

**ALT BEDEN  
ELEKTROMYOSTİMÜLASYON  
ANTRENMANI VE DETRAINİNG'İN  
PERFORMANSA ETKİLERİ**

**Celil KAÇOĞLU**

© Copyright 2020

*Bu kitabın, basım, yayın ve satış hakları Akademisyen Kitabevi A.Ş.'ne aittir. Anılan kuruluşun izni alınmadan kitabıın tümü ya da bölümleri mekanik, elektronik, fotokopi, manyetik kağıt ve/ veya başka yöntemlerle çoğaltılamaz, basılamaz, dağıtılamaz. Tablo, şekil ve grafikler izin alınmadan, ticari amaçlı kullanılamaz. Bu kitap T.C. Kültür Bakanlığı bandrolü ile satılmaktadır.*

Bu tez çalışması, Anadolu Üniversitesi Bilimsel Araştırma Projeleri Komisyonu tarafından desteklenmiştir (Proje No: 1108S131).

**ISBN**

978-625-7106-10-8

**Kitap Adı**

Alt Beden Elektromyostimülasyon Antrenmanı ve Detraining'in  
Performans Etkileri

**Yazar**

Celil KAÇOĞLU

**Yayın Koordinatörü**

Yasin Dilmen

**Sayfa ve Kapak Tasarımı**

Akademisyen Dizgi Ünitesi

**Yayıncı Sertifika No**

47518

**Baskı ve Cilt**

Sonçağ Matbaacılık

**Bisac Code**

SPO000000

**DOI**

10.37609/akya.362

**GENEL DAĞITIM**

**Akademisyen Kitabevi A.Ş.**

*Halk Sokak 5 / A*

*Yenişehir / Ankara*

*Tel: 0312 431 16 33*

*siparis@akademisyen.com*

**www.akademisyen.com**

**CANIM ANNEME**

## **TEŞEKKÜR**

Bu uzun ve zorlu süreçte bana en büyük desteği sağlayan çok değerli hocalarıma, aileme ve dostlarımı sonsuz teşekkürlerimi sunmaktan onur ve mutluluk duyuyorum. Öncelikle, beni bu konuda çalışmaya teşvik eden danışmanım Sayın Doç. Dr. Mehmet KALE'ye teşekkür ederim.

Araştırmamın izleme aşamalarında öneriler ve eleştirilerde bulunarak araştırmaya katkıda bulunan Sayın Prof. Dr. Ayşe KİN İŞLER'e ve Sayın Prof. Dr. Hayri ERTAN ile savunma jürisi esnafındaki değerli eleştiri ve değerlendirmeleri için Sayın Yrd. Doç. Dr. Ayhan Taner ERDOĞAN ve Sayın Dr. Öğr. Üyesi Hakan KATIRCI'ya teşekkürlerimi sunarım.

Araştırma için gerekli olan gönüllü katılımcılara ulaşmamda bana yardımcı olan ve desteklerini esirgemeyen Sayın Yrd. Doç. Dr. Gülsün AYDIN, Yrd. Doç. Dr. Barış GÜROL, Dr. Öğr. Üyesi Süleyman MUNUSTURLAR, Dr. Öğr. Üyesi Hüseyin KÖSE, Doç. Dr. Müge AKYILDIZ MUNUSTURLAR, Dr. Öğr. Üyesi Elvin O. GÜNGÖR, Doç. Dr. Halil Orbay ÇOBANOĞLU, Öğr. Gör. Ahmet USLU, Öğr. Gör. Evrensel HEPER, Öğr. Gör. Ahmet ŞENER, Uzm. Hakan SİVRİSERVİ, Ansay HIZAL, Nurullah ÇİTPİŞ, Mustafa GÜNEŞ ve adını yazmadığım tüm arkadaşlarına en içten teşekkürlerimi sunarım.

İstatistiksel analizlerde yapmış olduğu çok değerli yönlendirmeleri için Sayın Araş. Gör. Duygu AYDIN HAKLI'ya teşekkür ederim.

Doğduğum günden beri her zaman yanımdayan ve her anımda bana desteklerini esirgemeyen anneme, babama ve canımdan çok sevdiğim ablalarıma sonsuz teşekkürlerimi, dünyanın en güzel üç kızı olan yeğenlerime de en derin ve karşılıksız sevgilerimi sunarım.

---

Teşekkür

---

Araştırma boyunca destek, ilgi ve sabırlarını esirgemeyen ve minnettar olduğum değerli katılımcı arkadaşlarımın tümüne teşekkürlerin en büyüğünü sunarım.

Celil KAÇOĞLU  
Eskişehir, 2020

# İÇİNDEKİLER

<b>GİRİŞ ve AMAÇ .....</b>	<b>1</b>
Giriş.....	1
Amaç.....	1
Problem .....	1
Denenceler .....	1
Sınırlılıklar .....	5
Varsayımlar .....	6
Tanımlar .....	6
Önem .....	7
Kaynak Bilgisi .....	10
EMS'nin Kimyasal Mekanizması.....	15
Aksiyon Potansiyeli.....	17
Elektriksel Akımların Şiddet-Süre Eğrisi .....	20
EMS'nin Fizyolojik Mekanizması.....	21
EMS'nin Nöral Mekanizması .....	25
EMS Parametreleri ve Düzenlemeleri.....	29
Genlik .....	32
Genlik Yükseliş ve Düşüş Zamanı.....	34
Frekans.....	34
Atım Süresi.....	38
İş Zamanı.....	40
Elektrotlar.....	41

<b>GEREÇ ve YÖNTEM .....</b>	<b>45</b>
Araştırma Grubu.....	45
Veri Toplama Araçları .....	46
Antropometrik Ölçüm Araçları .....	46
Vücut Yağ Yüzdesi Ölçüm Aracı.....	47
Sıçrama Ölçüm Aracı .....	48
Sprint Koşusu Ölçüm Araçları.....	49
İzokinetik Kas Kuvveti Ölçüm Aracı.....	49
Anaerobik Güç ve Kapasite Ölçüm Aracı .....	50
Saha ve Laboratuvar Koşulları Ölçüm Aracı .....	50
Araştırmmanın Deseni.....	51
EMS Antrenmanı .....	53
Verilerin Toplanması .....	56
Antropometrik Ölçümler.....	57
Vücut Yağ Yüzdesi Ölçümü .....	59
Sıçrama Yüksekliği Ölçümleri .....	60
Sprint Koşu Testi .....	61
İzokinetik Kas Kuvveti Ölçümü .....	61
Anaerobik Güç ve Kapasite Testi.....	62
Verilerin Analizi .....	63
<b>BULGULAR.....</b>	<b>65</b>
Antropometri ve Vücut Yağ Yüzdesi Bulguları .....	67
Sıçrama Bulguları.....	74
40m Sprint Koşu Süresi Bulguları .....	77
İzokinetik Kuvvet Bulguları .....	79
Anaerobik Güç ve Kapasite Bulguları.....	97

<b>TARTIŞMA .....</b>	<b>101</b>
Antropometri ve Vücut	
Yağ Yüzdesindeki Değişimler.....	101
Sıçrama Parametrelerindeki Değişimler .....	110
40m Sprint Koşu Süresindeki Değişimler .....	124
İzokinetik Kuvvet Parametrelerindeki Değişimler .	128
Anaerobik Güç ve Kapasitedeki Değişimler .....	138
<b>SONUÇ ve ÖNERİLER.....</b>	<b>141</b>
Sonuç .....	141
Öneriler.....	143
<b>KAYNAKLAR.....</b>	<b>145</b>

