Student: Rob Sykes **Question:** For a 57-year-old man recovering from a L-sided CVA that occurred 2 weeks ago, is FES therapy more effective than conventional non-FES therapy at improving walking ability?					**Date:** 3/13/2016 **Search:** PubMed, CINAHL
Author/ Title/ Year	**Purpose/Design/ Subjects**	**Intervention or description**	**Measurements**	**Outcomes**	**Comments /limitations**
Bogataj U, Gros N, Kijajić M, Aćimović, Maležič M. The Rehabilitation of gait in patients with hemiplegia: A comparison between conventional therapy and multichannel functional electrical stimulation therapy. (1995)	The purpose of this study was to compare the effectiveness of multichannel functional electrical stimulation (MFES) to conventional rehabilitation techniques in patients with severe hemiplegia. Randomized controlled, cross-over design. Subjects (n=20) were inpatients at a rehabilitation center in Slovenia who were rehabilitating from cerebrovascular accident. Patients were only included if they required weightbearing support from at least one therapist during ambulation. They were randomly allocated to one of two groups. Group 1 (n=10) received 3 weeks of conventional therapy followed by 3 weeks of MFES. Group 2 (n=10) received 3 weeks of MFES followed by 3 weeks of conventional therapy. Average time since stroke was 116 ± 66 days and 104 ± 62 days in groups 1 and	All subjects participated in therapy 5 times/week. Conventional therapy consisted of physical therapy for 1-2 hours/day in addition to medical treatment, other rehabilitation therapies (e.g., occupational and speech therapy), and other services (e.g., psychology, social work). MFES therapy only replaced the gait training portion of conventional physical therapy. The remaining therapy time was identical to the conventional therapy group. MFES involved the delivery of electrical stimulation to the following muscle groups: ankle dorsiflexors, ankle plantar flexors, hamstrings, quadriceps, gluteus maximus, and triceps brachii (for arm swing). The pattern of stimulation was set to match muscle activity during gait. Duration of MFES therapy was 30 minutes to 1 hour.	Outcome measures were recorded at baseline, after 3 weeks, and following the end of therapy at 6 weeks. Groups were compared according to mean gait speed, mean stride length, mean stride time, mean gait cadence, and the Fugl-Meyer test. Gait speed, stride length, gait cadence, and Fugl-Meyer scores were used as a composite measure of overall performance. Biomechanical variables of gait were measured by having subjects walk at their self-selected gait speed.	Group 2 (MFES first) demonstrated a significantly greater mean improvement in performance compared to Group 1 (conventional therapy alone first). In both groups, the mean improvement during periods of MFES combined with conventional therapy was significantly greater than the mean improvement during periods of conventional therapy alone. There was a poor correlation between Fugl-Meyer scores and biomechanical gait variables. There were negative correlations between improvements in measured variables (i.e., Fugl-Meyer, stride time, stride length, and gait speed) and subjects' age. There were also negative correlations between improvements in measured variables (i.e., Fugl-Meyer, stride length, and gait speed) and onset	The protocol followed in this study may not be practical for most clinical settings. It involves a complex trial-and-error approach that is needed to personalize the stimulation settings to each patient's gait characteristics. While this degree of specificity may be necessary for optimal outcomes, it is unfeasible in most clinical circumstances secondary to time constraints and personnel requirements. In addition to the therapist who was providing physical assistance to the patient, an engineer was required during therapy sessions to manage and control the stimulator. Regarding the study's results, the authors did not offer a thorough presentation of their findings. It was impossible to discern between-group differences at the 3-week mark compared to the 6-

