Benefits of Cycling with Functional Electrical Stimulation (FES)

CLINICAL RESEARCH SUMMARY

Everybody needs to stay active to stay healthy, as a lack of physical activity can lead to obesity, diabetes, cardiovascular disease, and even anxiety and depression. This is an even greater problem for millions of people around the world with disorders like spinal cord injury, stroke, multiple sclerosis, cerebral palsy, traumatic brain injury, and others with muscle weakness or paralysis, who find it nearly impossible to stay active and healthy because of their limited mobility.

Decades of research have proven that people with paralysis who regularly participate in stationary cycling combined with functional electrical stimulation (FES) can gain tremendous benefits. FES-cycling empowers people to stay active and healthy, despite muscle weakness or paralysis, by keeping their legs moving and helping them to activate their own muscles. The benefits of FES-cycling are essentially the same as the benefits of traditional, able-bodied cycling, with some unique benefits for people with paralysis.

Figure 1: Quadriplegic using the MyoCycle FES bike.

The following sections list the benefits, along with related research, that can be gained by using an FES bike for at least 30-60 minutes per day, 3 days per week. While most of the research focuses on people with spinal cord injury, the benefits for people with other paralyzing conditions are similar.

PREVENT ATROPHY / BUILD MUSCLE

One of the biggest concerns following any injury is muscle loss (atrophy). Muscle atrophy can lead to weakness, poor self-image, lowered metabolism, and even pressure sores, since muscles help cushion skin and bones. Research shows that FES bikes can prevent and even reverse muscle atrophy by reactivating weak or paralyzed muscles to produce a functional motion. Just like with other forms of exercise, regularly using your muscles to do work against ever-increasing resistance causes them to grow, if you get proper rest and nutrition. FES bikes are no different.

Related Research: 2, 7, 12, 14, 15, 17, 19, 22, 23, 24, 25, 27, 29, 30, 32, 35, 36, 41, 43, 45, 46, 47, 48, 50, 52, 55, 57, 59, 60, 61

INCREASE STRENGTH

Paralysis could be defined as a complete loss of strength, which is the ability to activate muscles to produce force. FES bikes activate paralyzed muscles, improving neuromuscular conditioning and forcing the muscles to adapt. Increased strength improves the functional capabilities of people with paralysis, contributing significantly to a better quality of life.

Related Research: 2, 3, 7, 8, 9, 15, 17, 22, 23, 28, 29, 30, 41, 43, 44, 45, 46, 47, 50, 53, 54, 55, 58, 60

BUILD ENDURANCE

Building endurance enables people with paralysis to be physically active for longer periods of time. Increasing the duration of an activity is just as important for health as increasing the intensity of the activity. FES bikes make it easy to progressively build endurance, especially in the legs, despite paralysis.

Related Research: 1, 2, 3, 4, 6, 7, 8, 9, 12, 13, 14, 15, 17, 18, 20, 21, 22, 23, 24, 25, 28, 29, 30, 32, 36, 38, 41, 43, 45, 52, 53, 54, 57

REGAIN SENSATION

A healthy sense of touch and proprioception is necessary to prevent injury and to experience many of life's simple pleasures. There are many reports of FES users regaining sensation, even though the cause is still unknown. The probable cause is that FES can lower the activation threshold for neurons, making it easier for sensory circuits to communicate with the brain.

Related Research: 22, 28, 36, 47, 48

RECOVER FUNCTION

Building strength and endurance and recovering sensation can all contribute to a recovery of functional capabilities. FES can also strengthen remaining connections and help build new connections in the nervous system through plasticity. As a result, studies with people with paralysis who used an FES bike often report that the subjects recovered function and were better able to perform activities of daily life.

Related Research: 2, 7, 17, 22, 23, 28, 36, 39, 43, 44, 47, 48, 50, 51, 52, 54, 56, 58, 60, 62

INCREASE/MAINTAIN RANGE OF MOTION

FES bikes enable people with paralysis to move their limbs through a normal cycling range of motion, which is greater than the range of motion for walking. This passive motion, combined with the blood circulation effects of active muscle contractions, enable FES bikes to improve joint range of motion for people with paralysis.

