Focal Muscle Vibration: A Powerful Clinical Tool to Improve Balance, Strength, and Agility

By Tom Michaud, DC

Over the past 15 years, some amazing research has shown that when a contracted muscle is vibrated at a specific frequency and intensity, it can produce long-term changes in athletic performance and balance. In an interesting study of competitive volleyball players, Brunetti et al. (1) show that the application of just 3 sessions of focal muscle vibration (FMV) applied bilaterally over contracted quadriceps muscles produced a 26% increase in muscle power and 13% increase in counter movement jump height. Even more surprising, these changes persisted for more than 6 months. The increase in power was nearly 3 times the increase in the control group, even though athletes all followed the same team-training protocols. Additional research shows that FMV reduces fatigue while exercising (2), increases the speed in which a muscle generates force (3), increases maximum muscular power by 30% in young people (4) and up to 50% in older adults (5). Although the exact mechanism for improved performance remains unclear, most experts agree that FMV enhances output from muscle spindles, which in turn improves the synchronization and coordination between agonist and antagonist muscles producing smoother more efficient joint/muscle interactions (6) (Fig. 1).

Because spindles interact with so many movement-related interneurons, including spinocerebellar neurons, FMV has the ability to modify motor activity throughout the body, not just in the treated limb. Studies using transcranial magnetic resonance have shown that applying FMV to a contracted muscle causes a significant rearrangement of the motor cortex (7, 8), which is comparable to the cortical remodeling associated with traditional long-term training programs. These changes are not present when FMV is applied to a relaxed muscle.

It should be emphasized that FMV is very different from whole body vibration in which an individual stands on a vibrating platform while exercising. Although early research showed some benefit to whole body vibration, more recent research shows that long-term exposure to the mechanical waves generated by whole body vibration can be hazardous over time (9,10). In contrast, the 0.3 to 0.5 mm displacements associated with FMV are barely noticeable and can easily be maintained within ranges proven to be safe for vibration stimulation (11).

The improved performance associated with FMV is particularly helpful when treating older adults. In 2009, researchers from Italy took 60 sedentary older women (average age of 65) and applied FMV to the distal quadriceps for 10 minutes, 3 times per day, for 3 days (12). Subjects were divided into 3 groups.