	2, respectively.			of CVA; however, these correlations were poor and likely negligible.	week mark, because this information was not presented. Also, it was unclear as to the frequency of MFES gait training. It is assumed that it was a component of every therapy session (i.e., 5 days/week).
Kafri M, Laufer Y. Therapeutic effects of functional electrical stimulation on gait in individuals post-stroke. (2015)	The purpose of this systematic review was to examine the therapeutic effects of lower extremity functional electrical stimulation (LE FES) in individuals post-stroke. Systematic review of 16 studies. Five of the studies examined the effects of FES among patients during the acute or subacute phases of recovery (i.e., onset <3 months). Results concerning these studies are the chief concern of this evidence table.	FES was applied in variety of methods across included studies. Four studies applied FES during overground walking, 4 studies utilized FES as an orthotic device, 3 studies applied FES in conjunction with a gait trainer, 2 studies applied FES during body weight support treadmill training, 2 studies applied FES during cycling, and 1 study applied FES during hip movements in side-lying. Thirteen studies utilized surface electrodes as opposed to implanted electrodes.	The therapeutic effects of LE FES were classified into two categories: mobility-related therapeutic effects and body function-related therapeutic effects.	*Mobility-related therapeutic effects*: Gait speed was the most commonly assessed outcome measure. Overall, studies demonstrated clinically significant improvements in gait speed. In 2 of the studies concerning acute or subacute stroke, positive effects were also demonstrated for walking independence. *Body function-related therapeutic effects*: Nine of the 10 studies that assessed muscle strength demonstrated positive effects for LE FES. Three of these studies involved patients with acute or subacute stroke. All four of the studies that assessed spasticity, one of which involved patients with acute or subacute stroke, found positive effects for	The biggest limitation of this systematic review as it relates to the current PICO question is that most of the included studies examined the effects of LE FES during the chronic phase of recovery post stroke. The studies that involved subjects in the acute and subacute phases of recovery were quite heterogenous: 2 studies applied FES during cycling, 2 studies applied FES in conjunction with a gait trainer, and 1 study applied FES during hip movements in side-lying. Each of these applications of FES require specific pieces of equipment. Therefore, the practicability of implementing these interventions in a clinical setting will depend on the resources of the clinic.

				LE FES. Comparisons between LE FES interventions and interventions without FES were largely inconsistent.	Lastly, although this systematic review found overall positive effects for the use of LE FES, it was unable to draw any conclusions regarding the superiority of LE FES compared to other non-FES interventions.
Lairamore CI, Garrison MK, Bourgeon L, Mennemeier M. Lower extremity functional electrical stimulation during inpatient rehabilitation: A pilot study investigating gait and muscle activity in persons with stroke or brain injury. (2014)	The purpose of this study was to determine whether or not FES applied to the tibialis anterior (TA) during inpatient rehabilitation can improve gait speed, FIM locomotion scores, or TA muscle activity in patients with hemiplegia and foot drop. Randomized control trial. Subjects were inpatients in an inpatient rehabilitation program 2 to 33 days post stroke (n=28), TBI (n=3), or surgical removal of an aneurysm (n=1). Subjects were only included if they could walk at least 10 m with moderate assistance or less. Total n=26. Control group n=13. Experimental group n=13. The average time since injury was 15.5 ± 8.2 days in the experimental group and 12.9 ± 5.9 days in the control group. There were originally 32 enrolled	Both groups received physical therapy 5 days/week for 1.5 hours/session. Gait training occurred 3 times/week for 45 minutes at a time. During gait training, both groups wore the Bioness L300 neuroprosthesis. The control group received sensory level stimulation while the experimental group received enough amplitude to evoke ankle dorsiflexion. Gait training was founded upon the principles of Neuro-Developmental Treatment (NDT).	Outcome measures were recorded prior to treatment and within 12 to 48 hours of the final treatment session. The primary outcome measure was comfortable self-selected gait speed while not wearing the neuroprosthesis or any type of ankle orthosis. This was measured using the GAITRite walkway. Secondary outcome measures included the FIM locomotion score and TA muscle activity during both the swing phase and loading phase of gait.	Both groups demonstrated significant within-groups improvements from baseline to post-intervention in gait speed, TA muscle activity during swing phase of gait, and FIM locomotion scores. There were no significant between-group differences in change in gait speed, change in TA muscle activity, or change in FIM locomotion scores.	This study is particularly relevant to the PICO question because it examines the affects of FES during the acute phase of stroke in an inpatient rehabilitation setting. Compared to other studies that have examined the effects of FES intervention over a longer period of time, the average number of FES sessions in this study was 3.85. Small sample size represents one limitation of this study. Another limitation is that other pathologies were included in addition to stroke. However, patients with stroke comprised 85% of both the experimental and control groups.

