

## **The Truth about Open Kinetic Chain and Closed Kinetic Preventative Knee Exercises**

**Jim Ochse ATC, CSCS, \*D,PES, NSCA-CPT, \*D**

Integrating preventative knee exercises should be an important part of any personal trainer's repertoire. Every year knee problems ranging from patellar tendonitis, patellofemoral pain syndrome, medial collateral ligament sprains, and anterior cruciate ligament injuries are encountered by clients. The question arises as to what specific exercises can be implemented into a client's program. Are open kinetic chain exercises (OKC) better for certain clients? When should I start incorporating closed chain exercises into my client's program?

Let us first examine open chain exercises. Open chain exercises sometimes get a bad rap when it comes to strengthening the knees. However, in the initial phases of strengthening until the client achieves sufficient, these exercises should be utilized.

Some of the open kinetic chain exercises most often used to strengthen the knee are the quadriceps set, whereby the client performs an isometric contraction by pushing downward into the table or floor for 5-10 seconds, without moving the leg through a range of motion. Other exercises include the straight leg raise and the short arc quad extension. Among these, the quadriceps set is the most effective in producing quadriceps activity (Gough and Ladley, 1971). The rectus femoris works more in the straight leg raise and the short arc quad exercise. Vastus medialis activity is most apparent during a quad set. As would be expected, quadriceps muscles work more during a knee extension exercise than during a straight leg raise (Knight, Martin, and Londeree, 1979.) Open chain exercises are an important tool in restoring quadriceps strength, so these are essential elements in an exercise program for a client with isolated weakness.

Open and closed chain exercises have been the subject of debate, especially if a personal trainer has a client that has completed Anterior Cruciate Ligament (ACL) rehabilitation. Most recently, the type of exercise advocated for ACL injuries has been closed kinetic chain exercise. Research demonstrates a reduction in anterior shear stress and ACL strain in weight bearing activities that are performed in 0 degrees to 60 degrees. The least amount of anterior displacement in ACL deficient knees occurs during a closed chain exercise at 60 degrees, while the greater displacement in open chain activities at 30 degrees (Jenkins, et. al., 1977.)

It has been assumed that closed chain exercises recruit a co-contraction of the hamstrings and quadriceps to provide stability; but this has yet to be

substantiated through research. For example, investigators have demonstrated that the lateral step-up exercise, thought to recruit hamstrings and quadriceps, recruits the vastus lateralis and vastus medialis components of the quadriceps muscle significantly, but does little to recruit the hamstrings (Worrell, Crisp, and LaRosa, 1998.) Joint compressive forces in closed chain exercises may be responsible for reducing the shearing forces and anterior translation that occur in open chain activities (Isear, Erikson, and Worrell, 1997)

Yack and colleagues found that OKC exercises (such as knee extensions) caused greater anterior displacement (ATD) than CKC exercises (parallel squat.) These researchers found that OKC exercises place repetitive stress on already injured tissues and on tissue not primarily involved in the exercise. For clients that are recovering from surgeries, after completing initial OKC exercises and have sufficient strength, the implementation of closed chain squats, step-ups, and closed chain terminal knee extension with theraband are the exercises of choice.

In the OKC, there is less anterior shear stresses applied to the ACL in knee extension exercises from 60 degrees to 90 degrees flexion, and more is applied in terminal knee extension ranges of motion (Beynon et. al. 1995.) The greatest shear to the ACL occurs in 0 to 40 degrees flexion. The quadray for the personal trainer is that 30 degrees is the best possible position for quadriceps strengthening, but puts the greatest strain on the ACL. Less strain is applied to the ACL in closed chain activities, but an increase in patellofemoral joint force in closed chain activities beyond 50 degrees flexion. This can cause a dilemma with clients that have had ACL deficiencies or patellofemoral pain. Closed chain activities are less stressful for an ACL deficient client, but many clients have difficulty performing closed chain activities because of the pain. Based on research and the practical experience of the author, once the client has gained sufficient strength in the quadriceps and hamstrings muscles, CKC exercises can be incorporated into a client's program.

