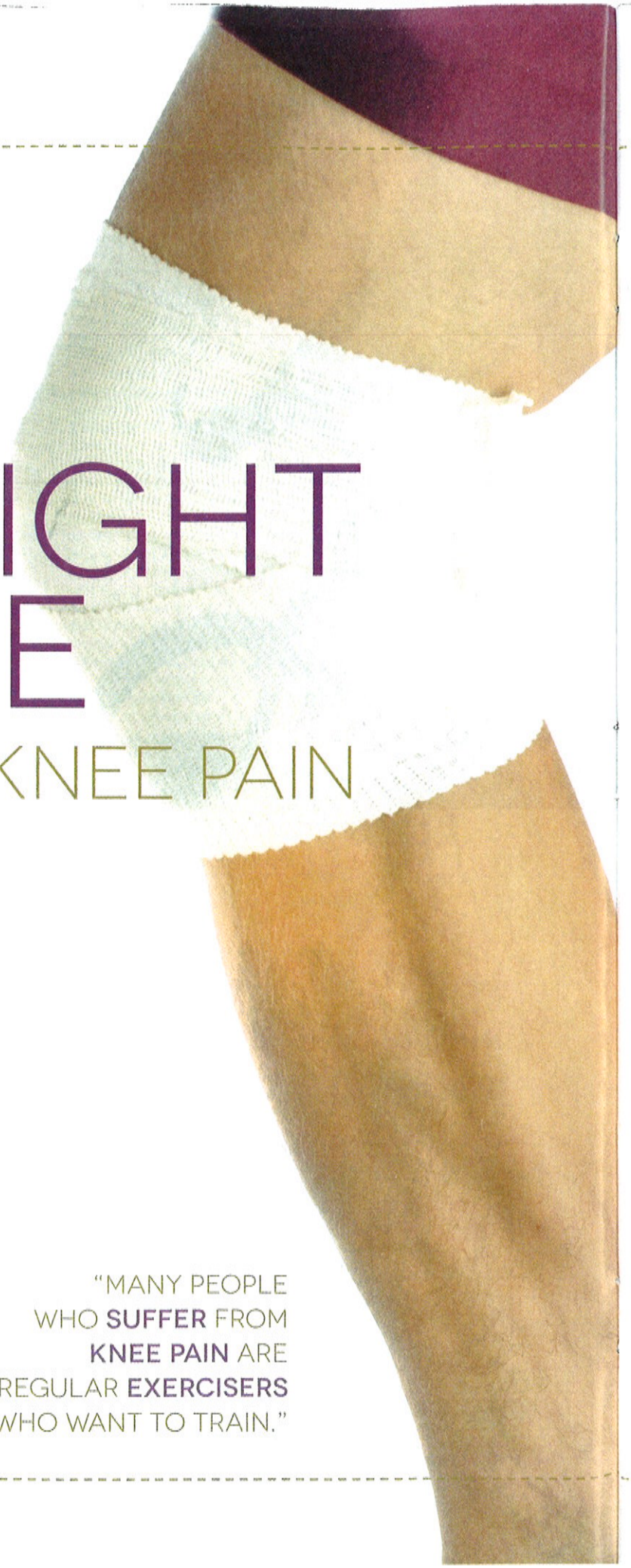

FINDING THE RIGHT ANGLE TO REMEDY KNEE PAIN

Focus on the Quadriceps

BY AMY ASHMORE, PhD

Many people who suffer from knee pain are regular exercisers who want to train. The key to helping those individuals is to understand the anatomy and function of the quadriceps muscle and how they can use this knowledge to their advantage.

The quadriceps is the largest muscle *group* in our body. It is the primary knee extensor and is made up of the rectus femoris, vastus lateralis, vastus intermedius and vastus medialis. Each of these four muscles is distinct in both anatomy and function. Although the four muscles of the quadriceps do make up one muscle, when we think of them as such, we tend to forget the importance of working each of these muscles separately. This can lead to muscle imbalances and dysfunction as well as diminishing the full repertoire of tools necessary to remedy knee pain and keep it away.

"MANY PEOPLE WHO **SUFFER** FROM **KNEE PAIN** ARE REGULAR **EXERCISERS** WHO WANT TO TRAIN."

To analyze the quadriceps, the first step is to separate the rectus femoris from the three vastus muscles. The rectus femoris is different from the vastus in two fundamental ways:

1. The rectus femoris crosses two joints—the knee and hip.
2. It has a different function at different hip angles than the vastus group.

Next, if we were to take the rectus femoris away and just look at the vastus muscles, we would see two defining points:

1. The vastus lateralis (VL) is the largest (therefore strongest) of the three.
2. The vastus medialis (VM) is the weakest of the three (Mercer, 2011).

The strength difference between the VL and VM is important because the VM on the inside of the knee works with the VL on the outside to provide patellar stabilization and normal tracking. One of the most common sources of knee pain among people who exercise regularly is patellar tracking dysfunction. It is often caused by the strong VL pulling the patella outward and upward during activities such as jogging, elliptical use, and even walking. The mechanism is simple: The weaker VM cannot match the strength of the VL and allows the lateral pull of the patella.

For fitness professionals, the concept of dysfunction caused by a weak muscle within a group of muscles is critical. It is the **weakest link** and as such, limits the total amount of weight that can be lifted by a group of muscles. It may also limit the functionality of that group in general. For example, when we do a compound exercise such as a dead lift, the amount of weight that we can lift is limited by a weak link. This can be the grip strength of the wrist flexors and extensors or the erector spinae in the lower back.