	patients, but data for 6 of them were excluded for various reasons.				
Robbins SM, Houghton PE, Woodbury MG, Brown JL. The therapeutic effect of functional and transcutaneous electric stimulation on improving gait speed in stroke patients: A meta-analysis. (2006)	The purpose of this meta-analysis was to examine the therapeutic effects of functional electrical stimulation (FES) and transcutaneous electrical stimulation (TENS) on improving gait speed in individuals post stroke. Meta-analysis of eight studies. Four studies were controlled. The other four studies utilized either before-after or crossover designs. Total n=161. Only one study examined the effects of FES among patients in the acute or subacute phases of recovery (i.e., onset <6 months).	Three of the studies involved single-channel TENS as the intervention; these studies were deemed irrelevant to the current PICO question. Of the five studies that involved FES as the intervention, three studies examined the effects of multichannel FES and two examined single-channel FES.	The only outcome that was analyzed by the meta-analysis was therapeutic gait speed. Subjects received an intervention of FES but gait speed was assessed without the active application of FES. This differs from other studies that have examined the orthotic effects of FES, in which gait is examined during the application of FES. The authors reported mean changes in gait speed as well as effect sizes. Additionally, the three controlled trials examining the effectiveness of FES were combined and entered into a fixed-effects model.	Subjects demonstrated improved gait speed in 3 of the 5 studies that examined FES. The three controlled trials included in the fixed-effects model demonstrated homogeneity, and analysis revealed a statistically significant effect in favor of FES. The one study that examined the effects of FES among patients in the acute or subacute phases of recovery demonstrated a larger effect size (d=1.43) than any other study; the average effect size of FES during the chronic stage of recovery was 0.40. The mean effect size for multi-channel FES (d=1.38) was larger than the mean effect size for single-channel FES (d=0.09).	This meta-analysis was limited by the small number of studies that were included. Only five studies examined the effects of FES on gait speed, and only one of these studies involved subjects in the acute or subacute phases of recovery. This was the study by Bogataj et al that is examined separately in this evidence table. Of note, however, is the large effect size demonstrated by this study compared to the effect size of studies concerning chronic stroke. Additionally, this meta-analysis provides evidence for the superiority of multi-channel FES over single-channel FES. Although only two studies examined the effects of multi-channel FES, both of these studies demonstrated large effect sizes of 1.43 and 1.34. Of the three studies examining single-channel FES, only one demonstrated improvements in gait

