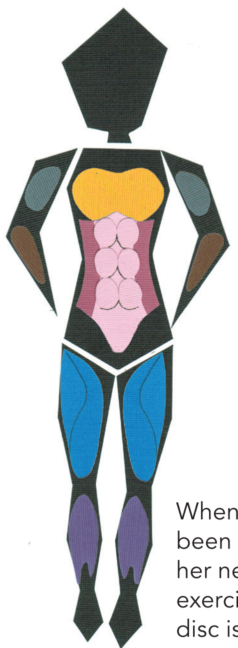
Education

Understanding Muscle Function



Has it been a while since you cracked an anatomy textbook? In a series of columns, chiropractor and educator Joe Muscolino and his wife, Pilates instructor Simona Cipriani, will give *Pilates Style* readers a quick review of the basics of kinesiology. This issue, we'll focus on muscle contractions.

by Dr. Joe Muscolino and Simona Cipriani

When Julie came to my studio having been diagnosed with a bulging disc in her neck, she was in pain and afraid to exercise. I explained what a bulging disc is and how we could exercise her body and strengthen and rehabilitate her spine without aggravating her neck. I then modified her session by having her work in the seated position on the Electric Chair with her spine stabilized against the back of the chair. By initiating the movement from her lower body through the core and up to the spine, I found a successful strategy to begin Julie's road to recovery.

But I wouldn't have known how to devise a safe and effective workout for Julie without a thorough understanding of kinesiology, in other words musculoskeletal anatomy and physiology. This knowledge allowed me to critically analyze what effect each Pilates exercise would have on Julie's body. The goal of this column is to introduce the key concepts of kinesiology and apply them to Pilates, empowering you to do effective clinical work.

TWO KEY QUESTIONS

When you work with a client, you need to continually ask and answer two questions: Which specific exercises should I choose for this particular client today? And, for each exercise chosen, do I need to modify it given his or her specific needs? This is especially important when you're working with a client who has an injury. An understanding of the fundamental principles of kinesiology allows you to modify your client's workout, creating a rehabilitative workout that can help remedy the client's musculoskeletal condition.

Although Pilates is a system, and there is definite wisdom of how Joseph Pilates sequenced the exercises during a workout, it is not always in the client's best interest to put him or her through the same routine as you do with every other client. An understanding of how muscles work allows you to evaluate the pros and cons of each exercise and modify these exercises as appropriate to create the ideal Pilates workout routine for each client. This way, you will not only be improving his or her general health and conditioning, but also helping to address and rehab your client's specific musculoskeletal condition.

HOW MUSCLES WORK

A muscle is a soft tissue organ that typically attaches from one bone to another, crossing the joint that is located between them (see Figure 1). (Though muscles are thought of as attaching only to bones, muscles also have fibrous attachments to nearby soft tissues, including other muscles.) When a muscle contracts, it creates a pulling force that is directed toward its center; this pulling force is transferred to both of its bony attachments by its tendons (see Figure 2 on opposite page). These bony attachments are located within different parts of the body. When the muscle contracts, it creates a pulling force that attempts to flex the elbow joint by pulling the forearm toward the upper arm or the upper arm toward the forearm in front.

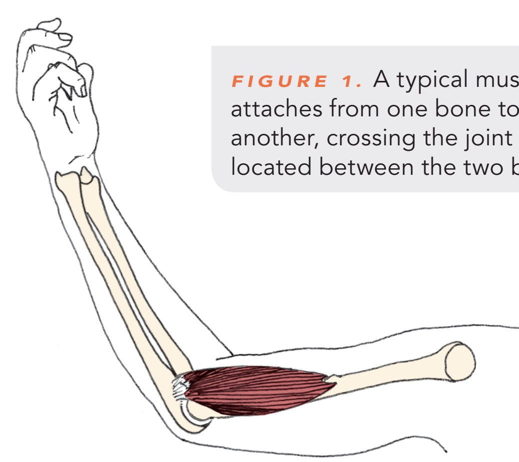


FIGURE 1. A typical muscle attaches from one bone to another, crossing the joint that is located between the two bones.

