ISSN 1855-9913

Journal of the Laser and Health Academy
Vol. 2020, No.1; www.laserandhealth.com

Characteristics of Functional Magnetic Stimulation

(Submitted for presentation at the 3rd LA&HA Super Symposium 2020; online Sept/Oct 2020)

dr. Vincent Wong,[1] dr. Jorge Gaviria,[2] doc. dr. Borut Fonda[3]
[1]*Vindoc Aesthetics, London, UK*
[2]*Advanced Laser Institute of America, Virginia, USA*
[3]*Faculty of Health Sciences, University of Primorska, Slovenia*

SUMMARY

a) Introduction

Functional magnetic stimulation (FMS) devices [1] work by creating a pulsed magnetic field, which means that the magnetic field density changes with time. A pulsed magnetic field induces electrical potential inside body tissue. The electrical potential causes electric current to flow, thus exciting the neurons in the body. A single action potential is then triggered by the excited neurons. When the excited neuron is a motor neuron, the triggered action potential causes the corresponding motor units in the muscle to contract.

b) Muscle contractions

The above principle can be used to achieve muscle contraction if two conditions are fulfilled. First, the electrical current that is induced in the body must be greater than a threshold value, and second, the motor neuron and consequentially the human muscle must not be in its refractory period. A refractory period is the time during which an action potential cannot be excited. The refractory period of a healthy human skeletal muscle is roughly 1-4 ms [2-4]. Theoretically, this principle can be applied for an unlimited amount of time and the muscle will behave identically as it did the first time a contraction was triggered. To be certain of achieving a muscle contraction every time a stimulus is triggered, we must deliver pulses with a pulse repetition frequency no higher than about 100 Hz, or one pulse every 5 ms.

Top performance magnetic devices (for example, Tesla Former, manufactured by Iskra Medical d.o.o., Slovenia) can deliver high pulse repetition frequencies, e.g. 80 Hz. Ideally, to trigger 50 000 contractions in 30 minutes, where the active time is 1 s and the pause time is also 1 s (50% duty cycle), a frequency of 56 Hz must be used. A frequency of 56 Hz delivers a trigger pulse every 18 ms, which is more than the muscle refractory period. Therefore, each trigger pulse will excite at least one muscle unit contraction. In the previously mentioned 80 Hz stimulation, with 1 s active time and 1 s passive time, 72 000 contractions can be achieved.

A logical question arises about what happens at such high frequencies (50 Hz or higher) after long-term stimulation (15 minutes or more), as muscle fatigue is a well-known phenomenon after prolonged stimulation. As muscles become fatigued, the muscle response decreases. A recent study has shown that even at high frequencies of about 100 Hz, muscle response was still present after a 15-minute stimulation period [5]. Based on the trend of response reduction by the minute as reported in the above study (Figure 1), we can deduce that even after a 30-minute stimulation period there will be considerable muscle response present at frequencies used by the Tesla Former device.

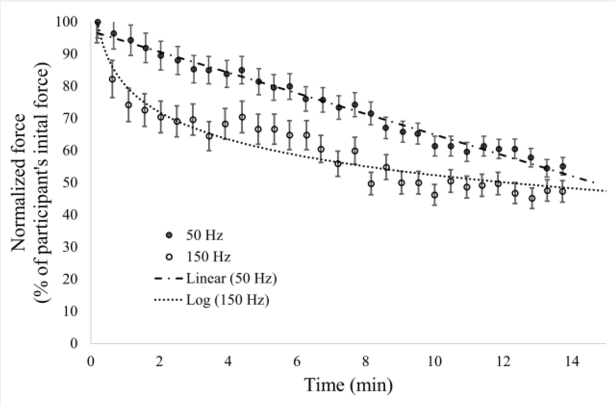

Fig 1: Curve fitting pattern of normalized stimulated force values obtained during a 15-minute fatigue test under all stimulation conditions. Data are presented as mean. Error bars represent standard error of mean. Adapted based on source: ref [5].

c) Fat burning

The body's energy demand is dramatically increased in periods of increased physical activity [6]. Muscle contraction requires energy in the form of the body's universal energy currency – the ATP molecule. ATP production for muscle contraction is derived from two main energy storages: carbohydrate and fat. Carbohydrates are stored in the form of glycogen, which is broken down to glucose, while fat is stored in the form of triglycerides, which are broken down to fatty acids.

The metabolism of both glucose and fatty acids both converge at a common metabolite, the acetyl-coenzyme A, which is a key substrate for ATP production in the mitochondria, the cells' power plants.

As the body's carbohydrate reserves are precious and limited, their utilization is tightly regulated. In the periods of increased demands for energy - e.g. from extensive muscle contraction, the utilization of energy stored in the body's fat reserves is intensified.

The main fat reserve molecules are triglycerides, which are broken down to glycerol and fatty acids. The fatty acids can be further utilized to produce ATP for muscle contraction in the metabolic process of ß oxidation, which produces the acetyl coenzyme A molecule - the main substrate for mitochondrial ATP production. The fatty acids used as fuel for muscle contractions are mainly derived from the adipose tissue reserves and plasma VLDL.

d) Conclusions

In conclusion, functional magnetic stimulation (FMS) is a non-invasive treatment in which a pulsed magnetic field is applied to a localized part of the body. The magnetic field stimulates muscles and causes them to contract. These contractions may result in increased strength and endurance of muscles in the targeted body area. Depending on the magnetic pulse repetition rate, up to (or even more than) 50 000 contractions can be induced during a short 30-minute therapy session. Additionally, the increased muscle activity during the session increases catabolic processes that ensure ATP production from fatty acids. The functional muscle stimulation can therefore, along with diet and exercise, increase the rate of fat burning.

REFERENCES

1. Baechle, Thomas R., Roger W. Earle, in National Strength & Conditioning Association (U.S.), ur. 2008. *Essentials of strength training and conditioning*. 3rd ed. Champaign, IL: Human Kinetics.
2. Desmedt, J.E., ur. 1973. *Pathological Conduction in Nerve Fibers, Electromyography of Sphincter Muscles, Automatic Analysis of Electromyogram with Computers*. S. Karger AG.
3. Kimura, J, T Yamada, in R L Rodnitzky. 1978. „Refractory Period of Human Motor Nerve Fibres." *Journal of Neurology, Neurosurgery & Psychiatry* 41 (9): 784–90. https://doi.org/10.1136/jnnp.41.9.784.
4. Kimura, Jun. 1976. „A Method for Estimating the Refractory Period of Motor Fibers in the Human Peripheral Nerve". *Journal of the Neurological Sciences* 28 (4): 485–90. https://doi.org/10.1016/0022-510X(76)90119-2.
5. Kuwabara, Satoshi, Cindy S.-Y. Lin, Ilona Mogyoros, Cecilia Cappelen-Smith, in David Burke. 2001. „Voluntary Contraction Impairs the Refractory Period of Transmission in Healthy Human Axons". *The Journal of Physiology* 531 (1): 265–75. https://doi.org/10.1111/j.1469-7793.2001.0265j.x.
6. Rongsawad, Kitima, in Jonjin Ratanapinunchai. 2018. „Effects of Very High Stimulation Frequency and Wide-Pulse Duration on Stimulated Force and Fatigue of Quadriceps in Healthy Participants". *Annals of Rehabilitation Medicine* 42 (2): 250. https://doi.org/10.5535/arm.2018.42.2.250.
7. Hultman, Eric. 1995. „Fuel Selection, Muscle Fibre". *Proceedings of the Nutrition Society* 54 (1): 107–21. https://doi.org/10.1079/PNS19950041.