					speed and its effect size (d=0.37) was appreciably smaller than those of the multi-channel FES studies.
Tan Z, Liu H, Yan T, et al. The effectiveness of functional electrical stimulation based on a normal gait pattern on subjects with early stroke: A randomized controlled trial. (2014)	The purpose of this study was to examine the effectiveness of multichannel FES based on a normal gait pattern compared to dual-channel FES. Single-blind, randomized, controlled trial. Patients with ischemic stroke (onset 3 months ago or less) were recruited from three different rehabilitation medicine departments in China and were randomized to a four-channel FES group, a four-channel placebo group, or a dual-channel FES group. Total n=45. Four-channel FES group n=16. Four-channel placebo group n=15. Dual-channel FES group n=14. There were originally 55 subjects, but ten were unable to complete the intervention for various reasons.	All subjects received 1 hour/day of conventional stroke rehabilitation (i.e., 30 minutes of physical therapy and 30 minutes of occupational therapy) on 5 days/week for 3 weeks. The four-channel FES group received stimulation to the affected quadriceps, hamstrings, tibialis anterior, and gastrocnemius. The dual-channel FES group received stimulation to the affected tibialis anterior, peroneus longus, and peroneus brevis. The placebo group was set up to mimic the four-channel FES group, but no stimulation was delivered. All subjects were positioned in side-lying with the affected lower extremity on top and supported by two slings. Subjects received 1 session of FES/day on 5 days/week for 3 weeks. Each session lasted 30 minutes.	Outcome measures were recorded prior to treatment, once weekly during the 3 weeks of treatment, and at 3 months follow-up. The authors used the Fugl-Meyer Movement Assessment (FMA) to measure lower extremity motor function, the Postural Assessment Scale for Stroke Patients (PASS) and Berg Balance Scale (BBS) to measure functional balance, the Functional Ambulatory Category (FAC) to assess gait performance, and the Modified Barthel Index (MBI) to assess performance of activities of daily living.	All groups demonstrated significant within-group improvements from baseline in all outcome measures. At 2 weeks, the four-channel FES group demonstrated significantly better BBS scores than the other two groups and significantly better MBI scores than the dual-channel FES group. At 3 weeks, the four-channel FES group demonstrated significantly better FMA scores than the dual-channel FES group, significantly better PASS and BBS scores than the placebo group, and significantly better MBI scores than both of the other two groups. At the 3-month follow-up, the four-channel FES group maintained significantly better BBS and MBI scores than the placebo group. Also at follow-up, the four-channel FES group demonstrated a mean FAC score that is consistent with independent walking,	The authors provide a good description of the electrical stimulation parameters; however, they fail to state whether patients were instructed to actively participate in the FES training or allow the electrical stimulation to perform all of the work. Due to dropout rate, the study was underpowered according to the a priori power analysis. Nevertheless, the four-channel FES group demonstrated significantly better outcomes in multiple measures. Furthermore, even though statistical significance was not always achieved, the four-channel FES group demonstrated better scores than the other two groups on every outcome measures and at every measurement period (except at baseline). Eight subjects were either unavailable or refused to report back at the 3-month follow-up, which

				whereas the other two groups did not.	may have influenced the results. Lastly, because there was no control group that received an equal dose of conventional therapy only, this study does not provide any insight into whether four-channel FES is superior to conventional therapeutic interventions.
Yamaguchi T, Tanabe S, Muraoka Y, et al. Immediate effects of electrical stimulation combined with passive locomotion-like movement on gait velocity and spasticity in persons with hemiparetic stroke: A randomized controlled study. (2012)	The purpose of this study was to compare the immediate effects of combined electrical stimulation and passive locomotion-like hip movement (ES-PM) with electrical stimulation alone (ES) and passive locomotion-like hip movement alone (PM). Single-masked, randomized controlled trial. Subjects were patients at a rehabilitation center in Japan who experienced a unilateral stroke within the preceding 6 months (range, 21-169 days) from the time of enrollment. To be included in the study, patients had to demonstrate a Functional Ambulation Category (FAC) greater than 3. Twenty-seven subjects were randomly assigned to	The ES-PM group received 1 session (lasting 20 minutes) of electrical stimulation combined with passive locomotion-like movement of the hip. Subjects were positioned in supine with surface electrodes attached to the paretic tibialis anterior and soleus and with the knee and ankle joints fixed rigidly by a brace. Passive hip movement was performed using a therapeutic exercise machine (Yasukawa Electric Corp.). This machine moved the hip through the range of 0-40 degrees at a rate of 8 degrees/second. The delivery of electrical stimulation was synchronized with hip joint angle, which was measured by an electric	Maximum gait velocity and spasticity of the ankle dorsiflexors were measured prior to the intervention and immediately following the intervention. Maximum gait velocity was measured by having subjects walk as fast as possible on a 10-meter walkway with 1-meter acceleration and deceleration zones. The average of two trials was taken as their gait velocity. Spasticity of the ankle dorsiflexors was measured using the modified Ashworth scale.	The ES-PM group demonstrated a significant improvement in maximal gait velocity following the intervention compared to both the ES and PM groups. The ES and PM groups demonstrated no between-group difference in gait velocity following their respective interventions. There were no significant between-group differences in spasticity following the intervention. However, 6 out of 9 subjects in the ES-PM group demonstrated improved spasticity compared to only 3 out of 9 in each of the other two groups.	This study differs from other studies in that it considers the immediate effects of a single session of electrical stimulation among patients with subacute stroke. However, it cannot speak to the duration or longevity of these immediate effects. Perhaps the biggest limitation of this study is that it is not practical for most practice settings. It requires special equipment to perform the passive locomotion-like movement, equipment that many therapeutic settings are unlikely to possess. Regarding the protocol that was followed, the authors did not clearly explain why the ankle was rigidly fixed. It is curious that