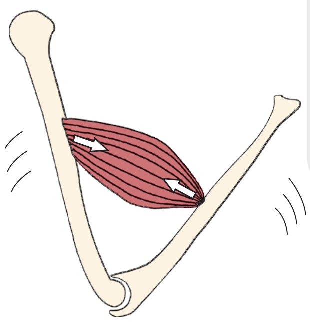


FIGURE 2. When a muscle contracts, it exerts a pulling force toward its center on both of its bony attachments.

Whether or not the muscle actually succeeds in flexing the elbow joint by moving either the forearm or the upper arm depends upon the strength of the muscle's contraction compared to the resistance to motion of the forearm and upper arm. For a body part to be moved, its resistance to motion must be overcome. In most situations, the resistance is the weight of the body part. For the muscles that cross the elbow joint, this means that they must generate enough force to move the weight of the distal forearm (and attached hand) or the weight of the proximal upper arm (and attached trunk). Because the forearm and hand weigh less than the upper arm and trunk, if the muscle is to succeed in flexing the elbow joint, it only needs to generate enough force to move the lighter distal attachment. This motion is called flexion of the forearm at the elbow joint (see Figure 3).

TERMS: PROXIMAL AND DISTAL

The upper arm is called the proximal attachment because it is closer to the core of the body, and the forearm is called the distal attachment because it is farther from the core of the body.

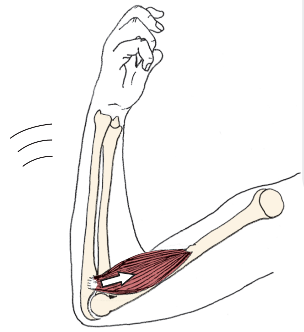


FIGURE 3. When a muscle crossing the elbow joint contracts and shortens, the standard joint action is for the distal forearm attachment to move.

TYPES OF MUSCLE CONTRACTIONS

When a muscle contracts with enough force to overcome the resistance to movement and succeeds in shortening and moving one or both of its attachments, that muscle is called a mover muscle (or agonist muscle) and its contraction is called a concentric contraction.

CONCENTRIC CONTRACTIONS

Concentric contractions are shortening contractions; these are the typical contractions that are thought of when muscles work. Muscles can also eccentrically contract and isometrically contract, however: An eccentric contraction is a lengthening contraction and an isometric contraction is one in which the muscle stays the same length. What determines whether a muscle contracts concentrically, eccentrically or isometrically is how much force it generates compared to the force of the body part's resistance to motion.

STANDARD AND REVERSE CONCENTRIC CONTRACTIONS

Whenever a muscle concentrically contracts and moves its distal attachment, it is called a "standard action" (see Figure 3 above). It's referred to as a standard action because a distal attachment is lighter than a proximal attachment.

Distal attachments do not always do the moving, however. A mover muscle can contract and move the proximal attachment instead. When this occurs, it is called a "reverse action." For instance, when the hand holds on to an immovable object such as a pull-up bar, and a pull-up is performed, the forearm is stabilized, and the upper arm, along with the rest of the body, moves instead. Reverse actions occur when the distal attachment is stabilized and therefore more resistant to moving than the proximal one (see Figure 4). Reverse actions occur much more often than many people realize, for instance, when you use a banister to pull yourself upstairs, you're performing a reverse action at the elbow joint.

It is also possible for both a standard and reverse action to occur simultaneously (see Figure 5). An example of this is canoeing. When we place the paddle in the water and pull it toward us, the paddle, hand and forearm move toward the upper arm, but the upper arm also moves toward the forearm, pulling our body and the canoe forward in the water.

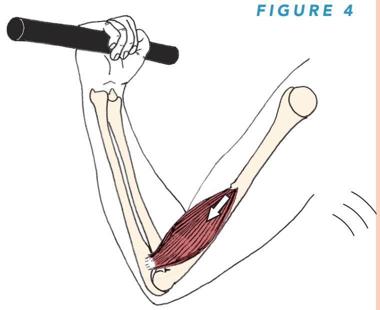


FIGURE 4

FIGURE 4. When a muscle crossing the elbow joint contracts and moves the upper arm instead of the forearm, it is called a reverse action. For example, this motion of flexing the upper arm at the elbow joint occurs when a pull-up is performed.

