by joseph e. muscolino, DC

"The body is a marvelous machine... a chemical laboratory, a power-house. Every movement, voluntary or involuntary, full of secrets & marvels!"

—Theodor Herzl (1860 - 1904)

Back to Basics:

Actions & Reverse Actions of a Muscle

There is no denying that one of the most important factors to massage therapists is excellent hands-on technique. However, when working clinically, a firm understanding and application of the principles of kinesiology is of equal value. Kinesiology literally means the study of motion. Given that motion of the body is primarily caused by the internal forces created within our body by muscle contractions, a solid understanding of the mechanism of muscle contraction is of paramount importance. This is true both when assessing a client's dysfunction as well as when determining the appropriate therapy for a client.

When a muscle contracts, it creates a pulling force on its attachments that is directed toward the center of the muscle. This pulling force attempts to shorten the muscle. If its contractile pulling force is greater than the resistance force it meets, the muscle succeeds in shortening (concentrically contracts) and creates movement of one or both of its attachments (Figure 1). It's essential to understand that when a muscle contracts, it has no ability to choose which one of its attachments will move—a muscle contraction

RESOURCES

For more reading about kinesiology, try "Kinesiology of the Musculoskeletal System: Foundations for Physical Rehabilitation" by Donald Neumann.

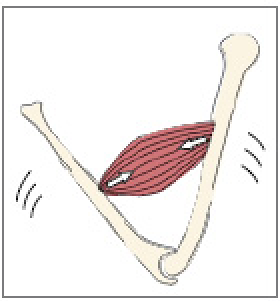


Figure 1 illustrates that when a muscle contracts, it creates a pulling force toward its center. If this pulling force is sufficient to cause movement, the muscle succeeds is shortening as it contracts. It's said to concentrically contract.

pulls equally upon both of its attachments. The determination of which attachment moves—in other words, the intention and control of musculoskeletal movement—resides within the central nervous system.

A muscle is effectively a machine under the will of the nervous system. When the nervous system wills a movement pattern, it co-orders certain muscles—or more precisely, specific motor units of certain muscles—to contract. The coordination of these forces acts upon the skeleton across joints, resulting in movement of our body parts at these joints. If the co-ordering is well done, we exhibit a well coordinated, graceful movement pattern. The term used to describe the nervous system's muscular coordination patterns of movement and/or posture is *muscle memory*. Muscle memory resides in the nervous system, not in the muscles themselves.

Insertion & Origin

To examine the mechanism of a muscle contraction, let's call the two attachments of a muscle Bone A and Bone B. When a muscle concentrically contracts, three different scenarios can result: 1) Bone A is mobile and moves toward Bone B, which is fixed; 2) Bone B is mobile and moves toward Bone A, which is fixed; and 3) both Bones A and B are mobile and move toward each other and neither attachment is fixed (Figure 2).

You probably learned to name muscle attachments as origin and insertion, and that when a muscle contracts, the origin stays fixed and the insertion moves.* For example, the humeral attachment of the brachialis muscle is called the origin, and the ulnar attachment is called the insertion. When the action of the brachialis is studied, you learn that its insertion (the forearm) moves toward its origin (the arm), resulting in flexion of the forearm at the elbow joint (Figure 3a). This action typically occurs because the forearm is lighter and, therefore, offers less resistance to moving than

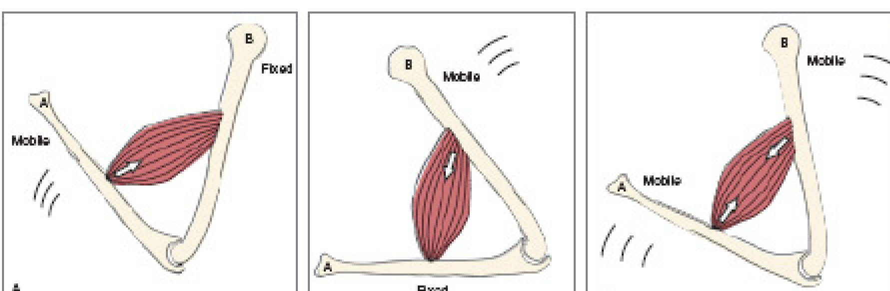


FIGURE 2 shows the three scenarios that can result when a muscle concentrically contracts. Naming the attachments of the muscle Bone A and Bone B, either Bone A can move toward Bone B, Bone B can move toward Bone A, or both bones A and B can move toward each other.