	one of three groups: electrical stimulation combined with passive locomotion-like hip movement (n=9), electrical stimulation only (n=9), or passive locomotion-like hip movement only (n=9). There were 0 dropouts, and all subjects completed the protocol.	goniometer. The ES group received the same electrical stimulation protocol minus passive hip movement. The PM group received the same passive hip movement minus electrical stimulation.			they would inhibit ankle joint motion while providing electrical stimulation to muscles crossing the ankle joint. The findings of this study are further limited by its small sample size and its failure to assess baseline differences between groups. Lastly, this study only included patients who were ambulating at a higher level of functioning (i.e., FAC >3).
Yan T, Hui-Chan CWY, Li LSW. Functional electrical stimulation improves motor recovery of the lower extremity and walking ability of subjects with first acute stroke: A randomized placebo-controlled trial. (2005)	The purpose of this study was to determine if standard rehabilitation plus FES during the acute phase of stroke yields better motor function and functional mobility outcomes than standard rehabilitation alone or standard rehabilitation plus placebo FES. Assessor blinded, randomized controlled trial. Subjects were inpatients in a hospital. Average time since stroke 9.2 ± 4.1 days. Subjects were randomized to an FES group (n=13), a placebo group (n=15), or a standard rehabilitation group (SR) (n=13). Total n=41. There were originally 45 subjects, but	All subjects received the same standard rehabilitation (i.e., 1 hour/day of physiotherapy and 1 hour/day of occupational therapy) on 5 days/week for a total of 3 weeks. The FES group also received FES for 30 minutes per day on 5 days/week for a total of 3 weeks. FES was delivered via two dual-channel stimulators providing stimulation to the affected quadriceps, hamstring, tibialis anterior (TA), and medial gastrocnemius. Subjects were positioned in side-lying with the affected lower extremity on top and supported by a sling. The FES activation	Outcome measures were recorded prior to treatment, once weekly during the 3 weeks of treatment, and at follow-up (8 weeks after stroke). The authors used the composite spasticity scale (CSS) to measure ankle plantar flexor tone and the timed "Up & Go" (TUG) to assess walking ability. Joint torque and surface EMG were used to assess motor function of the tibialis anterior and gastrocnemius. From these measures, the authors determined the maximum isometric voluntary contraction	All three groups demonstrated gradual increases in CSS scores over the course of the study. At week 3, the percentage increase in the FES group was significantly less than the percentage increase in the placebo and SR groups. Compared to the SR group, the FES group demonstrated a significantly greater increase in dorsiflexion torque at weeks 1, 2, 3, and 8. Compared to the placebo group, the FES group demonstrated a significantly greater increase in dorsiflexion torque at week 3. Compared to the SR	This study is different from others in that subjects' average time since stroke was 9.2 ± 4.1 days. Thus, this study is particularly relevant to physical therapists treating patients with stroke in an acute inpatient rehabilitation setting. Despite an 11% dropout rate, the study was still adequately powered, according to the authors' a priori calculation. Perhaps the biggest limitation of this study is that is fails to offer a fair comparison between the FES and SR groups. The FES group received 30 extra minutes of therapy on 5 days/week