In summary, open kinetic chain exercises sometimes get a bad rap when it comes to strengthening the knee. However, in the initial stages of strengthening, these exercises can be implemented into a client's program. There are many CKC that are related to every day life and sport-orientated activities. Principles that apply to these types of exercises include:

- 1) The elimination of muscle joint isolation exercises.
- 2) The initiation of all exercises with legs, including the leg press.
- 3) The majority of emphasis on leg work using multijoint movements, such as squats versus knee extensions.

The utilization of OKC and CKC depends upon the individual histories, whether the client has sufficient strength in the quadriceps muscle, their goals, and motivation play a role as to which exercises are adapted to their program.

## Leg Press



The client may initially use both legs and then progress to single leg press. To reduce patellofemoral pain in the knees, the feet should be positioned high on the platform. When extending the legs, the knees should remain in a partially unlocked position. As the client flexes the knees, the client should not go beyond 90 degrees of flexion. As the client increases strength in both legs, they can begin with a light plyometric activity.

In the supine position, they can add resistive concentric and eccentric activity by having the client push off the platform and catch him/her as the feet return to the platform. The speed of the exercise depends on the force with which the client pushes off the platform and the amount of resistance used.

## Single Leg Press



Note that the client went only to 90 degrees flexion. The same rule applies for extension of the knee. Keep the knee in a partially unlocked position. Keep the lead leg high on the platform to reduce patellofemoral irritation/pain in the knee region.

## Squat Exercise

The squat primarily strengthens the quadriceps, hip flexors, hamstrings and gluteal muscles. The client bends at the hips and knees, but the knees should remain over the ankles so that the lower leg does not go beyond a perpendicular line to the floor. If the knee is flexed more than 90 degrees, patellofemoral stress increases and pain may result.

Common errors with this exercise include positioning the feet too close to the wall so that flexion goes beyond 90 degrees, placing more weight on an extremity, and hiking the hip so that the knee does not flex.

## SQUAT EXERCISE



## Terminal Knee Extension Exercise



This exercise is used to increase weight-bearing strength in the terminal-extension

range. A piece of theraband tubing is anchored around a stable object such as an upright bar, door jamb, or table leg. It is placed around the posterior knee. A pad or towel roll between the knee and band will enhance comfort. The client stands facing the door jamb or table with the knee slightly flexed from 30 to 45 degrees, with the theraband on the involved extremity. The quadriceps muscle is tightened to straighten but not lock the knee. The position is held up to five seconds and then slowly released and repeated several times.

## Lunges



Free weight or dumbbell lunges are performed from a two foot starting position. The client steps directly forward then recovers. The knee should remain in line with the second toe, and the arch should be lifted as weight is placed on the extremity. Common errors are to allow the arch to fall and the knee to move into a valgus position (Bending outward or away from the midline.) The knee should not move forward ahead of the foot. The lower leg should remain at an angle no more than perpendicular to the floor.