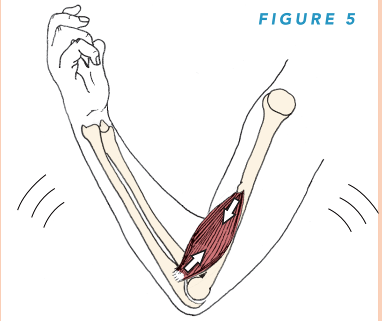


FIGURE 5

FIGURE 5. When a muscle contracts, both the standard and reverse actions can occur. Here we see flexion of the forearm and flexion of the upper arm at the elbow joint.

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OPEN-CHAIN AND CLOSED-CHAIN MOTIONS AND ADDING RESISTANCE

Standard mover actions occur when the distal attachment is free to move. These scenarios are called open-chain motions because the end of the kinematic chain of body parts—the hand in the upper extremity and the foot in the lower extremity—is "open" and free to move. These motions are extremely common in Pilates matwork and occur, for example, when doing the Hundred.

Reverse mover actions occur when the distal body attachment is not free to move. These scenarios are called closed-chain motions because the end of the chain of body parts is "closed" against an immovable object and not free to move, for instance, when the hand is holding onto a fixed object or the foot is planted on the floor or some other fixed object. Closed-chain reverse actions often occur with Pilates apparatus work, for example, when the feet are placed against the Reformer's footbar and the proximal body and carriage are moved.

It is also possible to have a mixed open-chain/closed-chain motion. An example of this in Pilates is using the Reformer straps, such as when doing the Frog (see Figures 10 and 11); the straps provide resistance that causes proximal motion of the body and carriage, but they also yield and allow distal movement of the foot.

FIGURE 10

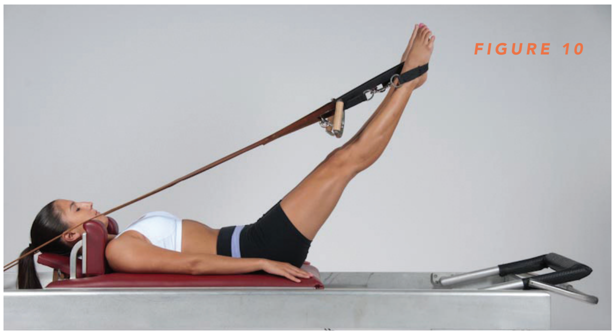
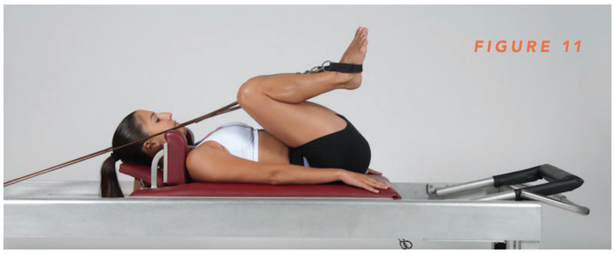


FIGURE 11



FIGURES 10 & 11. The Frog exercise on the Reformer is an example of a mixed open-chain and closed-chain exercise.

ECCENTRIC CONTRACTIONS

Eccentric contractions are lengthening contractions that occur whenever a muscle contracts with less force than the resistance force. Because the muscle lengthens, its attachments move away from each other. These contractions occur most commonly to slow down the force of gravity. For example, if we want to lower a glass of water to a tabletop, we allow gravity to bring our hand and forearm down, but we contract our elbow joint flexor musculature to slow the descent (see Figure 6). An eccentrically contracting muscle does not create this motion; instead it slows it down; in other words, it opposes the motion that is occurring. For that reason, an eccentrically contracting muscle is called an "antagonist."

A good example of eccentric contraction when doing Pilates is doing a Roll-Up on the mat. When we return back to the mat, abdominal wall musculature in the front of our body wall eccentrically contracts and lengthens, slowing down and controlling the descent of the upper body (see Figure 7).

FIGURE 6

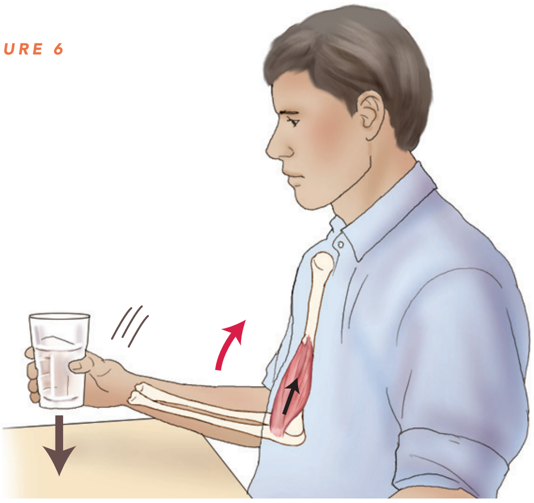


FIGURE 7

FIGURE 6. We are eccentrically contracting musculature to slow the force of gravity as we bring a glass down.