	five did not complete the intervention.	sequence was designed to mimic normal gait. The placebo group was set up to mimic the FES group, but no stimulation was delivered and treatment duration was 60 minutes rather than 30 minutes.	(MIVC) of the ankle dorsiflexors and plantar flexors, an integrated EMG (IEMG) value, and an EMG cocontraction ratio (IEMG area of antagonist / [IEMG area of antagonist + IEMG area of agonist]).	group, the FES group demonstrated a significantly greater increase in TA IEMG at weeks 1, 2, 3, and 8. Compared to the placebo group, the FES group demonstrated a significantly greater increase in TA IEMG at weeks 3 and 8. Compared to the SR group, the EMG cocontraction ratio during dorsiflexion was significantly reduced in the FES group at weeks 1, 2, 3, and 8. Compared to the placebo group, the EMG cocontraction ratio during dorsiflexion was significantly reduced in the FES group at weeks 2, 3, and 8. There were no between-group differences in TUG scores at any time point. However, a significantly larger percentage of subjects in the FES group were able to walk without personal assistance by weeks 2 (compared to the placebo group) or 3 (compared to the SR group) onward. Additionally, subjects in the FES groups tended to walk without personal assistance 2 to 3 days sooner than subjects in the other two groups. Eighty-	during the 3-week intervention. Therefore, it is also impossible to know whether the between group differences are truly due to FES or due to the 30 extra minutes of therapy that the FES group received each day.

				five percent of subjects in the FES group returned home compared to 53% and 46% in the placebo and SR groups, respectively.	
Yavuzer G, Geler-Külcü D, Sonel-Tur B, Kutlay S, Ergin S, Stam HJ. Neuromuscular electrical stimulation effect on lower-extremity motor recovery and gait kinematics of patients with stroke: A randomized controlled trial. (2006)	The purpose of this study was to compare conventional rehabilitation plus neuromuscular electrical stimulation (NMES) to conventional rehabilitation alone in patients 6 months or less post stroke. Assessor-blinded, randomized controlled trial. Twenty-five inpatients were allocated to one of two groups: NMES group (n=12) or control group (n=13). Mean time since stroke was 2.4 ± 1.1 months. To be included in the study, subjects had to be able to stand and take at least one step with or without assistance. However, dorsiflexion strength of the paretic lower extremity had to be less than 3/5. All of the subjects completed the study with no one missing more than 1 treatment session.	Both groups received conventional stroke rehabilitation, which occurred on 5 days/week for 4 weeks. Rehabilitation lasted between 2 and 5 hours each day. In addition to conventional rehabilitation, the NMES group received NMES for 10 minutes on 5 days/week for 4 weeks. NMES was applied to the paretic tibialis anterior muscle. Patients were not asked to volitionally contract their muscles during treatment; the stimulator performed all of the work. NMES was delivered with a 10 second on period and 50 second off period. No information was provided regarding the position of the patient during NMES.	Outcome measures were recorded 1 to 3 days before the start of the intervention and 1 to 3 days after the intervention ended. The authors used Brunnstrom stages 1 through 6 to measure lower-extremity motor recovery. Various gait kinematic measures were recorded by having subjects walk across a 10 meter walkway at a self-selected speed. These measures included: gait velocity, step length, percentage of stance phase on the paretic lower extremity, sagittal plane motion of the pelvis, hip, knee, and ankle, maximum angle of ankle dorsiflexion during swing phase, and maximum angle of plantarflexion at initial contact.	At baseline, the control group demonstrated a significantly faster walking velocity than the NMES group. Both groups demonstrated significant improvements in Brunnstrom stages, but no between-group difference in improvement was observed. Both groups demonstrated improvements in kinematic measures of gait but, again, no between-groups differences were observed.	Baseline differences in walking velocity may have interfered with the results of this study. This study was also limited by a small sample size. Furthermore, the authors made no mention of how the patient was positioned during NMES. All that is known is that NMES was delivered to induce repetitive ankle dorsiflexion. Treatment session duration in this study (10 minutes per session) was much shorter than in other studies. Lastly, the design of this study was further limited by the uneven treatment times between the two groups. The experimental group received 10 extra minutes of therapy each day for the entire duration of the 4-week intervention.

