Exercise for Rehabilitation and Treatment: Summary of Research

Summary 13: Hamstring Strain

October 2009

Q: What types of exercises are most effective at reducing the incidence of hamstring strain injury?

To answer this question, we performed a comprehensive search of the PubMed database (May 2009) for randomized, controlled trials and systematic reviews that addressed this specific research question.¹

Five studies met the criteria for inclusion in this review, comparing eccentric strengthening (Nordic hamstring lowers) to stretching and/or strengthening (1,2,3), evaluating the effectiveness of sport specific exercises (4), and comparing stretching and strengthening to progressive agility and trunk strengthening (5).

Four of the studies were prospective in design, investigating the incidence of hamstring injuries among uninjured athletes in soccer (1), rugby (2) and Australian rules football (3,4). Two of these studies concluded that eccentric strengthening exercise in the form of Nordic hamstring lowers results in a significantly reduced incidence of hamstring injuries compared to stretching (1) and strengthening (2).

Although one found no difference between Nordic lowers and stretching/ROM, the authors reported very poor compliance rates (3). The remaining study found a sport-specific exercise program significantly reduced injury rates (4).

The remaining study (5) evaluated the reinjury rate among athletes who were diagnosed with acute hamstring strain injuries. Compared to traditional stretching and strengthening, progressive agility and trunk stabilization training significantly reduced the reinjury rates with the first 2 wks of returning to sport as well as during the first yr (5).

Based on this review, it can be concluded that the risk of hamstring strain injury can be improved with eccentric strengthening exercise, and a reduced risk of reinjury may be found with progressive agility and trunk stabilization training. It is important to note that all of the reviewed studies were conducted among athletic populations, and exercises may need to be modified or progressed appropriately. Sample exercises from VHI PC-Kits have been provided based on examples from these studies.
Hypothesis/Aim: To determine the effectiveness of eccentric strength training and flexibility training on the risk for hamstring strains among soccer players.

Subjects: Elite male soccer teams with 18-24 players per team from Iceland (10-17 teams) and Norway (14 teams) participated in the study. No specific inclusion criteria were stated.

Groups: Each team decided whether to participate in the intervention or the control (no exercise). During the 2001 season, all teams choosing the intervention completed the warm up and flexibility exercises and Icelandic teams also completed the eccentric strength exercises. During the 2002 season, all teams completed the warm up and eccentric strength programs.

Duration: The length of the study was 4 competitive seasons (1999-2002) in Iceland and 3 competitive seasons in Norway (2000-2002). Baseline data was collected in 1999 and 2000, and the interventions were completed in 2001 and 2002.

Warm up: All subjects performed a contract-relax hamstring stretch. From a kneeling position, the front leg is lifted with a bent knee and the subjects press their heel into the ground, contracting the hamstring for 10 sec. The front knee straightens for a 20 sec hamstring stretch. Subjects completed 3x/leg prior to every training session.

Flexibility: With the subject in a supine position with 1 leg raised, a partner supports the leg and leans forward to passively stretch the hamstring. The subject presses against the partner's shoulder for a 10 sec hamstring contraction. A second passive hamstring stretch is held for 45 sec. Subjects completed 3x/leg, 1-3x/wk during training sessions.

Eccentric strength (Nordic hamstring lowers): The ankles of the subject are secured by a partner, while the subject uses the hamstrings eccentrically to resist a forward fall and lands in a push up position with the chest touching the ground. The subject uses the hamstring concentrically and pushes off with the hands back to the starting position. Load was increased by raising the speed at the starting phase. Subjects progressively increased to 3 sets of 12, 10, 8 repetitions 1-3x/wk during training sessions.

Outcome Measures: Incidence of hamstring strain injury. Hamstring strains occurring during match play or organized training and resulting from acute muscle actions (e.g., sprinting, shooting, accelerating) were registered by each team's physical therapists and collected on a monthly basis. A player was defined as injured until he could return to play. Injury severity was defined by the length of absence from play and was classified as minor (<=7 days), moderate (8-21 days) or severe (>21 days). Incidence of strains was expressed as the number of strains/1000 hr of playing time.

