy of the Hamstrings

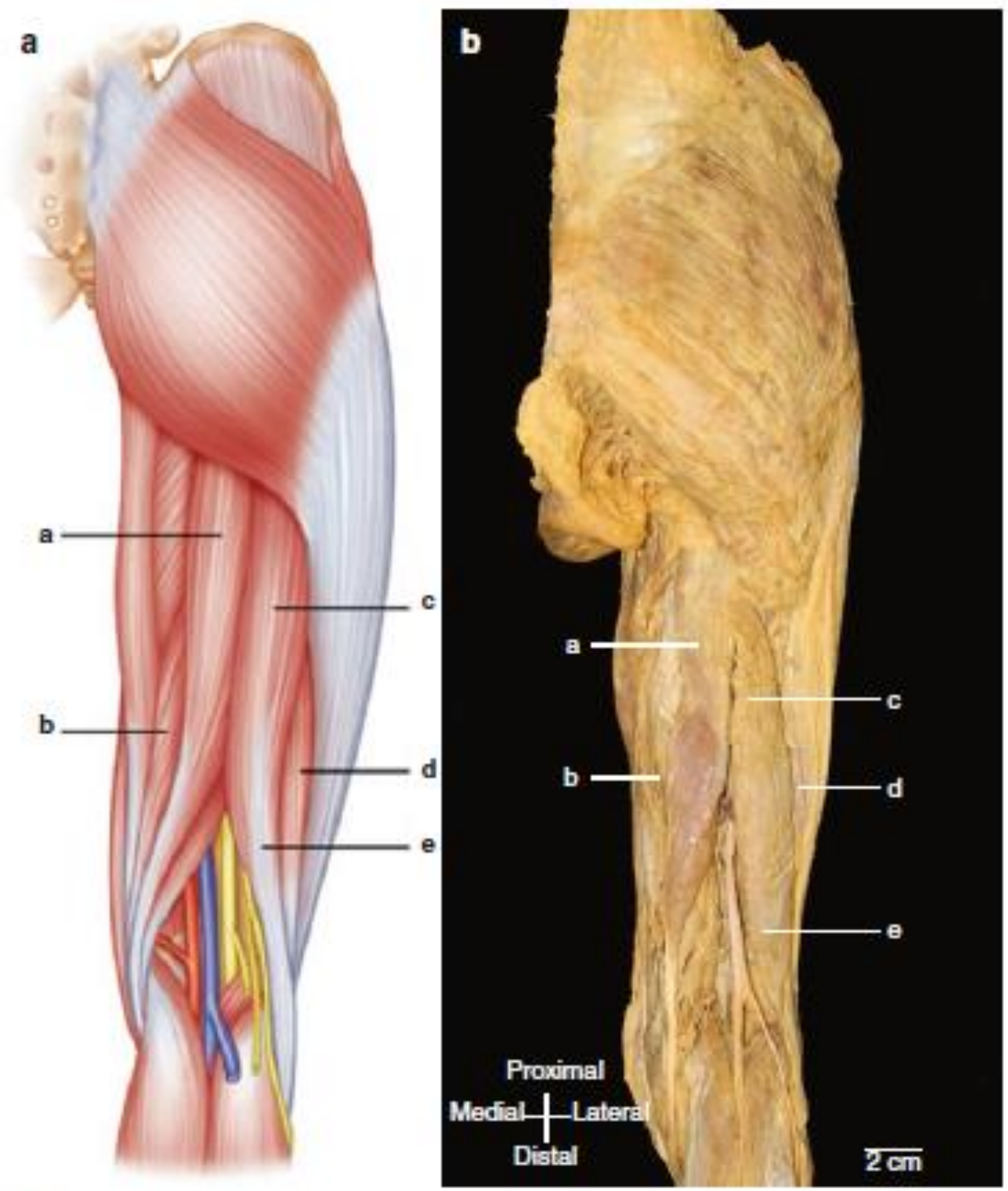
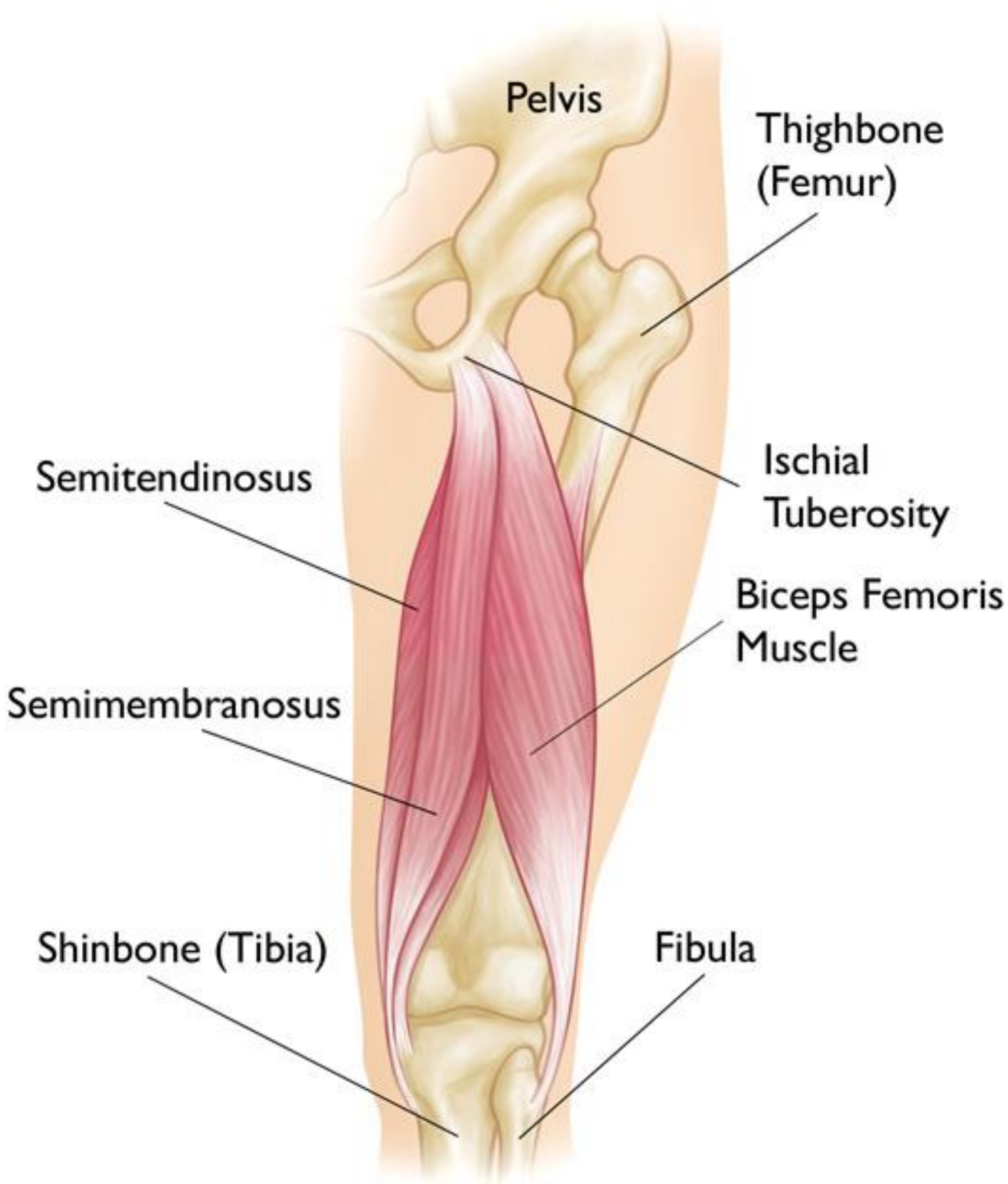


Fig. 1.1 Illustration (**a**) and dissection (**b**) of the right posterior thigh demonstrating the gross anatomy of the hamstring muscle group. The hamstrings consist of ST (**a**) and SM (**b**) on the medial side and the long head (**c**, **e**) and short head (**d**) of BF, laterally. (Figure **a** printed with permission from Kaeding and Borchers (2014) [1])

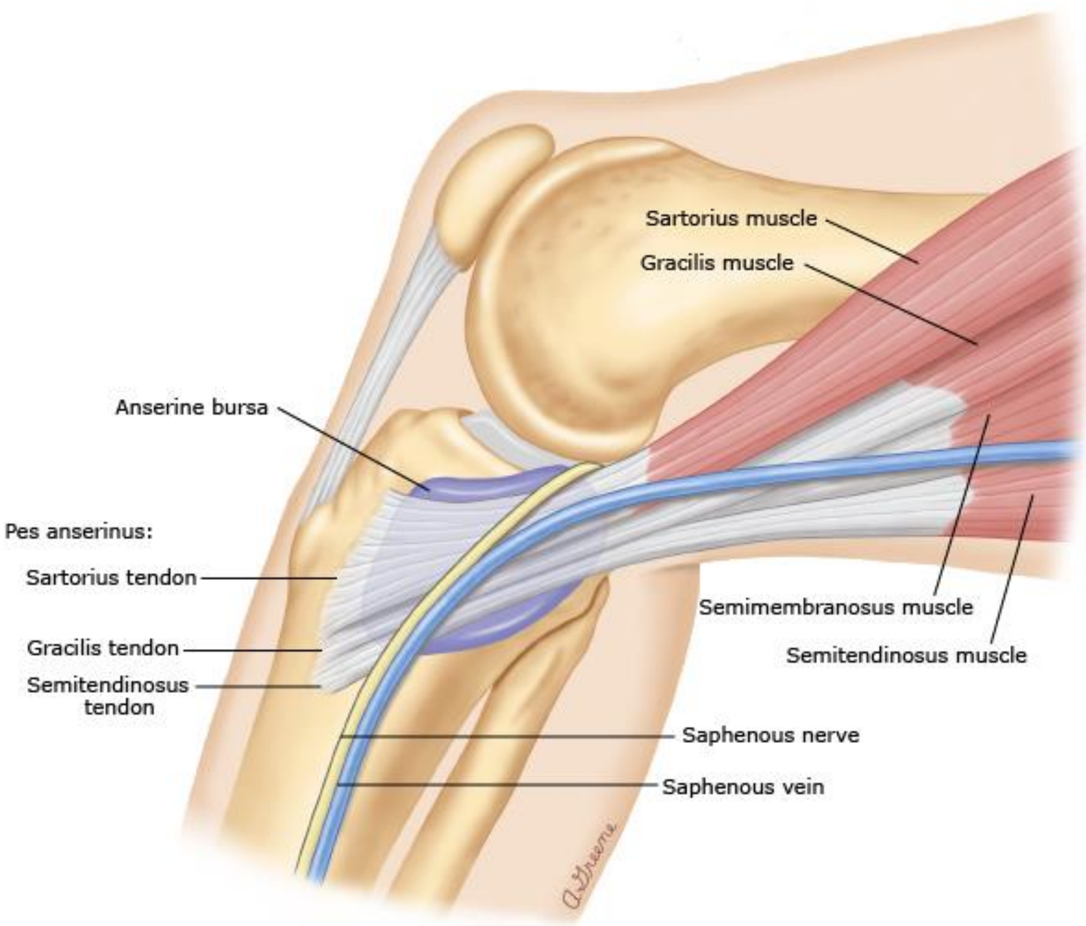
Anatomy


Pelvis
Thighbone
(Femur)
Ischial
Tuberosity
Semitendinosus
Biceps Femoris
Muscle
Semimembranosus
Shinbone (Tibia)
Fibula

- سه عضله دوسررانی، نیم وتری و نیم غشایی است که در قسمت خلفی ران قرار دارند.
- عمل این عضلات بازکردن ران و خم کردن زانو است و هر سه عضله به وسیلهٔ عصب سیاتیک عصب دهی میشوند. Ham به حفرهٔ پشت زانو و به Stringتاندونهای موجود اشاره دارد.

- دو سر رانی: تاندون دیستال عضله ی دو سر رانی دراز ترین تاندون در مجموعه ی همسترینگ است که به طور متوسط ۲۷ سانتی متر ارزیابی شده است که تا٦٥ تا ٦٠٪ طول عضله همسترینگ کشش پذیر است
- نیم غشایی: تاندون دیستال این عضله نقش کلیدی در سمت داخل پشتی پا دارد که موقعیت آن در نزدیکی لیگامنت کولترال داخلی و لیگامان ابلیک پشتی و در نهایت به سمت شاخ پشتی مینیسک داخلی قرار می گیرد. در زانو نیم غشایی عملکرد یک مقاوم در برابر نیروی والگوس (زمانی که زانو در حال اکستنشن است)و چرخاننده ی خارجی در زمان خم بودن زانو را دارد

- نیم وتری: این عضله مبدا مشترک با سر دراز بایسپس از ایسکیوم لگن دارد همچنین به دلیل ساخته شدن تقریبا نیمی از جرمش (semi) از تاندون (tendinousis) به این نام معروف است، تاندون دیستال این عضله دراز و باریک بر روی سطح عضله ی نیم غشایی قرار گرفته است.
- نیم وتری همراه با تاندون دیستال عضله ی خیاطه و گراسیلیس، در ناحیه ی قدام داخلی پروگزیمال استخوان تیبیا چسبیده و "پس انسرینوس" را میسازند.



- شایعترین محل آسیب عضلات همسترینگ عضله دوسررانی (سردراز) و سپس نیم وتری و نیم غشایی است. ممکن است بخشی از این امر، به دلیل مکانیسم آسیب همسترینگ باشد اما در بسیاری از موارد، در هر آسیب بیشتر از یک عضله همسترینگ صدمه میبیند.
- عضلات همسترینگ با دسته ای از بخش اعصاب سیاتیک به استثنا سر کوتاه دوسر رانی که به وسیله ی عصب فیبولار تحریک میشود، عصب دهی شده است.
- دانشمندان معتقدند که آناتومی و ساختار خاص همسترینگ از جمله دو مفصله بودن سر دراز دو سر رانی دو لایه بودن تحریکات عصبی در دوسر رانی و کوتاهی فاشیای این ناحیه دلیل آسیب پذیر بودن این ناحیه به شمارمیرود

سوال

- کدام بخش عضله همسترینگ بیشتر آسیب می بیند: سر ثابت یا سر متحرک؟ با توجه به مکانیزم وقوع آسیب توضیح دهید.

اپیدمیولوژی آسیبهای همسترینگ در ورزش

- استرین شایع ترین آسیب
- در فعالیت هایی اتفاق می افتد که نیازمند حرکت و شتاب ناگهانی و حداکثر سرعت است

جدول (۶-۱): خطر کشیدگی همسترینگ در ورزش های مختلف.اعداد گزارش شده میانگین برآورد شده‌ای براساس اطلاعات موجود هستند.

