Hamstring Injury Prevention and Risk Factor Management: A Systematic Review and Meta-Analysis of Randomized Controlled Trials

Samuel S. Rudisill BS, Nathan H. Varady MD MBA, Michael P. Kucharik BS, Christopher T. Eberlin BS, Wendy M. Meek BS, Sara A. Naessig BS, Alexander E. Adams BS, Scott D. Martin MD

Sports Medicine, Department of Orthopaedic Surgery, Mass General Brigham, Boston, Massachusetts, USA

BACKGROUND AND OBJECTIVES

- Hamstring injury is one of the most common injuries among athletes, representing nearly half of all muscle injuries and 12-29% of total injuries.
- Considering the potentially prolonged absence from sport and high rate of recurrence, hamstring injuries are of great concern to athletes and sports medicine specialists as there may be substantial competitive and financial implications.
- Several risk factors have been identified including deficits in strength and flexibility, reduced hamstrings:quadriceps (H:Q) ratio, and asymmetry in strength and flexibility between limbs.
- Numerous training programs have been developed and are being implemented by athletes, trainers, coaches, and therapists to address these risk factors and prevent hamstring injury, however optimal methods remain unclear, and the prevalence of hamstring injury has continued to rise in recent years.
- The purpose of this study was (1) to systematically review the literature concerning evidence-based hamstring injury prevention and (2) to quantitatively assess the effectiveness of injury prevention programs in reducing injury incidence and managing risk factors.

METHODS

- In October 2020, a computerized search of MEDLINE, CINAHL, Cochrane CENTRAL Register of Controlled Trials, and SPORTDiscus was conducted with subsequent manual screening of selected article reference lists.
- Studies were screened by two independent reviewers and those meeting each of the following eligibility criteria were included:

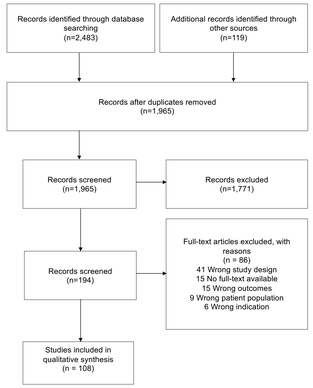


Figure 1. Study flowchart.

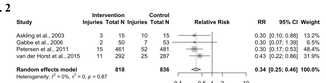
- Randomized Controlled Trial (RCT) study design was used
- Subjects were non-injured adults (≥18 years of age) involved in recreational, semi-professional, or professional athletic activity
- The authors evaluated an intervention for hamstring injury prevention or mitigation of risk factors
- Reported outcomes included injury incidence, strength, flexibility, fascicle length, H:Q ratio, and/or limb asymmetries
- Crossover studies were excluded to avoid potential carryover effects
- Meta-analyses were performed for interventions and outcomes for which there were at least three comparable studies with requisite data available.

RESULTS

- 108 studies were included, comprised of 14-942 athletes with a mean age ranging from 18.0-36.1 years.
- Evaluated interventions included eccentric and concentric training, stretching, proprioceptive neuromuscular facilitation (PNF), neurodynamic sliding, vibration therapy, massage, resistance training, dry needling, kinesiotaping, and blood flow-restricted training.

Hamstring Injury Prevention

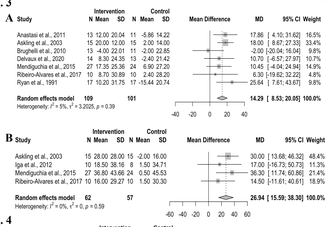
Fig. 2



Hamstring injury risk was reduced following 10-13 weeks of eccentric training compared to ordinary training (Figure 2).

Risk Factor Management

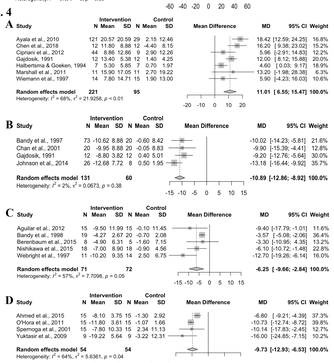
Fig. 3



Concentric strength was improved by eccentric training (Figure 3A), as well as concentric, blood flow-restricted, whole-body vibration (WBV), heavy back squat, FIFA 11+, and plyometric protocols.

Eccentric strength was improved by eccentric training (Figure 3B), as well as concentric, WBV, and plyometric protocols.

Fig. 4



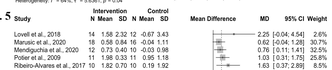
Flexibility as measured by straight leg raise (SLR) was increased by static stretching (Figure 4A).

Flexibility as measured by knee extension deficit (KED) was improved by static stretching (Figure 4B).

