COMPARISON OF MUSCLE ACTIVITY DURING COMMON LOWER EXTREMITY REHABILITATION EXERCISES

Sabrina Silver[1], Cara L. Lewis[1] and Riann Palmieri-Smith[1]

[1]Division of Kinesiology, University of Michigan, Ann Arbor, Michigan, USA,
caralew@umich.edu

INTRODUCTION

Similar to the muscle redundancy problem in musculoskeletal modeling, rehabilitation specialists face a challenge when designing exercises to preferentially strengthen one muscle within a group of muscles that perform similar functions. For example, targeting the iliopsoas muscle separate from the rectus femoris muscle or the vastus medialis separate from the other knee extensor muscles is difficult. The purpose of this study was to evaluate muscle activity during the performance of commonly utilized rehabilitation exercises proposed to preferentially target specific muscles within a synergistic group.

METHODS AND PROCEDURES

Eight subjects participated voluntarily in this study. Subjects with current or recent history of significant hip or knee pain or neurological disorders were excluded. Each subject gave informed consent prior to participation.

Reflective markers were placed on the subject's trunk, pelvis and legs. Surface electromyography (EMG) electrodes were placed over the muscle bellies of the vastus lateralis, vastus medialis, rectus femoris, medial hamstrings, lateral hamstring and iliopsoas muscles. Iliopsoas was placed lateral to the femoral pulse, medial to rectus femoris, and inferior to the inguinal ligament (Gottschall and Kram, 2005). To ensure correct placement of iliopsoas electrode, each subject performed a pair of movements in quadruped as recommended by Cram and Kasman (1998). For the first movement, with the knee raised slightly off of the ground the subject brought the knee to the chest. For the second movement, the subject extended both the hip and knee out behind. If electrode placement was correct, an iliopsoas burst is seen only during the first movement of hip flexion. If questionable muscle activity was noted, the electrodes were repositioned and retested.

Kinematic and electromyographic data were collected while subjects performed supine hip flexion with knee flexion (heel slide) and supine hip flexion with knee extended (straight leg raising) under different conditions. Subjects performed heel slides naturally, and with the instruction to "dig" into the surface while sliding the heel. It is a clinical belief that performing a heel slide while digging into a surface will elicit iliopsoas activity without eliciting rectus femoris activity, despite both muscles' role as hip flexors. Subjects performed straight leg raises under three conditions: with the leg in neutral rotation, lateral rotation and medial rotation. Performing straight leg raises in different positions of femoral rotation is thought to target the knee extensor muscles differently. A metronome was used to regulate the speed of each movement which was performed through the same range of motion for each condition. We randomized the order of the conditions and collected five trials of each condition.

For each muscle, the average root mean square (RMS) of the EMG data was

calculated from the start of movement to the end of movement as determined by the kinematic data. For each subject, we averaged the values from the five trials. We used repeated measures analysis of variance followed by paired t-tests if appropriate to determine differences in muscle activity between exercises.

RESULTS

Variations in the exercises had an effect on the activity of certain muscles. The rectus femoris muscle activity was less in the heel slide with dig condition than the heel slide condition ($p = 0.002$). Conversely, the activity of the medial hamstrings and lateral hamstring was higher in the heel slide with dig condition than without the dig ($p < 0.05$). The iliopsoas muscle activity was similar across all exercises and conditions. Knee extensor muscle activity was similar in all straight leg raise conditions.

DISCUSSION

Modifying the heel slide exercise to include digging the heel into the ground was successful in reducing the rectus femoris muscle activity while maintaining iliopsoas activity. The hamstring muscles may have been inhibiting the rectus femoris activity as these muscles have antagonistic actions at the knee. In contrast, we did not find a difference in the muscle activity of the knee extensors during performance of the straight leg raise in three different rotation positions in this limited sample.

SUMMARY

Exercises thought to preferentially target specific muscles within a muscle synergy group should be carefully tested. Antagonistic muscle activity may be useful in reducing activation of one muscle while maintaining activation of another muscle which has a slightly different function.

REFERENCES

Cram, JR and Kasman, GS (1998). *Electrode Placement.* Gaithersburg, MD: Aspen.

Gottschall, JS and Kram, R (2005). *J Appl Physiol,* 99:23-30.

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Exercise	Iliopsoas	Rectus Femoris	Vastus Lateralis	Vastus Medialis	Medial Hamstrings	Lateral Hamstring
Heel Slide	0.057	**0.007**	0.004	0.010	**0.008**	**0.008**
	(0.018)	**(0.001)**	(0.001)	(0.003)	**(0.002)**	**(0.002)**
Heel Slide w/ Dig	0.096	**0.005**	0.008	0.011	**0.035**	**0.032**
	(0.036)	**(0.001)**	(0.003)	(0.002)	**(0.010)**	**(0.012)**
SLR – Medial	0.036	0.024	0.016	0.020	0.005	0.004
	(0.014)	(0.003)	(0.006)	(0.003)	(0.001)	(0.001)
SLR – Neutral	0.057	0.024	0.015	0.018	0.004	0.004
	(0.031)	(0.003)	(0.005)	(0.003)	(0.001)	(0.001)
SLR – Lateral	0.066	0.027	0.011	0.016	0.005	0.005
	(0.029)	(0.003)	(0.003)	(0.003)	(0.001)	(0.001)

Table 1. Mean (and s.e.m.) root mean square (RMS) from the start of the movement to the end of movement. Bolded cells indicate significant difference between conditions.