## KAYNAKLAR

- Aagaard, P., Simonsen, E.B., Andersen, J.L., Magnusson, P., Dyhre-Poulsen, P., Neural adaptation to resistance training: changes in evoked V-wave and H-reflex responses, *J. Appl. Physiol.*, 92 (6), 2309-2318 (2002).
- Alberti, G., Ragazzi, R., Effects on maximum strength and vertical jump ability of electromyostimulation vs voluntary isometric training, *Medicina dello Sport*, 60 (4), 557-65 (2007).
- Aldayel, A., Jubeau, M., McGuigan, M., Nosaka, K., Comparison between alternating and pulsed current electrical muscle stimulation for muscle and systemic acute responses, *J. Appl. Physiol.*, 109 (3), 735-44 (2010).
- Alemdaroğlu, U., The *Relationship between muscle strength, anaerobic performance, agility, sprint ability and vertical jump performance in professional basketball players*, *J. Hum. Kinet.*, 31 (1), 149-158 (2012).
- Alon, G., Kantor, G., Ho, H.S., Effects of electrode size on basic excitatory responses and on selected stimulus parameters, *J. Orthop. Sports. Phys. Ther.*, 20 (1), 29-35 (1994).
- Ashley, Z., Sutherland, H., Lanmuller, H., Unger, E., Li, F., Mayr, W., Kern, H., Jarvis, J.C., Salmons, S., Determination of the chronaxie and rheobase of denervated limb muscles in conscious rabbits, *Artif. Organs*, 29 (3), 212-215 (2005).
- Avila, M.A., Brasileiro, J.S., Salvini, T.F., Electrical stimulation and isokinetic training: effects on strength and neuromuscular properties of healthy young adults, *Brazilian J. Phys. Ther.*, 12 (6), 435-440 (2008).
- Babault, N., Cometti, G., Bernardin, M., Pousson, M., Chatard, J.C., Effects of electromyostimulation training on muscle strength and power of elite rugby players, *J. Strength Cond. Res.*, 21 (2), 431-437 (2007).
- Babault, N., Cometti, C., Maffiliuetti, N.A., Deley, G., Does electrical stimulation enhance post-exercise recovery?, *Eur. J. Appl. Physiol.*, 111 (10), 2501-2507 (2011).
- Balogun, J.A., Onilari, O.O., Akeju, O.A., Marzouk, D.K., High voltage electrical stimulation in the augmentation of muscle strength: Effects of pulse frequency, *Arch. Phys. Med. Rehabil.*, 74 (9), 910-916 (1993).
- Barr, R.C., Basic electrophysiology, In: *Biomedical Engineering Fundamentals*, J.D. Bronzino, D.R. Peterson (Eds.), 4th Ed., CRC Press, Taylor & Francis Group, FL, USA, 38-1, (2015).

- Baumgartner, R.N., Chumlea, W.C., Roche, A.F., Bioelectric impedance phase angle and body composition, *Am. J. Clin. Nutr.*, 48 (1), 16-23 (1988).
- Bax, L., Staes, F., Verhagen, A., Does neuromuscular electrical stimulation strengthen the quadriceps femoris? A systematic review of randomised controlled trials, *Sports Med.*, 35 (3), 191-212 (2005).
- Beaudreau, S.A., Finger, S., Medical electricity and madness in the 18th century: The legacies of Benjamin Franklin and Jan Ingenousz, *Perspect. Biol. Med.*, 49 (3), 333 (2006).
- Bergquist, A.J., Clair, J.M., Lagerquist, O., Mang, C.S., Okuma, Y., Collins, D.F., Neuromuscular electrical stimulation: implications of the electrically evoked sensory volley, *Eur. J. Appl. Physiol.*, 111 (10), 2409-26 (2011a).
- Bergquist, A.J., Clair, J.M., Collins, D.F., Motor unit recruitment when neuromuscular electrical stimulation is applied over a nerve trunk compared with a muscle belly: Triceps surae, *J. Appl. Physiol.*, 110 (3), 627-637 (2011b).
- Bezerra, P., Zhou, S., Crowley, Z., Brooks, L., Hooper, A., Effects of unilateral electromyostimulation superimposed on voluntary training on strength and cross-sectional area, *Muscle Nerve*, 40 (3), 430-7 (2009).
- Bigard, A.X., Lienhard, F., Merino, D., Serrurier, B., Guezennec, C.Y., Effects of surface electrostimulation on the structure and metabolic properties in monkey skeletal muscle, *Med. Sci. Sports Exerc.*, 25 (3), 355-62 (1993).
- Bijur, P.E., Silver, W., Gallagher, E.J., Reliability of the visual analog scale for measurement of acute pain, *Acad. Emerg. Med.*, 8 (12), 1153-7 (2001).
- Billot, M., Martin, A., Paizis, C., Cometti, C., Babault, N., Effects of an electrostimulation training program on strength, jumping, and kicking capacities in soccer players, *J. Strength Cond. Res.*, 24 (5), 1407-1413 (2010).
- Binder-Macleod, S.A., Halden, E.E., Jungles, K.A., Effects of stimulation intensity on the physiological responses of human motor units, *Med. Sci. Sports Exerc.*, 27 (4), 556-565 (1995).
- Bircan, C., Senocak, O., Peker, O., Kaya, A., Tamci, S.A., Gulbahar, S., Akalin, E., Efficacy of two forms of electrical stimulation in increasing quadriceps strength: A randomized controlled trial, *Clin. Rehabil.*, 16 (2), 194-9 (2002).
- Blazevich, A.J., Jenkins, D.G., Predicting sprint running times from isokinetic and squat lift tests: A regression analysis, *J. Strength Cond. Res.*, 12 (2), 101-103 (1998).
- Blickenstorfer, A., Kleiser, R., Keller, T., Keisker, B., Meyer, M., Riener, R., Kollias, S., Cortical and subcortical correlates of functional electrical stimulation of wrist extensor and flexor muscles revealed by fMRI, *Hum. Brain Mapp.*, 30 (3), 963-975 (2009).
- Bosco, C., Komi, P.V., Mechanical characteristics and fiber composition of human leg extensor muscles, *Eur. J. Appl. Physiol. Occup. Physiol.*, 41 (4), 275-84 (1979).
- Bosco, C., Komi, P.V., Influence of aging on the mechanical behavior of leg extensor muscles, *Eur. J. Appl. Physiol. Occup. Physiol.*, 45 (2-3), 209-19 (1980).

- Botter, A., Oprandi, G., Lanfranco, F., Allasia, S., Maffiuletti, N.A., Minetto, M.A., Atlas of the muscle motor points for the lower limb: Implications for electrical stimulation procedures and electrode positioning, *Eur. J. Appl. Physiol.*, 111 (10), 2461-71 (2011).
- Braddom, R.L., *Physical Medicine and Rehabilitation*, Elsevier Health Sciences, USA, (2010).
- Bresadola, M., Medicine and science in the life of Luigi Galvani (1737-1798), *Brain Res. Bull.*, 46 (5), 372 (1998).
- Brocherie, F., Babault, N., Cometti, G., Maffiuletti, N., Chatard, J.C., Electrostimulation training effects on the physical performance of ice hockey players, *Med. Sci. Sports Exerc.*, 37 (3), 455-60 (2005).
- Brooke, J.D., Cheng, J., Collins, D.F., McIlroy, W.E., Misiaszek, J.E., Staines, W.R., Sensori-sensory afferent conditioning with leg movement: Gain control in spinal reflex and ascending paths, *Prog. Neurobiol.*, 51 (4), 393-421 (1997).
- Brooks, M.E., Smith, E.M., Currier, D.P., Effect of longitudinal versus transverse electrode placement on torque production by the quadriceps femoris muscle during neuromuscular electrical stimulation, *J. Orthop. Sports Phys. Ther.*, 11 (11), 530-534 (1990).
- Brown, L.E., Whitehurst, M., Load range, In: *Isokinetics in Human Performance*, L.E. Brown, (Ed.), Human Kinetics, IL, USA, 114 (2000).
- Browne, T., *Pseudodoxia Epidemica: or, Enquiries into Very Many Received Tenents, and Commonly Presumed Truths*, 6th ed., Printed for N. Ekins, London, 82-86 (1672).
- Brunel, N., van Rossum, M.C., Lapicque's 1907 paper: From frogs to integrate-and-fire, *Biol. Cybern.*, 97 (5-6), 337-339 (2007).
- Burns, W.E., *Science in The Enlightenment: An Encyclopedia*, ABC-CLIO, California, USA, 107 (2003).
- Cabric, M., Appell, H.J., Resic, A., Effects of electrical stimulation of different frequencies on the myonuclei and fiber size in human muscle, *Int. J. Sports Med.*, 8 (5), 323-6 (1987).
- Cardinale, M., Newton, R., Kazunori, N., *Strength and Conditioning: Biological Principles and Practical Applications*, Wiley-Blackwell, NJ, USA, 193-197 (2010).
- Chan, K.M., Maffulli, N., *Principles and Practice of Isokinetics in Sports Medicine*, Williams & Wilkins, Hong Kong, 44,117-119,121,122 (1996).
- Clark, R.B., *Anatomy and Physiology: Understanding The Human Body*, Jones Barlett Publishers, MA, USA, 173 (2005).
- Clementy, J., Rouves, D., Garrigue, S., Barold, S.S., Jaïs, P., Haïssaguerre, M., High impedance leads and safety margin. Electrical considerations based on a simplified expression of the 'paradigm', *Europace*, 4 (2), 121-128 (2002).
- Collins, D.F., Burke, D., Gandevia, S.C., Large involuntary forces consistent with plateau-like behavior of human motoneurons, *J. Neurosci.*, 21 (11), 4059-4065 (2001).