Flexibility as measured by knee extension deficit (KED) was improved by dynamic stretching (Figure 4C).

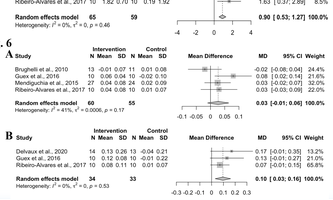
Flexibility as measured by knee extension deficit (KED) was improved by PNF (Figure 4D).

Fig. 5



Fascicle length was increased by eccentric training (Figure 5) and sprint training, whereas concentric training was associated with length reduction.

Fig. 6



Conventional H:Q Ratio was not affected by eccentric (Figure 6A), concentric, plyometric, FIFA 11+, stretching, or resistance training.

Functional H:Q Ratio was improved with eccentric training (Figure 6B). Stretching, FIFA 11+, and concentric training elicited no effects.

CONCLUSIONS

- Despite the devastating impact of hamstring injury in sport, optimal methods of injury prevention have remained unclear and injury prevalence has risen in recent years. According to the literature, however, several strategies exist to prevent hamstring injury and address known risk factors.
- Support is provided for eccentric training to reduce hamstring injury incidence by as much as 70% while improving strength, fascicle length, H:Q ratio, and limb asymmetry.
- Limitations in flexibility are best addressed through stretching-based interventions. Static stretching produces the greatest increase in range of motion, however dynamic stretching and PNF techniques result in more persistent effects while avoiding associated reductions in strength.
- Plyometrics, WBV, and blood flow-restriction are also beneficial in addressing various risk factors.
- Taken together, the results of this systematic review and meta-analysis can assist athletes, trainers, coaches, and therapists in developing optimal hamstring training practices and preventing hamstring injuries.

LIMITATIONS AND FUTURE DIRECTIONS

- This systematic review and meta-analysis included 108 RCTs, of which 19 raised *some concerns* and 7 presented *high* risk of bias.
- Meta-analyses were performed when possible, however data pooling was limited due to differences in intervention protocols, patient populations, and outcome measures.
- Studies reporting outcomes from only compliant subjects (i.e., per protocol) were included, potentially resulting in overestimation of true effects of intervention.
- Hamstring injury rates have continued to increase despite previously reported benefits to injury prevention protocols. Future research is needed to investigate and address barriers to program implementation and compliance.

FUNDING SOURCE

The authors gratefully acknowledge the funding and generosity of the Conine Family Fund for Joint Research.

KEY REFERENCES

- Aguilar AJ, DiStefano LJ, Brown CN, Herman DC, Guskiewicz KM, Padua DA. A dynamic warm-up model increases quadriceps strength and hamstring flexibility. *J Strength Cond Res.* 2012;26(4):1130-1141
- Ahmed H, Iqbal A, Anwer S, Alghadir A. Effect of modified hold-relax stretching and static stretching on hamstring muscle flexibility. *J Phys Ther Sci.* 2015;27(2):535-538
- Askling C, Karlsson J, Thorstensson A. Hamstring injury occurrence in elite soccer players after preseason strength training with eccentric overload. *Scand J Med Sci Sports.* 2003;13(4):244-250
- Ayala F, de Baranda Andujar PS. Effect of 3 different active stretch durations on hip flexion range of motion. *J Strength Cond Res.* 2010;24(2):430-436
- Bahr R, Thorborg K, Ekstrand J. Evidence-based hamstring injury prevention is not adopted by the majority of Champions League or Norwegian Premier League football teams: the Nordic Hamstring survey. *Br J Sports Med.* 2015;49(22):1466-1471
- Bandy WD, Irion JM, Briggler M. The effect of static stretch and dynamic range of motion training on the flexibility of the hamstring muscles. *J Orthop Sports Phys Ther.* 1998;27(4):295-300
- Bourne MN, Duhig SJ, Timmins RG, et al. Impact of the Nordic hamstring and hip extension exercises on hamstring architecture and morphology: implications for injury prevention. *British journal of sports medicine.* 2017;51(5):469-477
- Croisier J, Ganteaume S, Binet J, Genty M, Ferret J. Strength imbalances and prevention of hamstring injury in professional soccer players: a prospective study. *Am J Sports Med.* 2008;36(8):1469-1475
- Ekstrand J, Walden M, Hagglund 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;50(12):731-737
- Fasen JM, O'Connor AM, Schwartz SL, et al. A randomized controlled trial of hamstring stretching: comparison of four techniques. *J Strength Cond Res.* 2009;23(2):660-667
- Guex KJ, Lugrin V, Borloz S, Millet GP. Influence on Strength and Flexibility of a Swing Phase-Specific Hamstring Eccentric Program in Sprinters' General Preparation. *Journal of strength and conditioning research.* 2016;30(2):525-532