

Electrical muscle stimulation

Clinical Policy ID: CCP.1377

Recent review date: 5/2024

Next review date: 9/2025

Policy contains: Functional electrical stimulation; neuromuscular electrical stimulation; physical rehabilitation

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Coverage policy

Electrical muscle stimulation (also referred to as neuromuscular electrical stimulation) is clinically proven and, therefore, may be medically necessary when used in accordance with U.S. Food and Drug Administration labeling instructions for each device for the following indications:

- Correcting foot drop of central neurological origin when an ankle-foot orthosis is not tolerated (Moll, 2017; National Institute for Health and Care Excellence, 2009; Prenton, 2018).
- Attenuating muscle disuse atrophy in immobilized lower limbs following a non-neurological injury or surgery with intact nerve supply (Conley, 2021; Hauger, 2018; Wylde, 2018).
- Correcting or preventing glenohumeral subluxation after an acute or subacute stroke (Lee, 2017; Winstein, 2016).
- Restoring upper limb function after an acute or subacute stroke or spinal cord injury with minimal volitional movement, combined with task-specific training (de Freitas, 2018; Fehlings, 2017; Mirkowski, 2019; Monte-Silva, 2019; National Institute for Health and Care Excellence, 2023).
- To enable independent ambulation using Parastep 1® for those with spinal cord injury who meet criteria including:
 - Intact lower motor units from L1 down.
 - Stability for weight bearing with balance/trunk control.

- Responsive muscles and sensation to stimulation
- Independent transfers and standing three plus minutes.
- Motivation/ability to use device long term.
- Finger function to operate controls.
- Six plus months post-injury/surgery.
- No hip/knee degeneration or osteoporotic fractures.

Limitations

All other uses of electrical muscle stimulation are not medically necessary, as the safety and effectiveness has not been established. These include, but are not limited to:

- Muscle disuse atrophy in members with spinal cord injury.
- Pain control.
- Non-medical uses (e.g., exercise).
- Oropharyngeal dysphagia (Almeida, 2020; Alamer, 2020; Diéguez-Pérez, 2020; López-Liria, 2020).
- Edema reduction (Burgess, 2019).
- Knee osteoarthritis in a non-surgical member (Novak, 2020).

Alternative covered services

- Occupational therapy.
- Physical therapy.
- Speech therapy.
- Specialist consultation.
- Hip-knee-ankle-foot orthoses.

Background

Electrical stimulation is one of many interventions employed to restore body movement critical for daily function and quality of life. Available in many forms, electrical stimulation facilitates changes in either bioelectrical or biochemical communication among cellular components to effect muscle action, pain modulation, and performance. Electrodes may be positioned transcutaneously, percutaneously, or subcutaneously. Small portable units with modifiable capabilities are the most popular, because they allow providers to set parameters and design custom programs that patients can use in the clinic or at home (Doucet, 2012).

Transcutaneous methods such as transcutaneous electrical nerve stimulation and interferential current work at lower frequencies (0.5 to 100 Hz) in the bioelectric range to alter pain signals that travel to the brain, thereby decreasing acute and chronic pain without any discernable muscle contraction. Other benefits may be improved circulation, lymphatic flow, swelling, and muscle function. Similarly, higher-frequency electrical stimulation is used to decrease pain, improve circulation, and speed wound healing (Doucet, 2012).

Electrical muscle stimulation, also referred to as neuromuscular electrical stimulation or e-stim, typically delivers higher frequencies (20 – 50 Hz) to produce muscle tetany and contraction. It has two main purposes: 1) to treat muscle atrophy during temporary extremity immobilization; and 2) to pair the stimulation simultaneously or intermittently with a functional task in neurologically impaired individuals (commonly referred to as functional electrical stimulation). Electrical muscle stimulation was first applied clinically to correct foot drop in paraplegics and has become an integral part of modern rehabilitation programs (Doucet, 2012).

