Neural Integration: Stimulating the Muscle to Move

Structure and Function. While the muscle fiber is the basic unit of contraction, without its intricate link to the nervous system, coordinated movement could not occur. The central nervous system is linked to muscle fibers by way of motor neurons. These neurons vary in size and innervate varying numbers of muscle fibers depending on fiber-type and muscle function. Slow-twitch fibers are innervated by smaller motor neurons. Fast-twitch fibers are innervated by larger motor neurons. In terms of speed and magnitude of conduction, think of the motor neurons for type I fibers as drinking straws and those of type II fibers as fire hoses.

The number of fibers innervated by a single neuron depends on the muscle and its function. Large muscles responsible for large-scale movements, such as the rectus femoris muscle of the thigh, have a low ratio of motor neurons to fibers, with a single motor neuron innervating a large number of fibers, up to one neuron for as many as 1000 fibers (1:1000). Muscles responsible for fine motor activity, such as certain eye muscles, may have a high ratio of neurons to fibers, nearing 1:10. The term **motor unit** is used to describe a motor neuron and all of the fibers it innervates, and the **neuromuscular system** is the functional integrated whole of the body's nerves and muscles. The motor unit is the basic functional unit of the neuromuscular system, since muscle fibers fire only within motor units and never individually. Heavy, high-velocity training over time improves recruitment, defined as the quantity of motor units in the muscle actually generating force during contraction. A higher percentage of recruited motor units means more force and more power. Average novice trainees can recruit around 70% of their available motor units on the day they start training. Intermediates have increased their neuromuscular ability to

recruit motor units and generate force, and by the time they become advanced trainees they may be able to recruit in excess of 95% of the available motor units. Neuromuscular improvement is one of the main reasons strength and power can be gained in the absence of muscle-mass increases.

The number of fibers innervated by a motor neuron dictates the maximum amount of force the motor unit can produce during contraction. The more fibers contained in the motor unit, the higher the force production. Once a motor neuron is activated, all the fibers it innervates will contract. The amount of force a muscle generates will vary with the number of motor units recruited. If all the motor units in a muscle are recruited simultaneously—a rare occurrence in larger muscles—maximal force is generated.

Motor units are recruited in a specific order, according to each one's threshold of stimulus required for the contraction to occur. Lower-threshold slow-twitch motor units are recruited initially regardless of the intensity of the exercise. These motor units are associated with the maintenance of normal posture, and as such they fire most of the time the body is upright. Walking causes low-threshold motor unit recruitment, since posture is being maintained while the body propels itself forward. The muscles associated with posture and walking therefore would be expected to have proportionately higher percentages of slow-twitch fibers, and they do. During low-intensity aerobic-type exercise, slow-twitch motor units are preferentially recruited, but as intensity increases, higher-threshold fast-twitch motor units are recruited. Low-threshold fibers continue to be recruited at high intensities but their contribution is negligible relative to the contribution of the high-threshold fibers. If high power output is the objective of the training program, it must be designed to improve the ability to recruit high-threshold fast-twitch motor units.