ورزش	بروز در مسابقه[1]	بروز در تمرین[1]	رتبه[2]
دو سرعت	---	---	(۳۸درصد -۲۸/۶درصد) ۱
راگبی	۵/۶	۰/۳	(۱۰/۷درصد -۹/۷ درصد) ۱
فوتبال استرالیایی	۳/۷-۸/۶	NA	(۲۳/۸درصد -۱۳/۷درصد) ۱
فوتبال مردان	۲/۴-۴/۱	۰/۴-۰/۷	(۱۶/۵درصد -۱۱/۰ درصد) ۱
فوتبال زنان	NA	NA	(۱۳/۱درصد) ۱
فوتبال آمریکایی	NA	NA	(۴/۹درصد) ۲

تشخیص آسیبهای همسترینگ

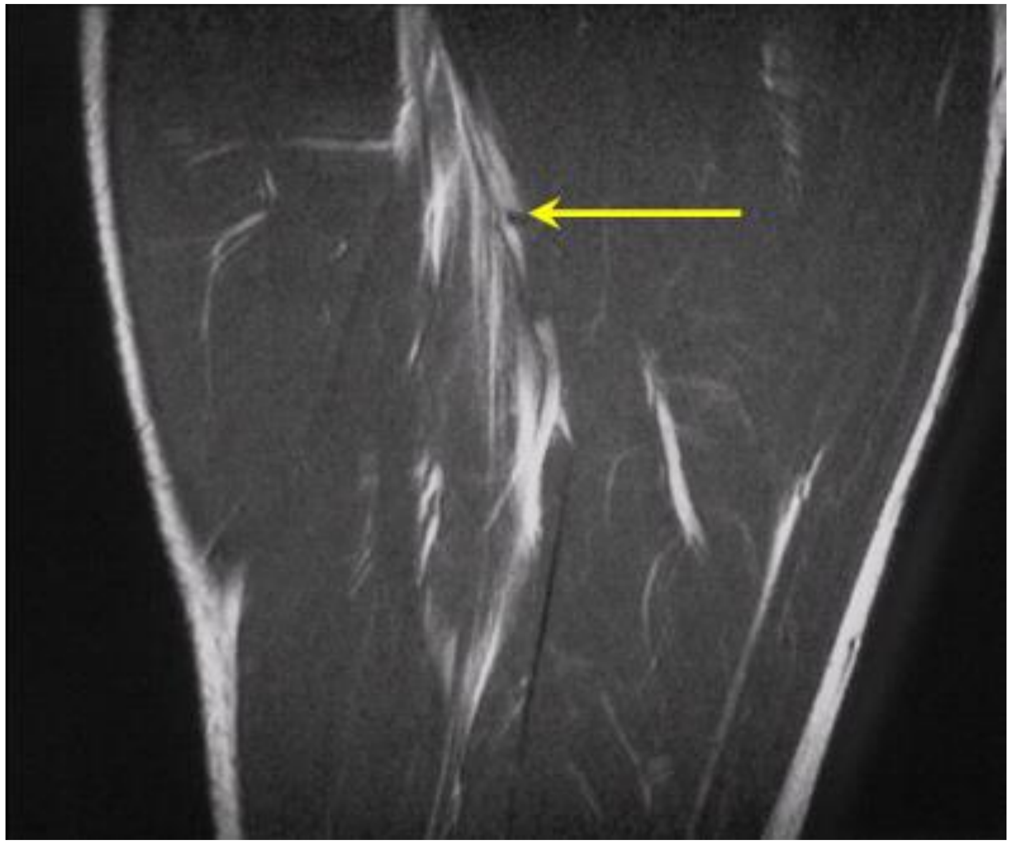
- شروع ناگهانی درد در پشت ران در لحظه ای است که فرد افزایش سرعت یا شتاب دویدن

علایم بالینی

- شایعترین نشانه بالینی، دردی است که هنگام مقاومت در برابر انقباض عضلات همسترینگ ایجاد می شود و با حساسیت زیاد به هنگام لمس در قسمت ران و کبودی

MRI

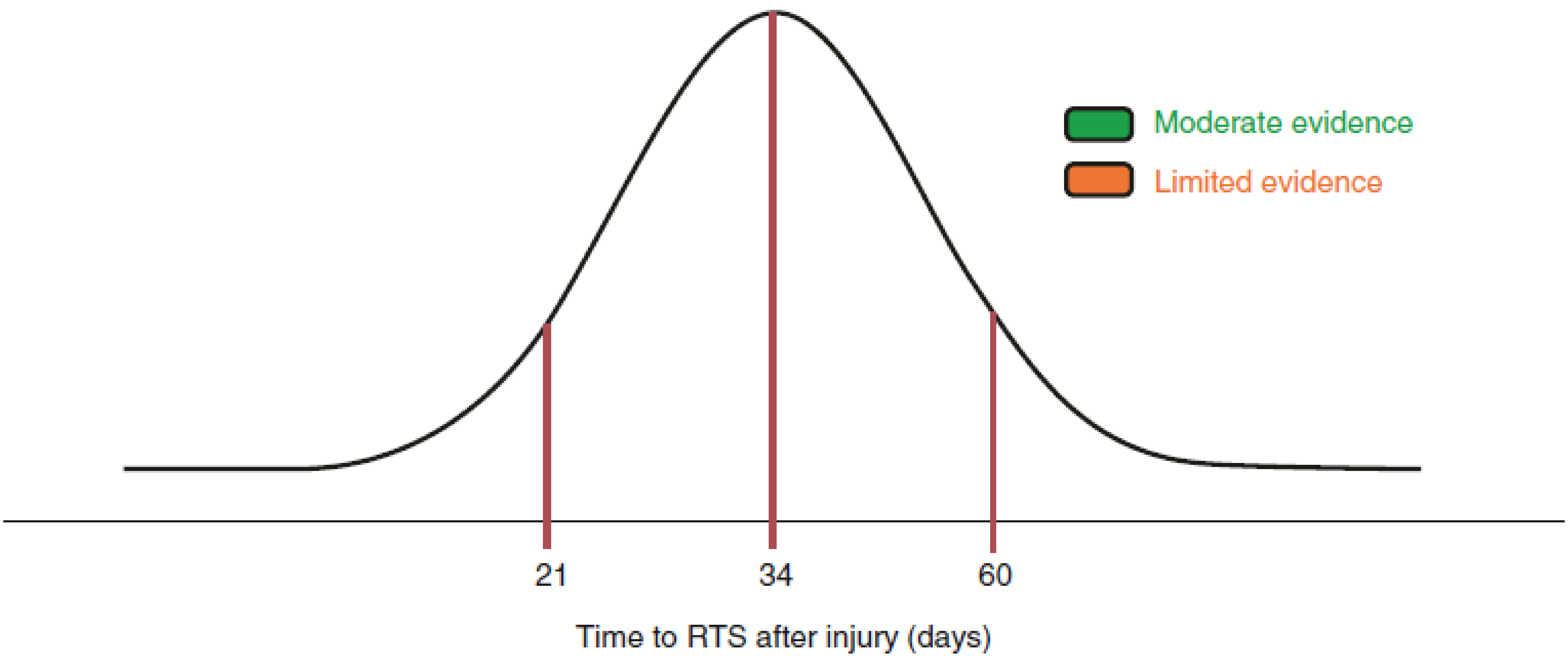
قابلیت هایی در پیش بینی روند بهبودی آسیبدیدگی [۴] دارد



Hyperintensity of the proximal portion of the long head of biceps femoris muscle is compatible with a strain (arrow).

از دست دادن زمان در اثر آسیب همسترینگ

- ماهیت دردآفرین این آسیب، دامنه تعداد روزهای غیبت از ورزش میتواند به طور چشمگیری افزایش یابد.
- بین دو تا سه هفته
- این آسیب از آسیبهای پر تکرار و رایج است.
- وقوع مجدد بین ۱۲ درصد تا ۳۵ درصد گزارش شده است.
- تیمهای جوانتر و ورزشکاران خردسال کمتر دچار آسیب همسترینگ میشوند.

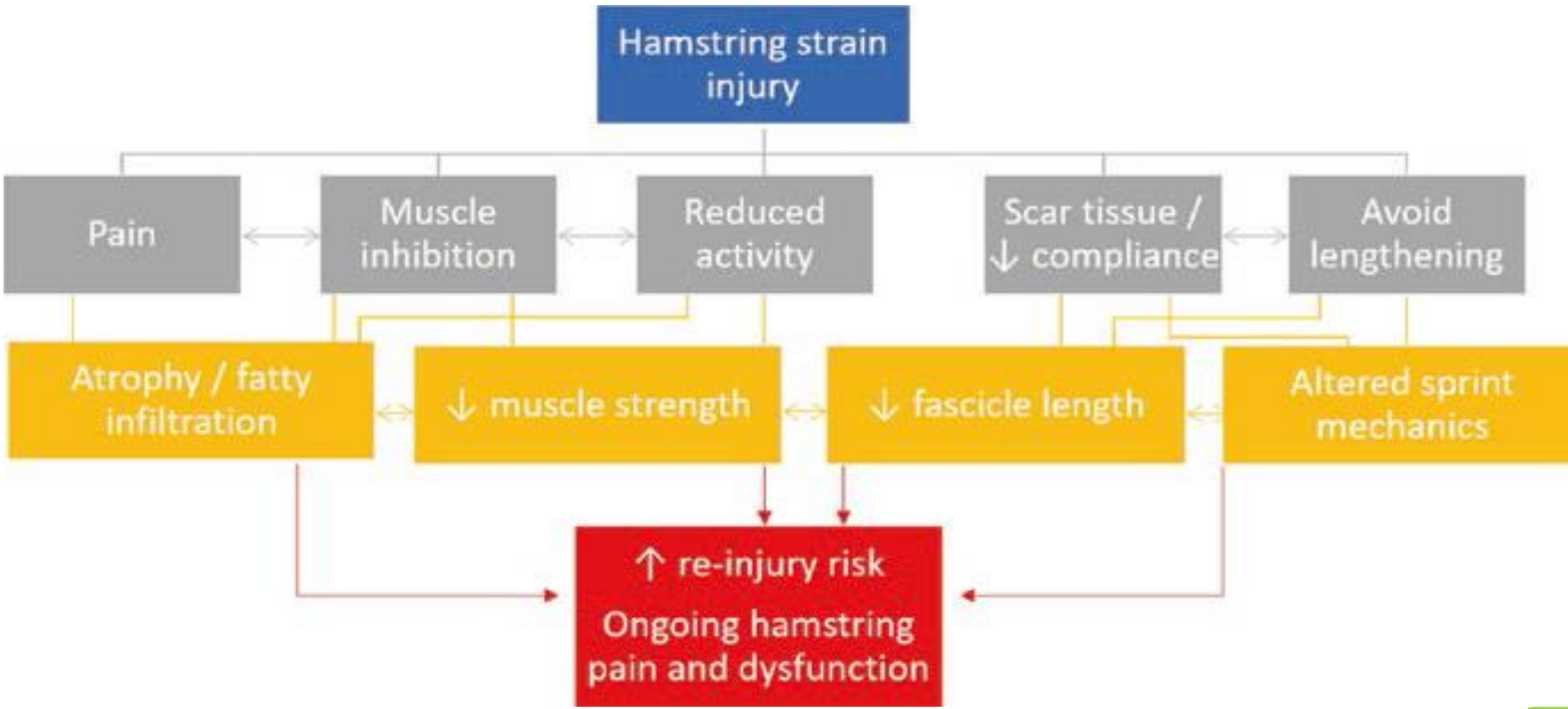


Moderate evidence
Limited evidence
21
34
60
Time to RTS after injury (days)

عوامل خطر ساز کلیدی

عوامل خطر ساز	خطر نسبی[1]	شواهد[2]	مدارک (شواهد علمی)
عوامل خطر ساز درونی			
کشیدگی همسترینگ قبلی	۲/۱–۱۱/۶	++	مطالعات آینده‌نگر قوی
وسعت کشیدگی همسترینگ ≤ ۲۱۸ cm^3	۲/۳	+	اندازه گیری با MRI
سابقه آسیب زانو	۵/۶	+	
افزایش سن	۱/۱–۱/۴	++	مستقل از سابقه آسیب همسترینگ
نژاد			
نژادهای بومی در فوتبال استرالیایی	۱۱/۲	+	فقط یک مطالعه
فوتبالیست سیاه پوست	NA	+	فقط یک مطالعه
کاهش قدرت عضله همسترینگ	NA	+	مطالعات متناقض
انعطاف پذیری عضله همسترینگ	NA	۰	مطالعات ضعیف
جنسیت	NA	۰	نبود تحقیق
عوامل خطر ساز بیرونی			
خستگی عضلانی	NA	+	مطالعات مشاهده‌ای
بازی در مسابقات سطوح بالاتر	NA	+	مطالعات مشاهده‌ای
گرم کردن ناکافی	NA	۰	نبود مدارک
پست بازی	NA	+	مطالعات مشاهده‌ای

- آسیب قبلی خواص و ماهیت عضله را تغییر می دهد.
- پس از آسیب و ترمیم عضلانی، توانایی جذب نیروی تارهای عضلانی کاهش می یابد و عضله بیشتر مستعد آسیب دوباره می شود.
- بافت اسکار عضلات روی خواص عضله اثر میگذارد به ویژه کم شدن انتقال نیرو از عضله به تاندون موجب میشود عضله در معرض افزایش خطر آسیب دوباره قرار بگیرد
- In fact, 59% of all recurrent hamstring injuries occur within the first month after RTP



Hamstring strain injury
Pain
Muscle inhibition
Reduced activity
Scar tissue / ↓ compliance
Avoid lengthening
Atrophy / fatty infiltration
↓ muscle strength
↓ fascicle length
Altered sprint mechanics
↑ re-injury risk
Ongoing hamstring pain and dysfunction

سن بالای ورزشکاران

- مطالعات نشان داده اند که افزایش سن، با کاهش سطح مقطع عرضی عضلات اسکلتی همراه است.
- میزان عصب برداری فیبرهای عضلانی با افزایش سن ، بیشتر می شود.
- کاهش انعطاف پذیری و افزایش خستگی عضله

وسعت کشیدگی عضلات همسترینگ

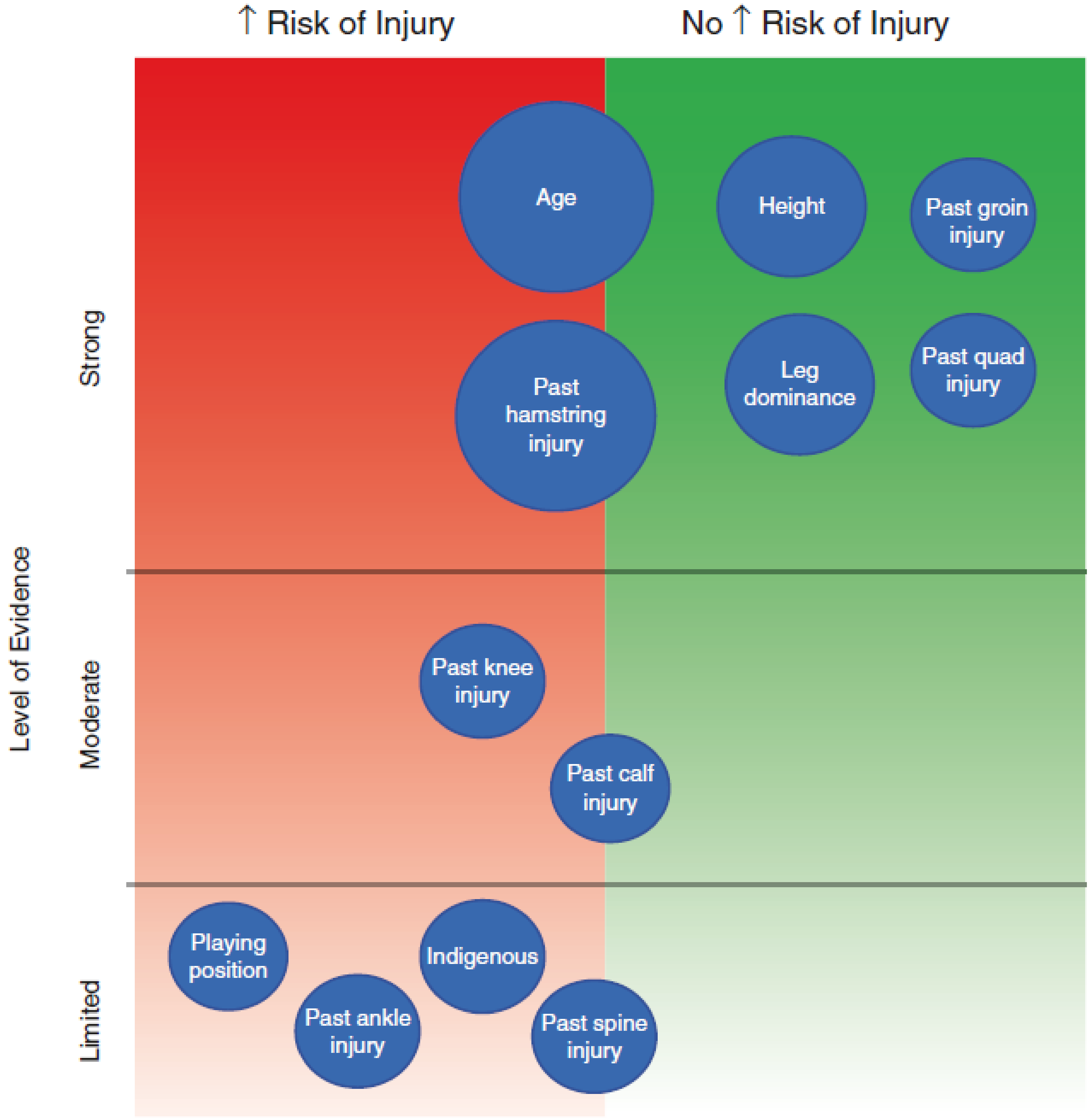
- ورزشکارانی که دچار کشیدگی عضلانی در مقیاس بزرگ بیش از ۲۰ سانتی متر در مقایسه با ورزشکارانی که کشیدگی عضلانی در مقیاس کوچکتری دارند؛ بیشتر در معرض خطر آسیب دوباره قرار می گیرند.
- بافت زخم، اتروفی
- ویسکوالاستیک

نژاد

- فوتبالیستهای سیاه پوست غیر بومی و بازیکنان فوتبال استرالیایی بومی به طور قابل توجهی بیشتر از بازیکنان سفید پوست، کشیدگی همسترینگ را متحمل میشوند.
- که این بازیکنان، به طور کلی در ورزش خاصی در مقایسه با همتایان سفید پوست خود سریعتر باشند. این امر به این نتیجه گیری منجر میشود که عضلات این ورزشکاران به علت اینکه به نسبت، میزان فیبرهای عضلانی نوع دوم بیشتری دارد