## Closed Chain Proprioceptive Exercises

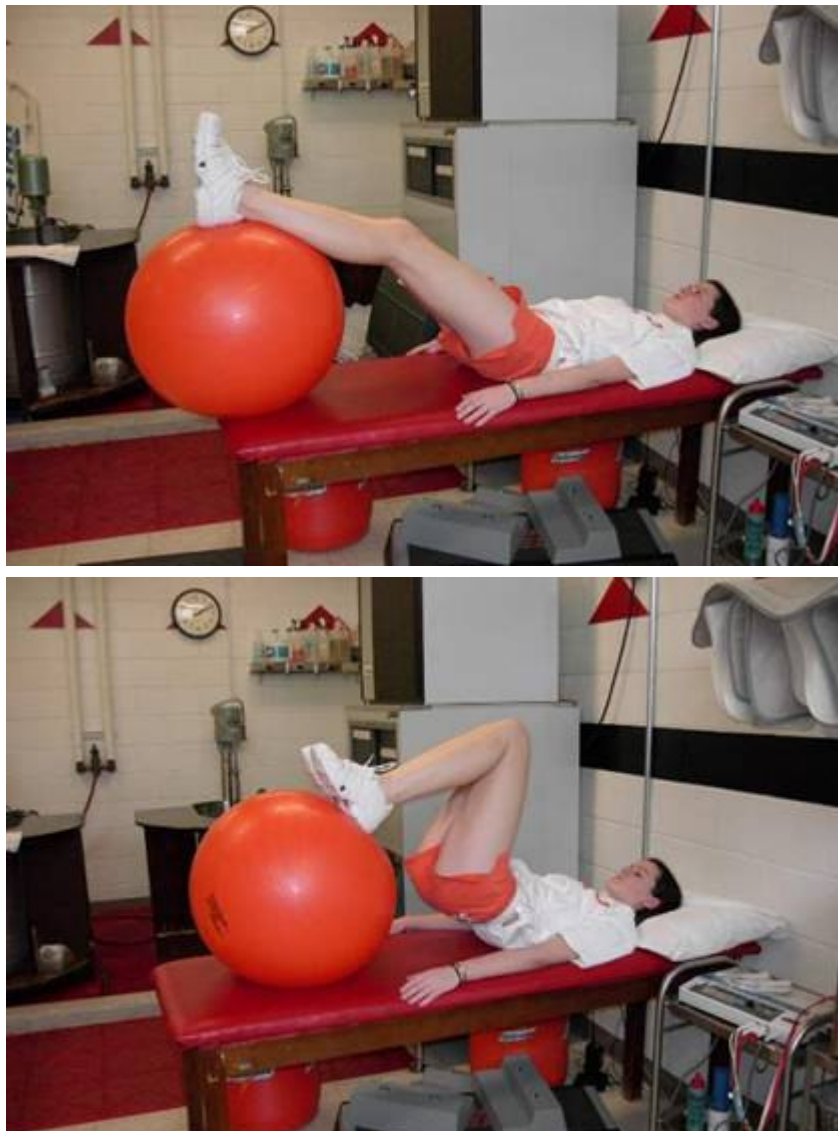


Figure 1 depicts the ball pick-up exercise, whereby the client bends down with the knee slightly bent. The client shown is on a foam roller to increase the level

of difficulty of the exercise. This creates a very unstable environment for the client, and integrates many functional movements.

Figure 2 depicts the client on a foam roller working on his sense of balance (proprioception) and his kinesthetic sense of where his body is in space. Initially have the client balance on one leg with the floor. As they become more proficient, then the level of difficulty can be increased by adding the foam roller.

### **Swiss Ball Hamstrings Curls**



The Swiss ball hamstring is a great exercise not only for the hamstring area, but also great for the abdominals and core area. Initially, have the client only raise their bridge from the table or floor to 2-6 inches. As they become comfortable



with the exercise, have them increase their bridge. Bring the legs as close to the buttocks as possible. This exercise is far superior to the prone hamstring curls on a machine. It really isolates the hamstring region.

## Open Chain Exercises

### Leg Extension



The knee extension machine should be used with caution. Many strength and conditioning specialists do not advocate its use because of the potential injury to the patellofemoral joint and to the ACL (anterior cruciate ligament), particularly with clients that have had patellofemoral problems or post surgery ACL clients. Limited range of motion from 90 degrees to 40 degrees of flexion can be used as part of the client's program.

### Short Arc Quadriceps Exercise



An open chain version of terminal knee extension or short arc quads can be used initially for clients that have weakness in the last 30 degree of extension. Angles used are from 30 degrees flexion to 0 degrees of extension. Clients that are predisposed to patellofemoral pain or ACL deficient clients may not be able to perform this exercise due to pain exacerbation.

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Questions pertaining to any of this information can be sent to Jim Ochse at [ochse@peakcondition.net](mailto:ochse@peakcondition.net), or visit his website at [www.peakcondition.net](http://www.peakcondition.net).