Hamstring strains are a very common injury in many sports. Recurrence rates for this injury have been reported to be as high as 30%. Research has shown that the optimal angle for torque production in injured hamstrings occurs at a shorter muscle length compared to the uninjured side. Eccentric exercises have been shown to increase muscle strength and to cause a shift in the angle of peak torque to a longer muscle length, making them an essential component in effective rehabilitation protocols. Asking et al. demonstrated a 45% reduction in the time to return to sport following a hamstring injury using eccentric exercises that required no equipment and used body weight for resistance. While this eccentrically-biased rehabilitation protocol has been shown to result in a faster return to sport and seems to protect against reinjury, the actual training stimulus (i.e. relative muscle activity levels) for such exercises and the effect of these exercises on strength improvements and the length-tension relationship of the knee flexors has not been established.

**Background:** Rehabilitation emphasizing eccentrically-biased exercises have been shown to result in faster returns to sports after hamstring strains. The training stimulus for such exercises and their effect on the length-tension relationship has not been established.

**Objectives:** To document EMG activities of the hamstrings and gluteus maximus during 4 eccentric hamstring strengthening exercises and to assess knee flexion strength and the length-tension relationship following an eccentric hamstring strengthening program.

**Study Design:** Twelve healthy subjects participated in this study. Electromyographic activities from the biceps femoris, semitendinosus and gluteus maximus were recorded as subjects performed: (1) standing hip extension with elastic resistance, (2) trunk flexion in single limb stance (Diver), (3) standing hip (Glider), and (4) supine side-lying bridge (Silder). Baseline isometric knee flexion strength was measured at 90, 75, 50 and 30 degrees of knee flexion with the subject seated and the hip flexed to 30 degrees from horizontal. After completing the four-week training program, strength tests were repeated. Repeated-measures ANOVA were used to compare EMG activity between muscles and to assess angle-specific strength improvements.

**Results:** Hamstring activity exceeded gluteus maximus activity for resisted hip extension, Glider and Diver exercises (P < 0.001) but not for the Diver (P = 0.587). Hamstring activation was greater during the Diver and resisted hip-extension and lowest during the Glider and the Diver/Knee flexion strength improved by 9.5% (P = 0.034), but this was not angle-specific (Training by Angle P = 0.674).

**Conclusions:** The short-term home training program effectively targeted the hamstrings and resulted in strength gains that were similar at short and long muscle lengths. These data demonstrate that hamstring strength can be improved using eccentrically biased unilateral exercises without the use of weights or other equipment.

**Materials and Methods**

Twelve healthy, uninjured subjects (8M, 3F; Age: 32±10 yrs, Height: 1.7±0.2m, Weight: 75.4±8.6 kg) participated in a four-week hamstring strengthening program.

**Inclusion Criteria:**
- No free of injury to the lower extremities at the time of testing
- No lower extremity or hamstring injuries within the past 6 months
- No knee surgeries within the past year

**Training Program:**
Four unilateral exercises were performed three times per week for four weeks:
- 1) Hip extension with elastic band
- 2) Diver
- 3) Glider
- 4) Slider

Each exercise was first performed by one leg then the contralateral leg before moving to the next exercise.

**Week 1:** 3 sets, 10 reps; **Week 2:** 3 sets, 12 reps; **Weeks 3-4:** 3 sets, 15 reps

**Results**

<table>
<thead>
<tr>
<th>Exercise</th>
<th>Hip Ext.</th>
<th>Diver</th>
<th>Glider</th>
<th>Slider</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hip Ext. with elastic band</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Diver</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Glider</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Slider</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
</tbody>
</table>

**Electromyographic Analysis:**
- EMG data acquired as subjects performed five repetitions of each of the four strength training exercises on each leg.
- Electromyograms placed over:
  - Biceps femoris (long head)
  - Semitendinosus
  - Gluteus Maximus
- Peak EMG activation levels for each muscle, expressed as a percent of MVC, during the eccentric phase of each repetition were averaged and compared across exercises.

**Strength Testing:**
- Isometric strength of the knee flexors was measured at baseline and after completing the training program.
- Subjects seated in a dynamometer (Biodex, System 2, Shirley, NY, USA) with the hip flexed to 50 degrees from horizontal.

**Discussion and Conclusions**

This short-term home training program resulted in a small but significant strength improvement but without shifting the length-tension relationship to greater strength at longer muscle lengths. A possible reason for this could be that the fact that these exercises may not have sufficiently lengthened the hamstrings to produce a shift in the length-tension relationship. Future research is needed to design eccentric exercises which place the hamstrings in the lengthened state and require little or no equipment.

Despite not placing the hamstrings in the lengthened state, the exercises examined in this study improved strength and flexibility and may enhance core control. Each of these characteristics have been shown to be instrumental in reducing primary and secondary hamstring strains. Strength exercises that combine elements of balance and flexibility may accelerate an athlete’s progression through rehabilitation to return to sport phase, as opposed to using exercises which address each element individually.

These data demonstrate that hamstring strengthening can be improved using eccentrically biased unilateral exercises without the use of weights or other equipment. This targeted training program, which utilizes simple exercises and minimal equipment, can be performed in the home or in the gym and is easily adapted to different athletic populations and settings.

**References**