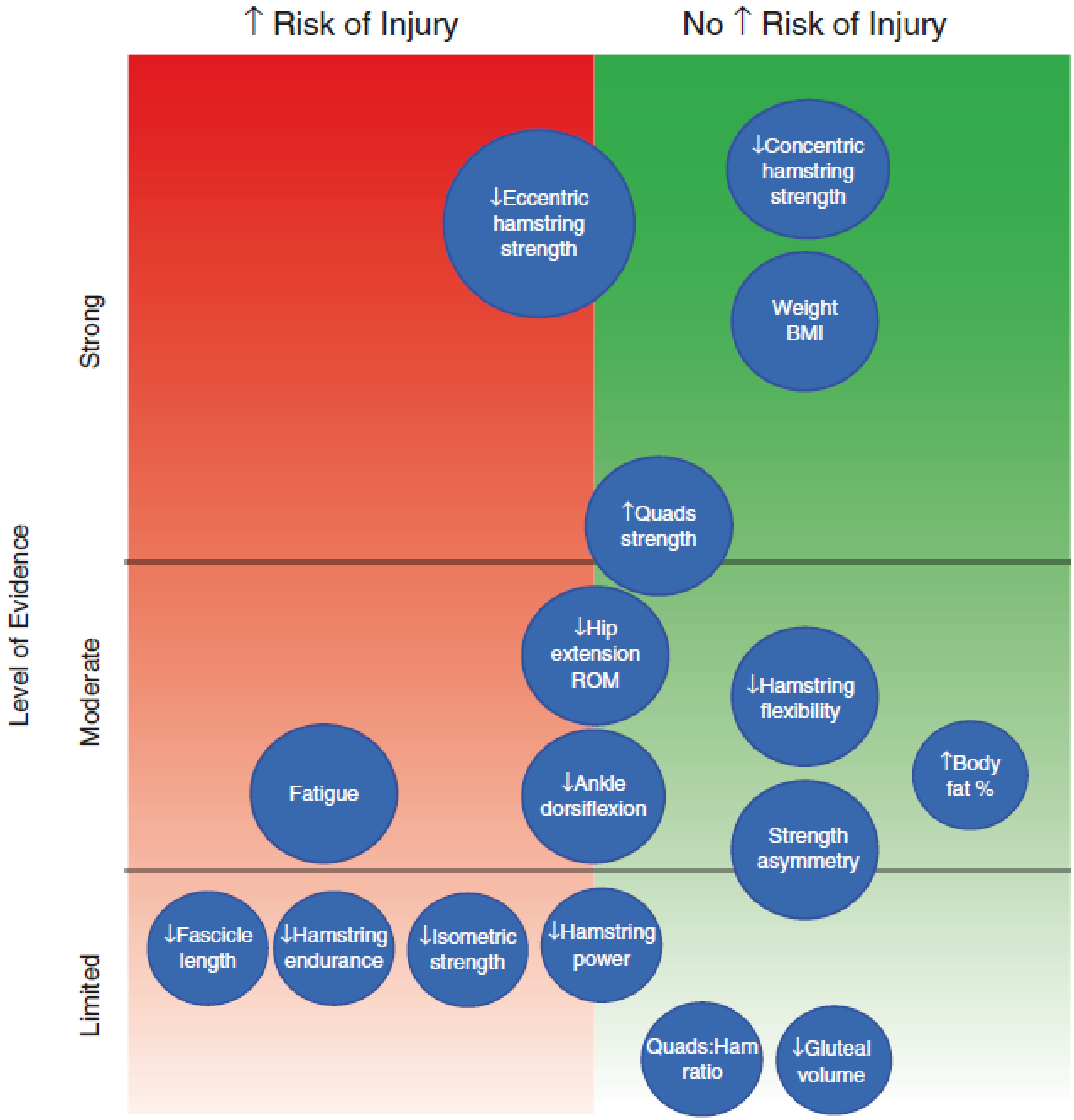
خستگی

- عضله همسترینگ در شرایط خستگی در مقایسه با شرایط بدون خستگی، میزان جذب نیروی کمتری دارد
- همسترینگ در زمان دویدن، جذب نیرویی است که به وسیلۀ پای متحرک تولید میشود. کاهش میزان جذب نیرو، میتواند دلیل احتمالی افزایش خطر آسیب دیدگی در عضلات خسته باشد.


↑ Risk of Injury
No ↑ Risk of Injury
Level of Evidence
Strong
Moderate
Limited
Age
Height
Past groin injury
Past hamstring injury
Leg dominance
Past quad injury
Past knee injury
Past calf injury
Playing position
Indigenous
Past ankle injury
Past spine injury

Clinical Implications: Extrinsic Factors

- Training load influences risk of hamstring injury and performance. As yet, no specific metric demonstrates overall effectiveness in identifying which players will be injured.
- Higher chronic training loads could potentially lower the risk of hamstring injury.
- Avoiding acute spikes in training load, especially during preseason training camps, should be considered when planning for the season.
- Recent exposure to high-speed running can influence the subsequent susceptibility to hamstring injury. High-speed running exposure should be monitored where possible.
- Other stakeholders, such as the player and coaching staff, should be involved in decision-making as one potential strategy to avoid injury.


↑ Risk of Injury
No ↑ Risk of Injury
Level of Evidence
Strong
Moderate
Limited
↓Eccentric hamstring strength
↓Concentric hamstring strength
Weight BMI
↑Quads strength
↓Hip extension ROM
↓Hamstring flexibility
↑Body fat %
Fatigue
↓Ankle dorsiflexion
Strength asymmetry
↓Fascicle length
↓Hamstring endurance
↓Isometric strength
↓Hamstring power
Quads:Ham ratio
↓Gluteal volume

Clinical Implications: Intrinsic Risk Factors (Modifiable)

- Strength is associated with increased risk of hamstring injury: clinicians should focus on eccentric strengthening as both primary and secondary prevention.
- Flexibility of the ankle may be important to consider.
- The need for flexibility of the hamstring muscle as a whole is not supported; however, the length of individual muscle fascicles of the hamstring may be critical.
- Fatigue and impaired recovery of muscle function after loading are essential considerations for examining risk.
- Neuromuscular inhibition may be present post-injury, and rehabilitation should include efforts to improve components that contribute to neuromuscular function.
- Power and ballistic measures, such as the CMJ, may add valuable information for understanding an athlete's risk profile.

HOW do hamstring injuries happen?

- Hamstring injuries can be subdivided into two types: the stretch-type hamstring injury and the sprint-type hamstring injury.
- Stretch-type hamstring injuries are caused by a slow or sudden uncontrolled stretch and occur most frequently in dancing, gymnastics, This type of injury typically occurs in the proximal free tendon of the semimembranosus muscle
- Although the clinical presentation of the stretch-type injury is usually mild at first, this type of hamstring injury generally implies a longer rehabilitation time

- Sprint-type hamstring injuries occur in explosive running and cutting sports, such as soccer, athletics, rugby, field hockey, and the various varieties of football (e.g. soccer, Australian Rules Football, American Football etc.). In more than 80% of cases, the injury is located in the long head of the biceps femoris
- Biomechanical analyses have shown that sprint-type hamstring injuries typically occur in the latter part of the swing phase during sprinting

2 type of hamstring injuries

- In football:

  70% of hamstring injuries in football occur during high speed running

  84% of these injuries affecting the Bicep Femoris

- Although initially appearing less severe than running related Bicep Femoris injuries the stretch type injuries often have prolonged healing and recovery times as they typically involve the free proximal tendon

Askling et al., 2007, 2007b, 2012,2013; Arnason, 2008; Ekstrand et al., 2012; Woods et al., 2004.

- در فاز پایانی دویدن (زمانی که ران خم و زانو باز است)، همسترینگ انرژی الاستیسیتی زیادی را جهت آماده کردن تماس calcaneus جذب میکند و موجب ایجاد شتاب منفی، و مستعد شدن عضلات برای آسیب میشود که در این میان عضله ی دو سر رانی در میان عضلات همسترینگ فعالترین عضله محسوب می گردد.

- In this phase, the hamstrings first contract eccentrically to decelerate the previously accelerated limb, and then transit into concentric contraction to produce hip extension. In this part of the running cycle, hamstrings reach their peak length, produce the largest force and perform majority of the negative work (Chumanov, Heiderscheit, & Thelen, 2011; Schache, Dorn, Blanch, Brown, & Pandy, 2012).

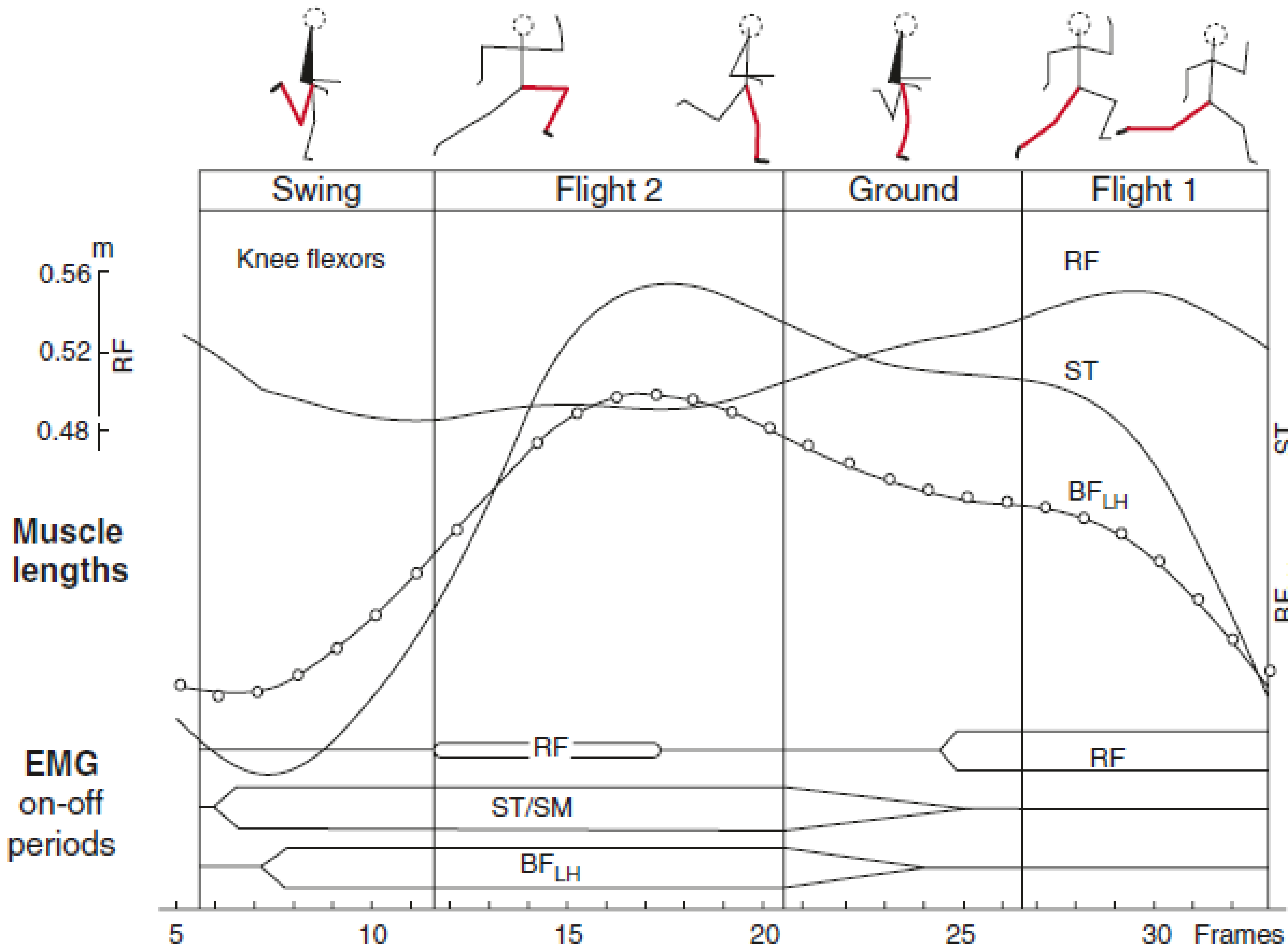


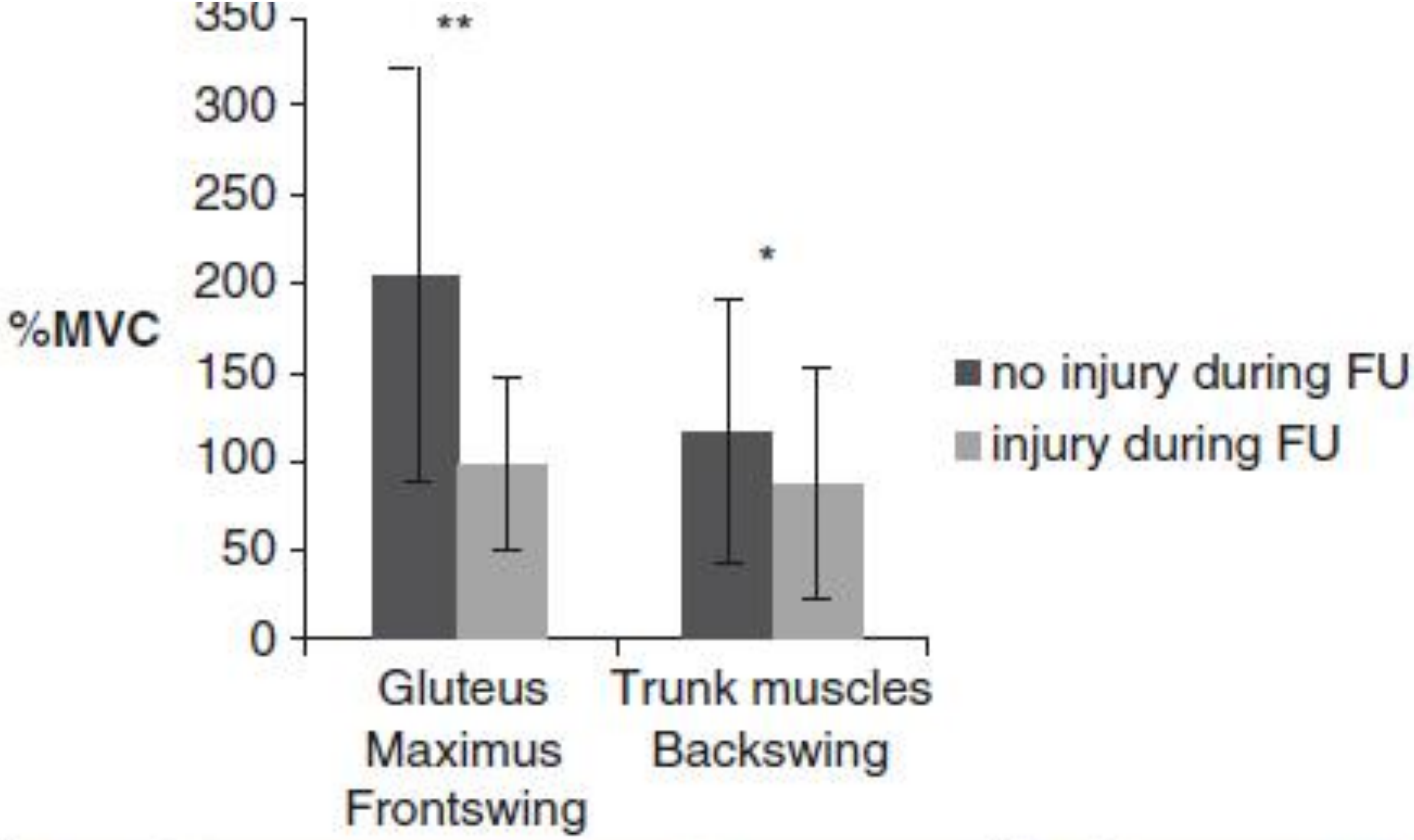
Fig. 5.2 Surface electromyographical (sEMG) activity and muscle lengths of the medial (semimembranosus and semitendinosus (SM and ST) and lateral (biceps femoris long head BF_{LH}) hamstrings throughout various phases of the gait cycle. *RF* rectus femoris, *m* metres

Hamstring running injuries

- Both the swing and the stance phase of sprinting, where the hamstring muscles are put under tension while lengthening (eccentric musculotendinous contraction) to decelerate knee extension have been suggested as possible scenarios of injury occurrence

- This has laid the foundations of current prevention methods (eccentric strength training) of hamstring injury in football