FIGURE 7. During the Roll-Up, eccentric muscle contraction occurs in the anterior abdominal wall as the client brings the body back down toward the mat with control.

ADDING INTERNAL RESISTANCE TO THE ANTAGONISTS

As a general rule, eccentrically contracting antagonist muscles only need to work against the external resistance force of gravity acting on the client's body. It is common in Pilates, however, to add to gravity's resistance force with internal muscle contractions, such as when you lower the thigh toward the mat during the Double-Leg Straight Stretch (see figure 12). Gravity brings the thigh down into extension toward the mat, and the hip flexor muscles eccentrically contract to slow this motion. If we cue the client to contract the hip extensor muscles during this motion, however, the hip flexors will now be working against both gravity and the contraction of the hip extensor muscles. This increases the contraction force and therefore the strengthening of the hip flexor musculature.

FIGURE 12. During the Double-Leg Straight Stretch mat exercise, the client can be cued to contract the hip extensor musculature to create internal resistance that the hip flexor musculature works against as the thighs descend toward the mat.

ISOMETRIC CONTRACTIONS

An isometric contraction occurs when a muscle contracts yet stays the same length because it contracts with the same degree of force as the resistance force. A good example of isometric contraction is two opponents at a stalemate when arm wrestling (see Figure 8).

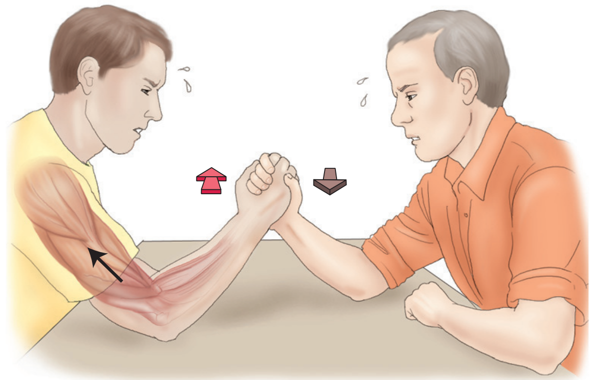


FIGURE 8. Two opponents are isometrically contracting while at a stalemate when arm wrestling.

The Teaser is another good example of an isometric contraction at work: After the position is attained, it is often held for a few seconds, during which time the client's musculature is contracting isometrically (see Figure 9). An isometric contraction does not cause motion of a body part, nor does it slow down motion; rather it entirely stops the motion that would occur due to an external force, usually gravity. Thus, isometric contractions are responsible for stabilizing a body part so that it does not move. (Note: Pilates does not tend to hold isometric static, full-body postures like other body-conditioning methods—such as yoga—often do.)

FIGURE 9. Isometric muscle contractions occur when performing the Teaser.

By adding an understanding of kinesiology to a knowledge of the exercises prescribed by Joseph Pilates, instructors will have even greater success in helping clients achieve their goals, whether it's better overall fitness or rehabilitation of injuries. **PS**

FIGURE CREDITS:

Figures 1-6 and Figure 8 from *Muscolino JE: Kinesiology: The Skeletal System and Muscle Function, ed. 2.* St. Louis, 2011, Mosby.

Figure 9 courtesy Simona Cipriani, *The Art of Control*. Photography by Christopher Duggan.

Figure 7, 10, 11, 12 courtesy Simona Cipriani, *The Art of Control*. photography by Yanik Chauvin *www.yanikchauvin.com*.

Dr. Joe Muscolino has been an author and educator in the world of manual and movement therapies for more than 25 years. For more information, visit www.learnmuscles.com or follow him on Facebook at The Art and Science of Kinesiology.

Simona Cipriani is a former dancer and has been a Pilates instructor for 18 years. She owns and runs The Art of Control at Purchase College, SUNY in Purchase, New York. For more information, visit www.artofcontrol.com.