Electroceutical therapy, also referred to as bioelectric nerve block, uses even higher electrical frequencies (ranging from 1 to 20,000 Hz) to mimic the human bioelectric system. An example of this is the Hako-Med PRO ElecDT 2000. This device employs a proprietary concept called Horizontal® Therapy into its product, which the

manufacturer claims can treat both bioelectrical and biochemical cellular communication components in one treatment session by holding the bioelectric intensity constant while changing the frequency. Due to safety concerns, it may only be prescribed and administered under the supervision of a health care provider experienced in this method of treatment.

Regulation

The U.S. Food and Drug Administration regulates neuromuscular electrical stimulators for clinical use either through the 510(k) process or the premarket approval process. Devices required to go through the more rigorous premarket approval process have additional issues of safety and efficacy. Several devices have been approved for a range of indications that often overlap with other transcutaneous methods (U.S. Food and Drug Administration, 2023a, 2023b):

- Stroke rehabilitation by muscle re-education.
- Relaxation of muscle spasm.
- Attenuation of disuse atrophy.
- Increasing local blood circulation.
- Muscle re-education for other conditions.
- Maintaining or increasing range of motion.
- Prevention of deep vein thrombosis following surgery.

Unlike neuromuscular electrical stimulators (product codes IPF, GZI, and MKD), approved uses for transcutaneous methods, such as interferential current therapy, typically include control of pain. As such, these devices are regulated as transcutaneous electrical nerve stimulators (product code LIH).

Findings

The evidence from several systematic reviews, meta-analyses, and guidelines suggests electrical muscle stimulation is safe and efficacious when used in accordance with established rehabilitation protocols requiring supervision or in unattended settings (Fehlings, 2017; Gatewood, 2017; Ho, 2014; Lee, 2017; Moll, 2017; National Institute for Health and Care Excellence, 2009, 2023; Prenton, 2016; Winstein, 2016). The strongest evidence for neuromuscular electrical stimulation based on systematic reviews and meta-analyses supports its use for improving swallowing function and limb strength in stroke patients, as well as strengthening muscles in patients with knee surgery, chronic kidney disease, and advanced diseases like respiratory failure, heart failure, and cancer. Potential benefits are also seen for enhancing rehabilitation and gross motor function in cerebral palsy, postural control in spastic diplegia, and respiratory function in spinal cord injury.

Professional Clinical Guidelines

Neuromuscular electrical stimulation is reasonably recommended in several circumstances for stroke rehabilitation based on generally strong levels of evidence, according to joint guidelines issued by the American Heart Association/American Stroke Association (Winstein, 2016). It can be considered as an alternative to an ankle foot orthosis for treating foot drop, supported by strong Level B evidence. Neuromuscular electrical stimulation is also reasonably recommended for individuals in the first few months post-stroke who have minimal voluntary movement, in order to facilitate improvement, backed by strong Level A evidence. Managing increased muscle tone temporarily with neuromuscular electrical stimulation as an adjunct to rehabilitation therapy is a reasonable option with moderate Level A evidence. Finally, neuromuscular electrical stimulation is reasonably recommended for treating shoulder instability, with the strongest Level A evidence (Winstein, 2016).

The National Institute for Health and Care Excellence has issued two guidelines related to electrical muscle stimulation. The first issued in 2009 noted that evidence supports the safety and efficacy of the treatment for

improving gait in patients with drop foot caused by upper motor neuron lesions from conditions like stroke, cerebral palsy, multiple sclerosis or spinal cord injury (National Institute for Health and Care Excellence, 2009). A supplemental guideline issued in 2023 notes that electrical stimulation is not recommended for routine use in the rehabilitation of the hand or arm after stroke. However, a trial of electrical stimulation therapy is suggested as part of a comprehensive rehabilitation program for individuals who exhibit evidence of muscle contraction post-stroke but cannot move their arm against resistance. The continuation of this therapy is advised if it leads to improvements in the person's strength and their ability to practice functional tasks, such as maintaining range of motion or enhancing grasp and release (National Institute for Health and Care Excellence, 2023).