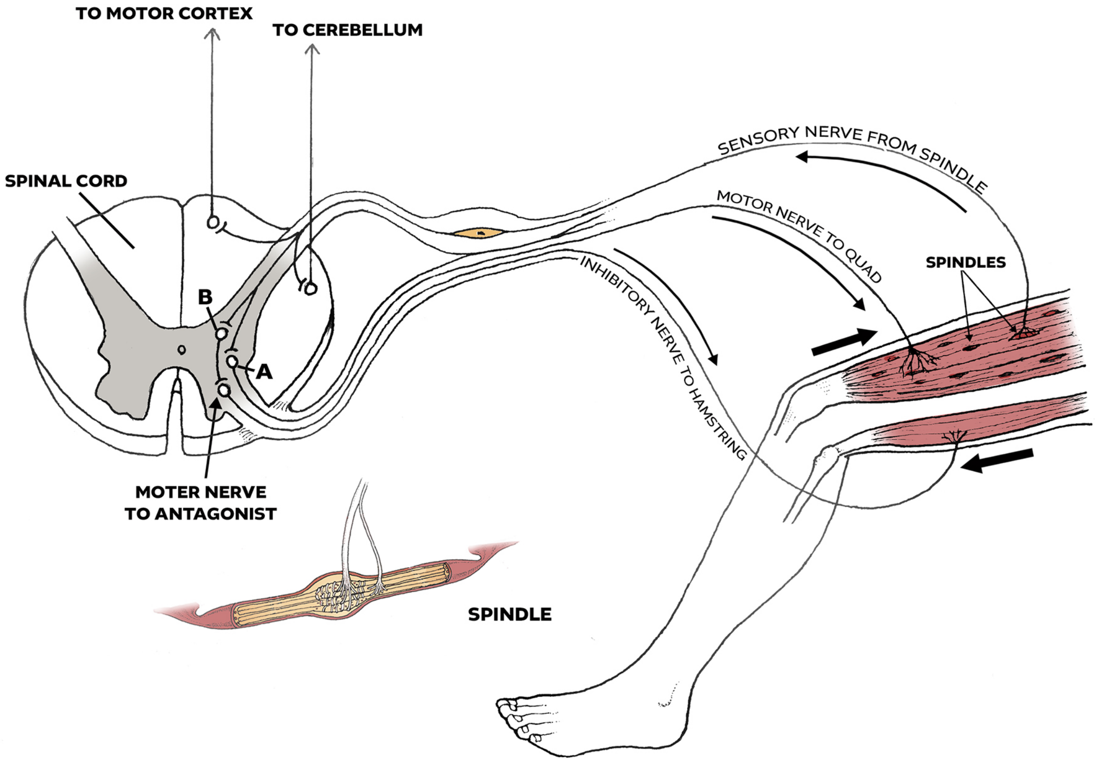

Fig. 1. Muscle spindles are small sensory receptors located in parallel series along muscle fibers. When a muscle is suddenly lengthened, the change in muscle length is detected by the muscle spindle, which sends this information along its sensory nerve directly into the spinal cord. Upon entering the spinal cord, the sensory nerve branches to send input regarding the degree and the velocity of the muscle's length change to the cerebellum and to the motor cortex. The cerebellum and motor cortex respond to the changes in muscle length with complex movement patterns to restore static and dynamic equilibrium. The sensory nerve from the spindle then splits and sends one branch to a motor nerve that causes an immediate contraction of the stretched muscle (**A**) (as in the patellar tendon reflex), and another branch to an inhibitory nerve that relaxes the antagonist (**B**). In addition to stimulating the stretched muscle, the spindle also signals every synergist of the stretched muscle to respond with a protective contraction. The synchrony and intensity of the agonist/antagonist interactions (which are completely controlled by spindles) are essential for smooth and efficient joint motions. Unfortunately, when a muscle is damaged, the connective tissue around the spindle stiffens to the point that even slight movements cause the stiffened tissue (mostly the perimysium surrounding muscle fascicles) to pull on the spindle, causing the spindle to discharge in response to even minor movements. Excessive activation of muscle spindles creates a vicious cycle in that it greatly increases muscle tension (via increased activity of the motor nerve), which negatively affects agonist/antagonist interactions. Because focal muscle vibration has been proven to reduce sensory output from the muscle spindles (via presynaptic inhibition), it essentially rewires the entire reflex loop, relaxing the muscle spindle and preventing the aberrant motor discharges. The end result of FMV is a significant decrease in muscle tension and improved coordination between agonist and antagonist. Note that this is a simplified explanation of a complex process as input from GTOs and gamma motor neurons were not discussed.

One group received FMV while simultaneously tensing their quadriceps, the next group received FMV with their quads relaxed, and a third group received placebo stimulation. Before and after the 3-day intervention, researchers measured movement of the center of pressure on a force platform, vertical jump height and leg power with an electromagnetic motion sensor. Consistent with prior research, the group that received FMV while the quadriceps were contracted had dramatic improvements in both balance and performance. 24 hours after the intervention, this group had 20% reductions in center of pressure movement (confirming significant improvements in balance), 55% improvements in jump height, and 35% improvements in leg power. Even more surprising, the center of pressure recordings continued to improve, with 25% improvement at 30 days and 35% improvement at 90 days. Leg power increased 40% at 30 days, and 50% at 90 days. Shockingly, vertical jump increased appreciably over the 3 months following the intervention, increasing 70% at 30 days and 90% at 90 days. The authors emphasize that because this 3-day intervention produced long-term changes in balance and motor control, it would be particularly effective in preventing falls in the elderly and for improving overall strength and coordination in older adults without having them perform intensive training regimens that have notoriously low compliance in older adults.

In their 2021 systematic review of focal muscle vibration, Fattorini et al. (6) state the best outcomes occur when the muscle being vibrated is isometrically contracted. Apparently, the isometric contraction increases muscle stiffness, which in turn, increases the depth of penetration of the vibratory stimulus. This is consistent with research showing that the vast majority of spindles exist deep inside of muscles (13), explaining the better outcomes with the deeper vibratory transmissions associated with mild isometric contractions.

One of the only areas of confusion regarding FMV is choosing the proper frequency and displacement. Some authors suggest 100 Hz with 0.2-0.5 millimeter displacements (12), while others suggest 60 Hz with 0.5 mm displacements are ideal (14,15). I've used both frequencies for the past 4 years and evaluated center of pressure displacement and range of motion following intervention, and I've consistently noticed that 60 cps with 0.5 mm displacement works the best. This particular frequency can also be used as a screen to identify people with core proprioceptive deficits, which allows for the application of corrective rehabilitative exercises (14).