Chumanov et al., 2012; Orchard, 2012; Petersen et al., 2011



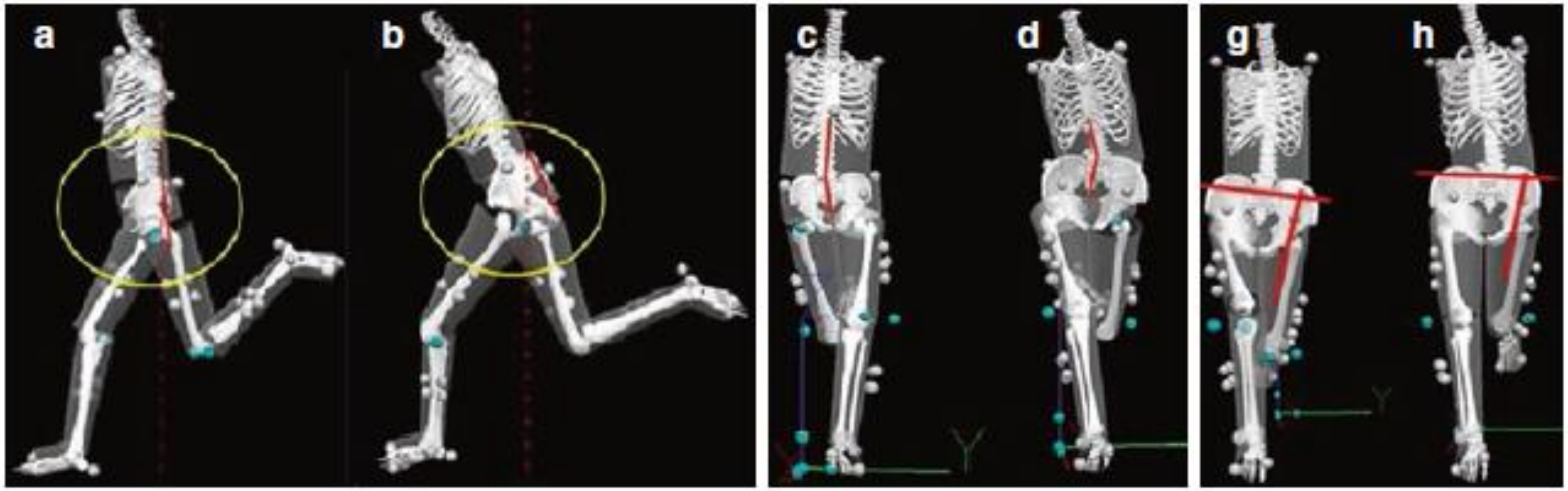
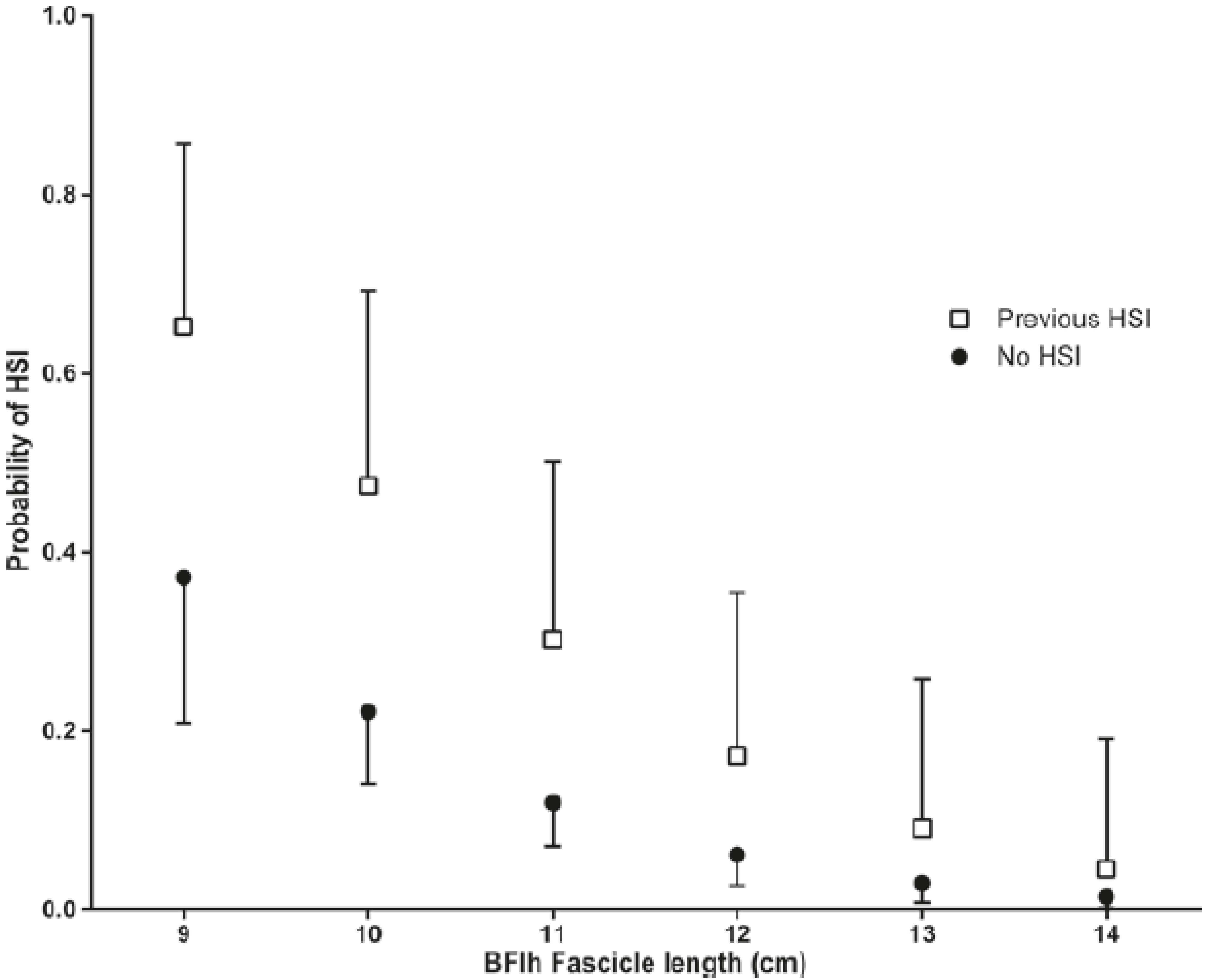


Fig. 5.4 Top: 3D kinematic and sEMG analysis of maximal overground sprint. Middle: Players who subsequently sustained hamstring injury displayed lower gluteus maximus (GM) EMG in forward swing and lower trunk muscle EMG during back swing (airborne) phases of high-speed running than those without injury. Bottom: Soccer players who subsequently sustained hamstring injury during follow-up (FU) demonstrated more anterior pelvic tilt (**b**) and thoraco-pelvic lateral flexion (**d**) than players who did not sustain injury (**a** and **c**). (Reproduced from Schuermans et al.



1.0
0.8
0.6
0.4
0.2
0.0
Probability of HSI
Previous HSI
No HSI
9
10
11
12
13
14
BFlh Fascicle length (cm)

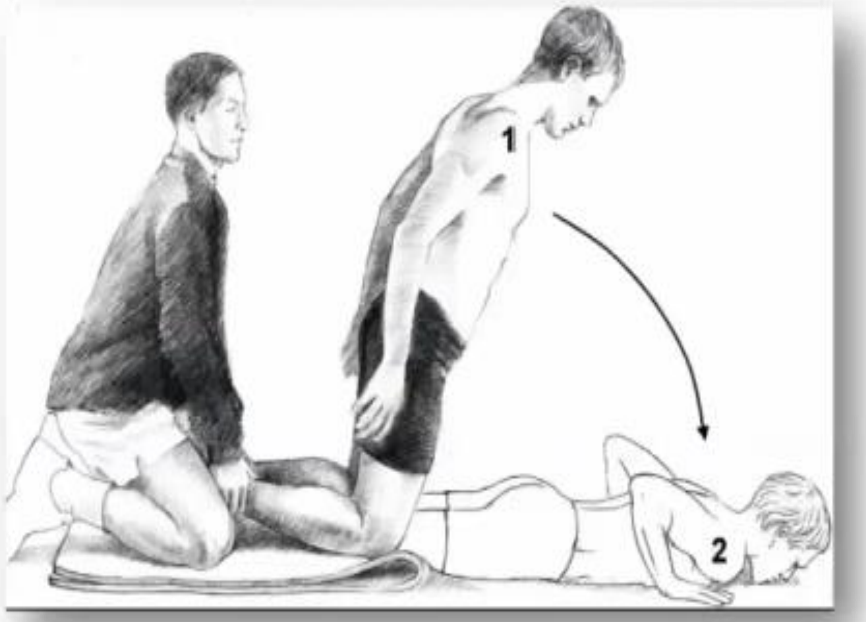
WHY are hamstring injuries on the rise?

Team not using evidence based approach?

Teams not using evidenced based approaches:

1. Nordics ‘reduce’ 65-70% hamstring injuries (Good et al., 2015; Petersen et al., 2011++)
2. Only 11% of elite teams fully adopt the Nordic Hamstring Exercise (NHE) programme

(Bahr et al., 2015)



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Original article

Evidence-based hamstring injury prevention is not adopted by the majority of Champions League or Norwegian Premier League football teams: the Nordic Hamstring survey

Roald Bahr[1, 2], Kristian Thorborg[3, 4], Jan Ekstrand[5]

The greater demand for high speed?

- The greater demand for high speed running in elite level football match play may explain or at least contribute to an increased incidence and risk for hamstring injuries in elite football
- .+30 - 35% over a 7-year period up to 2013:
  - High intensity distance: 890 ± 299 vs. 1 151 ± 337 m
  - Sprint distance: 232 ± 114 vs. 350 ± 139 m

> Int J Sports Med. 2014 Dec;35(13):1095-100. doi: 10.1055/s-0034-1375695. Epub 2014 Jul 10.

The evolution of physical and technical performance parameters in the English Premier League

C Barnes [1], D T Archer [2], B Hogg [2], M Bush [2], P S Bradley [2]

They are not as simple as people make you think

➤ Hamstring injuries are complex multifactorial issues which require a holistic as opposed to singular strategy to their prevention

Editorials

Hamstring strain injuries: are we heading in the right direction?

Jurdan Mendiguchia[1], Eduard Alentorn-Geli[2], Matt Brughelli[3]

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Complex systems approach for sports injuries: moving from risk factor identification to injury pattern recognition—narrative review and new concept

N F N Bittencourt,[1] W H Meeuwisse,[2] L D Mendonça,[3] A Nettel-Aguirre,[4] J M Ocarino,[5] S T Fonseca[5]

Recommendations for hamstring injury prevention in elite football: translating research into practice

Matthew Buckthorpe,[1,2,3] Steve Wright,[1] Stewart Bruce-Low,[1] Gianni Nanni,[4] Thomas Sturdy,[1] Aleksander Stephan Gross,[1] Laura Bowen,[1] Bill Styles,[1] Stefano Della Villa,[2] Michael Davison,[3] Mo Gimpel[1]

Editorial

Hamstring muscle injuries in elite football: translating research into practice

Matthew Buckthorpe[1, 2, 3], Mo Gimpel[1], Steve Wright[1], Thomas Sturdy[1], Matthew Stride[2]

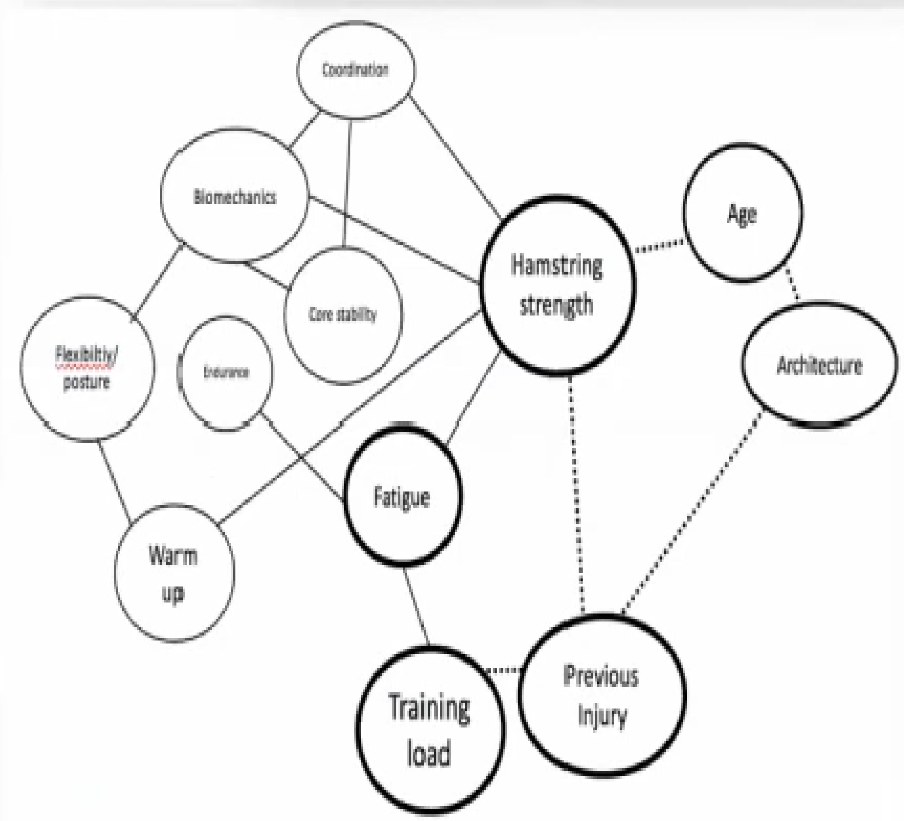
Randomized Controlled Trial > Med Sci Sports Exerc. 2017 Jul;49(7):1482-1492.
doi: 10.1249/MSS.0000000000001241.

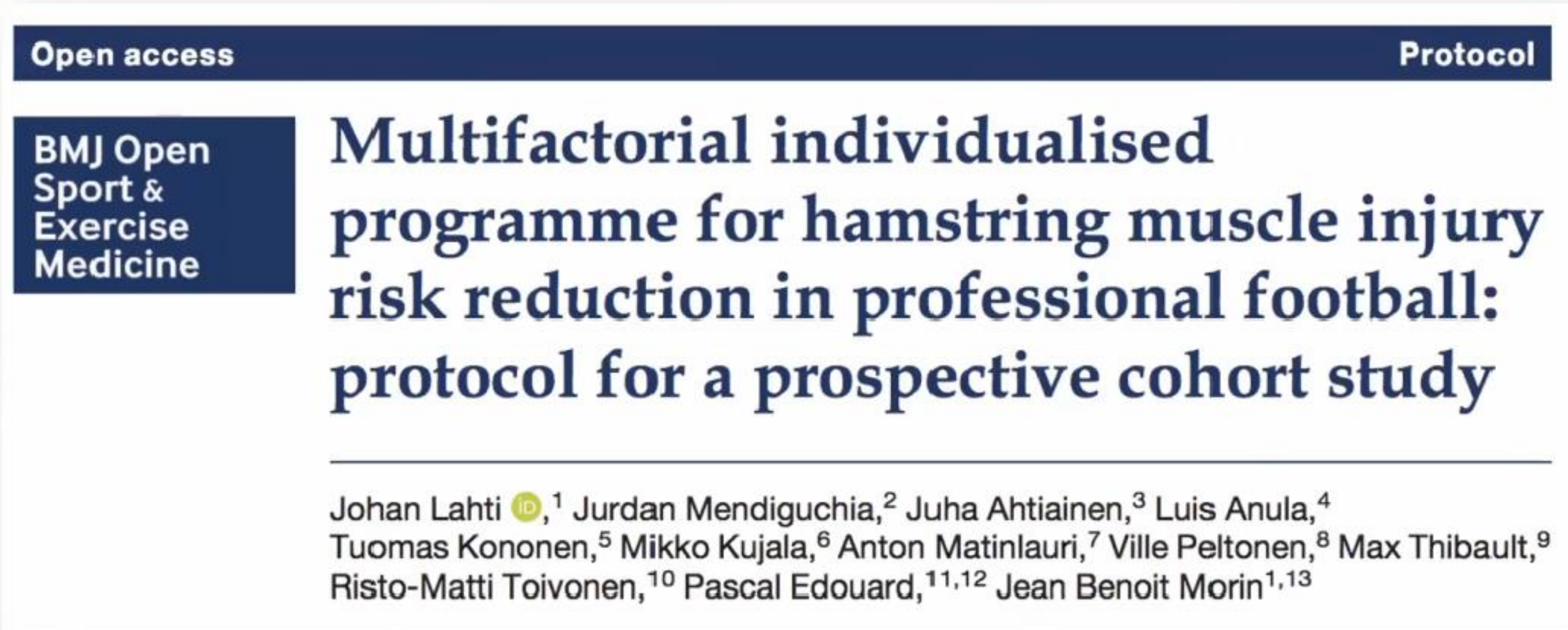
A Multifactorial, Criteria-based Progressive Algorithm for Hamstring Injury Treatment

Jurdan Mendiguchia [1], Enrique Martinez-Ruiz, Pascal Edouard, Jean-Benoît Morin, Francisco Martinez-Martinez, Fernando Idoate, Alberto Mendez-Villanueva

Recurrent hamstring muscle injury: applying the limited evidence in the professional football setting with a seven-point programme

Peter Brukner,[1] Andrew Nealon,[1] Christopher Morgan,[1] Darren Burgess,[1] Andrew Dunn[2]





Open access

Protocol

BMJ Open Sport & Exercise Medicine

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

Johan Lahti [1] Jurdan Mendiguchia,[2] Juha Ahtiainen,[3] Luis Anula,[4] Tuomas Kononen,[5] Mikko Kujala,[6] Anton Matinlauri,[7] Ville Peltonen,[8] Max Thibault,[9] Risto-Matti Toivonen,[10] Pascal Edouard,[11,12] Jean Benoit Morin[1,13]