- Computer Sports Medicine, Inc. (CSMI) Humac®/Norm™ Testing & Rehabilitation System User's Guide Model 770. Computer Sports Medicine Inc., Chapter 6, Page 1-3, USA, (2006).
- Cotte, T., Chatard, J.C., Isokinetic strength and sprint times in english premier league football players, *Biol. Sport*, 28, 89-94 (2011).
- Davies, G.J., Heiderscheit, B., Brinks, K., Test interpretation, In: Isokinetics in Human Performance, L.E. Brown, (Ed.), Human Kinetics, IL, USA, 13,14,114 (2000).
- de Boulogne, G.B.D., The Mechanism of Human Facial Expression (Studies in Emotion and Social Interaction), R.A. Cuthbertson (Ed.&Translate), Cambridge Uni. Press, Cambridge, 9-10 (1990).
- Dehail, P., Duclos, C., Barat, M., Electrical stimulation and muscle strengthening, *Ann. Readapt. Med. Phys.*, 51 (6), 441-451 (2008).
- Deley, G., Cometti, C., Fatnassi, A., Paizis, C., Babault, N., Effects of combined electromyostimulation and gymnastics training in prepubertal girls, *J. Strength Cond. Res.*, 25 (2), 520-526 (2011).
- Delitto, A., Rose, S.J., McKown, J.M., Lehman, R.C., Thomas, J.A., Shively, R.A., Electrical stimulation versus voluntary exercise in strengthening thigh musculature after anterior cruciate ligament surgery, *Phys. Ther.*, 68 (5), 660-663 (1988).
- Delitto, A., Brown, M., Strube, M.J., Rose, S.J., Lehman, R.C., Electrical stimulation of quadriceps femoris in an elite weight lifter: A single subject experiment, *Int. J. Sports Med.*, 10 (3), 187-91 (1989).
- Delitto, A., Snyder-Mackler, L., Two theories of muscle strength augmentation using percutaneous electrical stimulation, *Phys. Ther.*, 70 (3), 158-164 (1990).
- Delitto, A., Strube, M.J., Shulman, A.D., Minor, S.D., A study of discomfort with electrical stimulation, *Phys. Ther.*, 72 (6), 410-21 (1992).
- Delitto, A., "Russian electrical stimulation": Putting this perspective into perspective, *Phys. Ther.*, 82 (10), 1017-8 (2002).
- DeStaso, J., Kaminski, T.W., Perrin D.H., Relationship between drop vertical jump heights and isokinetic measures utilizing the stretch-shortening cycle, *Isokinet. Exerc. Sci.*, 6, 175-179 (1997).
- Divieti, L., Borniquez, C., Crivellini, M., Galli, M., Mancarella, M., Electrical stimulation of the triceps surae for muscular strength improvement in volleyball players, Proceedings of the 11. International Symposium on Biomechanics in Sports, 23-26 June, Massachusetts, USA, 243-247 (1993).
- Doucet, B.M., Lamb, A., Griffinb, L., Neuromuscular electrical stimulation for skeletal muscle function, *Yale J. Biol. Med.*, 85 (2), 201-15 (2012).
- Dreibati, B., Lavet, C., Pinti, A., Poumarat, G., Characterization of an electric stimulation protocol for muscular exercise, *Ann. Phys. Rehabil. Med.*, 54 (1), 25-35 (2011).
- Duchateau, J., Hainaut, K., Training effects of sub-maximal electrostimulation in a human muscle, *Med. Sci. Sports Exerc.*, 20 (1), 99-104 (1988).

- Duclay, J., Martin, A., Evoked H-reflex and V-wave responses during maximal isometric, concentric, and eccentric muscle contraction, *J. Neurophysiol.*, 94 (5), 3555-3562 (2005).
- Dudley, G.A., Stevenson, S.W., Use of electrical stimulation in strength and power training, In: *Strength and Power in Sport*, 2nd Ed., P.V. Komi (Ed.), Blackwell Science Ltd., Oxford, UK, 426-437 (2008).
- Dvir, Z., Isokinetics: Muscle Testing, Interpretation, and Clinical Applications, 2nd Ed., Churchill Livingstone, Edinburgh, 139 (2004).
- Enoka, R.M., Muscle strength and its development new perspectives, *Sports Med.*, 6 (3), 146-168 (1988).
- Enoka, R.M., Activation order of motor axons in electrically evoked contractions, *Muscle Nerve*, 25 (6), 763-764 (2002).
- Eston, R., Hawes, M., Martin, A., Reilly, T., Human body composition, In: *Kinanthropometry and Exercise Physiology Laboratory Manual*, Vol.1: *Anthropometry*, R. Eston, T. Reilly (Eds.), 3rd Ed., Routledge Taylor and Francis Group, NY, USA, ,13-14,16-18,29-35,43 (2009).
- Fahey, T.D., Harvey, M., Schroeder, R.V., Ferguson, F., Influence of sex differences and knee joint position on electrical stimulation-modulated strength increases, *Med. Sci. Sports Exerc.*, 17 (1), 144-7 (1985).
- Farthing, J.P., Cross-education of strength depends on limb dominance: Implications for theory and application, *Exerc. Sport. Sci. Rev.*, 37 (4), 179-187 (2009).
- Feiereisen, P., Duchateau, J., Hainaut, K., Motor unit recruitment order during voluntary and electrically induced contractions in the tibialis anterior, *Exp. Brain Res.*, 114 (1), 117-123 (1997).
- Ferguson, J.P., Blackley, M.W., Knight, R.D., Sutlive, T.G., Underwood FB, Greathouse DG., Effects of varying electrode site placements on the torque output of an electrically stimulated involuntary quadriceps femoris muscle contraction, *J. Orthop. Sports Phys. Ther.*, 11 (1), 24-9 (1989).
- Filipovic, A., Kleinöder, H., Dörmann, U., Mester, J., Electromyostimulation-A systematic review of the influence of training regimens and stimulation parameters on effectiveness in electromyostimulation training of selected strength parameters, *J. Strength Cond. Res.*, 25 (11), 3218-3238 (2011).
- Filipovic, A., Kleinöder, H., Dörmann, U., Mester, J., Electromyostimulation-A systematic review of the effects of different electromyostimulation methods on selected strength parameters in trained and elite athletes, *J. Strength Cond. Res.*, 26 (9), 2600-14 (2012).
- Fleck, S.J., Kraemer, W., Detraining, In: *Designing Resistance Training Programs*, 4 Ed., Human Kinetics, IL, USA, 297, (2014).
- Forehand, C.J., The action potential, synaptic transmission, and maintenance of nerve function, In: *Medical Physiology: Principles for Clinical Medicine*, R. Rhoades, D.R. Bell (Eds.), 3rd Ed., Wolters Kluwer/Lippincott Williams&Wilkins, Baltimore, USA, 41,45,46 (2009).

