# Electrical muscle stimulation

**Electrical muscle stimulation** (EMS), also known as **neuromuscular electrical stimulation** (NMES) or **electromyostimulation**, is the elicitation of muscle contraction using electric impulses. The impulses are generated by a device and delivered through electrodes on the skin in direct proximity to the muscles to be stimulated. The impulses mimic the action potential coming from the central nervous system, causing the muscles to contract. The electrodes are generally pads that adhere to the skin. EMS is both a form of electrotherapy and of muscle training. It is cited by important authors[1] as complementary technique for sport training, and there is published research[2] on the results obtained. In the United States, EMS devices are regulated by the U.S. Food and Drug Administration (FDA).[3]

## History

Luigi Galvani (1791) provided the first scientific evidence that current can activate muscle. During the 19th and 20th century researchers studied and documented the exact electrical properties that generate muscle movement.[4] [5] It was discovered that the body functions induced by electrical stimulation caused long-term changes in the muscles.[6] [7] In the '60s Soviet sport scientists applied EMS in the training of elite athletes, claiming 40% force gains.[8] In the '70s these studies were shared during conferences with the Western sport establishments. However, results were conflicting, perhaps because the mechanisms in which EMS acted was poorly understood.[9] Recent medical physiology research[10] [11] [12] pinpointed the mechanisms by which electrical stimulation causes adaptation of cells of muscles, blood vessels[13] [14] [15] and nerves.

## Theory

EMS causes adaptation, i.e. training, of muscle fibers.[16] Because of the characteristics of skeletal muscle fibers, different types of fibers[17] can be activated to differing degrees by different types of EMS, and the modifications induced depend on the pattern of EMS activity.[18] These patterns, referred to as protocols or programs, will cause a different response from contraction of different fiber types. Some programs will improve fatigue resistance, i.e. endurance, others will increase force production.[12]

## Use

EMS can be used both as a training[19] [20] [21] and a therapeutic[22] [23] tool.

In medicine EMS is used for rehabilitation purposes, for instance in Physical therapy in the prevention of disuse muscle atrophy which can occur for example after musculoskeletal injuries, such as damage to bones, joints, muscles, ligaments and tendons. However, this should not be confused with TENS (Transcutaneous Electrical Nerve Stimulator): the use of electric current in pain therapy.

Because of the effect that strengthened and toned muscles have on appearance (a stronger muscle has larger cross-section[24] ), EMS is also used by a niche of practitioners for aesthetics goals.[25] [26] [27] The FDA rejects certification of devices that claim weight reduction.[28] EMS devices cause a calorie burning that is marginal at best: calories are burnt in significant amount only when most of the body is involved in physical exercise: several muscles, the heart and the respiratory system are all engaged at once.[29] In general, spot reduction of fat deposits by exercising only a few muscles underneath, voluntarily or electrically, does not work.

In EMS training few muscular groups are targeted at the same time, for specific training goals.[30] The effectiveness of the devices for sport training has been debated. A niche of coaches regularly use professional EMS devices as integral part of the training of their athletes; some of these are high profile coaches, such as track coach Charlie Francis, who used the technique to supplement the training of Olympic-level athletes.[31] Non-professional devices

target home-market consumers[32] with wearable units in which EMS circuitry is contained in belt-like garments (ab toning belts) or other clothing items.

## FDA certification

The U.S. Food and Drug Administration (FDA) certifies and releases EMS devices into two broad categories: over-the counter devices (OTC), and prescription devices. OTC devices are marketable only for muscle toning; prescription devices can only be purchased with a medical prescription for therapy and should be used under supervision of an authorized practitioner, for the following uses:

- Relaxation of muscle spasms;
- Prevention or retardation of disuse atrophy;
- Increasing local blood circulation;
- Muscle re-education;
- Immediate post-surgical stimulation of calf muscles to prevent venous thrombosis;
- Maintaining or increasing range of motion.

The FDA mandates that manuals prominently display contraindication, warnings, precautions and adverse reactions, including: no use for wearer of pacemaker; no use on vital parts, such as carotid sinus nerves, across the chest, or across the brain; caution in the use during pregnancy, menstruation, and other particular conditions that may be affected by muscle contractions; potential adverse effects include skin irritations and burns

Only FDA-certified devices can be lawfully sold in the US without medical prescription. These can be found at the corresponding FDA webpage for certified devices.[33] The FTC has cracked down on consumer EMS devices that made unsubstantiated claims;[34] many have been removed from the market, some have obtained FDA certification.