*The definitions of origin and insertion are not consistent. Some medical dictionaries define the origin as the less mobile or more fixed attachment; others define it as the proximal attachment of a muscle. Similarly, some medical dictionaries define the insertion as the more mobile or less fixed attachment; others define it as the distal attachment.

insertion & origin further explored

If the origin is originally defined as being fixed, then when the origin of a muscle moves, should it now be called the insertion? In other words, is the ulnar attachment of the brachialis now the origin? The same question could be asked about the insertion. Reverse actions point out an inherent ambiguity and contradiction with the terms origin and insertion. A simpler and more consistent terminology would be to simply name the proximal attachment as the *proximal attachment* and the distal attachment as the *distal attachment*, and skip the terms origin and insertion entirely.

does the arm, which is heavier. Furthermore, if the arm does move, the entire trunk would have to move along with it, which increases the resistance to the arm moving.

Reverse Actions

The danger in learning muscles in this manner is that it tends to create a rigid picture of how muscles work, a picture that isn't always true. A concentrically contracting muscle doesn't always move its insertion toward its origin; it's entirely possible for the origin to move toward the insertion instead. For example, looking at a concentric contraction of the brachialis, it's possible for the brachialis to flex the elbow joint by moving the arm toward the forearm. This would naturally occur if the distal end of the upper extremity is more fixed than the proximal end, as it is when the hand is holding onto an immovable bar when performing a pull-up (Figure 3b). The joint action is flexion of the arm at the elbow joint. This type of joint action of a muscle where a mobile origin moves toward a fixed insertion is called a *reverse action*.

It might seem that reverse actions are not very common, but they actually occur quite often. Other examples of reverse actions at the elbow joint include pulling on a banister when climbing a staircase or paddling a canoe. In the lower extremity, reverse actions probably occur

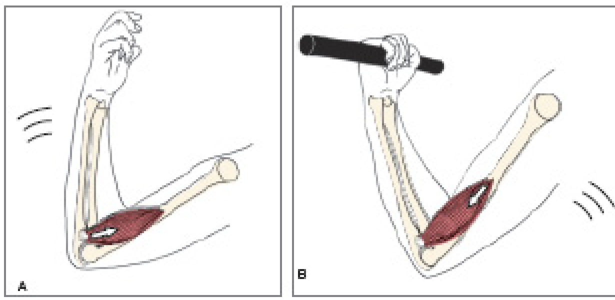


Figure 3 illustrates two possible scenarios when the brachialis contracts. Figure 3a shows flexion of the forearm at the elbow joint. Figure 3b shows flexion of the arm at the elbow joint, an example of a reverse action.

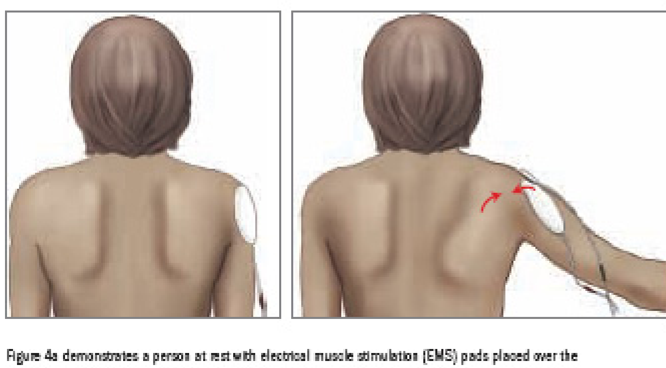
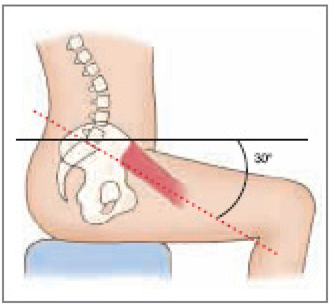
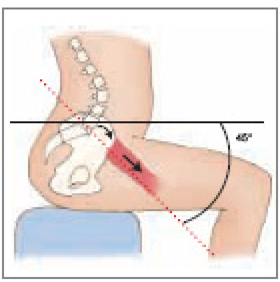