Related Research: 2, 63

INCREASE CYCLING POWER OUTPUT

FES bikes activate the muscles of the legs that contribute most to cycling: the quadriceps, hamstrings, and glutes. Building strength in these muscles through cycling enables those muscles to do more work, and consistent repetition improves the neural efficiency of the motion. The result is that people with paralysis who regularly use an FES bike can improve their cycling ability. This effect can even happen instantaneously, as the FES applied to the muscles can be felt, helping a person with sensation to coordinate their own volitional effort to improve their cycling performance.

Related Research: 1, 2, 3, 4, 5, 6, 7, 8, 9, 12, 13, 14, 15, 18, 20, 21, 24, 25, 27, 30, 32, 33, 36, 41, 43, 45, 46, 48, 53, 58, 60

IMPROVE SELF-IMAGE

Exercise in general can help people to build muscle and lose weight. Since an FES bike enables people with paralysis to exercise, it can help improve their self-image via the same mechanism: bigger muscles and less body fat.

Related Research: 22, 23, 43

IMPROVE QUALITY OF LIFE

There are many different factors that contribute to quality of life. For people with paralysis, three major factors are functional ability, self-image, and health. Research has shown that FES bikes can improve all three of these factors. If an FES bike is used in a community setting, the social interaction alone can also improve quality of life.

Related Research: 2, 7, 22, 23, 28, 34, 43, 45, 47, 52, 56, 60, 61

RELAX MUSCLE SPASMS

FES has the power to relax muscle spasms for hours after the FES has finished. This works because the FES fatigues the muscles and improves blood flow to them, altering their biomechanics and causing them to relax. FES bikes can do this for the muscles they stimulate and their antagonists, and as a result, subjects in studies have sometimes reported less reliance on anti-spasm medications.

Related Research: 2, 7, 22, 23, 34, 43, 47, 50, 52, 56, 63

PREVENT BONE LOSS

People with paralysis often suffer from bone loss (osteopenia or osteoporosis) for the same reason astronauts in space do -- no load. When enough force is applied to a bone, microfractures occur that get repaired in a way that leaves the bones stronger. Without that force, bones resorb and lose their strength, ultimately increasing the risk for bone fractures. FES bikes activate muscles in the legs, causing the legs to cycle against a load, all of which applies force to the bones. Research has shown that FES cycling can increase bone density in key areas that are prone to fractures, making fractures less likely to occur.

Related Research: 6, 9, 11, 22, 23, 25, 32, 33, 35, 38, 42, 43, 45, 55, 59, 61

IMPROVE CARDIORESPIRATORY FITNESS

When muscles do work, they demand oxygen. In response, the heart and lungs increase their activity to pump more oxygenated blood into the muscles. FES bikes have the same effect for people with paralysis, since they make the paralyzed muscles do work. Because the muscles in the legs are so large, this effect can be more significant than upper body exercise, making FES bikes great for improving cardiorespiratory fitness.

Related Research: 1, 3, 4, 5, 8, 12, 13, 16, 23, 29, 31, 33, 37, 40, 43, 45, 48, 49, 55, 56, 57, 60, 61

IMPROVE BLOOD CIRCULATION

When muscles do work, a few things happen. They help to physically pump blood back to the heart via the veins, and they demand more oxygenated blood from the heart and lungs. FES bikes aid in this process by activating paralyzed muscles and increasing the activity in the circulatory system. The result is better blood circulation, especially through the legs, which can improve skin integrity, warm the legs up, and relax spasticity.

Related Research: 1, 3, 4, 5, 7, 10, 13, 14, 18, 20, 23, 27, 29, 31, 43, 45, 48, 49, 50, 53, 57, 61

IMPROVE INSULIN SENSITIVITY / GLUCOSE TOLERANCE

Physical activity affects how the body regulates its insulin supply in response to glucose intake. For people with paralysis, this is especially important, because they are at higher risk for diabetes because of their inactivity. Research results suggest that FES bikes enable people with paralysis to stay active, improving their insulin/glucose dynamics, and potentially reducing their risk for diabetes.

Related Research: 19, 21, 36, 43, 45, 48

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