Neuromuscular electrical stimulation

In an immobilized extremity, neuromuscular electrical stimulation can control edema, increase local blood circulation, maintain muscle tone, or delay the development of disuse atrophy (Doucet, 2012). It has been proposed as treatment for muscle atrophy in conditions such as cerebral palsy, congestive heart failure, progressive neuromuscular diseases, chronic obstructive pulmonary disease, and upper extremity hemiplegia. In these populations, the rationale for use is to enhance the effects of rehabilitation or provide an alternative for patients with muscle weakness who have difficulty engaging with traditional rehabilitation services.

Post-Stroke Dysphagia and Motor Impairment

Several systematic reviews have found that neuromuscular electrical stimulation improves swallowing function and limb strength in stroke patients. Alamer (2020) analyzed 11 randomized controlled trials with 784 patients and found moderate to high quality evidence that neuromuscular electrical stimulation combined with swallowing therapy was more effective than swallowing therapy alone for improving dysphagia post-stroke. Chiang (2019) compared different stimulation techniques in 19 randomized controlled trials with 691 stroke patients and found neuromuscular electrical stimulation significantly improved swallowing function versus placebo. Wang (2021) meta-analyzed 20 studies totaling 914 stroke patients and found neuromuscular electrical stimulation groups had significantly better dysphagia outcomes than control groups. For limb function, Yang (2019) reviewed 48 randomized controlled trials with 1712 stroke patients and found neuromuscular electrical stimulation significantly improved arm function and strength compared to placebo. Monte (2019) meta-analyzed 26 randomized controlled trials with 782 patients and found a robust short-term effect of electromyography-triggered neuromuscular electrical stimulation on upper limb motor impairment, especially in chronic stroke.

Muscle Strengthening in Other Populations

Quadriceps strength after knee surgery: Gatewood (2017) reviewed 7 studies with over 300 patients and found neuromuscular electrical stimulation improved post-operative quadriceps strength and function. Conley (2021) identified optimal neuromuscular electrical stimulation parameters from 8 randomized controlled trials with 559 patients.

Chronic kidney disease: Schardong (2020) meta-analyzed 10 studies with 242 hemodialysis patients and found neuromuscular electrical stimulation significantly improved quadriceps strength, upper limb strength, and functional capacity. Valenzuela (2020) reviewed 8 trials with 221 patients and found neuromuscular electrical stimulation during dialysis improved walk distance, cycling workload, and limb strength.

Advanced disease: A Cochrane review by Jones (2016) of 18 randomized controlled trials with 933 participants found neuromuscular electrical stimulation improved quadriceps strength and muscle mass in patients with respiratory disease, heart failure, and cancer.

Spinal cord injury: de Freitas (2018) analyzed 5 studies with 170 patients but found insufficient evidence that neuromuscular electrical stimulation was superior to other treatments for improving strength.

Rehabilitation and Functional Outcomes

Beyond strength, neuromuscular electrical stimulation may enhance rehabilitation and physical function in certain populations. Chen (2023) meta-analyzed 14 randomized controlled trials with 421 children with cerebral palsy and found neuromuscular electrical stimulation significantly improved walking speed and gross motor scores compared to conventional therapy alone. McCaughey (2016) reviewed 14 studies in 129 spinal cord injury patients and found abdominal functional electrical stimulation acutely improved cough and chronically increased vital capacity and peak expiratory flow. Dewar (2015) concluded level II evidence from 2 studies supported functional stimulation combined with rehabilitation for improving postural alignment in children with spastic diplegia, but called for more research.

Edema and Pain Management

A few reviews suggest potential benefits of neuromuscular electrical stimulation for managing edema and pain, though the evidence is limited. Burgess (2019) found 6 of 7 studies totaling over 200 patients showed neuromuscular electrical stimulation effectively reduced edema in various conditions. Novak (2020) reviewed 9 randomized controlled trials and recommended neuromuscular electrical stimulation combined with strengthening exercises for reducing pain in knee osteoarthritis. However, Zayed (2020) meta-analyzed 6 randomized controlled trials with 718 critically ill patients and found no significant effect of neuromuscular electrical stimulation on ICU outcomes. Martimbianco (2017) found very low quality evidence from up to 4 trials with 118 participants that neuromuscular electrical stimulation plus exercise slightly reduced patellofemoral pain compared to exercise alone.