## References


[1] Zatsiorsky, Kraemer - 2006. Science and Practice of Strength Training - EMS, page 132-133; Human Kinetics.

[2] Numerous articles in research journals attest increased muscular performance by utilizing EMS; the Journal of Strength and Conditioning Research for instance lists the following articles

- Effects of Electrostimulation Training on Muscle Strength and Power of Elite Rugby Players (http://www.nsca-jscr.org/pt/re/jscr/abstract.00124278-200705000-00025.htm;jsessionid=Lh6RYP482GHqG4FzsSLgLTLLL1J2vxLy106cn6WlJNSTyfZYlfVG!2016747336!181195628!8091!-1?index=1&database=ppvovft&results=1&count=10&searchid=1&nav=search);
- Effects of Electromyostimulation Training and Volleyball Practice on Jumping Ability. (http://www.nsca-jscr.org/pt/re/jscr/abstract.00124278-200308000-00025.htm;jsessionid=Lh6RYP482GHqG4FzsSLgLTLLL1J2vxLy106cn6WlJNSTyfZYlfVG!2016747336!181195628!8091!-1?index=1&database=ppvovft&results=1&count=10&searchid=2&nav=search)
- Supplemental EMS and Dynamic Weight Training: Effects on Knee Extensor Strength and Vertical Jump of Female College Track & Field Athletes. (http://www.nsca-jscr.org/pt/re/jscr/abstract.00124278-199808000-00001.htm;jsessionid=Lh6RYP482GHqG4FzsSLgLTLLL1J2vxLy106cn6WlJNSTyfZYlfVG!2016747336!181195628!8091!-1?index=1&database=ppvovft&results=1&count=10&searchid=2&nav=search)
- The Effects of Combined Electromyostimulation and Dynamic Muscular Contractions on the Strength of College Basketball Players. (http://www.nsca-jscr.org/pt/re/jscr/abstract.00124278-199602000-00008.htm;jsessionid=Lh6RYP482GHqG4FzsSLgLTLLL1J2vxLy106cn6WlJNSTyfZYlfVG!2016747336!181195628!8091!-1?index=1&database=ppvovft&results=1&count=10&searchid=2&nav=search)

[3] FDA Guidance Document for Powered Muscle Stimulator (http://www.fda.gov/cdrh/ode/2246.pdf), standard indications for use, page 4; contraindications, p. 7; warnings and precautions, p. 8. Product code: NGX (http://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfPCD/classification.cfm?ID=4464)

[4] L. Ranvier, De quelques faits relatifa à l'histologie et à la physiologie des muscles striés, Arch. Physiol. Norm. Path. 6:1–15 (1874).

[5] D. Denny-Brown, On the nature of postural reflexes, Proc. Roy. Soc. (Biol.) 104:252–301(1929)

[6] A. J. Buller, J. C. Eccles, and R. M. Eccles, Interactions between motoneurones and muscles in respect of the characteristic speeds of their responses, J. Physiol. 150:417–439 (1960).

[7] D. Pette, M. E. Smith, H. W. Staudte, and G. Vrbová, Effects of long-term electrical stimulation on some contractile and metabolic characteristics of fast rabbit muscle, Pflüger's Arch. 338:257–272 (1973).

[8] A. Ward, N. Shkuratova - 2002. Russian Electrical Stimulation: The Early Experiments. Physical Therapy. Volume 82. Number 10 (http://www.thefreelibrary.com/Russian+electrical+stimulation:+the+early+experiments.+(Perspective).-a093081458)

[9] Mel Siff - 1990. Applications of Electrostimulation in Physical Conditioning: A Review. Journal of Strength & Conditioning Research. 4(1):20-26 (http://www.getcited.org/pub/103365249)

[10] G. Vrbová, T. Gordon, and R. Jones, Nerve-Muscle Interaction (Chapman & Hall, London, 1995)

[11] Salmons S, Vrbová G (May 1969). "The influence of activity on some contractile characteristics of mammalian fast and slow muscles" (http://www.jphysiol.org/cgi/pmidlookup?view=long&pmid=5767881). *J. Physiol. (Lond.)* **201** (3): 535–49. PMC 1351409. PMID 5767881. .