اقدامات پیشگیرانه

	قبل از حادثه	هنگام حادثه	پس از حادثه
ورزشکار	بهبود ویژگی‌های تمرین افزایش مقاومت در برابر خستگی شناسایی ورزشکار در معرض خطر و اجرای برنامه پیشگیری تقویت عضله همسترینگ بهبود انعطاف‌پذیری عضله گرم کردن	به حداقل رساندن خستگی	برنامه جامع و مناسب توان‌بخشی تعیین اندازه آسیب همسترینگ و سپس اجرای برنامه توان‌بخشی کافی
محیط/قوانین	–	–	–
تجهیزات	زیرشلوار استرچ	–	–

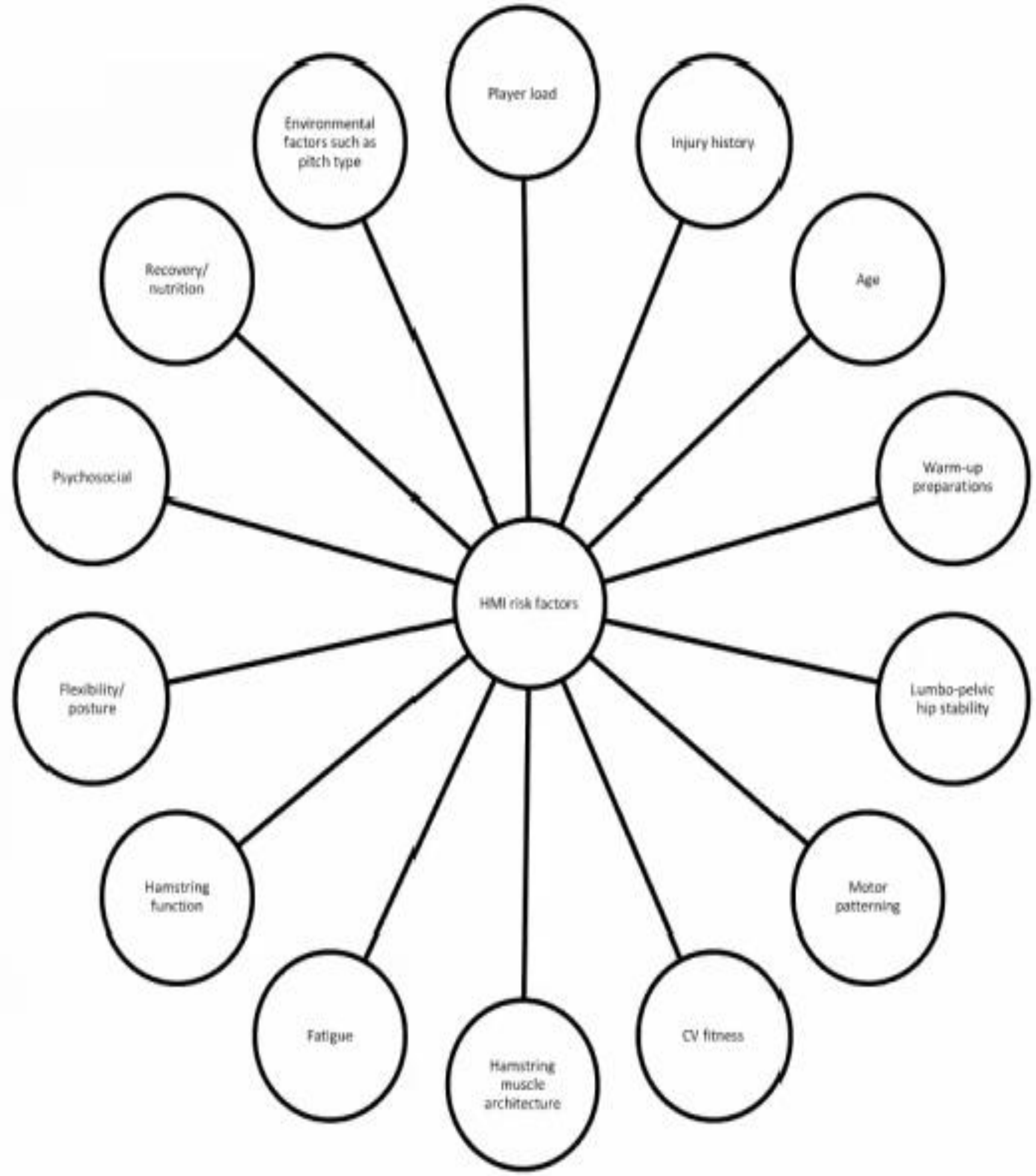
hamstring injuries prevention

Queensland Government
Department of Education, Training and the Arts

Important considerations in designing an injury prevention programme

1. risk factor analysis and planing

- Initially we need to consider all possible risk factors linked in some way to hamstring injuries blending theory, evidence and anecdotal experience



1. risk factor analysis and planing

Not all risk factors are created equal

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Recommendations for hamstring injury prevention in elite football: translating research into practice

Matthew Buckthorpe,[1,2,3] Steve Wright,[1] Stewart Bruce-Low,[1] Gianni Nanni,[4] Thomas Sturdy,[1] Aleksander Stephan Gross,[1] Laura Bowen,[1] Bill Styles,[1] Stefano Della Villa,[2] Michael Davison,[3] Mo Gimpel[1]

Table 1 Risk factors linked to hamstring strain injuries, either through prospective, retrospective or anecdotal evidence. The table shows the typical manner in which our team would classify the risk factors associated with hamstring strain injury

Important		Semi-important (implement where possible)	Recognised but does not inform normal practice
Specific risk factors	**General risk factors**		
Previous hamstring injury[14–16]	ACWR (all parameters)[48–51]	BFlh muscle/tendon architecture[83–85]	Wisdom teeth/dental hygiene[86]
Hamstring eccentric strength (fresh)[30 32 33]	Lumbopelvic hip stability[15 62–66]	Glute dominant hip extension pattern	TMJ dysfunction
Weekly speed exposure[44]	Functional strength[72 73]	SIJ kinematics	
Hamstring fatigue resistance[79 82 87]	ACWR (HSR/vHSR)[52]	Muscle fascicle length[30]	
	Psychosocial factors[57]	Tib/Fib joint	
	Individual recovery rates/strategies (sleep, rest, nutrition, massage, cryotherapy, hydrotherapy)	Environmental factors (eg, playing surface, travel, location of match, footwear, and so on)	
	Time between games[88]		
	Movement quality		
	Previous recent injury (any)		
	Aerobic fitness[74]		

ACWR, acute:chronic workload ratio; BFlh, biceps femoris long head; Fib, fibula; HSR, high-speed running; SIJ, sacroiliac joint; Tib, tibia; TMJ, temporomandibular joint; vHSR, very high-speed running.

2. gain key stakeholder buy-in

- Key decisions and practices often dependant on 'buy in' from key decision makers
- Coaches exert influence on injury risk, and as such, any injury prevention strategy needs to have their support
- Important to understand how people like to receive information.
  - Education and communication is important - Tailor messages to the individual

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Is there a correlation between coaches' leadership styles and injuries in elite football teams? A study of 36 elite teams in 17 countries

Jan Ekstrand,[1,2] Daniel Lundqvist,[1,3] Lars Lagerbäck,[2] Marc Vouillamoz,[4] Niki Papadimitiou,[4] Jon Karlsson[2,5]

Communication quality between the medical team and the head coach/manager is associated with injury burden and player availability in elite football clubs

Jan Ekstrand,[1,2] Daniel Lundqvist,[3] Michael Davison,[2,4] Michel D'Hooghe,[2,5] Anne Marte Pensgaard[6]

3. target intervention at the individual player

- My experiential belief (different to some) is that it is essential to target interventions at the individuals risk profile

- Players are screened for health evaluations, MSK evaluation, athleticism at start of season/ pre-signing evaluation- Use this information to tailor programmes where possible

- There are general themes but tailoring interventions to a person's profile (or teams' profile) is important

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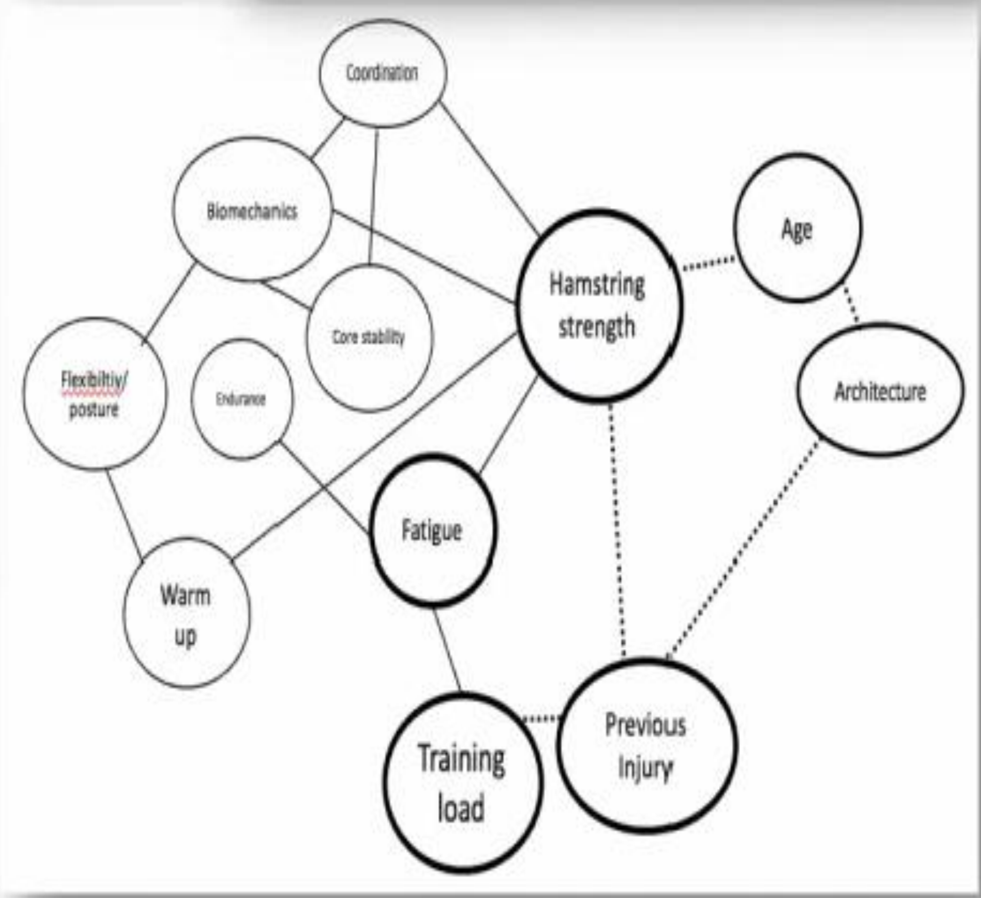
Complex systems approach for sports injuries: moving from risk factor identification to injury pattern recognition—narrative review and new concept

N F N Bittencourt,[1] W H Meeuwisse,[2] L D Mendonça,[3] A Nettel-Aguirre,[4] J M Ocarino,[5] S T Fonseca[5]



4. implement as part of a complete injury prevention

- It is important that any hamstring injury prevention programme be implemented as part of a complete injury prevention and performance programme

12% hamstring injuries

vs.

88% all other injuries

A 5-point plan to hamstring injury prevention

- STRENGTHEN THE HAMSTRING MUSCLES
- MONITOR PLAYER LOAD AND RECOVERY
- PRESCRIBE LUMBOPELVIC CONTROL EXERCISES
- INCORPORATE A FOCUS ON MOVEMENT QUALITY
- DEVELOP PLAYERS' PHYSICAL CONDITIONING

general versus specific strategy

- Some of the strategies are associated with reductions in 'general injury risk'
- Any strategy needs to focus on reducing the 'total injury burden'
- Just because its not yet linked to hamstrings does not mean it should not be part of the strategy

Table 1 Risk factors linked to hamstring strain injuries, either through prospective, retrospective or anecdotal evidence. The table shows the typical manner in which our team would classify the risk factors associated with hamstring strain injury

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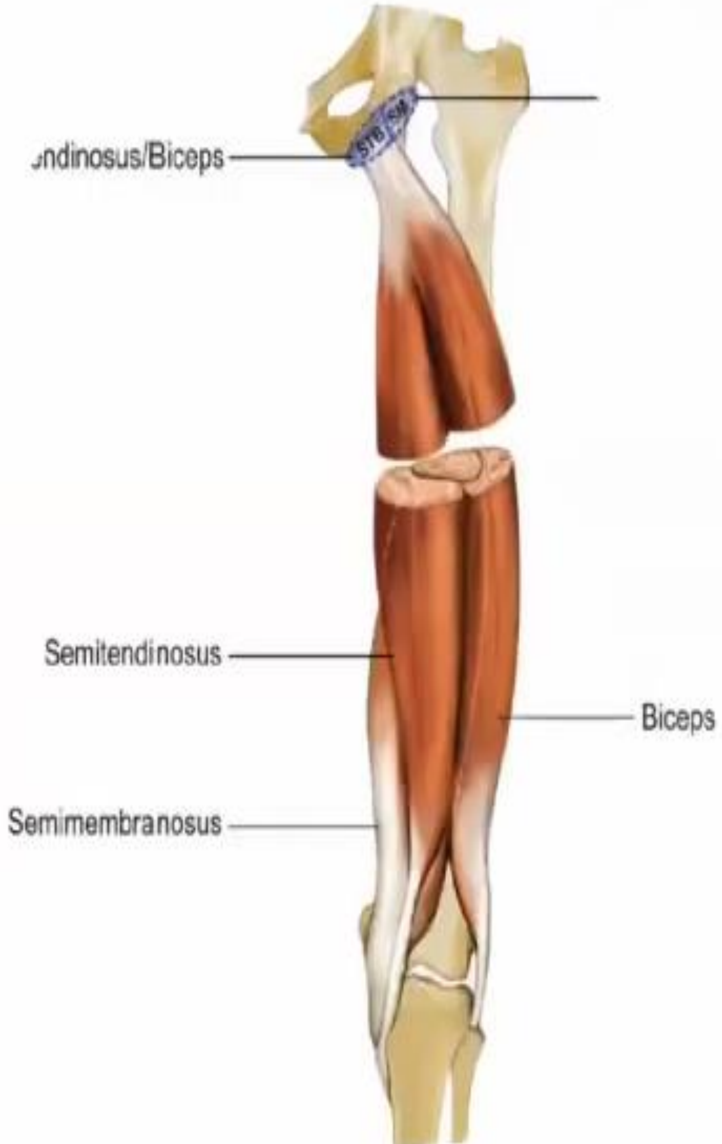
1. Exercise selection for 'strengthening' the hamstrings

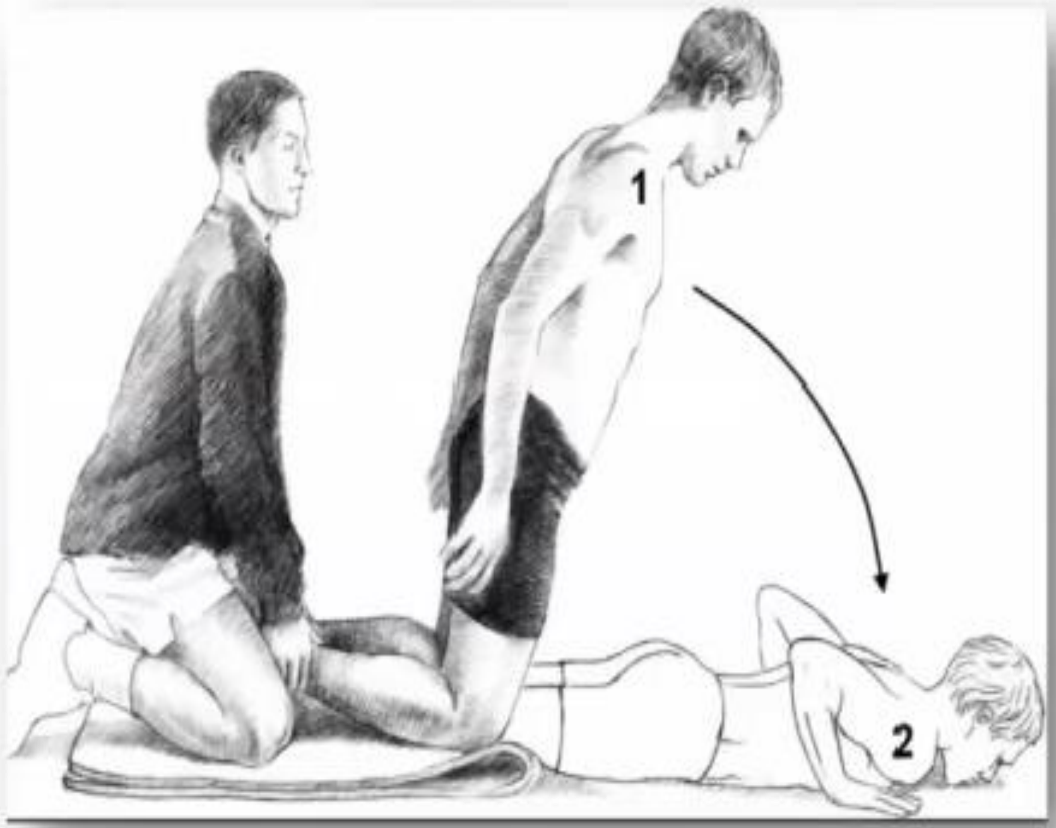
why strength theatrically important?