Specialty Populations

A few systematic reviews examined neuromuscular electrical stimulation in specialty populations with mixed findings:

Dysphonia: Almeida (2020) reviewed 11 studies with 382 patients and found while neuromuscular electrical stimulation showed some improvements in laryngeal function and vocal quality, heterogeneity in designs prevented determinations of overall effectiveness for treating dysphonia.

Parkinson's dysphagia: López-Liria (2020) found 2 studies with 199 Parkinson's patients where neuromuscular electrical stimulation did not significantly improve dysphagia compared to traditional therapy alone.

Chronic Obstructive Pulmonary Disease: An statement by Maltais noted neuromuscular electrical stimulation is emerging as a useful modality for muscle dysfunction in severe chronic obstructive pulmonary disease and exacerbations but did not quantify the evidence or make a formal recommendation. Orthopedic Applications Regarding orthopedic uses, evidence is lacking to support neuromuscular electrical stimulation, especially long-term. McAlindon's guidelines reviewed one systematic review and two randomized controlled trials with 107 patients and determined neuromuscular electrical stimulation was "not appropriate" for treating knee osteoarthritis. Wylde (2018) reviewed 17 randomized controlled trials with 2485 participants and found no interventions, including 1 neuromuscular electrical stimulation trial, reduced chronic pain beyond 3 months after total knee replacement.

Adverse Events and Limitations

Across the reviewed studies, no serious adverse events related to neuromuscular electrical stimulation were reported. However, several reviews noted limitations in the current evidence base, including small sample sizes, heterogeneous designs and outcome measures, lack of long-term follow-up, and overall low quality of many included studies. Newberry (2017) concluded evidence was insufficient to evaluate neuromuscular electrical stimulation effectiveness, largely due to poor quality and heterogeneous study design.

Functional electrical stimulation

In the lower extremities, functional electrical (muscle) stimulation has been used to perform stationary exercise and assist with standing and walking. For persons with upper extremity paralysis caused by injury or disease of the central nervous system, it has been used to improve hand function and range of motion, and correct or prevent glenohumeral subluxation in stroke. Devices used to augment stationary exercise are considered exercise equipment and not necessarily for medical use.

Functional Electrical Stimulation for Stroke

Several studies have investigated the impact of functional electrical stimulation on walking and upper extremity function in stroke patients. A systematic review and meta-analysis by Prenton (2016) synthesized 7 randomized controlled trials with a total of 815 stroke participants. The analysis found that functional electrical stimulation and ankle foot orthoses produced comparable improvements in walking speed, functional exercise capacity, timed up-and-go, and perceived mobility. The authors concluded that ankle foot orthoses have equally positive combined-orthotic effects as functional electrical stimulation on key walking measures for foot-drop caused by stroke.

In a systematic review and meta-analysis, Lee JH (2017) examined 11 randomized controlled trials with a total of 432 participants (216 receiving functional electrical stimulation plus conventional therapy, 216 receiving conventional therapy alone) to assess the effectiveness of functional electrical stimulation for managing shoulder subluxation post-stroke. The studies included participants with acute stroke who were 2.0 ± 2.2 months (intervention) and 1.6 ± 1.7 months (control) post-stroke, and those with chronic stroke who were 9.4 ± 4.1 months (intervention) and 9.1 ± 3.9 months (control) post-stroke.

Functional Electrical Stimulation for Spinal Cord Injury

The use of functional electrical stimulation for restoring functions in individuals with spinal cord injury has been reviewed in several studies. Fehlings (2017) reviewed two randomized controlled trials involving a total of 89 patients with acute and subacute cervical spinal cord injury. One study found that compared to occupational therapy alone, functional electrical stimulation combined with occupational therapy resulted in significantly greater improvements on the Functional Independence Measure Motor subscore (15.0 vs 4.1 points), Functional Independence Measure Self-Care subscore (20.1 vs 10 points), and Spinal Cord Independence Measure Self-Care subscore (10.2 vs 3.1 points). The other study found no significant differences between functional electrical stimulation, biofeedback, combined functional electrical stimulation/biofeedback, and conventional strengthening for recovering tenodesis grasp. Based on this low-quality evidence, the guideline suggests offering functional electrical stimulation to improve hand and upper extremity function in individuals with acute and subacute cervical spinal cord injury.