- Forrester, B.J., Petrofsky, J.S., Effect of electrode size, shape, and placement during electrical stimulation, *J. Appl. Res.*, 4 (2), 346-354 (2004).
- Frontera, W.R., Part 1: Epidemiology and pathology, Section 1: Epidemiology of sports injuries: Implications for rehabilitation, In: *Rehabilitation of Sports Injuries-Scientific Basis: Olympic Encyclopaedia of Sports Medicine*, W.R. Frontera (Ed.), Wiley Publisher, Massachusetts, USA, 8 (2008).
- Fuentes, I., Cobos, A.R., Segade, L.A.D., Muscle fibre types and their distribution in the biceps and triceps brachii of the rat and rabbit, *J. Anat.*, 192 (2), 203-210 (1998).
- Garhammer, J., An introduction to the use of electrical muscle stimulation with athletes, *Natl. Strength & Cond. Assoc. J.*, 5 (4), 44-45 (1983).
- Geddes, L.A., Hoff, H.E., The discovery of bioelectricity and current electricity, the Galvani-Volta controversy, *IEEE Spectrum*, 8 (12), 38-46 (1971).
- Glinsky, J., Harvey, L., Van Es, P., Efficacy of electrical stimulation to increase muscle strength in people with neurological conditions: A systematic review, *Physiother. Res. Int.*, 12(3), 175-94 (2007).
- Gobbo, M., Gaffurini, P., Bissolotti, L., Esposito, F., Orizio, C., Transcutaneous neuromuscular electrical stimulation: Influence of electrode positioning and stimulus amplitude settings on muscle response, *Eur. J. Appl. Physiol.*, 111 (10), 2451-9 (2011).
- Gobbo, M., Maffiuletti, N.A., Orizio, C., Minetto,M.A., Muscle motor point identification is essential for optimizing neuromuscular electrical stimulation use, *J. Neuroeng. Rehabil.*, 11 (17), (2014).
- Gondin, J., Guette, M., Ballay, Y., Martin, A., Electromyostimulation training effects on neural drive and muscle architecture, *Med. Sci. Sports Exerc.*, 37, 1291-1299 (2005a).
- Gondin, J., Marie, G., Martin, A., Neural and muscular changes after 4 and 8 weeks of electromyostimulation training, *Comput. Methods Biomed. Eng. Imaging Vis.*, 8, 119-120 (2005b).
- Gondin, J., Brocca, L., Bellinzona, E., D'Antona, G., Maffiuletti, N.A., Miotti, D., Pellegrino, M.A., Bottinelli, R., Neuromuscular electrical stimulation training induces atypical adaptations of the human skeletal muscle phenotype: A functional and proteomic analysis, *J. Appl. Physiol.*, 110 (2), 433-450 (2011a).
- Gondin, J., Cozzone, P.J., Bendahan, D., Is high-frequency neuromuscular electrical stimulation a suitable tool for muscle performance improvement in both healthy humans and athletes?, *Eur. J. Appl. Physiol.*, 111 (10), 2473-87 (2011b).
- Gould, D., Kelly, D., Goldstone, L., Gammon, J., Examining the validity of pressure ulcer risk assessment scales: Developing and using illustrated patient simulations to collect the data, *J. Clin. Nurs.*, 10 (5), 697-706 (2001).
- Greenberger, H.B., Paterno, M.V., Relationship of knee extensor strength and hopping test performance in the assessment of lower extremity function, *J. Orthop. Sports Phys. Ther.*, 22 (5), 202-6 (1995).

- Gregory, C.M., Bickel, C.S., Recruitment patterns in human skeletal muscle during electrical stimulation, *Phys. Ther.*, 85 (4), 358-364 (2005).
- Gulick, D.T., Castel, J.C., Palermo, F.X., Draper, D.O., Effect of patterned electrical neuromuscular stimulation on vertical jump in collegiate athletes, *Sports Health*, 3 (2), 152 -157 (2011).
- Hainaut, K., Duchateau, J., Neuromuscular electrical stimulation and voluntary exercise, *Sports Med.*, 14 (2), 100-113 (1992).
- Hamid, S., Hayek, R., Role of electrical stimulation for rehabilitation and regeneration after spinal cord injury: An overview, *Eur. Spine J.*, 17 (9), 1256-69 (2008).
- Hardy, S.G.P., Spalding, T.B., Liu, H., Nick, T.G., Pearson, R.H., Hayes, A.V., Stokic, D.S., The Effect of transcutaneous electrical stimulation on spinal motor neuron excitability in people without known neuromuscular diseases: The roles of stimulus intensity and location, *Phys. Ther.*, 82 (4), 354-363 (2002).
- Harman, E.A., Rosenstein, M.T., Frykman, P.N., Rosenstein, R.M., The effects of arms and countermovement on vertical jumping, *Med. Sci. Sports Exerc.*, 22 (6), 825-833 (1990).
- Hartsell, H.D., Kramer, J.F., A comparison of the effects of electrode placement, muscle tension, and isometric torque of the knee extensors, *J. Orthop. Sports Phys. Ther.*, 15 (4), 168-74 (1992).
- Heidland, A., Fazeli, G., Klassen, A., Sebekova, K., Hennemann, H., Bahner, U., Di Iorio, B., Neuromuscular electrostimulation techniques: Historical aspects and current possibilities in treatment of pain and muscle wasting, *Clin. Nephrol.*, 79 (1), 12-23 (2013).
- Henneman, E., Somjen, G., Carpenter, D.O., Functional significance of cell size in spinal motoneurons, *J. Neurophysiol.*, 28 (3), 560-580 (1965).
- Hennessy, E., Coughlan, G., Caulfield, B., Crowe, L., Perumal, S.D., McDonnell, T.J., An investigation into the acute effects of electrical muscle stimulation on cardiopulmonary function in a chronic obstructive pulmonary disease patient - A pilot case study. Presented at: 1st Annual Conference of the International Functional Electrical Stimulation Society (UK and Ireland Chapter), University of Salford, 15-16 April, Manchester, UK, (2010).
- Herrero, J.A., Izquierdo, M., Maffuletti, N.A., Garcia-Lopez, J., Electromyostimulation and plyometric training effects on jumping and sprint time, *Int. J. Sports Med.*, 27 (7), 533-9 (2006).
- Herrero, A.J., Martin, J., Martin, T., Abadia, O., Fernandez, B., Garcia-Lopez, D., Short-term effect of strength training with and without superimposed electrical stimulation on muscle strength and anaerobic performance. A randomized controlled trial. Part I, *J. Strength Cond. Res.*, 24 (6), 1609-1615 (2010a).
- Herrero, A.J., Martin, J., Martin, T., Abadia, O., Fernandez, B., Garcia-Lopez, D., Short-term effect of plyometrics and strength training with and without superimposed electrical stimulation on muscle strength and anaerobic per-