- Injuries to muscle tendon junction occur when excess forces beyond mechanical limits occur

- So increase the limit and this should reduce the risk of injury!!!!

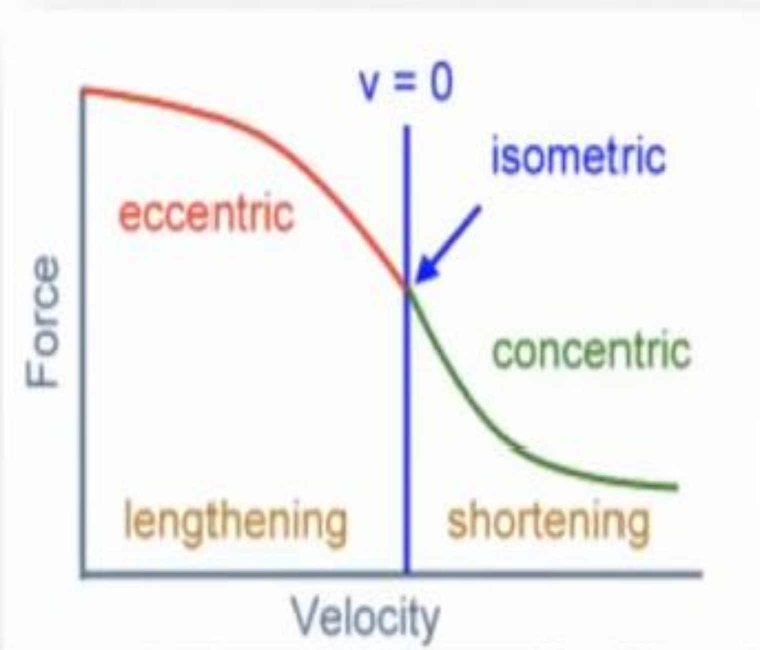
- The use of eccentric hamstring strength training is the most widely researched and recommended evidence-based strategy for HSI prevention and has been shown to significantly reduce the risk of primary and secondary hamstring injuries by 65%–85%

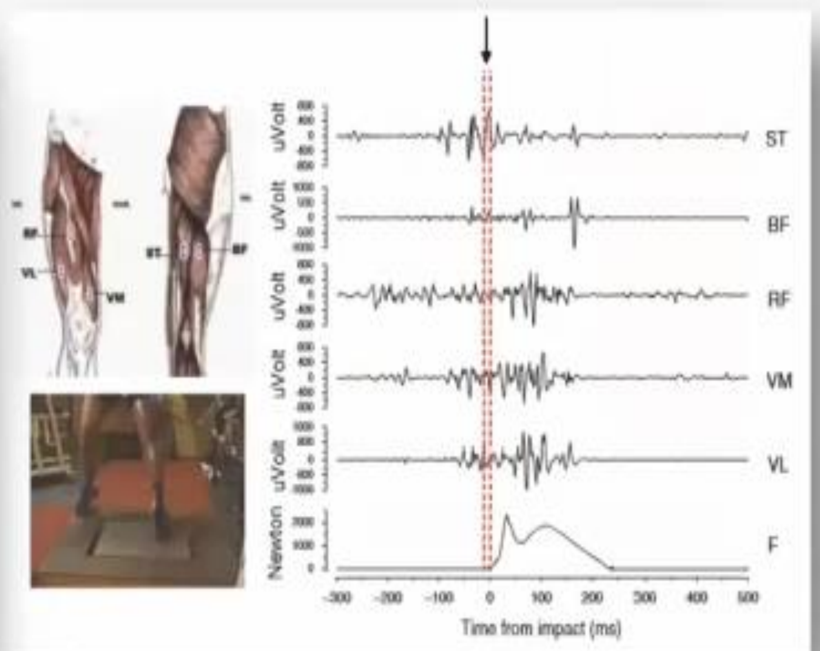


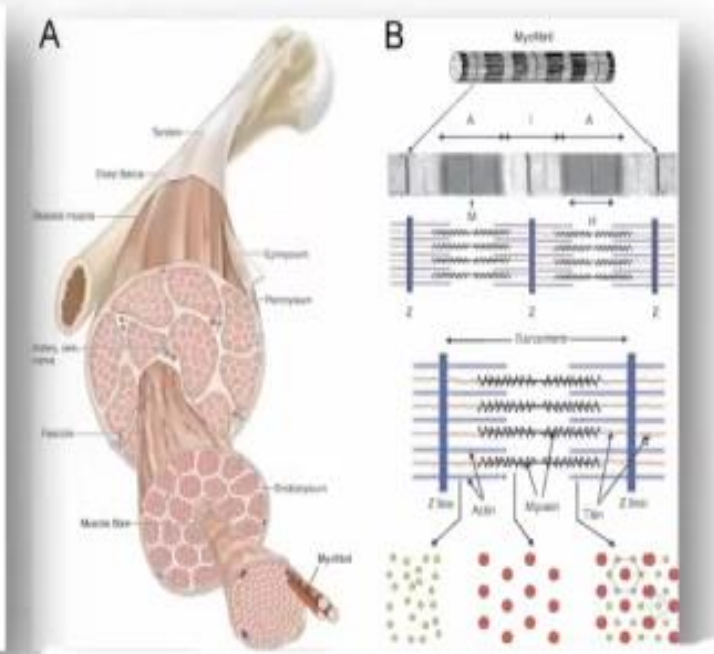
Goode et al., 2015; Petersen et al., 2011; Tyler et al., 2017

what is strength?

Strength is defined as the ability of the neuromuscular system to produce force (Siff, 2001) and is influenced by biomechanical, neural and morphological factors; the contributions of each depend on the strength task (Buckthorpe et al., 2018)







functional vs. isolated strength

- **Functional strength:** the ability to produce force in situations in which muscles are commonly used (and injured)

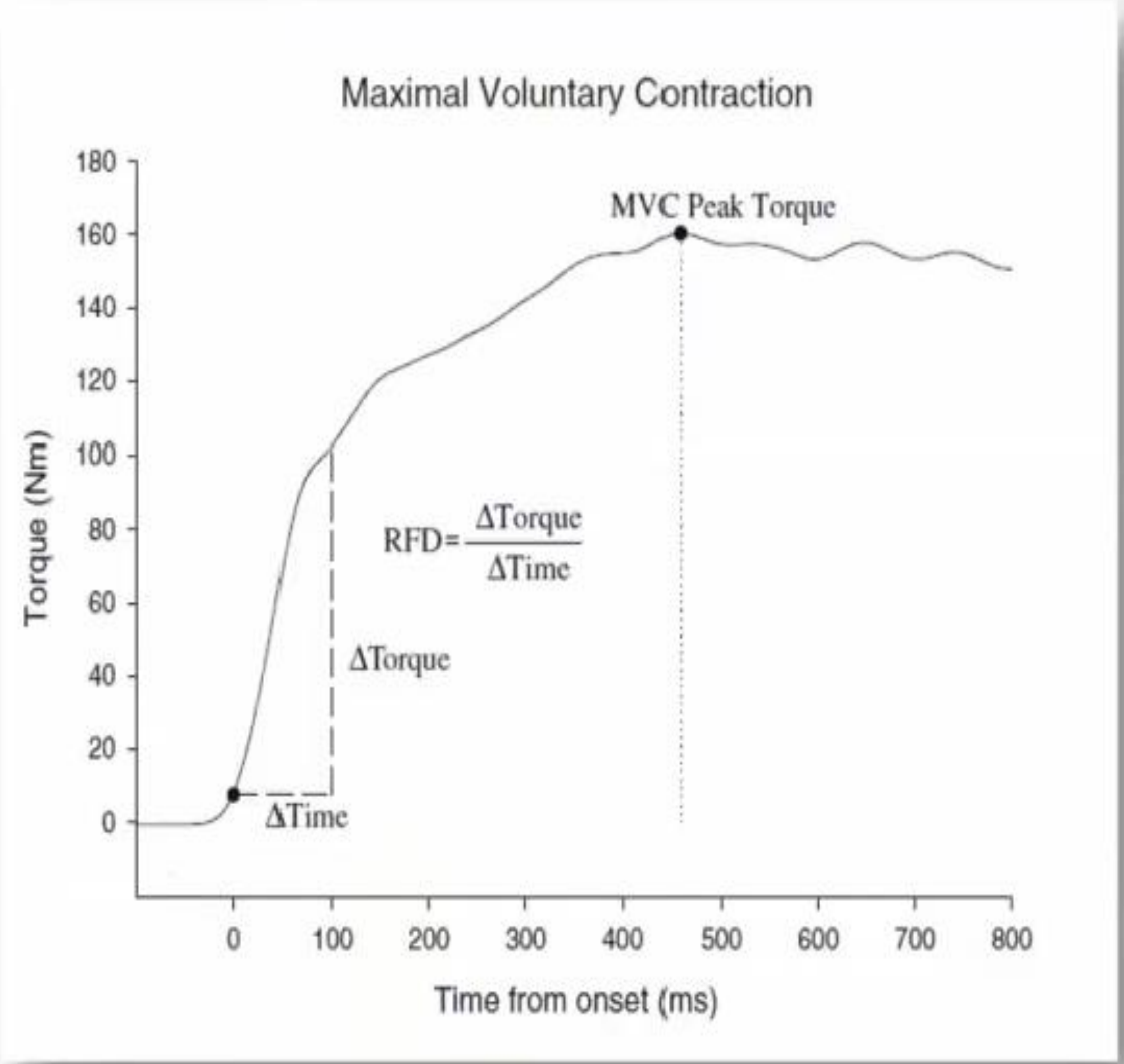
- **Isolated strength** tasks (i.e. isokinetic testing) minimise the requirements for neural control to develop the muscle's 'capacity' to produce force. They do not mimic the way in which the muscles function

- Most sporting actions and mechanisms of injury such as require high levels of fine motor control

- There are numerous biomechanical and neural differences between isolated and functional strength
  - Although isolated strength serves as a "capacity" to produce force, certain factors may limit the transfer of isolated strength to functional situations
  - Poor intermuscular coordination, can result in insufficient expression of isolated strength functionally due to agonist and antagonist compensation for dynamic stability, thereby compromising force output

we should consider explosive strength

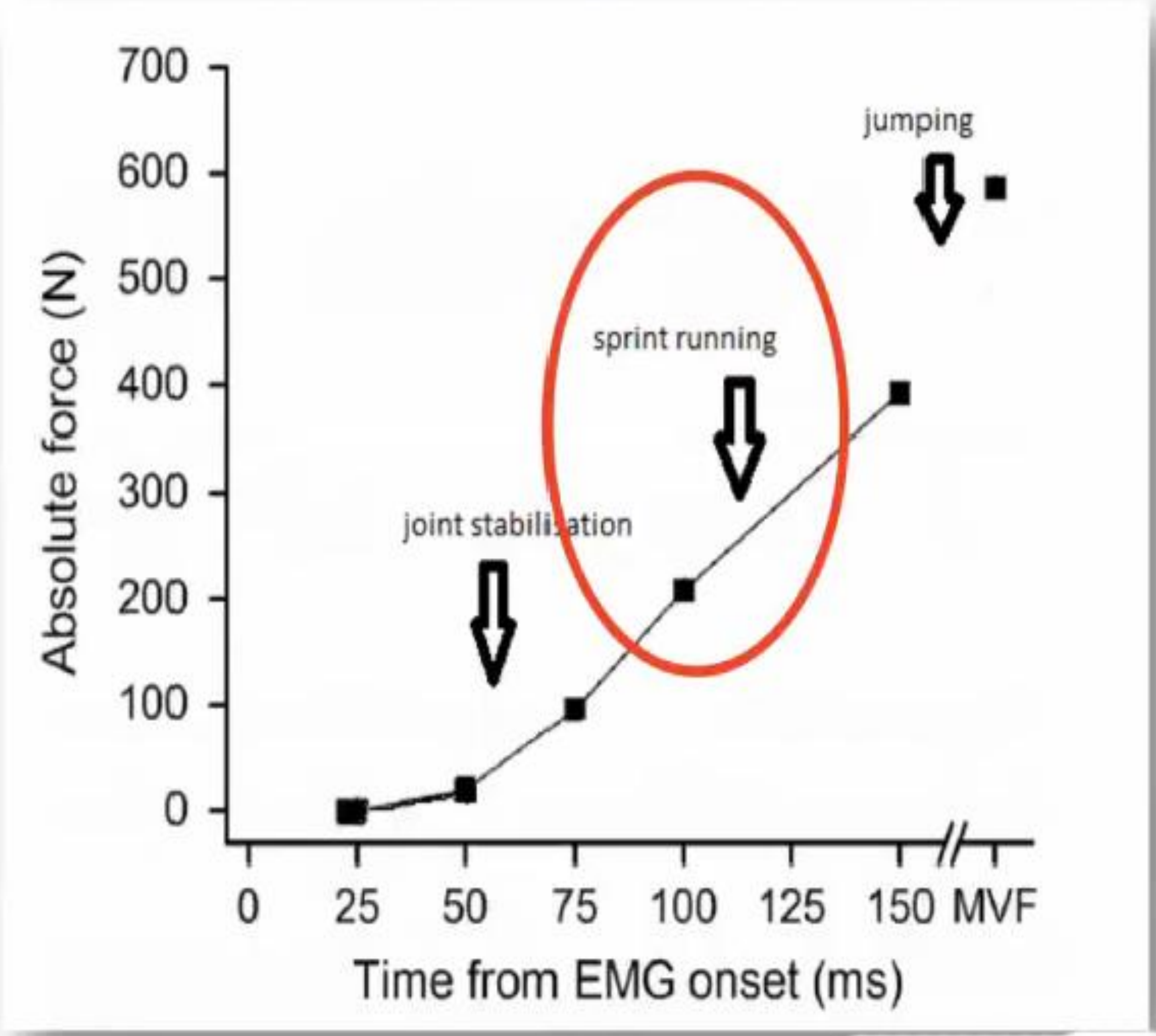
1) Maximal strength -



MVC – Maximal Voluntary Contraction

RFD – Rate of Force Development

2) Explosive strength -



EMG – Electromyography

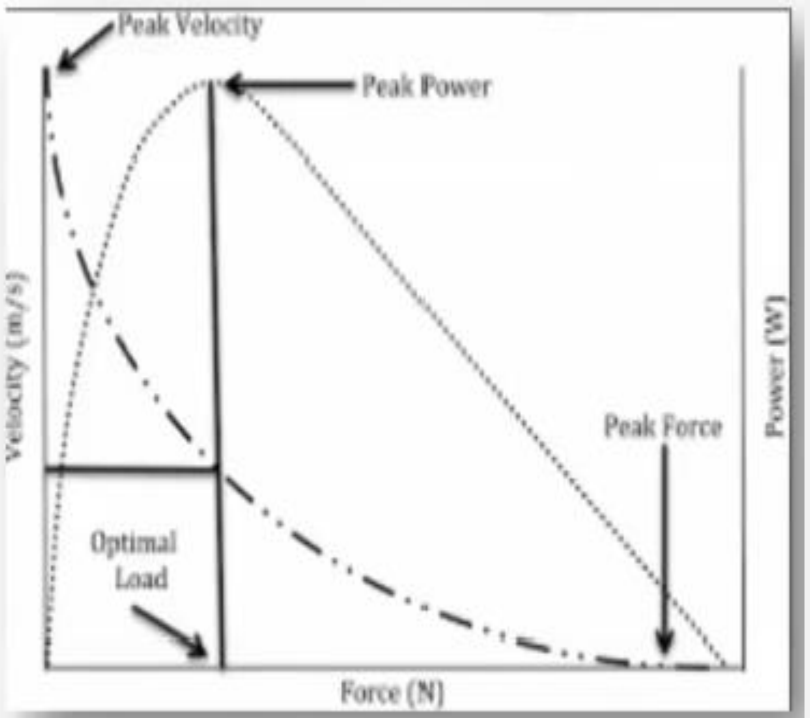
MVF – Maximal Voluntary Force

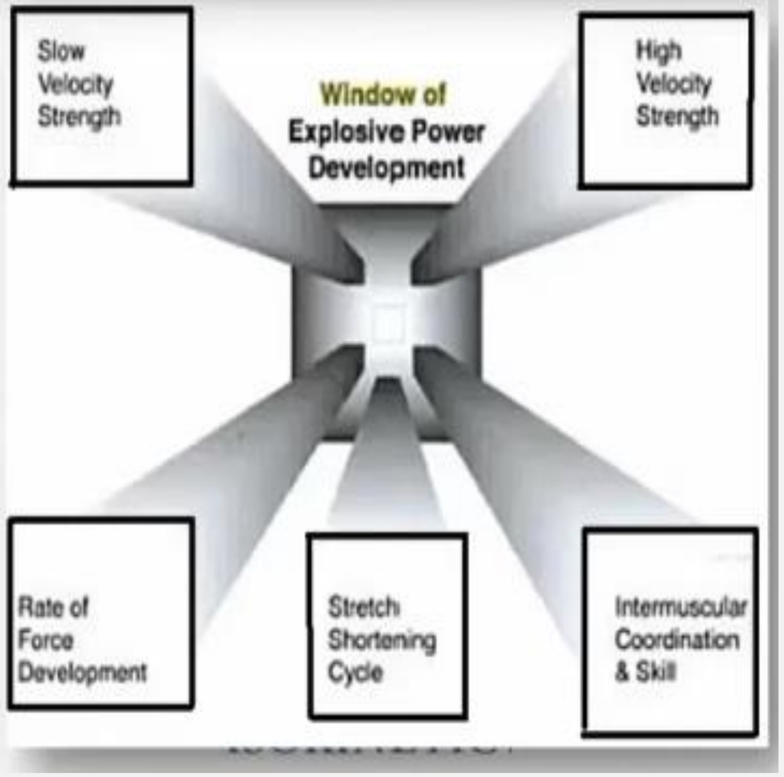
POWER AND HIGH VELOCITY STRENGTH

- RFD and power abilities are important in athletic rehabilitation and should be considered equally important alongside maximal strength (Buckthorpe & Roi, 2018)