Ho (2014) systematically reviewed functional electrical stimulation applications for various functions in spinal cord injury patients. The largest clinical trial of an upper extremity functional electrical stimulation neuroprosthesis (the Freehand trial) included 28 participants, all of whom improved independence in at least one task. A second generation implanted functional electrical stimulation system (IST-12) has been implanted in 12 spinal cord injury subjects, with each demonstrating improvement in at least 2 activities. For lower extremity function, functional

electrical stimulation neuroprosthesis recipients exhibited mean and median standing times of 10 and 3 minutes respectively, with some recipients in a Phase II trial standing over 20 minutes.

Functional Electrical Stimulation for Cerebral Palsy

Moll (2017) conducted a systematic review assessing the effect of functional electrical stimulation on ankle dorsiflexors in children and adolescents with spastic cerebral palsy during walking. The review included 14 articles (11 studies) with a total of 127 patients aged 5 to 19 years with Gross Motor Function Classification System levels I to III receiving functional electrical stimulation. Only five articles (three studies) were of level I to III evidence. Ankle dorsiflexion angle was the most frequently investigated outcome. Adverse events included skin irritation, poor tolerance, and acceptance issues. The review found some evidence supporting functional electrical stimulation use in children with spastic cerebral palsy for improving ankle and gait biomechanics, but more high-quality research is needed. In 2024, condensed and reorganized findings section clearly noting affirmative guidelines, and synthesizing commonalities across studies reviewed. No new studies were added and no policy changes are warranted.

References

On April 4, 2024, we searched PubMed and the databases of the Cochrane Library, the U.K. National Health Services Centre for Reviews and Dissemination, the Agency for Healthcare Research and Quality, and the Centers for Medicare & Medicaid Services. Search terms were “Electric Stimulation Therapy/therapeutic use” (MeSH), “Electric Stimulation Therapy/therapy” (MeSH), and “electrical stimulation.” We included the best available evidence according to established evidence hierarchies (typically systematic reviews, meta-analyses, and full economic analyses, where available) and professional guidelines based on such evidence and clinical expertise.

Alamer A, Melese H, Nigussie F. Effectiveness of neuromuscular electrical stimulation on post-stroke dysphagia: A systematic review of randomized controlled trials. *Clin Interv Aging*. 2020;15:1521-1531. Doi: 10.2147/cia.s262596.

Almeida ANS, Cunha DAD, Ferreira SLS, et al. Effect of electrical stimulation on the treatment of dysphonia: A systematic review. *J Voice*. 2020. Doi: 10.1016/j.jvoice.2020.08.002.

Alves IGN, Silva CMSE, Martinez BP, de Queiroz RS, Gomes-Neto M. Effects of neuromuscular electrical stimulation on exercise capacity, muscle strength and quality of life in COPD patients: A systematic review with meta-analysis. *Clin Rehabil*. 2022;36(4):449-471. Doi: 10.1177/02692155211067983.

Bath PM, Lee HS, Everton LF. Swallowing therapy for dysphagia in acute and subacute stroke. *Cochrane Database Syst Rev*. 2018;10(10):CD000323. Doi: 10.1002/14651858.CD000323.pub3.

Bistolfi A, Zanovello J, Ferracini R, et al. Evaluation of the effectiveness of neuromuscular electrical stimulation after total knee arthroplasty: A meta-analysis. *Am J Phys Med Rehabil*. 2018;97(2):123-130. Doi: 10.1097/phm.0000000000000847.

Burge AT, Cox NS, Abramson MJ, Holland AE. Interventions for promoting physical activity in people with chronic obstructive pulmonary disease (COPD). *Cochrane Database Syst Rev*. 2020;4(4):Cd012626. Doi: 10.1002/14651858.CD012626.pub2.

Burgess LC, Immins T, Swain I, Wainwright TW. Effectiveness of neuromuscular electrical stimulation for reducing oedema: A systematic review. *J Rehab Med*. 2019;51(4):237-243. Doi: 10.2340/16501977-2529.