If one muscle is stronger than another when they need to be of equal strength, a **muscle imbalance** develops. A muscle imbalance is defined as a difference in strength between two muscles. Think of an imbalance between muscles at a joint as similar to a pulley system where one set of ropes is overlengthened and loose while the other is short and tight. This is what can happen with the VL-VM strength ratio. But we can correct it and maintain it when we approach this common problem from a new angle.

BALANCING THE VL–VM STRENGTH RATIO

To balance the VL-VM strength ratio requires the **principle of specificity.** When targeting a muscle, an exercise which isolates that particular muscle is required.

It is tough to target the VM during compound movements. This is because the principle of the weakest link dictates that the larger and stronger muscles will take over during a compound movement. A good example is a squat. When the VM is fatigued or cannot lift the desired load, the larger VL and/or rectus femoris will dominate the lift. In the worst case the VM will simply fail to work, and it is common to see knees rotating inward or outward as the patella is not being maintained in proper position.

In the case of correcting the VL-VM imbalance, we want to get specific enough in the mechanics to target a particular fiber group within the VM. The VM has two fiber divisions based upon known fiber orientations. These are the VML (proximal) and VMO (distal). The VML is the length of the muscle while the VMO is the small teardrop part of the muscle above the knee. VMO fibers are considered to be the determinant of patellar tracking dysfunction caused by the VL-VM imbalance.

However, there is still some debate whether the actual two divisions exist from a nerve innervation perspective (Smith et al., 2009). Although the fiber differences are present anatomically, it remains to be shown that the two different fiber groups are truly controlled by distinct nerve pathways and thus have different functions.

Trainer's Tips:

- *When seated, rotate the femur outward from the hip.*
- *On the seated knee extension, manipulate the length of the lever arm so that it rests on the client's lower leg right above the foot. If it is too far away the torque is too great on the knee.*
- *On the seated knee extension, do not allow for full flexion—set the lever so that it does not return to the full flexed and down position.*
- *Use peak contraction (pause and squeeze the muscle) at full extension, but don't hyperextend.*
- *If you do use a squat or lunge exercise, make certain the client performs the last 20 to 30 degrees of knee extension at the top of the movement. Don't allow partial range-of-motion (ROM) repetitions. Partial ROM exercises will not recruit the VMO adequately.*

STRATEGIES TO EXERCISE WITH KNEE PAIN AND KEEP IT AWAY

Compensatory Action

Compensatory muscle action is when we compensate for a weak muscle

or recurring problem by substituting a similar movement. In some cases, this can be negative when we ignore a muscle or fail to use it and it atrophies or loses function. However, in some instances it can be helpful. For example, if we use compensatory action to protect a joint.

The quadriceps is designed in a way that allows us to exploit the anatomy of the rectus femoris. Because the rectus femoris crosses both the knee and hip joints, it does the most work when the hip is extended. So it works during stepping, but not during a seated leg extension. It also acts as a hip flexor to raise the knee to the hip while standing. The functional anatomy of the rectus femoris is important because it allows us to utilize pull forces during common cardio exercise to protect the knee.

Functional kinesiology dictates that when we produce a pull force we use concentric muscle contractions that reduce joint angles—think about pulling a drawer open. But, when we produce a push force, the length of the muscle as well as the joint angle increases. Typically pull forces are greater and they are easier for us to produce, while a push force can unnecessarily load a joint.

To apply push versus pull forces during common cardio exercise think about stair stepping. We can use hip flexion to recruit the powerful rectus femoris versus constantly pushing down on the knee. This increases the work load against gravity and uses more energy. To apply the concept, your client should think in terms of pulling up from the hip versus pushing down and repeatedly extending the knee.

Another way to protect knees during common cardio exercise is to exploit the size of the gluteus maximus. It is the largest muscle in the body (Silverman, 2011) and the primary hip extensor. By using it to extend the hip versus focusing exclusively on the knee action, we can both recruit the largest muscle in the body for energy use and protect the knees.

Minimizing Additional Forces That Act on the Knees

A final thing to think about when exercising individuals with knee pain and preventing it is to look at the forces that act on the joints during exercise. Shearing forces are those that are similar to twisting a cap on a water bottle. They occur when there is lateral or medial movement in a joint. Avoiding those motions that cause the immobile knee to move laterally or medially dramatically improves knee health.

In contrast to a shearing force is compression. This is a vertical force that acts on the knees when you jump, jog, step, or even do a lunge. It can be envisioned as when a hammer hits a nail. Although it is virtually impossible to avoid these forces during exercise, they can be minimized by varying movement patterns, limiting high impact, watching mechanics, and building strong muscles at the impact joints such as the knee.

The final type of force important to fitness professionals is the ground reaction force (GRF). The GRF is the ground exerting a force back when an object strikes it. GRF most commonly affects the feet, ankles and knees. Again, it is impossible to avoid these forces during human movement, but the same strategies used above to minimize compression forces can also be applied here.

EXERCISE SUGGESTIONS ON TRAINING QUADS

Among the recommended exercises advocated for training quads are

Step-ups, step-downs
Wall squats
Leg presses

A good strategy is to include any exercise that uses knee extension as a primary motion. Also recommended are one-legged or unilateral exercises—extension, squats (advanced) and leg presses, for example. These exercises work well because each side does equal work rather than the dominant side handling the work load.

CONCLUSION

Knee pain is very common among both the general public and persons who exercise regularly. The key to preventing knee pain and keeping it away lies in understanding the quadriceps muscle, strengthening it, exploring alternative exercises for the same purpose, and paying careful attention to exercise mechanics. AF

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