[12] Pette D, Vrbová G (June 1999). "What does chronic electrical stimulation teach us about muscle plasticity?". *Muscle Nerve* **22** (6): 666–77. doi:10.1002/(SICI)1097-4598(199906)22:6<666::AID-MUS3>3.0.CO;2-Z. PMID 10366220.

[13] Blomqvist CG, Saltin B (1983). "Cardiovascular adaptations to physical training" (http://arjournals.annualreviews.org/doi/abs/10.1146/annurev.ph.45.030183.001125?url_ver=Z39.88-2003&rfr_id=ori:rid:crossref.org&rfr_dat=cr_pub=ncbi.nlm.nih.gov). *Annu. Rev. Physiol.* **45**: 169–89. doi:10.1146/annurev.ph.45.030183.001125. PMID 6221687. .

[14] Cabric M, Appell HJ, Resic A (October 1987). "Stereological analysis of capillaries in electrostimulated human muscles". *Int J Sports Med* **8** (5): 327–30. doi:10.1055/s-2008-1025678. PMID 3679647.

[15] Harris BA (October 2005). "The influence of endurance and resistance exercise on muscle capillarization in the elderly: a review" (http://www3.interscience.wiley.com/resolve/openurl?genre=article&sid=nlm:pubmed&issn=0001-6772&date=2005&volume=185&issue=2&spage=89). *Acta Physiol. Scand.* **185** (2): 89–97. doi:10.1111/j.1365-201X.2005.01461.x. PMID 16168003. .

[16] Quoted from *National Skeletal Muscle Research Center*; UCSD, Muscle Physiology Home Page - Electrical Stimulation (http://muscle.ucsd.edu/musintro/es.shtml)

[17] Skeletal muscle Characteristics of skeletal muscle fiber types

[18] Salmons S, Vrbová G (May 1969). "The influence of activity on some contractile characteristics of mammalian fast and slow muscles" (http://www.jphysiol.org/cgi/pmidlookup?view=long&pmid=5767881). *J. Physiol.* **201** (3): 535–49. PMC 1351409. PMID 5767881. .

[19] Babault N, Cometti G, Bernardin M, Pousson M, Chatard JC (May 2007). "Effects of electromyostimulation training on muscle strength and power of elite rugby players". *J Strength Cond Res* **21** (2): 431–7. doi:10.1519/R-19365.1. PMID 17530954.

[20] Banerjee P, Caulfield B, Crowe L, Clark A (December 2005). "Prolonged electrical muscle stimulation exercise improves strength and aerobic capacity in healthy sedentary adults" (http://jap.physiology.org/cgi/pmidlookup?view=long&pmid=16081619). *J. Appl. Physiol.* **99** (6): 2307–11. doi:10.1152/japplphysiol.00891.2004. PMID 16081619. .

[21] J. P. Porcari, J. Miller, K. Cornwell, C. Foster, M. Gibson, K. McLean, and T. Kernozek, The effects of neuromuscular stimulation training on abdominal strength, endurance and selected anthropometric measure, J. Sports Sci. Med. 4:66–75 (2005).

[22] Lake DA (May 1992). "Neuromuscular electrical stimulation. An overview and its application in the treatment of sports injuries". *Sports Med* **13** (5): 320–36. PMID 1565927.

[23] Delitto A, Rose SJ, McKowen JM, Lehman RC, Thomas JA, Shively RA (1 May 1988). "Electrical stimulation versus voluntary exercise in strengthening thigh musculature after anterior cruciate ligament surgery" (http://www.ptjournal.org/cgi/pmidlookup?view=long&pmid=3258994). *Phys Ther* **68** (5): 660–3. PMID 3258994. .

[24] Muscle force is proportional to physiologic cross-sectional area (PCSA)...; quoted from *National Skeletal Muscle Research Center*; UCSD, Muscle Physiology Home Page - Skeletal Muscle Architecture (http://muscle.ucsd.edu/musintro/arch.shtml), Effect of Muscle Architecture on Muscle Function

[25] Currier WD (June 1963). "Effects of electronic stimulation of the VII nerve. I. On senescent changes of the face". *Ann. Otol. Rhinol. Laryngol.* **72**: 289–306. PMID 14024328.