- Chen R-C, Li X-Y, Guan L-L, et al. Effectiveness of neuromuscular electrical stimulation for the rehabilitation of moderate-to-severe COPD: A meta-analysis. *Int J Chron Obstruct Pulmon Dis*. 2016;11:2965-2975. Doi: 10.2147/COPD.S120555.
- Chen Y-H, Wang H-Y, Liao C-D, Liou T-H, Escorpizo R, Chen H-C. Effectiveness of neuromuscular electrical stimulation in improving mobility in children with cerebral palsy: A systematic review and meta-analysis of randomized controlled trials. *Clin Rehabil*. 2023;37(1):3-16. Doi: 10.1177/02692155221109661.
- Chiang C-F, Lin M-T, Hsiao M-Y, et al. Comparative efficacy of noninvasive neurostimulation therapies for acute and subacute poststroke dysphagia: A systematic review and network meta-analysis. *Arch Phys Med Rehabil*. 2019;100(4):739-750.e734. Doi: 10.1016/j.apmr.2018.09.117.
- Conley CEW, Mattacola CG, Jochimsen KN, et al. A comparison of neuromuscular electrical stimulation parameters for postoperative quadriceps strength in patients after knee surgery: A systematic review. *Sports Health*. 2021;13(2):116-127. Doi: 10.1177/1941738120964817.
- de Freitas GR, Szpoganicz C, Ilha J. Does neuromuscular electrical stimulation therapy increase voluntary muscle strength after spinal cord injury? A systematic review. *Top Spinal Cord Inj Rehabil*. 2018;24(1):6-17. Doi: 10.1310/sci16-00048.
- Dewar R, Love S, Johnston LM. Exercise interventions improve postural control in children with cerebral palsy: A systematic review. *Dev Med Child Neurol*. 2015;57(6):504-520. Doi: 10.1111/dmcn.12660.
- Di Sante L, Paoloni M, Dimaggio M, et al. Ultrasound-guided aspiration and corticosteroid injection compared to horizontal therapy for treatment of knee osteoarthritis complicated with Baker's cyst: A randomized, controlled trial. *Eur J Phys Rehabil Med*. 2012;48(4):561-567.
<https://www.minervamedica.it/en/journals/europa-medicophysica/article.php?cod=R33Y2012N04A0561>.
- Diéguez-Pérez I, Leirós-Rodríguez R. Effectiveness of different application parameters of neuromuscular electrical stimulation for the treatment of dysphagia after a stroke: A systematic review. *J Clin Med*. 2020;9(8). Doi: 10.3390/jcm9082618.
- Doucet BM, Lam A, Griffin L. Neuromuscular electrical stimulation for skeletal muscle function. *Yale J Biol Med*. 2012;85(2):201-215. National Center for Biotechnology Information.
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3375668/pdf/yjbm_85_2_201.pdf.
- Fehlings MG, Tetreault LA, Aarabi B, et al. A clinical practice guideline for the management of patients with acute spinal cord injury: Recommendations on the type and timing of rehabilitation. *Global Spine J*. 2017;7(3 Suppl):231S-238S. Doi: 10.1177/2192568217701910.
- Gatewood CT, Tran AA, Dragoo JL. The efficacy of post-operative devices following knee arthroscopic surgery: A systematic review. *Knee Surg Sports Traumatol Arthrosc*. 2017;25(2):501-516. Doi: 10.1007/s00167-016-4326-4.
- Hajibandeh S, Hajibandeh S, Antoniou GA, Scurr JR, Torella F. Neuromuscular electrical stimulation for thromboprophylaxis: A systematic review. *Phlebology*. 2015;30(9):589-602. Doi: 10.1177/0268355514567731.
- Hako-Med Holdings, Inc. Products Page. PRO ElecDT® 2000 WITH VasoPulse®2000.
<http://www.electromedicine.com/>. Published 2023.
- Hauger AV, Reiman MP, Bjordal JM, et al. Neuromuscular electrical stimulation is effective in strengthening the quadriceps muscle after anterior cruciate ligament surgery. *Knee Surg Sports Traumatol Arthrosc*. 2018;26(2):399-410. Doi: 10.1007/s00167-017-4669-5.
- Ho CH, Triolo RJ, Elias AL, et al. Functional electrical stimulation and spinal cord injury. *Phys Med Rehabil Clin N Am*. 2014;25(3):631-654, ix. Doi: 10.1016/j.pmr.2014.05.001.p

