Types of Muscle Contractions

When we perform activities of daily living, or any type of exercise, we almost always use different types of muscle contractions. For example, while stationary in any posture, some muscles are performing sustained contractions with no continuous shortening. During walking, we repeatedly contract muscles to induce shortening and in turn, body movement. Some phases of walking or running also require contractions that allow a more controlled lengthening of muscle which is important for coordinated refined movements. Equipment also exists that controls contractile speed and measures the force applied from muscle contraction at specific joint angles throughout a specific range of motion. Such equipment has clinical use, as it allows muscles and joints to be assessed at various phases of injury diagnosis and treatment rehabilitation. As you will also read, the ability to control contractile velocity has also nurtured a wealth of research into relationships between contractile velocity vs. muscular force and power.

Now that you are equipped with the knowledge of the molecular biology and energetics of muscle contraction, let us have a look at how we can contract muscle to serve different movement needs and revise some terminology that you should have learned in kinesiology or functional anatomy.

**Concentric vs. Eccentric**

All movement in a gravitational field, such as on earth, involves weight resistance exercise. Of course, to exercise requires repeated and/or sustained muscle contractions. There are three types of voluntary contractions. Contractions that cause a decrease in muscle length are referred to as concentric contractions. Contractions that occur while the muscle is lengthening are referred to as eccentric contractions. Remember that eccentric contractions typically occur to slow the rate of limb and/or joint movement in the direction of gravitational force. As both concentric and eccentric muscle actions involve changes in muscle length, they are both also referred to as isotonic contractions.

**Isometric**

Muscle can also be contracted without inducing a meaningful shortening of the muscle. Contractions without shortening are termed isometric contractions, and are common for maintaining posture. You will learn more about how maximal voluntary contractions always occur isometrically, and that increasing the velocity of muscle contraction decreases peak force development in latter Topics on resistance exercise.

**Isokinetic**

Isokinetic contractions are a special type of contraction necessitating the use of computerized equipment. Such equipment maintains a constant contraction velocity throughout the range of motion by near instantaneously adjusting resistance as muscle
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force application changes. When subjects perform isokinetic contractions, they must try to give full effort for each contraction (Figure 1). For example, Figure 2 presents the data for contractile force (torque) for multiple leg (knee) extension actions at different contractile velocities, as well as a one repetition maximal (1RM) contraction against a constant resistance. Note the increasing force (torque) as contractile velocity decreases, and that contractile force varies through a contraction and joint range of motion. Figure 2 also reveals that to force a constant contraction velocity for an isokinetic contraction, resistance must start relatively low, increase to a peak value at the muscle and joint’s optimum angle for force development, and once again decrease as this optimal angle of pull for the muscle has been passed. Without computerized adjustment of resistance, isokinetic contractions could not occur unless voluntarily controlled by the subject for low resistance and low velocity muscle contractions. Isokinetic fast velocity muscle contractions are impossible to accomplish without machine assistance to adjust resistance. The change joint angle during isotonic contractions can be monitored using an electronic goniometer.

Data obtained from isokinetic muscle contractions have shown that it is most difficult for us to cause muscle contractions for stretched muscles that insert around joints positioned near the beginning of their range of motion. If you resistance train, you will have observed this for any resistance action when using free weights. The hardest part of the action is the beginning! As you progress through the range of motion for the joint and action, it becomes easier to generate force and move the resistance. This is why resistance machines use a cam to adjust the angle of pull to a resistance, so that the initial phase of the contraction is less difficult, and to also ensure greatest resistance as the muscle and joint angle becomes more optimal for force development.

Maximal Voluntary Contraction

As stated prior, the force development during muscle contractions is greatest with zero velocity (isometric) and decreases progressively with increasing contraction velocity. Thus, when trying to measure the maximal force development by a muscle or muscle group, called the maximal voluntary contraction (MVC), it has to be done isometrically. The MVC is also joint angle specific, as isometric strength is influenced by joint angle for the same reasons of joint specific muscle contraction angles of force development as explained earlier. The optimal angle of pull for a given muscle and joint pair is easily seen when performing isokinetic contractions, as shown in Figure 2.
To measure the MVC of a muscle or muscle group, there needs to be a means to measure force application isometrically. You can do this on an isokinetic system by setting contraction velocity to zero. Alternatively, you can also use a device that can measure isometric force, such as a load cell, or a strain gauge. We use load cells quite a bit in our research laboratory at the University of New Mexico.

**Glossary Words**

**kinesiology** (or **functional anatomy**) is the scientific study of human movement.

**weight resistance exercise** involves the use of external loads to provide resistance against muscle contractions.

**resistance exercise** involves muscle contractions performed against resistance. While this is true for all muscle contraction in human movement, resistance exercise is typically used to define contractions against intentionally increased external load.

**concentric contractions** are those that are performed with muscle shortening.

**eccentric contractions** are those that are performed with muscle lengthening instead of shortening.

**isotonic contractions** are those that are performed with changes in muscle length.

**isometric contractions** are those that are performed with no change in muscle length.

**isokinetic muscle contractions** are those that occur at a constant velocity, which requires sophisticated electronic equipment. Such equipment is able to quantify force production throughout the range of motion of the contraction. Such contractions require maximal effort for correct implementation and interpretation.

**contraction velocity** is the speed of muscle contraction.

**resistance** is the load against which muscles contract.

**range of motion** is the angular range of a joint caused by muscle contraction.

**angle of pull** is the angle at a specific point in time for isotonic contractions, or for isometric contractions, where muscle contraction generates force along a vector at the angle of pull.

**goniometer** is an instrument used to measure joint angles.

**electronic goniometer** is a goniometer equipped to output an electronic signal proportional to goniometer angle.
### Types of Muscle Contractions

| **free weights** | are a type of resistance training approach based on weighted barbells or dumbbells. |
| **maximal voluntary contraction (MVC)** | is a type of muscle contraction that generates the greatest force and this occurs at zero contractile velocity (isometric contraction). |