- Power is influenced by numerous factors

- Between ~25 and 80 % of the sprint running cycle, the hip is flexing with a peak velocity >700°/s (Kivi et al., 2002), whilst between ~55 and 95 % of the sprinting cycle, the knee is extending with a peak angular velocity greater than 1,000°/s (Zebis et al.. 2008)





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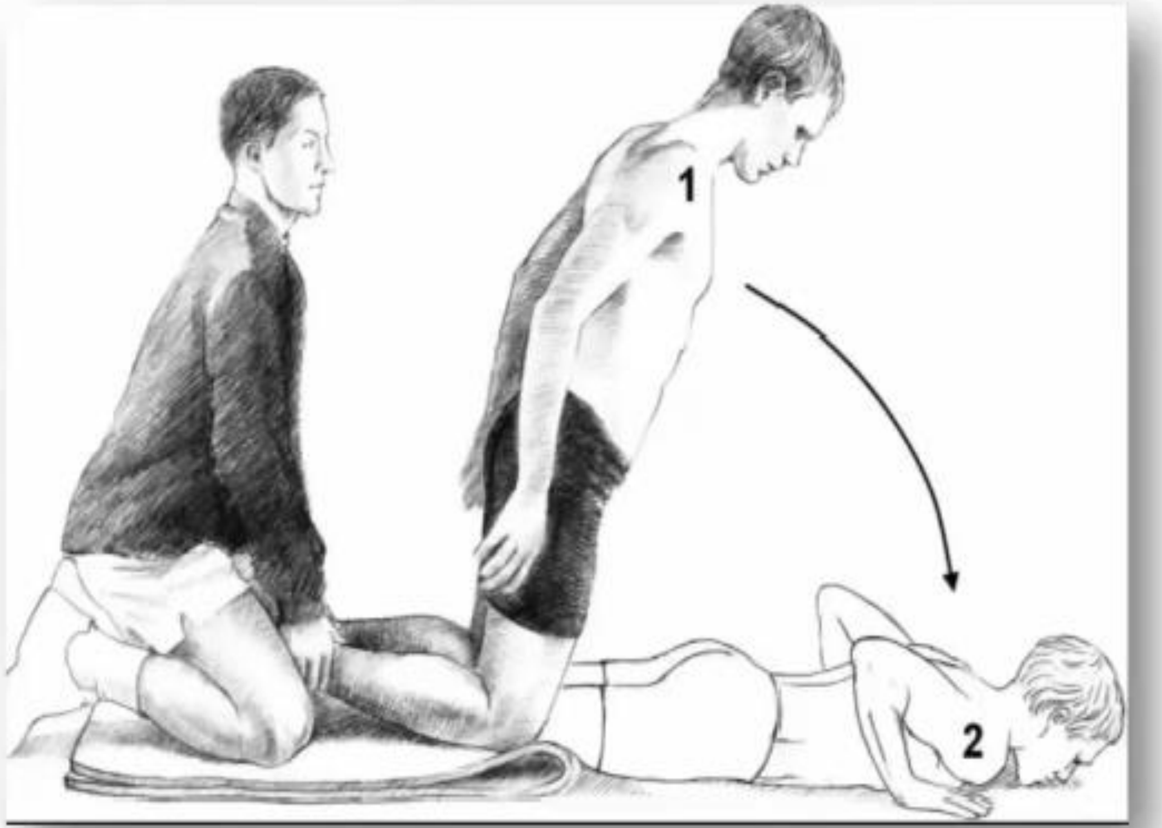
FOCUS ON ECCENTRICS



THE NORDIC HAMSTRING EXERCISE

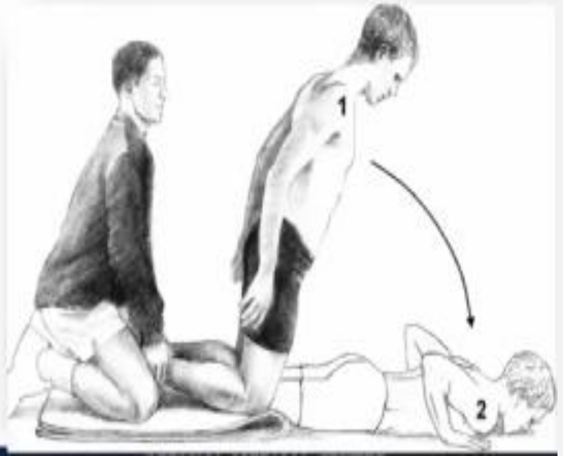
eccentric strength is the most important

- Hamstrings injuries thought to occur when hamstrings act eccentrically to brake the knee extension at the end of the running swing phase (Chumanov et al., 2012)

- Higher levels of eccentric but not concentric knee flexor strength have been shown in most (Bourne et al., 2015; van Dyk et al., 2016), but not all prospective studies (Bennell et al., 1998; Bourne et al., 2015) to be associated with a reduced risk of HSI.

- Adaptations to strength training are mode specific (Mjolsnes et al., 2004; Seger et al., 1998; Tomberlin et al., 1991)

- Use of eccentric hamstring strength training shown to significantly reduce the risk of primary and secondary hamstring injuries by 65%–85% Goode et al., 2015; Petersen et al., 2011; Tyler et al., 2017



large gains in strength with intensities

- Eccentric training overloads the muscle to a greater extent and enhances muscle mass, strength and power more than concentric training (Suchomel et al., 2019)

- There is a dose response relationship in training intensity and gains in strength

- Improvement in knee flexor eccentric strength after 6-10 weeks of knee based eccentric hamstring strengthening are typically 13-19% (Mjolsnes et al., 2004; Askling et al., 2003; Iga et al., 2012)

MUSCLE FASCICLE LENGTH IS AN IMPORTANT CONSIDERATION

- Professional players with short BFlh fascicles (< 10.6 cm) were at fourfold greater risk of HSI than players with longer fascicles (Timmins et al., 2016)

- HSI risk was reduced by 75% for every 0.5cm increase in fascicle length (Timmins et al., 2016)

- Eccentric training in general has also been shown to result in a rightward shift in the torque-joint angle relationship of the knee flexors (Brughell et al., 2010; Clark et al., 2005; Kilgallon et al., 2007; Potier et al., 2009), thought due to alterations in muscle fascicle length, which has been shown to increase after eccentric, but not concentrically based resistance training (Potier et al., 2009)

- In particular, a 16-34% increase BF fascicle length following 6-8 weeks of eccentric knee flexor training was reported (Timmons et al., 2016; Potier et al., 2009), whilst in one of these studies (Timmons et al., 2016), the authors reported a 6% shortening of BFLH fascicles following concentric only training on the same device.

lower volumes can also work

- High and low volume training groups for 6 weeks of Nordics

- Both groups increased eccentric strength
  - High: 28% ± 20%
  - Low: 34% ± 14%
- Both groups increased muscle fascicle lengths:
  - High: 23% ± 7%,
  - Low: 24% ± 4%,

> Scand J Med Sci Sports. 2018 Jul;28(7):1775-1783. doi: 10.1111/sms.13085. Epub 2018 May 8.

The effect of Nordic hamstring exercise training volume on biceps femoris long head architectural adaptation

J D Presland [1], R G Timmins [1], M N Bourne [2], M D Williams [3], D A Opar [1]

also consider isometrics (at high force and long length)

- Evidence suggests that training at longer muscle lengths can achieve similar adaptations in muscle fascicle length to eccentric strengthening.

- Fascicle length changes for the VL were similar after 10 weeks of concentric versus eccentric training at long muscle length (Blazevich et al., 2007), whilst 10 weeks of conventional (combined eccentric and concentric contractions) hip extension training at long hamstring lengths resulted in a 13% increase in BFLH fascicle length (Bourne et al., 2017)

- Thus, longer length isometrics could supplement high intensity eccentrics to elicit positive architectural adaptations in certain situations

Figure 9.1 Model for hamstring strain injury by Mendiguchia et al.[21]

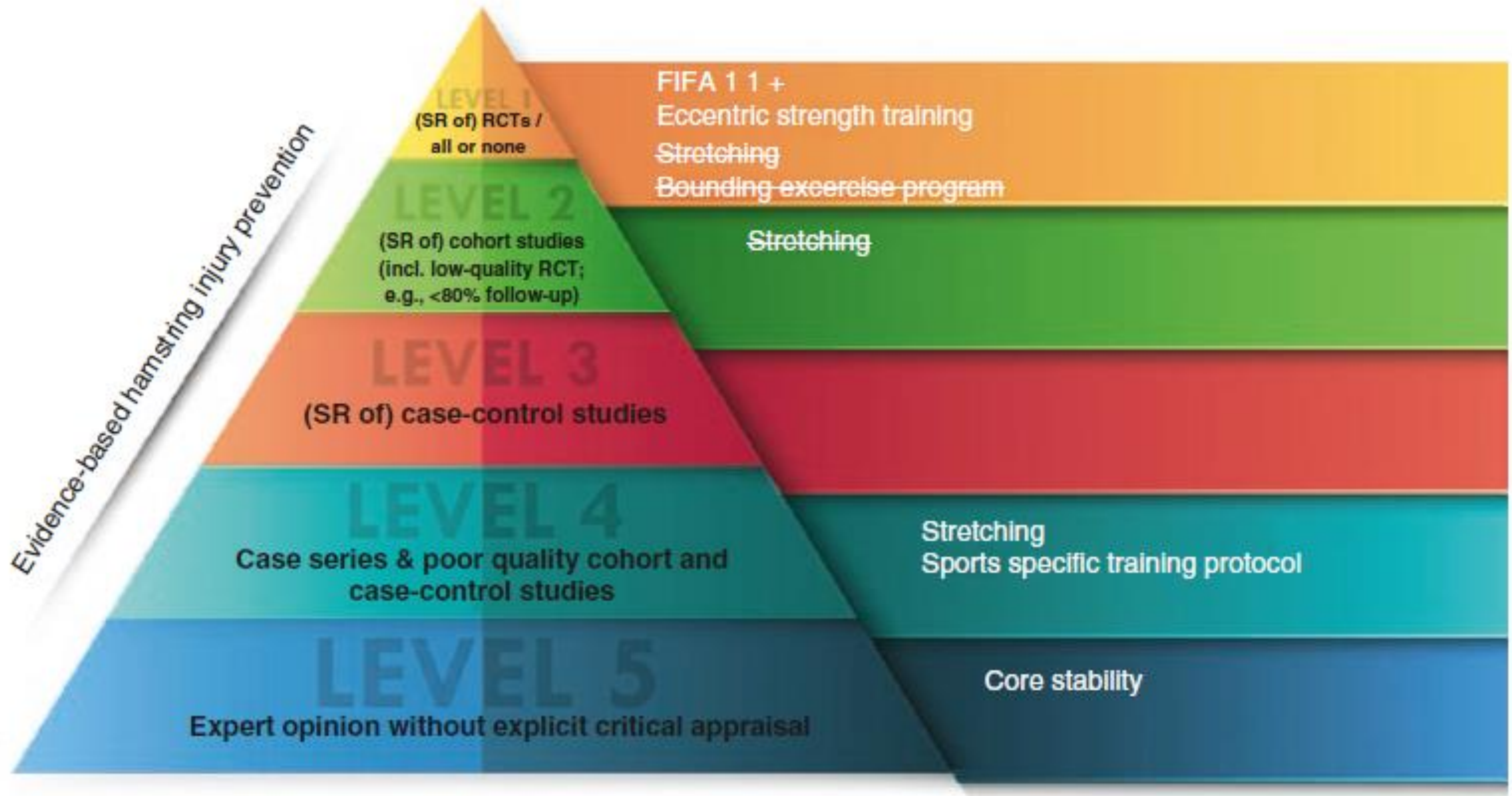


Fig. 6.1 Levels of evidence based on [2]. Variables with a strike-through the text indicate that this variable has shown no preventative effect


NORDBORD
HAMSTRING TESTING SYSTEM

2
3
VALD
536N
554N
518N
540N
1

2

BALANCE THE USE OF HIP AND KNEE DOMINANT EXERCISES

Hip Extension Strength Is Important

- Interventions aimed at increasing knee flexor strength, particularly eccentric knee flexor strength, have reduced HSI rates, across multiple sports

- The swing phase of sprinting, the moment arm and internal moments at the hip are double that at the knee (Novacheck, 1998; Higashihara et al., 2018)

- Weakness in hip extension strength was identified as a prospective risk factor for HSI in elite level sprinters (Sugiura et al., 2008)

J Orthop Sports Phys Ther. 2008 Aug;38(8):457-64. doi: 10.2519/jospt.2008.2575. Epub 2008 Aug 1.

Strength deficits identified with concentric action of the hip extensors and eccentric action of the hamstrings predispose to hamstring injury in elite sprinters

Yusaku Sugiura [1], Tomoyuki Saito, Keishoku Sakuraba, Kazuhiko Sakuma, Eiichi Suzuki

Different Exercise Elicit Different Loading Pattern

- Hamstrings are activated heterogeneously during a range of different exercises
- Knee dominant exercises - ST and BF short head.
- Hip extension exercises - semimembranosus and BFLH, as well as at the more proximal regions of the muscle.
- This reiterates the need for the use of a balanced approach of both knee flexion and hip extension dominant exercises, to target all the hamstring musculature

3

HAVE A STRONG FOCUS ON HIGH SPEED / SPRINT RUNNING

Lack of Sprinting Associated With Hamstring Injuries

- Evidence that heightened workloads particularly HSR/ sprint running in week(s) before injury associated with increased risk of HSI

- Elevated HSR in the week before injury demonstrated a 6.4 times increased risk of HIS (Duhig et al., 2016)

- Higher accumulated and acute workloads were associated with a greater injury risk, but progressive increases in chronic workload may develop the players' physical tolerance to higher acute loads and resilience to injury risk (Bowen et al., 2017)

- Other researchers have also found high training loads to be protective in elite team sport (Hulin et al., 2016)

- Regularly achieving peak or near-peak running speeds in training is associated with a lower risk of hamstring strain (Malone et al., 2017)

> J Sci Med Sport. 2017 Mar;20(3):250-254. doi: 10.1016/j.jsams.2016.08.005. Epub 2016 Aug 10.