Results: The effect of flexibility was assessed during the 2001 season in Norway with 7 teams completing flexibility training and 7 controls. There was no significant difference in the rate of hamstring injury between the groups (0.54 vs 0.35 injuries/1000 hr, p=0.2), although those completing training had significantly fewer "severe" hamstring injuries (0% vs 59%, p=0.006).

The effect of eccentric training was assessed during the 2001 season in Iceland (8 teams completed flexibility and strength, and 8 teams were control) and during the 2002 season in Iceland (5 completed strength only, and 5 were control) and in Norway (6 completed strength training only, and 8 were control). The incidence of hamstring injury was 65% lower with eccentric strength training compared to control (0.22 vs 0.62 injuries/1000 hr, p<0.001). There was no significant difference in the severity of injury.

Conclusions: The authors concluded that eccentric strength training using Nordic hamstring lowers was an effective way to reduce the risk of hamstring injury among soccer players. Flexibility training alone did not appear to have any preventative effect.
Hypothesis/Aim: To determine the effect of hamstring strengthening and stretching on hamstring muscle injuries among professional rugby players.

Subjects: 546 male players registered with the Rugby Football Union of the United Kingdom participated in the study.

Groups: Personnel from each club provided details on hamstring exercises that were used at each club. Players were then categorized into the following groups:

1. Strengthening (n=148)
2. Stretching and strengthening (n=144)
3. Stretching, strengthening, and Nordic strengthening (n=200)

Duration: The length of the study was 2 competitive seasons (2002-2003).

Strengthening: Subjects completed "regular concentric and eccentric hamstring exercises". The average number of sessions was 1.2/wk.

Strengthening and stretching: Subjects completed strengthening as above as well as static stretching. The average number of sessions was 1.8/wk (strengthening) and 2.6/wk (stretching).

Strengthening, stretching, and Nordic strengthening: Subjects completed strengthening and stretching as described above, as well as Nordic hamstring eccentric strengthening exercises. See Arnason, 2008 (1) for a description of the Nordic hamstring exercise. The average number of sessions was 1.3/wk (strengthening), 1.8/wk (stretching) and 1.3/wk (Nordic strengthening).

Outcome Measures: Incidence of hamstring strain injury. Hamstring muscle injuries were reported by rugby union club medical personnel and were defined as an injury that prevented a player from participating in training and/or match play for >24 hr or for at least 1 match. Lacerations, abrasions, and hematomas were not included. Diagnosis was based on clinical exam and/or imaging (26%). Injury severity was defined by the length of absence from play and was classified as minor (<=7 days), moderate (8-21 days) or severe (>21 days). Incidence of strains was expressed as the number of strains/1000 hr of playing time.

Results: The incidence of hamstring injuries during match play and training was significantly lower among the players that performed Nordic hamstring exercises (0.4 injuries/1000 hr) compared to the players doing strengthening (1.1 injuries/1000 hr), but not compared to players doing strengthening and stretching (0.6 injuries/1000 hr). There was no significant difference in the incidence of injuries between the groups doing strengthening and those doing strengthening and stretching. The severity of the injuries was also the lowest among those players doing Nordic strengthening [14 days injured vs 17 (strength) and 21 (strength/stretch)], although these differences were not statistically significant.

Conclusions: The authors concluded that the addition of the Nordic hamstring exercise to training programs may reduce the incidence and severity of hamstring injuries among rugby players.

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Hypothesis/Aim: To determine the effect of eccentric hamstring strengthening on hamstring muscle injuries among community level Australian Football players.

Both groups completed 5 training sessions in 12 weeks.

Outcome Measures: Incidence of hamstring strain injury. Hamstring muscle injuries were reported by the club physiotherapist and were defined as sudden onset of posterior thigh pain; tenderness with palpation; with or without pain during hamstring stretch; and with or without pain during hamstring contraction. Duration of lost playing time was not considered.

Results: During the season following the intervention, there was no significant
Subjects: 220 male players from 7 Victorian Amateur Football Association clubs participated in the study.

Groups: Players within each participating club were randomized (accounting for prior injury) to 1 of the following:
1. Eccentric hamstring program (n=114)
2. Control (n=106)

Duration: The length of the intervention was 12 wks, and the duration of assessment was 1 season (2004).

