



Current state of research

# Low-frequency electrical stimulation

## 1. Fields of application

Low-frequency electrical stimulation (less than 1 kHz) is used in numerous fields. These include medical or therapeutic applications such as prevention of muscular atrophy or faster recovery. Additional application areas include training to prevent or reduce back injuries or urinary incontinence. In both amateur and high-performance sports, low-

frequency EMS is also used in strength and endurance training. Reducing tension, muscle relaxation and massage are additional application areas.

## 2. Training methods

Particularly in strength training, low-frequency EMS strengthens voluntary contractions, whether static (isometric) in a given position or dynamic for

a specific range of motion (ROM). In practice, the subject contracts or moves the muscles, and intensified stimulation is applied simultaneously using an electrical current. This stimulation may be localized or involve several muscle groups, all the way to full-body EMS training. Another application is for combined training, where a mechanical stimulus (e.g. barbell training) and low-frequency EMS are used simultaneously or successively.

### 3. Current state of research

Low-frequency EMS is used in the above-mentioned fields in a variety of training configurations. The study by Fritzsche et al. (2010) demonstrates for the first time the effect of low-frequency full-body EMS training for patients with heart failure in secondary prevention. Improvements with regard to objective performance ability and the optimization of muscle physiology and metabolic parameters are significant. They far exceed the results obtained by established aerobic training methods in the framework of primary and secondary cardiac rehabilitation for patients with chronic heart failure. An up to 96% increase in oxygen uptake at the anaerobic threshold was demonstrated ( $VO_{2at}$  19.39  $\pm$  5.3 ml/kg of body weight [KG] before the start of training;  $VO_{2at}$  24.25  $\pm$  6.34 ml/kg KG at the end of the training phase;  $p < 0.05$ ). Diastolic blood pressure dropped significantly ( $psyst < 0.05$ ;  $pdiast < 0.001$ ), muscle growth measured up to 14% at constant weight. The training method had 100% acceptance (no dropouts) and patients registered significantly higher subjective performance ability (cf. Fritzsche et al. 2010).

Kemmler et al. (2009) investigated the influence of low-frequency full-body EMS training on body composition and cardiac size in elderly men with a metabolic disorder as per the IDF. The primary results of this controlled, randomized and partial-blind intervention study indicate significant effects with regard to abdominal fat mass, total body fat mass and appendicular skeletal muscle mass (ASMM) as criteria for sarcopenia (Baumgartner et al. 1998).

Low-frequency EMS can also be used effectively to increase strength for both untrained and fitness-oriented individuals. The average improvement of maximum isometric strength after EMS training for untrained subjects measured 23.5%. It should be emphasized that this type of training does not cause the high joint stress associated with mechanical training, that effort can be varied smoothly, and that training in variable angled positions can be accomplished effortlessly. In addition, combinations with other strength training methods are possible. Mixed training (machine hypertrophy) combined with EMS shows the largest maximum strength effects (Kreuzer et al. 2006). Isokinetic training (eccentric and concentric) combined with EMS increases muscle mass by approx. 10% in eight weeks (Ruther et al. 1995; Stevenson et al. 2001).

In high-performance sports, trained athletes from various sports exhibited increased isometric maximum strength of between 15% and 40%, with a median of 32.6% (Filipovic et al. 2011). Competitive swimmers achieved improvements in MVC (maximum voluntary contraction) in eccentric and concentric contractions of the latissimus dorsi and quadriceps femoris and improved freestyle swim times (Pichon et al. 1995). With regard to contraction velocity and performance, various authors confirm a positive effect on contraction speed (Alon et al. 1987, Balogun et al. 1993, Cabric et al. 1987). In addition, EMS training groups demonstrated a large gain with regard to movement speed, thus significantly improving performance (Kleinöder 2007). A combination of classic strength training (hypertrophy) and EMS training increases both performance factors (movement speed and strength) (Cabric et al. 1987; Dörmann 2011). This is particularly significant for sports performance, as speed, the decisive factor in many sports, can be improved in a short period of time.

In examining sprint and jump performances after EMS training, sprint studies demonstrate speed increases of 3.1% over a period of three weeks for high-performance athletes. Brocherie et al. improved 10 m sprint times for ice hockey players by 4.8%. In swimming, the 25 m time was reduced by 1.3% and the 50 m freestyle time by 1.45% (Pichon et al. 1995). In combined strength training (plyometrics/EMS), Herrero et al. (2006) achieved a 2.3% reduction of the 20 m sprint time in untrained subjects. Jump capacity after EMS training demonstrated improvements of between 2.3% and 19.2% after isometric EMS training (median +10%) and 6.7% to 21.4% after dynamic EMS training (Babault et al. 2007, Kots et al. 1971, Maffiuletti et al. 2000, Paillard 2008). After combined EMS training with classic strength training, the literature indicates median jump performance improvements of 11.2 $\pm$ 5.5% (Maffiuletti et al. 2002, Herrero et al. 2006).

Dr. Heinz Kleinöder

Dr. Heinz Kleinöder has been a lecturer at the Cologne German Sport University in the Institute for Training Sciences and Sports IT since 1990. He directs the Strength Diagnostics and Movement Research department. His work focuses on research for adapting various strength training stimuli (EMS and vibration) as well as differential diagnosis of conditional capacities of team and high-performance athletes in various sports. He also spent eight years working as a trainer in high-performance sports (Bayer Leverkusen tennis club) and gives frequent lectures on practical, science-based approaches in the above-named subjects at the Cologne Trainers' Academy.





## 4. Conclusion

The following conclusions can be drawn with regard to the various fields of application for low-frequency EMS: EMS training significantly improves strength endurance performances as well as the movement speed factor. Low-frequency EMS was used successfully in support of endurance training. This training method offers high potential in therapy for patients with heart failure (cf. Fritzsche 2010). With regard to body composition of elderly people, low-frequency full-body EMS training shows significant effects at low training volumes (approx. 45 min./week) and brief intervention periods (14 weeks). This leads to the conclusion that for individuals with low cardiac and orthopedic capacity, full-body EMS can be an alternative to conventional training programs (cf. Kemmler et al. 2009). For amateur and high-performance sports, improvements in the main static and dynamic strength parameters (maximum strength, contraction velocity and performance) were obser-

ved. Here dynamic methods are to be preferred, as intensity control through movement is simpler and the musculature is trained across its full range of motion (ROM).

In the field of low-frequency stimulation, EMS full-body training is a very interesting training form, as all muscle groups can be stimulated at various levels. This provides high flexibility in training control for individual muscle groups, and saves training time (15 to 20 minutes). Various goals can be pursued with low-frequency full-body EMS training (from muscle growth to relaxation, see above), so this training method is equally helpful for amateur and high-performance athletes. While many different training programs have led to training successes, further studies would be advisable in the future to continue to improve training management in the various fields of application.