High chronic training loads and exposure to bouts of maximal velocity running reduce injury risk in elite Gaelic football

Shane Malone [1], Mark Roe [2], Dominic A Doran [3], Tim J Gabbett [4], Kieran Collins [2]

Sprinting Involve High Hip And Knee Movement

ology 215, 1944-1908
pany of Biologists Ltd

RESEARCH ARTICLE

ategy shift in human running: dependence of running speed on hip and ankle muscle performance

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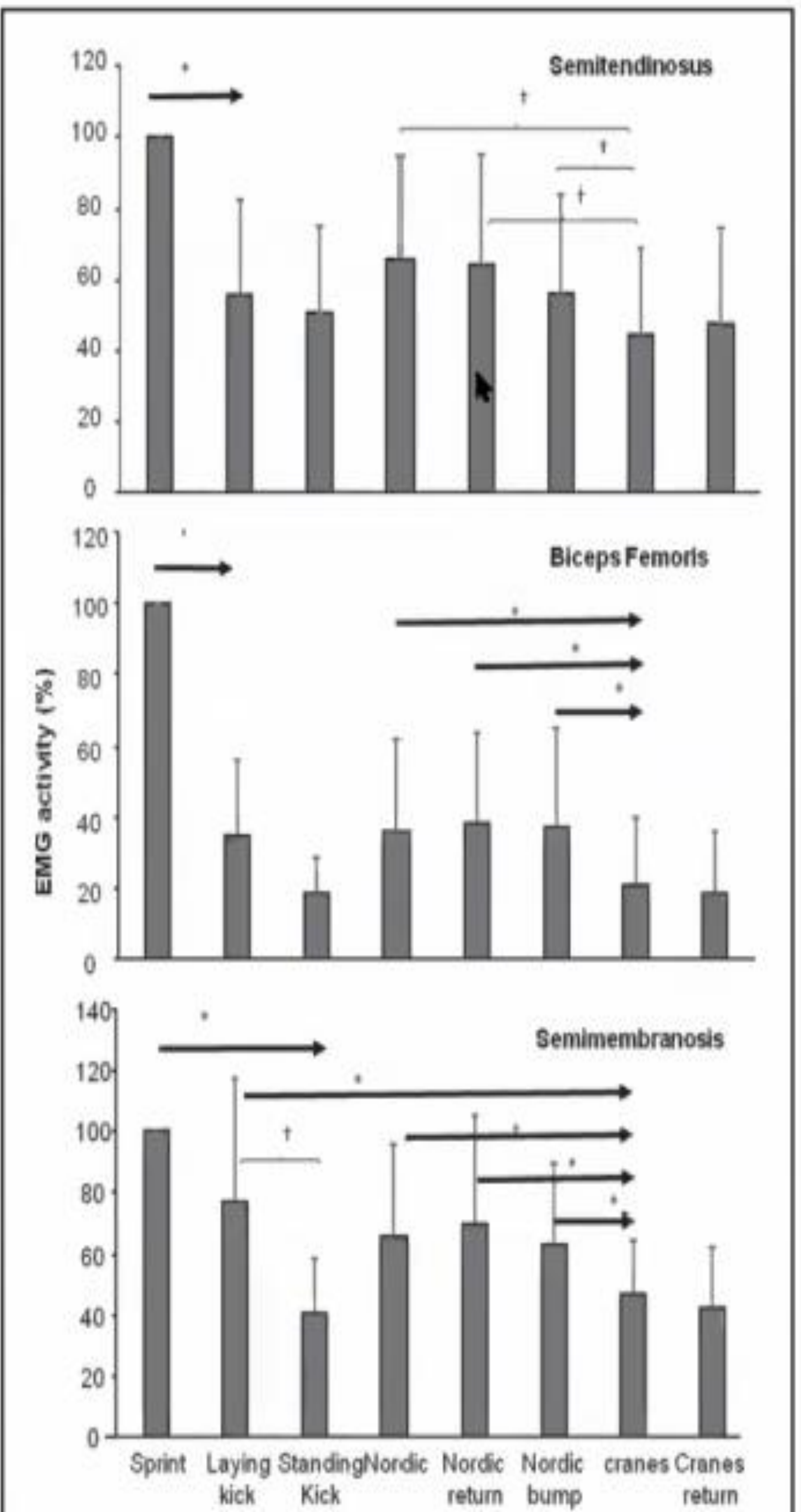
Accepted 13 February 2012

Speed	3.49 m/s	5.17 m/s	6.96 m/s	8.99 m/s
Hamstring forces	2.10 BW	2.66 BW	4.61 BW	8.95 BW

Table 2. Mean (±1 s.d.) magnitudes of stride length, stride frequency, ground contact time, peak muscle forces and peak muscle contributions to the vertical ground reaction force

Variable	Speed 1 3.49±0.12 m s^{-1} (*N*=9)	Speed 2 5.17±0.13 m s^{-1} (*N*=9)	Speed 3 6.96±0.13 m s^{-1} (*N*=8)	Speed 4 8.99±0.67 m s^{-1} (*N*=7)
Stride characteristics				
Stride length (m)	2.62±0.10[b,c,d]	3.42±0.13[a,c,d]	3.99±0.22[a,b]	4.10±0.26[a,b]
Stride frequency (s^{-1})	1.31±0.03[b,c,d]	1.47±0.05[a,c,d]	1.75±0.10[a,b,d]	2.18±0.10[a,b,c]
Ground contact time (s)	0.243±0.022[b,c,d]	0.188±0.015[a,c,d]	0.145±0.009[a,b,d]	0.118±0.011[a,b,c]
Peak forces developed by muscles (BW)				
ILPSO (swing)	1.97±0.37[b,c,d]	3.49±0.51[a,c,d]	5.91±0.98[a,b,d]	9.04±1.71[a,b,c]
GMAX (swing)	0.38±0.12[b,c,d]	0.64±0.17[a,c,d]	1.03±0.29[a,b,d]	2.22±0.60[a,b,c]
HAMS (swing)	2.10±0.38[b,c,d]	2.66±0.31[a,c,d]	4.61±0.74[a,b,d]	8.95±1.66[a,b,c]
RF (swing)	0.67±0.06[b,c,d]	1.19±0.17[a,c,d]	1.81±0.28[a,b,d]	2.80±0.39[a,b,c]
VAS (stance)	4.70±0.57	5.35±1.21	4.93±0.94	4.89±0.89
GAS (stance)	1.94±0.25[b,c,d]	2.65±0.44[a,c]	3.23±0.49[a,b]	2.97±0.34[a]
SOL (stance)	6.70±0.66[b,c,d]	7.92±0.82[a,c,d]	8.71±0.83[a,b,d]	7.34±0.72[a,b,c]
TIBANT (swing)	0.17±0.14[d]	0.22±0.16[d]	0.31±0.10[d]	0.50±0.11[a,b,c]

Sprinting Involves The Highest Activation of Hamstring



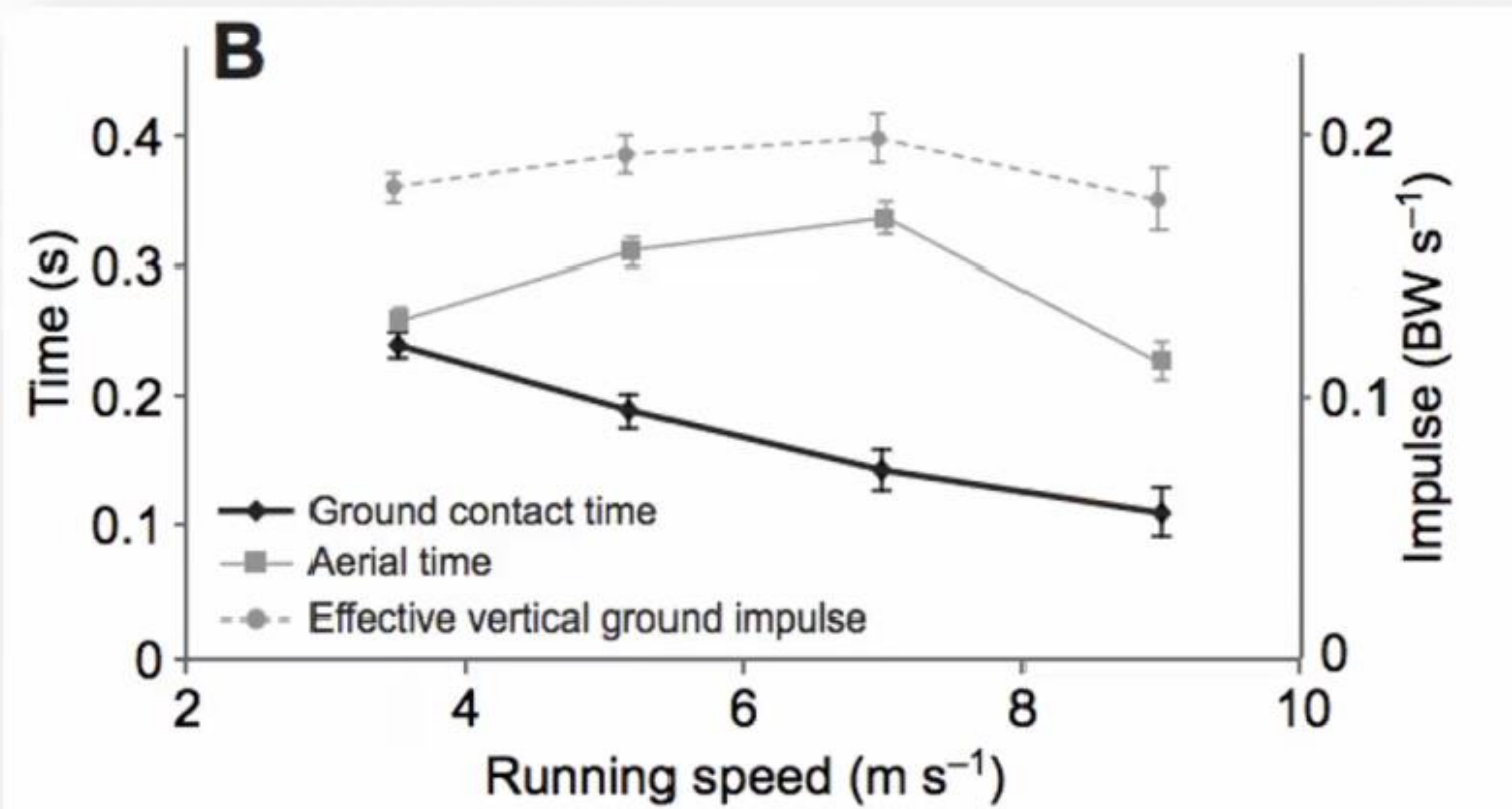
IJSPT

ORIGINAL RESEARCH

COMPARISON OF HAMSTRING MUSCLE ACTIVATION DURING HIGH-SPEED RUNNING AND VARIOUS HAMSTRING STRENGTHENING EXERCISES

Roland van den Tillaar[1]
Jens Asmund Brevik Solheim, MSc[1]
Jesper Bencke, PhD[2]

Sprinting Involve High Speeds And Low Ground Contract



Performance Benefits And Improved Buy-in

- Sprint running is a key discriminator in performance in football
- Easy to implement into training either in warm up
- Less resistance to adherence
- Likely increased coach support!

Aim to achieve>95% top speed

- Regularly achieving peak or near-peak running speeds in training is associated with a lower risk of HSI.

- As such, we aim to expose all players to within 95% of maximum speed one to two times per week.

› J Sci Med Sport. 2017 Mar;20(3):250-254. doi: 10.1016/j.jsams.2016.08.005. Epub 2016 Aug 10.

High chronic training loads and exposure to bouts of maximal velocity running reduce injury risk in elite Gaelic football

Shane Malone [1], Mark Roe [2], Dominic A Doran [3], Tim J Gabbett [4], Kieran Collins [2]

Recommendations for hamstring injury prevention in elite football: translating research into practice

Matthew Buckthorpe,[1,2,3] Steve Wright,[1] Stewart Bruce-Low,[1] Gianni Nanni,[4] Thomas Sturdy,[1] Aleksander Stephan Gross,[1] Laura Bowen,[1] Bill Styles,[1] Stefano Della Villa,[2] Michael Davison,[3] Mo Gimpel[1]

Include Top Ups In Those Not Playing Regular

- Training very good at mimicking at the cardiovascular demands as well as acceleration and deceleration demands of football but often results in little HSR and sprinting distances

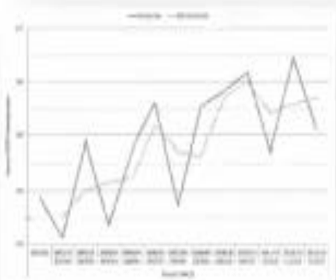
- Need to include specific HSR/ sprint running to achieve the require stimulus

- Monitor HSR/sprinting distance with GPS live during training and include top ups after training/ matches where needed

Table 4

Time period	Distance (%)	Distance (%) >16 km/h	Distance (%) >25 km/h	% Peak running speed (km.h^{-1})	Distance (%) (sum of Acc >2m.s^2 and dec <-2m.s^2)	Distance (%) (sum of Acc >3m.s^2 and dec <-3m.s^2)
OFR1	39	53	0	66	13	6
OFR 2	43	39	1	65	21	12
OFR3	38	33	2	73	31	22
RTT1	46	21	4	81	42	25
RTT2	41	18	3	78	43	27
Match	**11,700**	**2824**	**497**	**33**	**1150**	**584**

SUMMARY



- Hamstring injuries are on the rise
- They are more complex than you would think and require a more 'holistic approach'
- Consider the contextual factors
- Implement a 5-point plan
- Consider the specific strengthening approach and balance the use of eccentrics and isometrics, knee and hip exercises and use HSR/ sprint running

Fig. 12.3 The sliding leg curl. The sliding (eccentric phase) can be done with one or two limbs, and extra mass can be held on the hips

Fig. 12.4 The glute-ham raise exercise

Fig. 12.5 The razor curl

Fig. 12.6 The 45° hip extension exercise. (From Messer et al. [89] with permission)

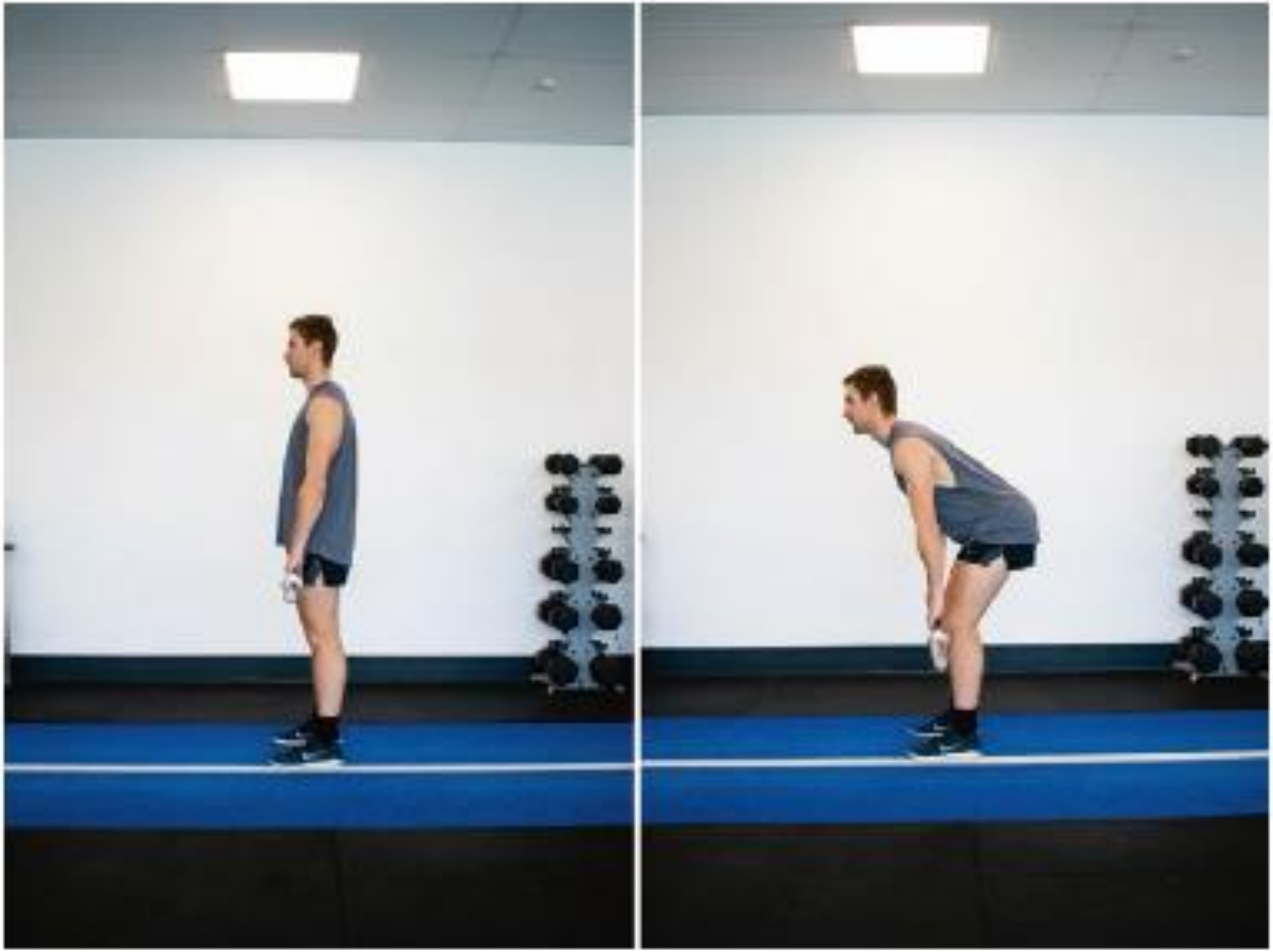


Fig. 12.7 The Romanian dead lift

Fig. 12.9 The good morning exercise

Fig. 12.10 The kettlebell swing exercise

Fig. 12.11 The hip thrust exercise

FLYWHEEL TRAINING