- formance: A randomized controlled trial. Part II, *J. Strength Cond. Res.*, 24 (6), 1616-1622 (2010b).
- Holcomb, W.R., Is neuromuscular electrical stimulation an effective alternative to resistance training?, *Strength & Cond. J.*, 27 (3), 76-79 (2005).
- Holcomb, W.R., Effect of training with neuromuscular electrical stimulation on elbow flexion strength, *J. Sports Sci. Med.*, 5 (2), 276-281 (2006).
- Holsheimer, J., Dijkstra, E.A., Demeulemeester, H., Nuttin, B., Chronaxie calculated from current-duration and voltage-duration data, *J. Neurosci. Methods*, 97 (1), 45-50 (2000).
- Hortobagyi, T., Maffiuletti, N.A., Neural adaptations to electrical stimulation strength training, *Eur. J. Appl. Physiol.*, 111 (10), 2439-49 (2011).
- Inbar, O., Bar-or, O., Skinner, J.S., The Wingate Anaerobic Test, Human Kinetics, Illinois, USA, 8-9,11 (1996).
- Innocenti, B., Facchinelli, D., Torti, S., Verza, A., Analysis of biomechanical quantities during a squat jump: Evaluation of a performance index, *J. Strength. Cond. Res.*, 20 (3), 709-715 (2006).
- Iossifidou, A., Baltzopoulos, V., Giakas G., Isokinetic knee extension and vertical jumping: Are they related?, *J. Sports Sci.*, 23 (10), 1121-7 (2005).
- Irnich, W., Georges Weiss' fundamental law of electrostimulation is 100 years old, *Pacing Clin. Electrophysiol.*, 25 (2), 245-8 (2002).
- Irnich, W., The terms "chronaxie" and "rheobase" are 100 years old, *Pacing Clin. Electrophysiol.*, 33 (4), 491-6 (2010).
- Jenkins, S.P.R., Sports Science Handbook: Volume 1: The Essential Guide to Kinesiology, Sport & Exercise Science, Multi-Science Publishing Co. Ltd., UK, 199, (2005).
- Jubeau, M., Gondin, J., Martin, A., Sartorio, A., Maffiuletti N.A., Random motor unit activation by electrostimulation, *Int. J. Sports Med.*, 28 (11), 901-4 (2007).
- Jubeau, M., Sartorio, A., Marinone, P.G., Agosti, F., Van Hoecke, J., Nosaka, K., Maffiuletti, N.A., Comparison between voluntary and stimulated contractions of the quadriceps femoris for growth hormone response and muscle damage, *J. Appl. Physiol.*, 104 (1), 75-81 (2008).
- Kaçoğlu, C., Kale, M., Elektriksel kas uyarlarına karşı tolerans gelişimi, *Proceeding of the 13.International Sport Sciences Congress, 07-09 November, Konya, Turkey*, 86 (2014a).
- Kaçoğlu, C., Kale, M., The effects of a 6-week superimpose whole body electromyostimulation training program on selected performance parameters in female canoer players, *Proceeding of the IAPESGW Regional Symposium: International Gender Issues and Sport, 4-5 September, Ankara, Turkey*, 133 (2014b).
- Kale, M., Kaçoğlu, C., The acute effects of different frequencies of lower-body electromyostimulation on jumping performance and isokinetic strength values, *Proceeding of the 12th International Sport Sciences Congress, 12-14 December, Denizli, Turkey*, 237 (2012).

- Kale, M., Kaçoğlu, C., Gürol, B., Elektromyostimülasyon antrenmanlarının nöral adaptasyon ve sportif performans üzerine etkileri, Spor Bilimleri Dergisi, 25 (3), 142-158 (2014).
- Keller, T., Kuhn, A., Electrodes for transcutaneous (surface) electrical stimulation, J. Automatic Control., 18 (2), 35-45 (2008).
- Kemmler, W., Schliffka, R., Mayhew, J.L., von Stengel, S., Effects of whole-body electromyostimulation on resting metabolic rate, body composition, and maximum strength in postmenopausal women: The training and electrostimulation trial, J. Strength Cond. Res., 24 (7), 1880-1887 (2010a).
- Kemmler, W., Birlauf, A., von Stengel, S., Einfluss eines elektromyostimulations-trainings auf die körperzusammensetzung bei älteren männern mit metabolischem syndrom. Die TEST-II-studie, Dtsch. Z. Sportmed., 61 (5), 117-123 (2010b).
- Kemmler, W., von Stengel, S., Alternative exercise technologies to fight against sarcopenia at old age: A series of studies and review, J. Aging Res., Vol.2012, 1-8 (2012).
- Kemmler, W., von Stengel, S., Schwarz, J., Mayhew, J.L., Effect of whole-body electromyostimulation on energy expenditure during exercise, J. Strength Cond. Res., 26 (1), 240-5 (2012).
- Kemmler, W., von Stengel, S., Whole-body electromyostimulation as a means to impact muscle mass and abdominal body fat in lean, sedentary, older female adults: Subanalysis of the TEST-III trial, Clin. Interv. Aging., 8, 1353-64 (2013).
- Kemmler, W., Bebenek, M., Engelke, K., von Stengel, S., Impact of whole-body electromyostimulation on body composition in elderly women at risk for sarcopenia: The training and electroStimulation trial (TEST-III), Age (Dordr), 36 (1), 395-406 (2014).
- Khurana, I., Textbook of Medical Physiology, Elsevier, UP, India, 66-67 (2005).
- Knaflitz, M., Merletti, R., De Luca, C.J., Inference of motor unit recruitment order in voluntary and electrically elicited contractions, J. Appl. Physiol., 68 (4), 1657-1667 (1990).
- Knight, K.L., Draper, D.O., Therapeutic Modalities: The Art and Science, 2nd Ed., Lippincott Williams & Wilkins, Baltimore, USA, 323-324 (2012).
- Knikou, M., The H-reflex as a probe: Pathways and pitfalls, J. Neurosci. Methods., 171 (1), 1-12 (2008).
- Komi, P.V., Bosco, C., Utilization of stored elastic energy in leg extensor muscles by men and women, Med. Sci. Sports., 10 (4), 261-5 (1978).
- Kramer, J.F., Lindsay, D.M., Magee, D., Wall, T., Mendryk, S.W., Comparison of voluntary and electrical stimulation contraction torque, J. Orthop. Sports Phys. Ther., 5 (6), 324-331 (1984).
- Kravitz, L., Heyward, V.H., Body composition, In: The Essential Assessment Toolbox, IDEA Health & Fitness, IDEA Health & Fitness Association, USA, 25, 26 (1999).

