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Considering Patellofemoral Pain: Exercise Prescription

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PHYSICAL THERAPISTS, ATHletic trainers, and strength and conditioning specialists commonly encounter diagnoses related to dysfunction of the patellofemoral joint. In previous articles, patellofemoral joint anatomy and biomechanical principles were outlined. It is the purpose of this article to apply these principles to the development of an effective strengthening routine. In most cases, a properly applied strengthening and exercise regimen will be most effective in treating individuals with patellofemoral pain. This is evident for a number of factors:

- Muscles (not only the VMO) hold the key to normalized function.
- Muscles have the greatest potential for normalizing contact forces.
- Muscles act as "shock absorbers" for the knee, especially when functioning in an eccentric manner. Strengthening enhances neuromuscular control of the lower-extremity kinetic chain.

Relative forces between the patella and femur must be considered when developing exercise prescriptions for individuals with patellofemoral pain. These forces have been calculated as the patellofemoral joint reaction (PFJR) forces. The PFJR force is defined as the resultant vector force equal and opposite the pull of the quadriceps and the patellar tendon. Steinkamp et al. (1993, *Am. J. Sports Med.* 21:438) demonstrated mathematically that maximal PFJR forces during the leg press occur when contact between the patellofemoral surfaces is greatest (60° to 90°), whereas relatively high PFJR forces during a leg extension occur when the patellofemoral contact is the least (0° to 30°). Although the PFJR force increases with increased flexion, it is important to remember that the area of contact also increases. This enhanced area of contact can effectively respond to disperse these forces. Conversely, although compressive forces might be lower for leg extensions, individuals with patellar articular degeneration and arthritic changes often experience pain during open-chain extensions from 30° to 0° as a result of the relatively large compressive forces being applied to minimal patellar contact areas. A summary of open kinetic chain (OKC) versus closed kinetic chain (CKC) exercises in terms of PFJR forces is shown in Table 1.

Because of the VMO's role in stabilizing the patella against lateral tracking and because it is more easily inhibited after injury or surgery, special attention has been placed on the effects of exercise on the VMO. Several researchers have recommended the performance of specific quadriceps exercises for their suggested preferential activation of the VMO. However, recent studies utilizing normalized EMG values failed to demonstrate preferential VMO activation with such specific exercises. In light of these studies, we have found that emphasis placed on activating the VMO is best accomplished by introducing an effective generalized quadriceps-strengthening program and that attempts to isolate this region are not always necessary. Although the quadriceps has been implicated as the major muscular stabilizer of the patella, the gluteal musculature and the hamstrings have also been cited as playing roles in patellar alignment. Therefore, strengthening of the gluteal and hamstring muscle groups is an important

Table 1
PFJR Forces: Open vs. Closed Kinetic Chain Exercises

Exercise	Range	PFJR forces	Pain-free contact area
Closed chain	30°–0°	Low	Low
Closed chain	90°–60°	Maximum	High
Open chain	30°–0°	Maximum	Low
Open chain	90°–60°	Moderate	High

ingredient in the exercise prescription.

To select the most effective and appropriate exercises to strengthen targeted muscles involving the patellofemoral joint, it is often helpful to analyze peak EMG activity levels and torque parameters for various exercises. Wilk et al. (1996, *Am. J. Sports Med.* 24:518) compared EMG and torque parameters during OKC knee extension and CKC leg press and squat and has listed the following conclusions:

- Peak quadriceps EMG activity during squat and leg press is from 88° to 102°.
- Peak quadriceps EMG activity during knee extension is from 35° to 11°.
- Hamstring activity is extremely low during leg press and knee extension.
- Cocontraction is noted only with squat.
- Peak extension torque during squat and leg press is from 74° to 102°.
- Peak extension torque during knee extension is from 56° to 70°.

According to their research and the work of several investigators, Wilk et al. (1997, *J. Sport Rehab.*) have organized exercises into the following three groups relative to the muscular activity produced:

- Muscular cocontractions: fitter, slideboard, squat (0° to 40°), lateral lunges (30°).
- Isolated quadriceps contraction: knee extension, wall squats, leg press (45° to 100°), lateral step-ups.
- Isolated hamstrings contractions: knee flexion, retrograde stair climbing, ascent phase of squat (with trunk flexion), front lunges.

We have found it helpful to separate those with patellofemoral arthritis from those who exhibit excessive patellar mobility. In most cases, those with degenerative patellar changes will have increased symptoms with exercises performed in deeper flexion angles. Individuals with patellar instability will typically experience their symptoms in the terminal ranges of knee extension. In general, those individuals with degenerative changes will tolerate closed-chain exercises in earlier ranges of flexion, whereas those with increased mobility will perform better in greater degrees of flexion (generally greater than 30°), where the patella is stabilized by the femoral condyles. It should be emphasized that individuals must be exercised in pain-free and stable ranges. Those with documented patellofemoral arthritis should continually be monitored to ensure that exercises are not being done in ranges that increase PFJR forces on degenerative patellar facets. As noted earlier, exercise prescriptions might differ for cases of patellofemoral instability and subluxation versus patellofemoral arthritis. Examples of such exercises are shown in Table 2. In addition, proprioceptive exercises are utilized to train the athlete in proper lower-extremity kinematics during functional activities.

Summary

Successful management of patellofemoral disorders involves a comprehensive plan of care based on the results of a thorough and continuous evaluation of underlying causative factors. Exercises should be avoided that apply excessive compressive forces on degenerative patellar surfaces. Exercises must be designed that provide bony stability for those with patellar hypermobility. Exercises that activate the target-

Table 2
Summary of Exercise Prescription

Exercise	Pain-free arthritis	Pain-free instability
Leg press	0°–30°	45°–120°
Wall squat	0°–30°	45°–90°
Step-ups	Pain-free range	Pain-free range
Squats	0°–45°	0°–90°
Lunges	0°–45°	0°–90°
Straight-leg raise	If tolerated without pain	Generally not performed
Leg extensions	0°–30° if pain free	90°–45° if pain free

ed muscle group should be emphasized. Exercises should also be performed in ranges that highly activate the targeted muscle group. Furthermore, it should be ensured that proper lower-extremity mechanics are maintained during all CKC activities.

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