[26] Al-Majed AA, Neumann CM, Brushart TM, Gordon T (1 April 2000). "Brief electrical stimulation promotes the speed and accuracy of motor axonal regeneration" (http://www.jneurosci.org/cgi/pmidlookup?view=long&pmid=10729340). *J. Neurosci.* **20** (7): 2602–8. PMID 10729340. .

[27] Agren MS, Engel MA, Mertz PM (September 1994). "Collagenase during burn wound healing: influence of a hydrogel dressing and pulsed electrical stimulation". *Plast. Reconstr. Surg.* **94** (3): 518–24. doi:10.1097/00006534-199409000-00015. PMID 8047605.

[28] FDA Import Alert 10/02/2009 *Electrical Muscle Stimulators and Iontophoresis Devices* (http://www.accessdata.fda.gov/cms_ia/importalert_240.html) Muscle stimulators are misbranded when any of the following claims are made: girth reduction, loss of inches, weight reduction, cellulite removal, bust development, body shaping and contouring, and spot reducing.

[29] Maffiuletti, Nicola A (2006-12). "The use of electrostimulation exercise in competitive sport" (http://www.ncbi.nlm.nih.gov/pubmed/19124897). *International Journal of Sports Physiology and Performance* **1** (4): 406–7. ISSN 1555-0265. PMID 19124897. . Retrieved 2009-03-28.

[30] Vrbova, Gerta; Olga Hudlicka, Kristin Schaefer Centofanti (2008). *Application of Muscle-Nerve Stimulation in Health and Disease*. Springer.

[31] Charlie Francis, The Truth About EMS -Electronic Muscle Stimulation: Facts and Fallacies T-Nation (http://www.t-nation.com/free_online_article/sports_body_training_performance/the_truth_about_ems&cr=)

[32] Effects of Neuromuscular Electrical Stimulation Training on Abdominal Strength, Endurance, and Selected Anthropometric Measures - Journal of Sports Science and Medicine (2005)4,66-75 (pdf) (http://www.jssm.org/vol4/n1/9/v4n1-9pdf.pdf)

[33] FDA-Certified Devices (http://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfPMN/pmn.cfm?start_search=1&ProductCode=ngx&KNumber=K&ThirdPartyReviewed=off&IVDProducts=off)

[34] FTC Charges Three Top-selling Electronic Abdominal Exercise Belts with Making False Claims (http://www.ftc.gov/opa/2002/05/projectabsurd.htm)

## External links

- Collection of Extensive Bibliography and Abstracts (http://www.globussht.com/EMSBiblioAMA.html)
- Seattle Times - opinion piece on personal electronic muscle stimulation belts (http://seattletimes.nwsource.com/pacificnw/2002/0526/fitness.html)
- John Porcari @ University of Wisconsin–La Crosse next plans to study ems buttocks and thigh toners (http://www.healthylivingtoday.net/story47.php)
- EMS Digest - A guide to electrostimulation theory and practice inspired by a workshop by Gianpaolo Boschetti (http://docs.google.com/Doc?docid=dgw665wn_33f8wb6ff9&hl=en)
- Casting new energy onto broken limbs (http://www.israel21c.org/bin/en.jsp?enDispWho=Articles^l2262&enPage=BlankPage&enDisplay=view&enDispWhat=object&enVersion=0&enZone=Health)

# Article Sources and Contributors

**Electrical muscle stimulation** *Source*: http://en.wikipedia.org/w/index.php?oldid=431020324 *Contributors*: 1exec1, Adambondy, Agoldstand, Alexf, Amalas, Barek, BeteTest, Blgilles, Blogjack, Candorwien, D.c.camero, Dandv, Dbenzhuser, Eb26us, Gciriani, Girlwithgreeneyes, GregorB, Ground Zero, Gwern, ITasteLikePaint, Ingolfson, Jivecat, Kabulykos, Linas, MEDISTIM, Maikel, Maralia, Master Of Ninja, Mlomize, Mojo-chan, NJGW, OlEnglish, Orangedwarf, RDBrown, Rich Farmbrough, Snoopydawg, Stickee, Tijfo098, UltraMagnus, Where next Columbus?, Xasodfuih, 63 anonymous edits

# License