- Krebs, C., Weinberg, J., Akesson, E., Introduction to the nervous system and basic neurophysiology, In: Neuroscience, C. Krebs, E. Akesson, J. Weinberg (Ed.), Wolters Kluwer/Lippincott Williams & Wilkins, Baltimore, USA, 12 (2012).
- Kyselovicova, O., Brcak M., The effect of electro-myo-stimulation on anthropometric parameters in adult women, Fiep Bulletin On-line, Special Ed. Article III, (83), 182-184 (2013).
- Lake, D.A., Neuromuscular electrical stimulation. An overview and its application in the treatment of sports injuries, Sport Med., 13 (5), 320-336 (1992).
- Lapicque, L., Retrograde polarization, a theory of systematic errors in measurements of muscular chronaxie through ringer's fluid or with large electrodes, J. Physiol., 76 (2), 262 (1932).
- Laughman, R.K., Youdas, J.W., Garrett, T.R., Chao, E.Y., Strength changes in the normal quadriceps femoris muscle as a result of electrical stimulation, Phys. Ther., 63 (4), 494-9 (1983).
- Lieber, R.L., Silva, P.D., Daniel, D.M., Equal effectiveness of electrical and volitional strength training for quadriceps femoris muscles after anterior cruciate ligament surgery, J. Orthop. Res., 14 (1), 131-8 (1996).
- Lindquist, A.R.R., Prado, C.L., Barros, R.M.L., Mattioli, R., Costa, P.H.L., Salvinini, T.F., Gait training combining partial body-weight support a treadmill, and functional electrical stimulation: effects on poststroke gait, Phys. Ther., 87 (9), 1144-1154 (2007).
- Linthorne, N.P., Analysis of standing vertical jumps using a force platform, American Journal of Physics, 69 (11), 1198-1204 (2001).
- Lloyd, T., Domenico, G.G., Strauss, G.R., Singer, K., A review of the use of electro-motor stimulation in human muscles, Aust. J. Physiother., 32 (1), 18-30 (1986).
- Locicero, R.D., The effect of electrical stimulation on isometric and isokinetic knee extension torque: Interaction of the kinestim electrical stimulator and the Cybex II+®, J. Orthop. Sports Phys. Ther., 13 (3), 143-148 (1991).
- Loeb, G.E., Galvani's delayed legacy: Neuromuscular electrical stimulation, Expert Rev. Med. Devices, 2 (4), 379-81 (2005).
- Lohman, T. G., Roche, A. F., Martorel, R., Anthropometric Standardization Manual, Champaign, Human Kinetics, IL, USA, 4, 8 (1988).
- Lyons, G.M., Leane, G.E., Clarke-Moloney, M., O'Brien, J.V., Grace, P.A., An investigation of the effect of electrode size and electrode location on comfort during stimulation of the gastrocnemius muscle, Med. Eng. Phys., 26 (10), 873-8 (2004).
- MacIntosh, B.R., Gardiner, P.F., McComas, A.J., Skeletal Muscle: Form and Function, Human Kinetics, IL, USA, 130,131 (2006).
- Maffiuletti, N.A., Cometti, G., Amiridis, I.G., Martin, A., Pousson, M., Chatard, J.C., The effects of electromyostimulation training and basketball practice on muscle strength and jumping ability, Int. J. Sports Med., 21 (6), 437-43 (2000).

- Maffiuletti, N.A., Dugnani, S., Folz, M., Di Pierno, E., Mauro, F., Effect of combined electrostimulation and plyometric training on vertical jump height, *Med. Sci. Sports Exerc.*, 34 (10), 1638-1644 (2002a).
- Maffiuletti, N.A., Pensini, M., Martin, A., Activation of human plantar flexor muscles increases after electromyostimulation training, *J. Appl. Physiol.*, 92 (4), 1383-1392 (2002b).
- Maffiuletti, N.A., Zory, R., Miotti, D., Pellegrino, M.A., Jubeau, M., Bottinelli, R., Neuromuscular adaptations to electrostimulation resistance training, *Am. J. Phys. Med. Rehabil.*, 85 (2), 167-75 (2006).
- Maffiuletti, N.A., Bramanti, J., Jubeau, M., Bizzini, M., Deley, G., Cometti, G., Feasibility and efficacy of progressive electrostimulation strength training for competitive tennis players, *J. Strength. Cond. Res.*, 23 (2), 677-682 (2009).
- Maffiuletti, N.A., Physiological and methodological considerations for the use of neuromuscular electrical stimulation, *Eur. J. Appl. Physiol.*, 110 (2), 223-234 (2010).
- Malatesta, D., Cattaneo, F., Dugnani, S., Maffiuletti, N.A., Effects of electromyostimulation training and volleyball practice on jumping ability, *J. Strength Cond. Res.*, 17 (3), 573-579 (2003).
- Malina, R.M., Antropometry, In: *Physiological Assessment of Human Fitness*, P.J. Maud, C. Foster (Eds.), Human Kinetics, IL, USA, 206-208 (1995).
- Malmivuo, J., Plonsey, R., *Bioelectromagnetism: Principles and Applications of Bioelectric and Biomagnetic Fields*, Oxford University Press, NY, USA, 13 (1995).
- Marqueste, T., Messan, F., Hug, F., Laurin, J., Dousset, E., Grelot, L., Decherchi, P., Effect of repetitive biphasic muscle electrostimulation training on vertical jump performances in female volleyball players, *Int. J. Sport Health Sci.*, 8 (0), 50-55 (2010).
- Martin, L., Cometti, G., Pousson, M., Morlon, B., The influence of electrostimulation on mechanical and morphological characteristics of the triceps surae, *J. Sports Sci.*, 12 (4), 377-81 (1994).
- Martínez-López, E.J., Benito-Martínez, E., Hita-Contreras, F., Lara-Sánchez, A., Martínez-Amat, A., Effects of electrostimulation and plyometric training program combination on jump height in teenage athletes, *J. Sports Sci. Med.*, 11, 727-735 (2012).
- Mathes, S., Link, T., Lehnens, N., Mester, J., Wahl, P., Chronic effects of superimposed electromyostimulation during cycling on aerobic and anaerobic capacity, Paper presented at: 20th Annual ECSS-Congress, 24-27 June, Malmö, Sweden, (2015).
- Maud, P.J., Foster, C., deKonning, J.J., Testing for anaerobic ability, In: *Physiological Assessment of Human Fitness*, 2nd Ed., P.J. Maud, C. Foster (Eds.), Human Kinetics, IL, USA, 79-80 (2006).
- McDowell, M.A., Fryar, C.D., Ogden, C.L., Flegal, K.M., *Anthropometric Reference Data for Children and Adults: United States, 2003-2006*, National

- Health Statistics Reports, No. 10, Hyattsville, MD, National Center for Health Statistics, 22 October, 10, 2 (2008).
- Mclosta, T.A., Carmark, J.A., Optimal burst duration during a facilitated quadriceps femoris contraction, *J. Athl. Train.*, 35(2), 145-150 (2000).
- Merrill, D.R., Bikson, M., Jefferys, J.G., Electrical stimulation of excitable tissue: Design of efficacious and safe protocols, *J. Neurosci. Methods*, 141 (2), 184 (2005).
- Miller, M., Downham, D., Lexell, J., Superimposed single impulse and pulse train electrical stimulation: A quantitative assessment during submaximal isometric knee extension in young, healthy men, *Muscle Nerve*, 22(8), 1038-46 (1999).
- Morrissey, M.C., Brewster, C.E., Shields, C.L., Brown, M., The effects of electrical stimulation on the quadriceps during postoperative knee immobilization, *Am. J. Sports Med.*, 13 (1), 40-5 (1985).
- Mortimer, J.T., Bhadra, N., Peripheral nerve and muscle stimulation, In: *Neuroprosthetics: Theory and Practice*, K.W. Horch, G.S. Dhillon (Eds.), World Scientific Publication Co. Inc., Singapore, 5 (2004).
- Murray, M.P., Gardner, G.M., Mollinger, L.A., Sepic, S.B., Strength of isometric and isokinetic contractions: Knee muscles of men aged 20 to 86, *Phys. Ther.* 60(4), 412-9 (1980).
- Nanda, K. B., *Electrotherapy Simplified*, Jaypee Brothers Medical Publishers, New Delhi, India, 112-114 (2008).
- Newman, M.A., Tarpenning, K.M., Marino, F.E., Relationships between isokinetic knee strength, single-sprint performance, and repeated-sprint ability in football players, *J. Strength Cond. Res.*, 18 (4), 867-872 (2004).
- Norton, K., Whittingham, N., Cartes, L., Kerr, D., Gore, C., Marfell-Jones, M., Measurement techniques in anthropometry, In: *Anthropometrika: A Textbook of Body Measurement for Sports and Health Courses*, K. Norton, T. Olds (Eds.), UNSW Press, Sydney, Australia, 59 (1996).
- Nosaka, K., Aldayel, A., Jubeau, M., Chen, T.C., Muscle damage induced by electrical stimulation, *Eur. J. Appl. Physiol.*, 111 (10), 2427-37 (2011).
- Paillard, T., Noé, F., Passelergue, P., Dupui, P., Electrical stimulation superimposed onto voluntary muscular contraction, *Sports Med.*, 35 (11), 951-66 (2005).
- Paillard, T., Combined application of neuromuscular electrical stimulation and voluntary muscular contractions, *Sports Med.*, 38 (2), 161-177 (2008).
- Paillard, T., Noe, F., Bernard, N., Dupui, P., Hazard, C., Effects of two types of neuromuscular electrical stimulation training on vertical jump performance, *J. Strength Cond. Res.*, 22, 1273-1278 (2008).
- Papaiordanidou, M., Guiraud, D., Varray, A., Kinetics of neuromuscular changes during low-frequency electrical stimulation, *Muscle Nerve*, 41(1), 54-62 (2010).
- Parent, A., Duchenne De Boulogne: A pioneer in neurology and medical photography, *Can. J. Neurol. Sci.*, 32 (3), 369-77 (2005).