- Jones S, Man WD, Gao W, et al. Neuromuscular electrical stimulation for muscle weakness in adults with advanced disease. *Cochrane Database Syst Rev.* 2016;10:CD009419. Doi: 10.1002/14651858.CD009419.pub3.
- Lee JH, Baker LL, Johnson RE, Tilson JK. Effectiveness of neuromuscular electrical stimulation for management of shoulder subluxation post-stroke: A systematic review with meta-analysis. *Clin Rehabil.* 2017;31(11):1431-1444. Doi: 10.1177/0269215517700696.
- López-Liria R, Parra-Egeda J, Vega-Ramírez FA, et al. Treatment of dysphagia in Parkinson's disease: A systematic review. *Int J Environ Res Public Health.* 2020;17(11). Doi: 10.3390/ijerph17114104.
- Maltais F, Decramer M, Casaburi R, et al. An official American Thoracic Society/European Respiratory Society statement: Update on limb muscle dysfunction in chronic obstructive pulmonary disease. *Am J Respir Crit Care Med.* 2014;189(9):e15-62. Doi: 10.1164/rccm.201402-0373ST.
- Martimbianco ALC, Torloni MR, Andriolo BN, Porfirio GJ, Riera R. Neuromuscular electrical stimulation (NMES) for patellofemoral pain syndrome. *Cochrane Database Syst Rev.* 2017;12:CD011289. Doi: 10.1002/14651858.CD011289.pub2.
- McAlindon TE, Bannuru RR, Sullivan MC, et al. OARSI guidelines for the non-surgical management of knee osteoarthritis. *Osteoarthritis Cartilage.* 2014;22(3):363-388. Doi: 10.1016/j.joca.2014.01.003.
- McCaughey EJ, Borotkanics RJ, Gollee H, Folz RJ, McLachlan AJ. Abdominal functional electrical stimulation to improve respiratory function after spinal cord injury: A systematic review and meta-analysis. *Spinal Cord.* 2016;54(9):628-639. Doi: 10.1038/sc.2016.31.
- Moll I, Vles JSH, Soudant D, et al. Functional electrical stimulation of the ankle dorsiflexors during walking in spastic cerebral palsy: A systematic review. *Dev Med Child Neurol.* 2017;59(12):1230-1236. Doi: 10.1111/dmcn.13501.
- Monte-Silva K, Piscitelli D. Electromyogram-related neuromuscular electrical stimulation for restoring wrist and hand movement in poststroke hemiplegia: A systematic review and meta-analysis. *Neurorehabil Neural Repair.* 2019;33(2):96-111. Doi: 10.1177/1545968319826053.
- National Institute for Health and Care Excellence. Functional electrical stimulation for drop foot of central neurological origin. Interventional procedures guidance [IPG278]. <https://www.nice.org.uk/guidance/ipg278/chapter/1-Guidance>. Published January 2009.
- National Institute for Health and Care Excellence. Stroke rehabilitation in adults. Clinical guideline [NG236]. <https://www.nice.org.uk/guidance/ng236>. Published October 18, 2023.
- Newberry SJ, FitzGerald J, SooHoo NF, et al. Treatment of osteoarthritis of the knee: An update review. Comparative Effectiveness Review No. 190. (Prepared by the RAND Southern California Evidence-based Practice Center under Contract No. 290-2015-00010-I.) AHRQ Publication No.17-EHC011-EF. Rockville, MD. Agency for Healthcare Research and Quality website. <https://effectivehealthcare.ahrq.gov/products/osteoarthritis-knee-update/research-2017>. Published May 4, 2017.
- Novak S, Guerron G, Zhou Z, Cheung G, Berteau J-P. New guidelines for electrical stimulation parameters in adult patients with knee osteoarthritis based on a systematic review of the current literature. *Am J Phys Med Rehabil.* 2020;99(8):682-688.
- Prenton S, Hollands KL, Kenney LP. Functional electrical stimulation versus ankle foot orthoses for foot-drop: A meta-analysis of orthotic effects. *J Rehabil Med.* 2016;48(8):646-656. Doi: 10.2340/16501977-2136.