You G, Liang H, Yan T. Functional electrical stimulation early after stroke improves lower limb motor function and ability in activities of daily living. (2014)	The purpose of this study was to determine whether or not FES leads to improvements in daily activities when applied to patients with early stroke (less than 3 months). Assessor-blinded, randomized control trial. Subjects were individuals with stroke who were inpatients in either the rehabilitation medicine or the neurology department at a hospital in China. Total n=37. Standard rehabilitation (SR) group n=18. FES (FES and SR) group n=19. There were originally 42 patients, but five dropped out due to personal reasons.	Both groups received treatment 5 days/week for 3 week. Both groups received SR, which consisted of 60 minutes of physiotherapy and 60 minutes of occupational therapy. The FES group also received 30 minutes of FES to stimulate ankle dorsiflexion and eversion (dual-channel stimulator). The investigators used 3x3 cm electrodes over tibialis anterior (ankle dorsiflexion) and peroneus brevis and longus (ankle eversion). FES was performed with patients sitting or supine.	Outcome measures were recorded prior to treatment and after weeks 2 and 3 of treatment. The authors used the Composite Spasticity Scale (CSS) to assess ankle plantarflexor spasticity, the Fugl-Myer Assessment (FMA) to assess lower limb mobility, the postural assessment scale for stroke patients (PASS) and Berg Balance Scale (BBS) to assess balance, and the modified Barthel Index (MBI) to assess performance of activities of daily living.	Both groups demonstrated increased CSS scores over the course of the study (indicating increased plantarflexor spasticity), but the percentage increase in the FES group's CSS score was significantly less than that of the SR group after both 2 and 3 weeks of treatment. Both groups demonstrated improved FMA scores after the 2nd and 3rd weeks of treatment, but the percentage increase in the FES group's score was significantly greater than that of the SR group after both 2 and 3 weeks of treatment. Both groups demonstrated increased PASS scores, but the percentage increase in the FES group's score was significantly greater than that of the control group at week 2. Both groups demonstrated increased BBS scores, but the increase in the FES group's score was significantly greater than that of the control group at week 3. The FES group demonstrated significantly greater improvements in MBI scores than the SR group at weeks 2 and 3. In	The authors fail to adequately describe the FES intervention. It is unknown if subjects were instructed to actively perform ankle dorsiflexion and eversion with the stimulator or if they were instructed to let the stimulator do all of the work. It is also impossible to know whether the between group differences are truly due to FES or due to the 30 extra minutes of therapy that the FES group received each day. The two groups did not receive the same amount of intervention time. Lastly, this study cannot speak to any long-term, lasting benefits or FES that persist even after the intervention is concluded.

				particular, the FES group demonstrated significantly greater improvements than the SR group on items of toilet use, transfer, mobility, and stairs.	

Summary/Synthesis:

The current literature does not offer a clear answer to the present PICO question. One systematic review[2] and one meta-analysis[4] were identified as appropriate for inclusion in this literature review. Kafri and Laufer[2] found that the use of lower extremity functional electrical stimulation (LE FES) during the rehabilitation of individuals post stroke can improve gait speed, walking independence, muscle strength, and spasticity. However, despite these positive findings in favor of LE FES, comparisons between FES therapy and non-FES therapy were largely equivocal.[2] Furthermore, the majority of the studies included in this systematic review involved participants in the chronic post-stroke phase of recovery.[2] A meta-analysis by Robbins and colleagues[4] examined the therapeutic effects of FES and transcutaneous electrical stimulation (TENS) on improving gait speed in individuals post stroke. Of the five studies that examined the effects of FES, only one involved patients in the acute or subacute phases of recovery (i.e., onset <6 months). Nevertheless, this one study demonstrated a substantially larger effect size compared to studies that involved patients in the chronic phase of recovery.[4] This finding lends support to the findings of Bogataj and colleagues who found a negative correlation between performance outcomes (i.e., Fugl-Meyer test, gait speed, and stride length) and elapsed time between stroke onset and the initiation of therapy.[1] It must be noted, however, that these negative correlations were very poor.[1]