- Parker, M.G., Bennett, M.J., Hieb, M.A., Hollar, A.C., Roe, A.A., Strength response in human quadriceps femoris muscle during 2 neuromuscular electrical stimulation programs, *J. Orthop. Sports Phys. Ther.*, 33 (12), 719-726 (2003).
- Parker, M.G., Keller, L., Evenson, J., Torque responses in human quadriceps to burst-modulated alternating current at 3 carrier frequencies, *J. Orthop. Sports Phys. Ther.*, 35 (4), 239-45 (2005).
- Peckham, P.H., Knutson, J.S., Functional electrical stimulation for neuromuscular applications, *Annu. Rev. Biomed. Eng.*, (7), 327-360 (2005).
- Pensini, M., Martin, A., Effect of voluntary contraction intensity on the H-reflex and V-wave responses, *Neurosci. Lett.*, 367 (3), 369-374 (2004).
- Perez, M., Lucia, A., Rivero, J.L., Serrano, A.L., Calbet, J.A., Delgado, M.A., Chicharro, J.L., Effects of transcutaneous short-term electrical stimulation on M. vastus lateralis characteristics of healthy young men, *Pflugers Arch.*, 443 (5-6), 866-74 (2002).
- Piccolino, M., Animal electricity and the birth of electrophysiology: The legacy of Luigi Galvani, *Brain Res. Bull.*, 46 (5), 384 (1998).
- Picerno, P., Camomilla, V., Capranica, L., Countermovement jump performance assessment using a wearable 3D inertial measurement unit, *J. Sports Sci.*, 29 (2), 139-146 (2011).
- Pichon, F., Chatard, J.C., Martin, A., Cometti, G., Electrical stimulation and swimming performance, *Med. Sci. Sports. Exerc.*, 27 (12), 1671-1676 (1995).
- Pierrot-Deseilligny, E., Burke, D., The Circuitry Of The Human Spinal Cord: Its Role In Motor Control And Movement Disorders*, Cambridge University Press., Cambridge, UK, 2 (2005).
- Plotnik, R., Kouyoumdjian, H., Introduction to Psychology, 10th Ed., Wadsworth/Cengage Learning, Belmont, USA, 52 (2013).
- Popovic, M.R., Keller, T., Pappas, I.P., Dietz, V., Morari, M., Surface-stimulation technology for grasping and walking neuroprostheses, *IEEE Eng. Med. Biol. Mag.*, 20 (1), 82-93 (2001).
- Porcari, J.P., McLean, K.P., Foster, C., Kernozek, T., Crenshaw, B., Swenson, C., Effects of electrical muscle stimulation on body composition, muscle strength and physical appearance, *J. Strength Cond. Res.*, 16 (2), 165-72 (2002).
- Porcari, J.P., Miller, J., Cornwell, K., Foster, C., Gibson, M., Mclean, K., Kernozek, T., The effects of neuromuscular electrical stimulation training on abdominal strength, endurance and selected anthropometric measures, *J. Sports Sci. Med.*, 4, 66-75 (2005).
- Press, J.M., Bergfeld, D.A., Physical modalities, In: *Clinical Sports Medicine: Medical Management and Rehabilitation*, W.R. Frontera (Ed.), Elsevier Inc., Philadelphia, USA, 214-215 (2007).
- Rand, M.K., Ohtsuki, T., EMG analysis of lower limb muscles in humans during quick change in running directions, *Gait Posture*, 12 (2), 169-83 (2000).

- Ratamess, N.A., Adaptation to anaerobic training programs, In: Essentials of Strength Training and Conditioning/National Strength and Conditioning Association, 3rd Ed., T.R. Baechle, W.E. Roger, (Eds.), Human Kinetics, IL, USA, 97 (2008).
- Reilly, J.P., Electrical Stimulation and Electropathology, Cambridge University Press, NY, USA, 145 (1992).
- Requena, S.B., Padial, P.P., González-Badillo, J.J., Percutaneous electrical stimulation in strength training: An update, *J. Strength Cond. Res.*, 19 (2), 438-448 (2005).
- Robinson, A.J., Instrumentation for electrotherapy, In: Clinical Electrophysiology Electrotherapy and Electrophysiologic Testing, 2nd Ed., A.J. Robinson, L. Snyder-Mackler (Eds.), Williams and Wilkins, Baltimore, USA, 27,44, 50-51 (1995).
- Robinson, A.J., Basic concepts in electricity and contemporary terminology in electrotherapy, In: Clinical Electrophysiology, Electrotherapy and Electrophysiologic Testing, 3rd Ed., A.J. Robinson, L. Snyder-Mackler, (Eds.), Wolters Kluwer/Lippincott Williams&Wilkins, Baltimore, USA, 2-3,5,13,15 (2008).
- Rooney, J.G., Currier, D.P., Nitz, A.J., Effect of variation in the burst and carrier frequency modes of neuromuscular electrical stimulation on pain perception of healthy subjects, *Phys. Ther.*, 72 (11), 800-809 (1992).
- Russ, D.W., Clark, B.C., Krause, J., Hagerman, F.C., Development of a neuromuscular electrical stimulation protocol for sprint training, *Med. Sci. Sports Exerc.*, 44 (9), 1810-1819 (2012).
- Schieppati, M., The Hoffmann reflex: A means of assessing spinal reflex excitability and its descending control in man, *Prog. Neurobiol.*, 28 (4), 345-376 (1987).
- Seyri, K., Maffiuletti, N., Effect of electromyostimulation training on muscle strength and sports performance, *Strength Cond. J.*, 33 (1), 70-75 (2011).
- Sheffler, L.R., Chae, J., Neuromuscular electrical stimulation in neurorehabilitation, *Muscle Nerve*, 35 (5), 562-590 (2007).
- Sherwood, L., Principles of neural and hormonal communication, In: Fundamentals of Physiology: A Human Perspective, 3rd Ed., Thomson Brooks/Cole, Southbank, Australia, 83 (2006).
- Siff, M., Applications of electrostimulation in physical conditioning: A review, *J. Strength Cond. Res.*, 4 (1), 20-26 (1990).
- Sinacore, D.R., Delitto, A., King, D.S., Roset, S.J., Type II fiber activation with electrical stimulation: A preliminary-report, *Phys. Ther.*, 70 (7), 416-422 (1990).
- Singer, K.P., The influence of unilateral electrical muscle stimulation on motor unit activity patterns in atrophic human quadriceps, *Aust. J. Physiother.*, 32 (1), 31-37 (1986).
- Singh, J., Textbook of Electrotherapy, Jaypee Digital, New Delhi, India, 1-68, (2005).