- Qaseem A, Wilt TJ, McLean RM, Forciea MA. Noninvasive treatments for acute, subacute, and chronic low back pain: A clinical practice guideline from the American College of Physicians. *Ann Intern Med*. 2017;166(7):514-530. Doi: 10.7326/m16-2367.
- Schardong J, Stein C, Della M  a Plentz R. Neuromuscular electrical stimulation in chronic kidney failure: A systematic review and meta-analysis. *Arch Phys Med Rehabil*. 2020;101(4):700-711. Doi: 10.1016/j.apmr.2019.11.008.
- Scutt P, Lee HS, Hamdy S, Bath PM. Pharyngeal electrical stimulation for treatment of poststroke dysphagia: Individual patient data meta-analysis of randomized controlled trials. *Stroke Res Treat*. 2015;2015:429053. Doi: 10.1155/2015/429053.
- Thomaz SR, Cipriano G, Jr., Formiga MF, et al. Effect of electrical stimulation on muscle atrophy and spasticity in patients with spinal cord injury - a systematic review with meta-analysis. *Spinal Cord*. 2019;57(4):258-266. Doi: 10.1038/s41393-019-0250-z.
- U.S. Food and Drug Administration. 510(k) Premarket Notification database searched using product codes IPF, GZI, and LIH. <https://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfPMN/pmn.cfm>. Last updated February 27, 2023 (a)
- U.S. Food and Drug Administration. Premarket approval (PMA) database searched using product code MKD. <https://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfPMA/pma.cfm>. Last updated February 27, 2023 (b)
- Valenzuela PL, Morales JS, Ruilope LM, et al. Intradialytic neuromuscular electrical stimulation improves functional capacity and muscle strength in people receiving haemodialysis: A systematic review. *J Physiother*. 2020;66(2):89-96. Doi: 10.1016/j.jphys.2020.03.006.
- Wang T, Dong L, Cong X, et al. Comparative efficacy of non-invasive neurostimulation therapies for poststroke dysphagia: A systematic review and meta-analysis. *Neurophysiol Clin*. 2021;51(6):493-506. Doi: 10.1016/j.neucli.2021.02.006.
- Winstein CJ, Stein J, Arena R, et al. Guidelines for adult stroke and recovery: A guideline for healthcare professionals from the American Heart Association/American Stroke Association. *Stroke*. 2016;47(6):e98-e169. Doi: 10.1161/str.0000000000000098.
- Wylde V, Dennis J, Gooberman-Hill R, Beswick AD. Effectiveness of postdischarge interventions for reducing the severity of chronic pain after total knee replacement: Systematic review of randomised controlled trials. *BMJ Open*. 2018;8(2):e020368. Doi: 10.1136/bmjopen-2017-020368.
- Yang J-D, Liao C-D, Huang S-W, et al. Effectiveness of electrical stimulation therapy in improving arm function after stroke: A systematic review and a meta-analysis of randomised controlled trials. *Clin Rehabil*. 2019;33(8):1286-1297. Doi: 10.1177/0269215519839165.
- Zayed Y, Kheiri B, Barbarawi M, et al. Effects of neuromuscular electrical stimulation in critically ill patients: A systematic review and meta-analysis of randomised controlled trials. *Aust Crit Care*. 2020;33(2):203-210. Doi: 10.1016/j.aucc.2019.04.003.

Policy updates

- 4/2018: initial review date and clinical policy effective date: 6/2018
- 5/2019: Policy references updated. Consolidated CCP.1027 into this policy. Policy ID changed.
- 5/2020: Policy references updated.
- 5/2021: Policy references updated.

5/2022: Policy references updated.

5/2023: Policy references updated.

5/2025: Policy references updated.