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Disclaimer
I, Andreas Bjerregaard
has no conflict of interest in giving this presentation
An Evidence-Based Framework for Strengthening Exercises to Prevent Hamstring Injury

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- provide the clinician with an evidence-based framework to prescribe selection of strengthening exercises to mitigate the risk of hamstring injury.
Session Learning Objectives

Hamstring landscape and background

- Strength a risk factor for hamstring injuries
- Does strength training protect against hamstring injury or re-injury
- Hamstring muscle activation in different exercises
- Hamstring architecture, morphology, and functional adaptation to different exercises

Hamstring strength for performance
Hamstring injuries is one of the most common muscle injury in football. 1/5 players will suffer an hamstring injury in any given season. Up to 20% of these will re-occurs.

Fig. 1. Injury incidence in the Australian Football League over 13 years. An injury is defined as "any physical or medical condition that prevents a player from participating in a regular season (home and away) match" (adapted from Orchard and Seward, with permission). HSI = hamstring strain injury; OP = osteitis pubis.


Ekstrand J, Waldén M, Hägglund M 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 Br J Sports Med 2016
Common injury mechanism occurs during the late swing phase of high-speed running and during extensive lengthening of the hamstrings

(Guex & Millet 2013, Askling, C. M., Malliaropoulos, N., & Karlsson, J. 2011)
Majority (around 80%) of hamstring injuries occur in Biceps Femoris Long Head ($BF_{LH}$).
Each hamstring injury will typically result in 17 days absence from training and competition.

• Mean 17 days (SD ± 21.1 days)

A hamstring injury not only diminish performance but also estimated to cost the elite soccer clubs €280000 per injury.

Keeping your top players on the pitch: the key to football medicine at a professional level
Jan Ekstrand¹,²,³

Highlighting the economical aspects, the average cost for a first team player being injured for 1 month is around 500 000 Euros.
Ekstrand J. Keeping your top players on the pitch: the key to football medicine at a professional level. Br J Sports Med 2013 (5)

CEO of Shakhtar Donetsk, Mr Sergei Palkin
Strength as a risk factor for hamstring injuries

Strength as a risk factor for hamstring injuries

Does Strength training protect against hamstring injury or re-injury

Hamstring muscle activation in different exercises

Hamstring architecture, morphology and functional to different exercises

Hamstring strength for performance
614 elite Qatari football players, 190 hamstrings injuries, 1931 test, 4 seasons:

14 Strength variables
Lower quadriceps concentric strength (Odds ratio 1.41, 95% CI 1.03-1.92)
Lower hamstring eccentric strength (Odds ratio 1.37, 95% CI, 1.01-1.85)

However, from a clinically point it can be impossible to predict who will get injured after the isokinetic test.
Strength as a risk factor for hamstring injuries
Field based measure

Short biceps femoris fascicles and eccentric knee flexor weakness increase the risk of hamstring injury in elite football (soccer): a prospective cohort study

Ryan G Timmins,1 Matthew N Bourne,2 Anthony J Shield,2 Morgan D Williams,3 Christian Lorenzen,1 David A Opar1

Pre-season screening on hamstring strength after Nordic Hamstring exercise

Follow for hamstring injury throughout the season

Pre-season screening on fascicle length
Combination of low eccentric strength <337N and short fascicle length <10.56cm increased the risk of a hamstring injury 4.4x and 4.1x respectively and the probability of injury was reduced by 21% for every 1 cm increase in fascicle length.
Strength as a risk factor for hamstring injuries

Key point. Get your Hamstring long and strong

Short and weak
Quadrant of doom < 337 N

Bourne, Matthew & Timmins, Ryan & Opar, David & Pizzari, Tania & Ruddy, Joshua & Sims, Casey & Williams, Morgan & Shield, Anthony. An Evidence-Based Framework for Strengthening Exercises to Prevent Hamstring Injury. Sports Med, 2018
Strength as a risk factor for hamstring injuries

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Hamstring strength for performance
Strength training protect against hamstring injury or re-injury

Nordic hamstring exercise: the Great hamstring saver?

By Petersen et al., American Journal of Sport Medicine, 2011

According to at least half a dozen recent studies, almost two-thirds of hamstring injuries might be prevented by increasing hamstrings eccentric strength

942 Danish soccer players randomly assigned to either an off-season program of the Nordic exercise or normal training

1. After warming up, kneel on the ground, with a spotter securing your ankles

2. Then, as slowly and smoothly as possible, lean forward so that your chest approaches the ground

3. Use your hamstrings to put the brakes on your forward momentum until you can no longer resist gravity

4. Put out your arms at that point to stop your fall

5. Allow your chest to touch the ground, then push yourself upright to repeat the exercise

-70% injuries in the participants following the Nordic exercise program

-85% injuries reported in players who had previously suffered hamstring damage
Including the Nordic hamstring exercise in injury prevention programmes halves the rate of hamstring injuries: a systematic review and meta-analysis of 8459 athletes

Nicol van Dyk,1,2 Fearghal P Behan,2 Rod Whiteley2

ABSTRACT
Research question Does the Nordic hamstring exercise (NHE) prevent hamstring injuries when included as part of an injury prevention intervention?
Design Systematic review and meta-analysis.
Eligibility criteria for selecting studies We considered the population to be any athletes participating in any sporting activity, the intervention to be the NHE, the comparison to be usual training or other prevention programmes, which did not include the NHE, and the outcome to be the incidence or rate of hamstring injuries.
Analysis The effect of including the NHE in injury prevention programmes compared with controls on hamstring injuries was assessed in 15 studies that reported the incidence across different sports and age groups in both women and men.
Data sources MEDLINE via PubMed, CINAHL via EBSCO, and OpenGrey.
Results There is a reduction in the overall injury risk ratio of 0.49 (95% CI 0.32 to 0.74; p < 0.0008) in favour of programmes including the NHE. Secondary analyses when pooling the eight randomised controlled studies demonstrated a small increase in the overall injury risk ratio of 0.52 (95% CI 0.32 to 0.85; p = 0.0008), still in favour of the NHE. Additionally, when studies with a high risk of bias were removed (n=3), there is an increase of 0.06 in the risk ratio to 0.55 (95% CI 0.34 to 0.89, p=0.004).
Conclusions Programmes that include the NHE reduce hamstring injuries by up to 51%. The NHE essentially halves the rate of hamstring injuries across multiple sports in different athletes.
Trial registration number PROSPERO CRD42018106150.