The key message from the latest research is that in order to maximize efficiency with FMV, the treated muscle must be isometrically contracted. While most studies show long-term outcomes with just a few sessions, I encourage people to buy their own motors and perform weekly at-home treatments (the motors typically cost about $65 each and can be purchased at humanlocomotion.com). Although FMV has the ability to rewire the central nervous system and improve agonist/antagonist relationships, you'll still have to do conventional rehab to improve tendon resiliency and muscle strength.

Because these motors are so small and the oscillations are mild, they can be placed on pretty much any muscle in the body (Fig. 2). They are particularly effective when treating chronic musculoskeletal injuries, and because they improve balance so quickly, FMV could help reduce the risk of falls in the elderly (6).

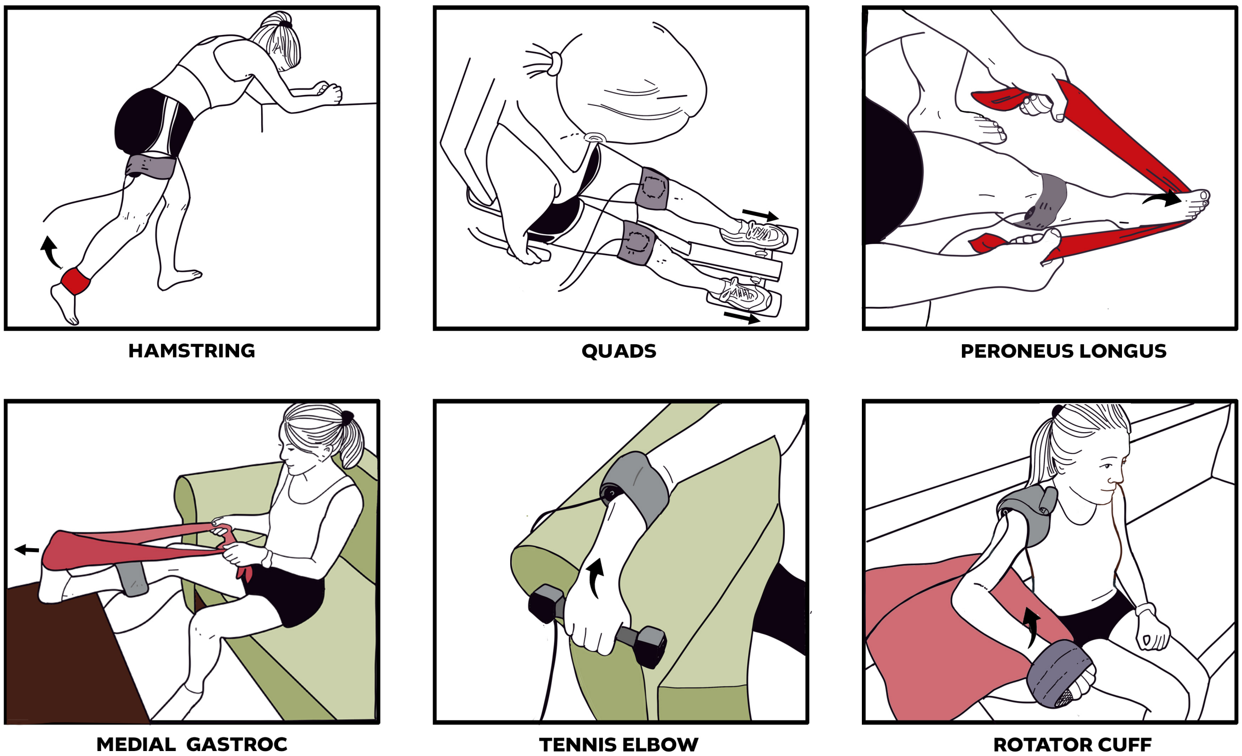

Fig. 2. How to use focal muscle vibration. The vibration devices can be easily attached to almost any muscle. Ankle weights and/or elastic bands can be used to apply light resistance and the typical protocol is to have the person perform a mild 10-minute isometric contraction with the motors running, followed by a 60-second rest. This is repeated 3 times each day for 3 consecutive days. In most cases, treatments are repeated once or twice a week for the next 4 to 6 weeks and home rehabilitative stretches and exercises are encouraged during this time period. When applied to the quadriceps, most researchers apply FMV to the distal muscle/tendon junction. People with chronic ankle instability respond especially well to FMV over the proximal peroneus longus, while chronic rotator cuff injuries do well with FMV applied directly over a tight infraspinatus.

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