Hypothesis/Aim: To determine the effect of stretching, sport specific drills, and anaerobic interval training on hamstring injuries among Australian rules football players.

Subjects: 1 professional Australian rules football team (about 70 players) participated in the study.

Groups: Single group prospective design comparing pre-intervention and intervention periods.

Duration: The length of the study was 4 competitive seasons. Baseline information was collected during the first 2 seasons, and the intervention was wks. 3 sessions were performed during pre-season and the final 2 during the season. Sessions were supervised by study personnel and were held every 2-3 wks after each club's regularly scheduled practice.

Eccentric hamstring program: Subjects completed Nordic hamstring lower [described in detail in Arnason, 2008 (1)]. Subjects performed 12 sets of 6 reps with 10 sec rest between reps and 2-3 min rest between sets.

Control: Subjects performed stretching and range of motion exercises including: standing gastrocnemius stretch; kneeling hip flexor stretch; supine and seated hamstring stretches; supine lumbar spine rotation. Subjects performed 3 reps of 15-30 sec each.

Pre intervention: During the pre-season period (16-20 wks) in the first 2 yrs of the study, training included the team's usual conditioning exercises such as a warm up run of about 800m, 10x60m accelerations, and lower limb stretches.

Intervention: During the pre-season period (16-20 wks) during study yrs 3 and 4, training was modified to incorporate "training as the game is played." This included: more running acceleration drills and emphasis on anaerobic conditioning as opposed to aerobic; 15 sec passive isometric hamstring stretches at varying knee angles performed when muscles were fatigued (e.g., during breaks in match play or in training); and a 5 min sport-specific running drill that required changing running speeds while running with the body positioned in trunk flexion, a position that puts the hamstrings at greater risk for strain. In this activity, a player would roll a ball on the ground while a partner would run behind attempting to take over. In addition, players who had previously trained with weights were told to avoid open chain leg exercises.

Outcome Measures: Incidence of hamstring strain injury. Hamstring injuries were defined as posterior thigh pain that was not caused by direct contact to the thigh. Injuries were confirmed by MRI.

Results: During the yrs with the intervention (study yrs 3 and 4), there were significantly fewer overall hamstring injuries (p<0.05), and significantly fewer occurred during matches (RR=0.3, p=0.01). The reduction in injuries occurring during practices was not significant (RR=0.4, p=0.3). In addition, significantly fewer games were missed due to injury (~36 games/season vs about ~11 games/season, p<0.001) during these same study yrs.

Conclusions: The authors concluded that a training program emphasizing the sport specific demands on the hamstrings reduced the risk of hamstring muscle injuries. A limitation of this study is that it is not possible to determine which component of the intervention was most effective. In addition, from year to year there was turnover in the
Hypothesis/Aim: To compare the effect of 2 rehabilitation programs on return to sport and reinjury among patients with acute hamstring strain.

Subjects: 24 adults (18 male; 6 female) meeting the following criteria: 14-50 yrs; acute first or second degree hamstring injury (within 10 days of injury); limitation of activity; symptoms including tenderness with palpation, pain with resisted prone knee flexion, and pain with passive tension during straight leg raise; and without other conditions that would limit the subject’s ability to complete the rehabilitation protocol.

Groups:
1. Stretching and strengthening (STST, n=11)
2. Progressive agility and trunk stabilization (PATS, n=13)

Duration: The length of the intervention varied based on the length of time required to return to sport. Assessments were completed according to patient progress but at least every 7 days. All subjects were followed up at 2 wks and 1 yr after return to sport to assess reinjury status.

Both groups participated in a home exercise program with follow up every 7 days. Both programs included 2 phases with progression to the second phase when subjects could walk with a normal gait pattern and do a high march in place without pain. The first phase for both groups included 20 min of ice to the hamstring following rehabilitation. Subjects completed exercise daily until they returned to sports, and then were encouraged to continue 3 days/wk for the next 2 mos. Compliance was set at 70%.

