



TES: Is it Dangerous or Merely Ineffective?

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The idea of using Threshold Electrical Stimulation (TES) to treat post-polio muscle weakness has been around for more than a decade. During that time there has been as much concern about the safety of polio survivors using TES as about its unproven usefulness in treating new muscle weakness.

TES sends electrical pulses through the skin that cause underlying muscles to contract, contractions that over time make muscle fibers bigger. This kind of electrical muscle stimulation was used by Christopher Reeve to reverse and prevent muscle atrophy in hope that his brain would someday again be able to communicate with his spinal cord motor neurons and allow his muscles to contract naturally.

But why would polio survivors want to use electrical stimulation to make their muscles bigger? There are two rationales. One has to do with the notion of "Progressive Post-Poliomyelitis Muscular Atrophy" (PPMA). In the early 1980's, researchers at the National Institutes of Health proposed PPMA as the name for new weakness in polio survivors (Lange, 1995). The name PPMA was a variation on Spinal Muscular Atrophy, a disease causing progressive muscle shrinking and weakness that is totally unrelated to polio and PPS. The problem with the name "PPMA" is that only a very small percentage of polio survivors actually have muscle atrophy. After three-plus decades of studying and treating polio survivors we have only seen a handful of patients whose muscles were actually shrinking. However, more than 75% of polio survivors do report new muscle weakness. Clearly, polio survivors' muscles get weaker even though they don't get smaller. So, if the only rationale behind TES is to make muscles bigger, then only a very small percentage of polio survivors would need TES.

However, the more common rationale for using TES is not just to make polio survivors' muscles bigger, but to make them bigger in order to make them stronger. Weight lifters "pump iron" in order to make all the individual fibers in their muscles bigger so that each fiber can do more work. TES does the "pumping up" artificially by externally stimulating the muscle with electricity to make fibers grow larger. The problem is that post-polio muscle weakness is not the result of small muscles fibers or even muscle atrophy. Post-polio muscle weakness results from poliovirus damaged nerves no longer being able to turn on muscle fibers that were pumped up and plumped up during the "use it or lose it" physical therapy for polio 50 years ago. Weakness results when polio survivors' nerves can't take keep on pumping those big muscle fibers.

Wherefore Post-Polio Muscle Weakness?

To understand the danger of plumping up muscles that are getting weaker, you need to remember the damage done by the poliovirus originally. Autopsies from the 1940's performed by Dr. David Bodian showed that paralytic polio survivors lost at least 60% of their motor neurons (Bodian, 1949). Even those who had so-called "non-paralytic" polio, as well as the apparently unaffected muscles in paralytic polio survivors, lost 40% of their motor neurons (Bruno, 2000). Motor neurons that survived the original polio onslaught, even though they themselves had been damaged internally by the poliovirus, changed in an amazing way. The remaining damaged neurons sent out sprouts -- like extra telephone wires -- to turn on the muscle fibers orphaned when their neurons were killed. So polio survivors have functioned for 50 years with about half the neurons with which they were born,

the remaining polio-damaged neurons on average doing *16 times* the work they originally did to compensate for the killed neurons.

Muscle fibers that still had a working motor neuron associated with them also changed. With extensive physical therapy, polio survivors' muscle fibers increased in size so that each fiber could do more work. Some polio survivors remember having had painful electrical stimulation right after they had polio to force muscle fibers to get bigger. Because muscle fibers became very large, some polio survivors have one leg's severely affected calf muscle that can almost fit within the circle formed by their thumb and forefinger, while the other calf muscle looks like it belongs to a football halfback.

It is the combination of too few poliovirus-damaged, over-sprouted, overworked neurons turning on oversized muscles that sets the stage for late-onset muscle weakness in polio survivors. Studies have shown that new weakness is related both to not only how much muscle strength was recovered after the original bout with polio but also to the number of years of physical therapy polio survivors had. Thus, the bigger the muscles were made to grow through physical therapy, the harder they worked and the more strain was placed on the few remaining, polio-damaged motor neurons. The reason muscles are now getting weaker -- and in a few cases, smaller -- is that poliovirus-damaged, over sprouted, overworked neurons can no longer make all those big muscles work. Simply, the bigger the muscles are the harder they "fall."