- Singh, J., Manual of Practical Electrotherapy, Jaypee Brothers Medical Publisher, New Delhi, India, 12,18-23 (2011).
- Singh, J., Textbook of Electrotherapy, 2nd Ed., Jaypee Digital, New Delhi, India, 1 (2012).
- Sircar, S., Principles of Medical Physiology, Thieme, Stuttgart, Germany, 80 (2008).
- Sköld, C., Lönn, L., Harms-Ringdahl, K., Hultling, C., Levi, R., Nash, M., Seiger, A., Effects of functional electrical stimulation training for six months on body composition and spasticity in motor complete tetraplegic spinal cord-injured individuals, *J. Rehabil. Med.*, 34 (1), 25-32 (2002).
- Smith, C.U.M., Brain and mind in the “long” eighteenth century, In: *Brain, Mind and Medicine: Essays in Eighteenth-Century Neuroscience*, H.A. Whitaker, C.U.M. Smith, S. Finger (Eds.), Springer, MI, USA, 17 (2007).
- Smith, J.C., Motl, R.W., Electromyographic indices of neuromuscular reflexes, *Int. J. Sports Psychol.*, 3 (3), 322-337 (2005).
- Snyder-Mackler, L., Delitto, A., Stralka, S.W., Bailey, S.L., Use of electrical stimulation to enhance recovery of quadriceps fmons muscle force production in patients following antenor cruciate ligament reconstruction, *Phys. Ther.*, 74 (10), 9001-907 (1994).
- Soo, C.L., Currier, D.P., Threlkeld, A.J., Augmenting voluntary torque of healthy muscle by optimization of electrical stimulation, *Phys. Ther.*, 68 (3), 333-7 (1988).
- Strauss, G.R., Domenico, D.D., Torque production in human upper and lower limb muscles with voluntary and electrically stimulated contractions, *Aust. J. Physiother.*, 32 (1), 38-49 (1986).
- Strojnik, V., Muscle activation level during maximal voluntary effort, *Eur. J. Appl. Physiol. Occup. Physiol.*, 72 (1-2), 144-9 (1995).
- Strojnik, V., The effects of superimposed electrical stimulation of the quadriceps on performance in different motor tasks, *J. Sports Med. Fitness*, 38 (3), 194-200 (1998).
- Şahin, Ö., Rehabilitasyonda izokinetik değerlendirmeler, *Cumhuriyet Tip Dergisi*, 32(4), 386-396 (2010).
- Tasaki, I., Electric stimulation and the excitatory process in the nerve fiber, *Am. J. Physiol.*, 125, 380-395 (1939).
- Thomas, C.K., Nelson, G., Than, L., Zijdewind, I., Motor unit activation order during electrically evoked contractions of paralyzed or partially paralyzed muscles, *Muscle Nerve*, 25 (6), 797-804 (2002).
- Treacy, C., SSS hücreleri ve aralarındaki iletişim, (Çeviri: D.F. Baş), In: *Nörolojik Bilimler Hemşireliği Kanita Dayalı Uygulamalar*, S. Woodward, A. Mesteky (Eds.), (Çeviri: M.A. Topçuoğlu, Z. Durna, A. Karadakovan), Nobel Tip Kitap Evi, İstanbul, Turkey, 9,11-12 (2013).
- Trimble, M.H., Enoka, R.M., Mechanisms underlying the training effects associated with neuromuscular electrical stimulation, *Phys. Ther.*, 71 (4), 273-280 (1991).

- Turostowski, I., Cometti, G., Cordano, M., Influence of electrostimulation on human quadriceps femoris muscle strength and muscle mass, Proceeding of the 10th Symp. ISBS, Milano, Italy, 139-141 (1992).
- Upton, A.R., McComas, A.J., Sica, R.E., Potentiation of "late" responses evoked in muscles during effort, *J. Neurol. Neurosurg. Psychiatry.*, 34 (6), 699-711 (1971).
- Vanderthommen, M., Duchateau, J., Electrical stimulation as a modality to improve performance of the neuromuscular system, *Exerc. Sport Sci. Rev.*, 35 (4), 180-185 (2007).
- Vaz, M.A., Aragão, F.A., Boschi, É.S., Fortuna, R., Melo, M.O., Effects of Russian current and low-frequency pulsed current on discomfort level and current amplitude at 10% maximal knee extensor torque, *Physiother. Theory Pract.*, 28 (8), 617-23 (2012).
- Venable, M.P., Collins, M.A., O'Bryant, H.S., Denegar, C.R., Sedivec, M.J., Alon, G., Effect of supplemental electrical stimulation on the development of strength, vertical jump performance and power, *J. Strength Cond. Res.*, 5 (3), 139-143 (1991).
- Ward, A.R., Shkuratova, N., Russian electrical stimulation: The early experiments, *Phys. Ther.*, 82 (10), 1019-1030 (2002).
- Ward, A.R., Robertson, V.J., Makowski, R.J., Optimal frequencies for electric stimulation using mediumfrequency alternating current, *Arch. Phys. Med. Rehabil.*, 83 (7), 1024-7 (2002).
- Ward, A.R., Oliver, W.G., Buccella, D., Wrist extensor torque production and discomfort associated with low-frequency and burst-modulated kilohertz-frequency currents, *Phys. Ther.*, 86 (10), 1360-7 (2006).
- Ward, A.R., Lucas-Toumbourou, S., Lowering of sensory, motor, and pain-tolerance thresholds with burst duration using kilohertz-frequency alternating current electric stimulation, *Arch. Phys. Med. Rehabil.*, 88 (8), 1036-41 (2007).
- Ward, A.R., Electrical stimulation using kilohertz-frequency alternating current, *Phys. Ther.*, 89 (2), 181-190 (2009).
- Wiemann, K., Tidow, G., Relative activity of hip and knee extensors in sprinting - implications for training, *New Stud. Athlet.*, 10, 29-49 (1995).
- Willoughby, D.S., Simpson, S., The effects of combined electromyostimulation and dynamic muscular contractions on the strength of college basketball players, *J. Strength Cond. Res.*, 10, 40-44 (1996).
- Willoughby, D.S., Simpson, S., Supplemental EMS and dynamic weight training: Effects on knee extensor strength and vertical jump of female college track & field athletes, *J. Strength Cond. Res.*, 12 (3), 131-137 (1998).
- Wolf, S.L., Ariel, G.B., Saar, D., Penny, M.A., Railey, P., The effect of muscle stimulation during resistive training on performance parameters, *Am. J. Sports Med.*, 14 (1), 18-23 (1986).
- Woolford, S.M., Polglaze, T., Rowsell, G., Spencer, M., Field testing principles and protocols, In: *Physiological Tests for Elite Athletes*, 2nd Ed., R. Tanner,

- C. Gore (Eds.), Australian Institute of Sport, Human Kinetics, IL, USA, 237 (2013).
- Yanagi, T., Shiba, N., Maeda, T., Iwasa, K., Umezawa, Y., Tagawa, Y., Matsuo, S., Nagata, K., Yamamoto, T., Basford, J.R., Agonist contractions against electrically stimulated antagonists, *Arch. Physical. Med. Rehabil.*, 84 (6), 843-848 (2003).
- Yavuzer, G., Geler-Külcü, D., Sonel-Tur, B., Kutlay, S., Ergin, S., Stam, H.J., Neuromuscular electric stimulation effect on lower-extremity motor recovery and gait kinematics of patients with stroke: A randomized controlled trial, *Arch. Phys. Med. Rehabil.*, 87 (4), 536-40 (2006).
- Young, W.B., James, R., Montgomery, L., Is muscle power related to running speed with changed of direction?, *J. Sports Med. Phys. Fitness*, 42 (3), 282-288 (2002).
- Zatsiorsky, V.M., Kraemer, W.J., Science and Practice of Strength Training, 2nd Ed., Human Kinetics, IL, USA, 62,132-133 (2006).
- Zehr, P.E., Considerations for use of the Hoffmann reflex in exercise studies, *Eur. J. Appl. Physiol.*, 86 (6), 455-468 (2002).
- Ziv, G., Lidor, R., Vertical jump in female and male basketball players: A review of observational and experimental studies, *J. Sci. Med. Sport.*, 13 (3), 332-339 (2010).
- Zory, R.F., Jubeau, M.M., Maffuletti, N.A., Contractile impairment after quadriceps strength training via electrical stimulation, *J. Strength Cond. Res.*, 24 (2), 458-64 (2010).