STST: Subjects completed daily stretching and isolated progressive resistance exercise. Examples of the exercises include: 4 x 20 sec supine hip flexion with knee extension (phase 1); 10 x 10 sec supine isometric hamstring contractions at 20° and 60° knee flexion (phase 1); 3 x 10 reps of prone leg curls with ankle weight (phase 2); 3 x 30 sec foot catches (phase 2).

PATS: Subjects completed daily progressive agility and trunk stabilization exercises. Examples of exercises include: 3 x 1 min sidestepping and grapevine (phase 1); 4 x 20 sec prone, supine, and side bridges (phase 1); 4 x 20 sec single leg windmill touches (phase 2); 2 x 15 reps PNF trunk pull-downs with theraband (phase 2).

Outcome Measures:

1. Time to return to sport: Subjects were allowed to return to sports when manually resisted knee flexion strength reached 5/5; there was no tenderness with palpation of the hamstring; and completion of running and agility tests without pain or tightness.

2. Reinjury rate: Reinjury rates were determined during the first 2 wks and the first yr after returning to sports. Reinjuries were based upon the subject reporting a specific mechanism of injury, pain with resisted knee flexion, tenderness with palpation, and decreased ability to do sport activities.

Results:

Time to return to sport. From the start of the rehabilitation program, the time required to meet the criteria for returning to sports activities was 33.3 days in the STST group and 18.8 days in the PATS group (p=0.2). Time for initial injury to return to sport also did not differ between groups.

Reinjury rate. Within the first 2 wks of return to sports, the reinjury rate was 54.5% (n=6) in the STST group while there were no reinjuries in the PATS group (p=0.003). Similarly, the reinjury rate within the first year was 70% (n=7) in the STST group and 7.7% (n=1) in the PATS group (p=0.006).

Conclusions: The rate of hamstring strain reinjury was significantly lower with progressive agility and trunk stabilization exercise as compared to stretching and strengthening exercise among a group of athletic adults. However, it should be noted that the same individual was responsible for both testing and rehabilitation.
### Table 2: Additional Exercises from VHI Exercise Kits

The exercises included in this newsletter are intended only as a sampling of exercises from the different VHI exercise collections that might be relevant to the topic discussed. Their inclusion in this newsletter does not represent any rehabilitation protocol or any suggested exercise progression that could be used with patients. Using the order of the exercises to create a rehabilitation program for patients is inappropriate and could result in serious injury.

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Table 2: Additional Exercises from VHI Exercise Kits (cont.)

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http://www.vhikits.com/newsletter/?issue=13
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References


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1 PubMed database was used to identify peer-reviewed research publications that addressed the specific clinical question (population, diagnosis, treatment, and outcome). For inclusion, studies must be a randomized controlled trial (RCTs) and published in English. A maximum of 10 RCTs were reviewed, with strength of design and publication year determining which studies to include.

2 No study footnotes needed.

3 Statistical definitions: 1) $P$-value ($p$) denotes the level of significance, where $p<0.05$ indicates a statistically significant result. 2) 95% Confidence Interval (95% CI): a range that contains the true population estimate 95% of the time. A smaller range indicates an estimate that is more precise. 3) Relative Risk (RR) is a ratio of proportions (ProportionTreatment / ProportionControl), RR less than 1.0 indicates the treatment group has a decreased risk of developing the condition/disease compared to the control group, while RR greater than 1.0 indicates the treatment group has an increased risk. 4) Incidence Risk Ratio (IRR) is the ratio of two incidence rates; the incidence rate among the treatment group divided by the incidence rate in the control group. IRR gives a relative measure of the effect of a given treatment with values less than 1.0 favoring the treatment. 5) Hazard Ratio (HR) is the relative likelihood of experiencing a particular event; an HR of 0.5 indicates that one group has half the risk of the other group. HR is broadly equivalent to RR, but is useful when the risk is not constant with respect to time as it uses information collected at different times. 6) Odds Ratio (OR) is the odds of an event happening in the treatment group expressed as a proportion of the odds of an event happening in the control group and can be interpreted similar to the RR. 7) Likelihood Ratio (LR) is the likelihood that a given test result would be expected in a patient with the target disorder compared to the likelihood that the same result would be expected in a patient without that disorder. The LR is used to assess how good a diagnostic test is and to help in selecting an appropriate diagnostic test(s) or sequence of tests.