A weakening or shrinking muscle is a sign that motor neurons are no longer able to "turn on" all those big muscle fibers. Those extra sprouts break off, like branches of a malnourished tree, and the motor neurons themselves die. The death of sprouts in weakening muscles was shown in a longitudinal study by Dale Lange at the Columbia-Presbyterian Medical Center (Lange, 1995). The death of motor neurons was documented in a study by Alan McComas at Canada's McMaster University (McComas, et al., 1997).

McComas actually performed two studies. First, he counted the number of remaining motor neurons in polio survivors. He found that muscles thought *not* to have been affected by polio had actually lost 40 percent of their motor neurons. These percentages mirror precisely David Bodian's findings of 50 years ago, confirming that at least 60 percent of motor neurons had to be killed by the poliovirus for muscles to show any weakness, and proving that there is no such thing as an "unaffected muscle" in someone who had had paralytic polio.

McComas' second study was equally revealing but more disturbing. He counted motor neurons in polio survivors (who were on average 55 years old, and not receiving treatment for PPS) and then studied them two years later. At follow-up, 78 percent of the subjects reported a decrease in muscle strength and had lost an average of 14 percent of their remaining motor neurons, approximately *seven times* the rate of loss expected in non-disabled subjects in their 60s! Most alarming was the finding that the two survivors who reported the greatest decrease in muscle strength had each lost 50 percent of their motor neurons during the prior two years. While these findings are frightening, they are also a guide to a rational treatment for PPS. "Our findings make clear that polio survivors should not be treated using electrical stimulation that causes muscle contraction," warns McComas, "nor should they engage in fatiguing exercise or activities that further stress polio-damaged neurons that are already overworking."

Wherefore TES?

McComas' warning that polio survivors should not use TES makes sense, a warning that is seconded by Dr. Rubin Feldman, the first doctor in Canada to study and treat PPS and the developer of the non-fatiguing exercise protocol for polio survivors. If polio survivors' muscles shrink over time, it is because their polio-damaged motor neurons can no longer activate all of those big muscle fibers.

Using TES to make muscles increase in size would put an even greater load on the remaining polio-damaged neurons, causing them to break down or even die and producing even more weakness. Using TES to increase the size of muscle fibers would be like plugging more toasters into an electrical outlet whose fuse had already blown when you had plugged in just one toaster.

McComas' warning about TES is powerful, not only because of his finding that polio survivors' overloaded motor neurons actually die with overuse, but also because he himself has studied the very TES unit that has been suggested for use by polio survivors. As of April, 2000, according to Mayatek, the company that manufactures the TES units, there has been not one published study of TES in the treatment of post-polio muscle weakness. In fact, since 1993, there have been only three studies published in medical journals about the use of TES; two describe the use of TES in cerebral palsy and one its use in treating incontinence in spinal bifida. Many years ago, Dr. Feldman and another prominent Canadian PPS researcher, offered to perform double-blind, placebo controlled studies of the effects and side-effects of TES in post-polio patients. The company refused their offers.

As with other untested treatments for PPS, anecdotal reports have been presented by device manufacturers and stories about treatment have been told by polio survivors. In Canada, TES has often been combined with Dr. Feldman's energy conservation plus non-fatiguing exercise PPS treatment program (Feldman, 1985). So anecdotal data saying TES is effective is colored by the proven effectiveness of daily rest periods and gentle, non-fatiguing exercise. We have heard from a number of polio survivors, including a few of our own patients, who have tried TES; they found the electrical pulses irritating and not one reported any increase in muscle strength. But, given individual differences in polio survivors' symptoms and the wonderful power of the placebo effect, all anecdotal data -- both pro and con -- must be ignored. Polio survivors need to wait until double-blind, placebo-controlled studies document the effectiveness and the dangers of TES.

More is not better.

TES proponents show MRI scans of muscles that, after electrical stimulation, have increased in size. Increasing muscle size is the last thing you want to do to an overworked, poliovirus-damaged motor neuron. When it comes to muscle size, more is not better for polio survivors.

Studies have shown that polio survivors can increase muscle strength by following The Golden Rule:

"If anything you do causes fatigue, weakness or pain, don't do it (or do less of it)!"

The Golden Rule, along with daily rest breaks, bracing and pacing, have been studied and have shown to increase muscle strength in polio survivors (Creange and Bruno, 1996; Bruno, 1998). If polio survivors want to try TES, they should save their money and motor neurons until controlled studies are published. There is no magic pill - nor magic electric box - to treat PPS muscle weakness. The first, best treatment for PPS is self-care.

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