Figure 4a demonstrates a person at rest with electrical muscle stimulation (EMS) pads placed over the deltoid muscle. In Figure 4b, when the EMS machine is turned on, an isolated concentric contraction of the deltoid muscle occurs. When the deltoid is the only muscle to contract as in Figure 4b, we see that it pulls the arm into abduction at the shoulder joint and also pulls the scapula into downward rotation at the shoulder joint (and the scapulocostal joint). Downward rotation of the scapula by the deltoid is an example of a reverse action. (DRAWN BY JEANNIE ROBERTSON, MODELED FROM PHOTOGRAPHS TAKEN BY DONALD A. NEUMANN PT, PHD, PROFESSOR, PHYSICAL THERAPY PROGRAM, MARQUETTE UNIVERSITY.)

Reverse actions shouldn't be confused with antagonistic actions. For example, the reverse action of flexion of the forearm at the elbow joint is flexion of the arm at the elbow joint. The antagonistic action of flexion of the forearm at the elbow joint is extension of the forearm at the elbow joint.





ILLUSTRATIONS © MOSBY

Figure 5 illustrates the reverse action pull of the hip flexors upon the pelvis. In Figure 5a, the hip flexor muscles are relaxed and we see a normal tilt of the pelvis in the sagittal plane. In Figure 5b, the hip flexor musculature is contracting and creating anterior tilt of the pelvis at the hip joints. If the trunk does not follow along with the pelvis, the result is an increased lumbar lordosis.
[ILLUSTRATION MODIFIED BY JEANNIE ROBERTSON.]

more often than the usually thought of actions occur. The reason for this is that when we are standing, our feet are planted on the ground, making our distal attachments more fixed than our proximal attachments. An example of a reverse action in the lower extremity is extending the thighs at the knee joints when rising from a seated to standing position. In fact, it is the reverse action of extending the thigh at the knee joint—not the extension of the leg at the knee joint—that accounts for the quadriceps femoris group being so large.

While all this may seem abstract and academic, it can become quite important when working with clients. For example, when the deltoid contracts, we think of it creating abduction of the arm at the shoulder joint. However, it can also downwardly rotate the scapula at the shoulder joint (Figure 4a, 4b). The result of this downward rotation while the arm abducts is to pinch the rotator cuff tendon and subacromial bursa between the scapula and humerus. Normally, this scapular downward rotation doesn't occur because the brain orders a simultaneous contraction of the upper trapezius to create a force of upward rotation, preventing the scapula from downwardly rotating. However, in clients who have a weak upper trapezius, the contraction of the deltoid can overpower the upper trapezius, resulting in rotator cuff impingement and possible subacromial bursitis.

Another example of a muscle's reverse action that can have clinical importance is hip flexor musculature contraction. We normally think of hip flexors as creating flexion of the thigh at the hip joint. However, when flexors of the hip joint are tight, they also pull upon the pelvis, creating a force of anterior tilt of the pelvis at the hip joints. If the pelvis anteriorly tilts and the trunk does not follow along with the pelvis, the result will be an increase of the normal lordosis of the lumbar spine (Figure 5a, 5b). This creates a hyperlordosis (swayback), which creates increased compression forces upon the posterior disc spaces and facet joints of the spine.

When working clinically, it's important that we learn to think critically and reason through the mechanics of our clients' postures and movement patterns. This requires a return to basics and, above all, a clear and fundamental knowledge of not only the typically learned actions of muscles, but also their reverse actions. ■

Joseph E. Muscolino, DC, is an instructor at the Connecticut Center for Massage Therapy and the owner of LearnMuscles in Redding, Connecticut. He is also the author of The Muscular System Manual & Kinesiology, The Skeletal System and Muscle Function textbooks (Elsevier, 2006). Visit Joseph's website at www.learnmuscles.com.