Figure 7 Sensitivity analysis demonstrating the change in effect by systematically removing individual studies included in the meta-analysis. The effect size shown is the pooled effect when a single (named) study is removed, with the overall effect listed as a reference.
Eccentric strength exercises in rehabilitation is effective in reducing return to sport time

**L protocol**
- Extender
- Driver
- Glider

**C protocol**
- Contract relax
- Cable pulley
- Supine hip bridge

Acute hamstring injuries in Swedish elite sprinters and jumpers: a prospective randomised controlled clinical trial comparing two rehabilitation protocols

Carl M Askling,1,2 Magnus Tengvar,3 Olga Tarasova,3 Alf Thorstensson1
Hamstring muscle activation in different exercises

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Hamstring strength for performance
Surface electromyography (sEMG) Hamstring muscle activation in different exercises

**EXERCISE SELECTION & HAMSTRING ACTIVATION**

Reference: Bourne et al. BJSM 2017

1. Bilateral stiff-leg deadlift
2. Hip hinge
3. Unilateral stiff-leg deadlift
4. Lunge
5. Unilateral bent-knee bridge
6. Unilateral straight knee bridge
7. Leg curl
8. 45° hip extension
9. Glute-ham raise
10. Nordic hamstring exercise

**Medial Hamstring nEMG**

Biceps Femoris nEMG

Medial hamstrings: semitendinosus + semimembranosus

Hip-extension exercise selectively activates the long hamstrings, and the Nordic exercise preferentially recruits the semitendinosus

Images provided by PresenterMedia
Hamstring muscle activation in different exercises

Strengthening Exercises to Prevent Hamstring Injury


Designed by @YLMSportScience

On the basis of these findings, it seems logical to prescribe athletes a combination of both hip- and knee-dominant movements to effectively target all heads of the hamstring.
Functional Magnetic Resonance Imaging (fMRI)

Acute hamstring muscle activation in NHE vs HE:

Bourne, Matthew & Timmins, Ryan & Opar, David & Pizzari, Tania & Ruddy, Joshua & Sims, Casey & Williams, Morgan & Shield, Anthony. An Evidence-Based Framework for Strengthening Exercises to Prevent Hamstring Injury. Sports Med, 2018
Hamstring architecture, morphology, and functional adaptation to different exercises

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Biceps femoris long head
HE v NHE effects on $B_{FH}$ fascicle length, Nordic strength and hamstring volume

Outcomes

1. Biceps femoris fascicle length

2. Nordic strength

3. Hamstring muscle volume


doi:10.1136/bjsports-2016-096130
**Fascicle length ECC vs. CON**

- 5 weeks intervention with **ECC (Nordic hamstring exercise vs. CON (2leg prone leg curl))**

**Protocol**
- Week 1 (2 x 2 x 6).
- Week 2 (2 x 3 x 6).
- Week 3 (2 x 4 x 6).
- Week 4 (2 x 5 x 6).
- Week 5 (1 x 5 x 6).

Dose response and compliance

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Strength as a risk factor for hamstring injuries

Strength training protect against hamstring injury or re-injury

Hamstring muscle activation in different exercises

Hamstring architecture, morphology and functional adaptation to different exercises

Hamstring strength for performance
Nordics and 10m sprint performance

Effects of the Nordic Hamstring exercise on sprint capacity in male football players: a randomized controlled trial
Lasse Ishøj, Per Hölmich, Per Aagaard, Kristian Thorborg, Thomas Bandholm and Andreas Serner

RESEARCH NOTE
Sprint and jump performance in elite male soccer players following a 10-week Nordic Hamstring exercise Protocol: a randomised pilot study
K. Krommes, J. Petersen, M. B. Nielsen, P. Aagaard, P. Hölmich and K. Thorborg

Acute adaptations and subsequent preservation of strength and speed measures following a Nordic hamstring curl intervention: a randomised controlled trial
James Siddler, Matt Greig, Kristian Weaver, Richard Michael Page, Damian Harper and Christopher Michael Brogden

Fastest 10-m sprint

10 m split times

Nordic group

Control group

3.5%
Control group completed regular conditioning and football training

some previous experience with the NHE, but systematic exposure to the NHE + intervention

Previous experience with the NHE + intervention
To sum up, this article ...

Strength as a risk factor for hamstring injuries

- Strength training protect against hamstring injury or re-injury

- Hamstring muscle activation in different exercises

- Hamstring architecture, morphology and functional adaptation to different exercises

Strength testing can not screen for future hamstring risk on a individual level. However, Eccentric strength does seems influence HSI Risk: Keep it Long and Strong

Nordic hamstring exercise) can halves the rate of hamstring injuries and re-injuries and the L protocol can reduce return to play time

Different exercises provide different muscle activation. Acute activation may be an important determinant of hypertrophy. Knowing about muscle activity in hip vs knee dominated exercise can help to optimize exercise selection

Specific muscle do increased in fascicle length. Dose response and compliance matters