Despite the fact that most of the available evidence pertains to individuals in the chronic phase of recovery, seven randomized controlled trials were reviewed that examined the effects of FES on individuals within the first six months of stroke onset.[1,3,5-9] The FES interventions examined by these studies were quite varied. One study applied FES with subjects positioned in either sitting or supine,[9] and one study did not specify the position of subjects during stimulation.[8] The degree to which these two studies applied electrical stimulation in a functional manner is questionable. Nevertheless, You and colleagues found that, compared to standard rehabilitation alone, the addition of FES led to better outcomes in spasticity, lower limb mobility, balance, and activities of daily living (ADLs).[9] Studies that implemented more functional applications of FES included two studies that applied FES with subjects in side-lying,[5,7] one study that applied FES in conjunction with passive locomotion-like movement of the hip,[6] and two studies that applied FES during gait training.[1,3] Of the gait training studies, Bogataj and colleagues[1] found that performance (i.e., gait speed, stride length, gait cadence, and Fugl-Meyer score) during periods of multichannel FES (MFES) combined with conventional therapy was significantly greater than during periods of conventional therapy alone. Conversely, Lairamore and colleagues[3] did not find any

differences between two groups that performed gait training with or without motor-level stimulation from a neuroprosthesis. One of the major differences between these two studies is the number of muscle groups that received stimulation. The MFES intervention that was implemented by Bogataj et al applied stimulation to the ankle dorsiflexors, ankle plantar flexors, hamstrings, quadriceps, gluteus maximus, and triceps brachii.[1] The Bioness L300 neuroprosthesis that was utilized by Lairamore et al only applied stimulation to the ankle dorsiflexors.[3] The superiority of MFES was further demonstrated by Tan and colleagues[5] who showed that, during treatment, four-channel FES was superior to dual-channel FES on measures of functional balance and ADL performance. Additionally, at the 3-month follow-up period, the four-channel FES group demonstrated a mean Functional Ambulatory Category (FAC) that is consistent with independent walking whereas the other groups did not.[5] Similar improvements in walking ability were demonstrated by Yan and colleagues[7] who found that a significantly greater percentage of subjects in the FES group were able to walk without personal assistance compared to subjects in the placebo and standard rehabilitation groups.

The available evidence supports the use of FES in the rehabilitation of patients during the acute and subacute phases of post-stroke rehabilitation. However, it cannot be said at this time whether or not FES therapy is more effective than non-FES therapy. Much of the current research has compared standard rehabilitation to standard rehabilitation plus an FES. However, in many of these studies, FES serves as an additional form of treatment such that both groups do not receive the same amount of total treatment.[7,8,9] Other studies include placebo groups but still fail to include a separate group that receives an equivalent amount of standard rehabilitation.[5,6] Only two studies included equivalent comparisons between FES treatment time and standard rehabilitation treatment time.[1,3] The study that only stimulated one muscle group failed to demonstrate any significant difference between the experimental and control groups.[3] The study that utilized MFES found that the combination of MFES and conventional therapy was superior to conventional therapy alone.

Based on current evidence, FES should be considered as a supplement to standard rehabilitation when working with patients in the acute and subacute phases of post-stroke rehabilitation. The optimal protocol for FES in this patient population has not been established. However, evidence suggests that the application of FES to more muscle groups is superior to the application of FES to fewer muscle groups. Future studies should take care to offer true comparisons between FES and standard rehabilitation in order to determine which intervention favors better outcomes.

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