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Knee Rehabilitation, Part I

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Recommendations for knee exercises are often based on anecdotal prescription. Much of this prescription is based on trends that arise from new exercise equipment or single-paper studies that have long been outdated. It would seem logical to place more weight on information gained from objective measurement of knee muscle activity: electromyographic (EMG) analysis. When examining knee (or any other exercise) recommendations based on EMG information, it is important to consider:

- the type of exercise used (i.e., elastic tubing versus pulley versus weights) and the amount of resistance used;
- whether the subjects are symptomatic or asymptomatic;
- whether the subjects have patellofemoral disorders, anterior cruciate deficiency, etc.;
- whether the subjects are postsurgical; and
- whether EMG measurements are taken with fine needles or surface electrodes. (It is generally assumed that data from implanted electrodes is more specific than surface electrodes which may allow some cross-talk or contamination from neighboring muscles.)

In early EMG studies conducted in the 1890s, Soderberg et al.,[1,2] using surface electrodes, determined that more muscle activity was detected in the vastus medialis, biceps femoris and gluteus medius using quadriceps isometric "setting" exercises than with a straight leg raise (SLR). The rectus femoris, on the other hand, was more active during the SLR. Skurja, et al.,[3] also found similar types of activity when comparing isometric knee extension versus the SLR. These findings went unchallenged for more than a decade. Another assumption, partially based on these studies, was that the vastus medialis obliques were isolated in their increased activity through the last 10 to 15 degrees of knee extension.

More recently, researchers have attempted to test some of these old concepts and to go beyond testing only the SLR or isometric exercise. Newer motivations are the need to find low-tech approaches to exercising

patients with specific problems, such as patellofemoral disorders and anterior cruciate deficiency: each presents unique problems to prescribing the type of exercise and, more importantly, the range-of-motion least harmful to each group. The "paradox" has been that patients with ACL deficiency might do better with closed chain (i.e., foot in contact with a surface) exercise in moderate degrees of flexion, while patients with patellofemoral problems would suffer from the increases in joint reaction and compression forces. Patients with patellofemoral problems do better with exercises close to full extension, yet this is a range considered functionally dangerous for patients with ACL injury or deficiency (especially if performed as an open-chain exercise) due to the imbalance of quadriceps contraction pulling the tibia forward without concomitant hamstring protection.

In 1994, Cryzlo, et al.,[4] measured the EMG activity about the kneeusing indwelling wire electrodes during the performance of a numberof exercises. These included:

- the straight leg raise (SLR) --subject supine, raises leg with knee straight until 75 degrees of hip flexion is reached;
- short-arc knee extension (SAEX) -- subject seated with knee flexed to 45 degrees off the end of the table; subject extended from 45 degrees to full extension using a 12.5-lb weight;
- short-arc knee extension with hamstring co-contraction (SAEHS) -- same as the SAEX, however, subjects were asked to press back against thigh roll (to elicit hamstring contraction) as they extended through 45 degrees to full extension;
- the squat -- subjects were asked to perform a two-legged squat to 90 degrees of knee flexion, hold for three seconds and return to original position;
- isometric knee co-contraction (ICO) -- "setting" exercises were performed at 15, 30 and 45 degrees of knee flexion with the subject contracting isometrically both the hamstrings and quadriceps.

A summary of the results follows:

- Although during the SLR there was more rectus femoris activity than with the vasti muscles, it was not statistically significant. Also, activity of the vastus medialis oblique (VMO) and vastus lateralis oblique (VLO) was essentially equal; there was no predominance of VMO activity. Activity of both the VMO and VLO was highest during the first 15 degrees of the SLR. Basically the same was found for the short-arc knee extension and short-arc with hamstring co-contraction (SAEHS) exercises, with significant increases in activity through the last 15 degrees of knee extension. Although the SAEHS

was designed to increase hamstring contraction, the activity level was quite low (highest activity between 30-45 degrees).

- With the squat, the VMO/VLO and rectus activity was generally higher than the hamstring activity. The VMO/VLO activity was more than the rectus femoris during the ascend phase and highest during the hold phase. For the rectus femoris, the highest activity was also during the hold phase. Hamstring activity was highest during the ascend phase (although extremely low activity in general).
- Isometric knee co-contraction was the only exercise to provide a balanced activity between flexors and extensors. It was the only exercise tested to demonstrate any significant activity for the hamstrings.

Clinically, the usefulness of this data is interpreted as such:

- Although the squat exercise may be a valuable alternative to knee extension in the ACL-deficient patient, it does little to activate (strengthen) the hamstrings. The hamstrings are necessary for a stable joint with ACL-deficient patients. A balanced exercise might be SAEHS or the ICO in all ranges except 15 degrees of flexion to full extension. In this terminal range of knee extension, there is an overbalance of quadriceps activity over hamstring activity.
- The final arc of 15 degrees of extension is suggested for strengthening the quadriceps, however, there is very little to suggest selected contraction of any of the quadriceps group (i.e., VMO over VLO or rectus).

Next month, we will examine other forms of exercise for the knee, including elastic tubing exercises, treadmill and stair-stepping.

References

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