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THE EFFECTS OF WHOLE-BODY ELECTRICAL MUSCLE STIMULATION ON SARCOPENIA

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1. Introduction

Electrical muscle stimulation (EMS) is the elicitation of muscle contraction using electric impulses. EMS has received an increasing amount of attention in the last few years for many reasons. EMS is capable of increasing muscle mass, strength and muscle power. Beyond that, it helps with the conditioning of healthy muscles. Further beneficial effects of EMS are also known, such as helping in weight control or being a solution for conditions such as cellulite. Also, it can be applied as a rehabilitation tool for balancing muscle imbalances caused by inappropriate muscle usage or restructure muscles damaged during aging or injuries.

The electric impulses are generated by EMS devices and delivered through cables to the electrodes on the skin surface of the muscles to be stimulated. Due to these impulses, the action potential is triggered in a similar way as in the case of impulses coming from the central nervous system. The resulting muscle contraction is similar to the natural movement and regular contractions of the muscles. Depending on the parameters of the electrical impulses (impulse frequency, impulse width, ramp-up, impulse duration, duration of rest), different types of muscle work can be imposed thus improving and facilitating muscle performance of the stimulated muscles.

EMS has several known beneficial effects in clinical applications. It can be used for preventive and rehabilitation purposes in neurology, orthopedics, rheumatology and many other medical fields.

- muscle strengthening, conditioning and increasing muscle mass,
- relaxation of muscle spasm,
- increasing local blood circulation,
- muscle re-education,
- prevention or retardation of disuse atrophy,
- prevention of venous thrombosis of the calf muscles immediately after surgery,
- maintaining or increasing the range of motion.

Even a short period of muscle disuse, due to illness or injury, results in substantial skeletal muscle atrophy. Skeletal muscle atrophy results from various conditions (including unloading, joint immobilization, denervation, and spinal cord injury) or it comes from a natural process, called sarcopenia when the physical activity of aging people gets to decrease, that leads to muscle mass reduction.

Electrical muscle stimulation is an effective way of preventing muscle atrophy. Atrophy can be treated in a preventive or therapeutic nature because EMS is a safe, autonomous and efficient way of increasing or maintaining muscle mass, strength, and functionality. [1-15]

We hypothesized that an EMS-elicited contraction would be helpful in decreasing the effects of sarcopenia.

The aims of this study were:

- To investigate changes in muscular mass on individuals with sarcopenia when utilizing XBody EMS devices.
- To investigate the relationship between the strength gains of sarcopenia individuals when utilizing XBody EMS devices.

2. Subjects

Two female subjects with sarcopenia participated in the study at the age of 62 and 56 years. The inclusion criteria were age over 55 years. Exclusion criteria were the presence of any medical condition that is described in the XBody Client's consent. The participants were measured according to the Functional Movement Screen (FMS) protocol and anthropometric standards.

3. Procedures

Detailed instructions concerning exercise, lifestyle, and nutritional habits were also provided. The participants were instructed to avoid strenuous exercise within 48 hours after the EMS training and maintain their normal caloric and liquid intake throughout the duration of the study.

XBody Newave which is a Whole-Body EMS (WB-EMS) device enables to stimulate the main muscle groups simultaneously. These muscle groups are the trapezius, back, lower back, pectoral, abs, glutes, quadriceps, hamstrings, arms, optional (e.g. shoulders, calves).

Generally, the exercise protocol of our trial closely applied the typical setting of commercial WB-EMS sessions with their low loading and low duration strategy. This means that a lower stimulation intensity was used, and the duration of the training session did not exceed 20 minutes.

In the first part of the study, an electric current was applied with an impulse frequency of 9 Hz in continuous stimulation mode. (In continuous mode, the stimulus is generated continuously, without impulse break periods.) The impulse width was 400 µs at the subject's maximum tolerance limit, for the first 16 sessions.

In the second part of the study, 16 sessions at 80 Hz were applied in burst mode. In this mode, active stimulation (impulse length) and break periods (impulse break - no stimulation) follow each other. In this case, both the impulse length and the impulse break values were set to 3 seconds, the impulse width was 350 µs.

Five dynamic exercises for the main muscle groups were performed without any additional weights and were structured in 2 sets of 20 repetitions. Squat movements with a range of motion from 90 to 180° flexion of the knee joint were carried out during all exercises.

In the continuous stimulation mode, the inhale-, exhale period were synchronized to the chosen exercises. In burst mode, the performance of the exercises was synchronized with the 3 seconds impulse length and 3 seconds impulse break stimulation cycle. The subjects were carefully instructed by research assistants on how to perform the exercises. Furthermore, the participants were acoustically and visually guided by XBody EMS Training videos that exactly controlled the 3-second exercise–3-second rest rhythm of the resistance protocol.
Because of the increasing tolerability of the current intensity during the session, the current intensity was adjusted (at the subject's maximum tolerance levels) after 2, 5, 8 and 13minutes. At least 3 days of rest was given between two sessions. The exercises and the main affected muscles are presented in the following table.

Exercises	The most loaded regions
Squat with TRX	Leg extensor, leg flexor, and gluteal muscles
Rowing with TRX	Arm, shoulder, core and upper back muscles
Lumberjack with Elastic Band	Core muscles
Glute Bridge	Gluteal, leg flexor, adductor and core muscles
Single Leg Raise	Iliopsoas and abdominal muscles

Table 1 Load region of the applied exercises

4. Measurements

4.1. Anthropometry measurements

Anthropometry measurements of height, weight, and body composition were applied. The body composition was determined by multi frequency, whole-body bioelectrical impedance technique (TANITA - OMRON BF511)

4.2. Functional Movement Tests (FMS)

Nowadays people are working to improve their flexibility, strength, endurance, and power in order to become stronger and healthier, despite being aware of the deficiency in their fundamental movements. If these fundamental weaknesses are not exposed, it can lead to muscular dysfunction, compensation, and even fatigue or pain, and due to these changes the training programs cannot improve the client's fitness and health in an effective way.

In the interest of individualizing each workout, it is important to determine who possesses, or lacks, the ability to perform certain essential movements.

The intended use of Functional Movement Screen (FMS) is to evaluate the quality of movement patterns for clients with identifying imbalances in mobility and stability during seven fundamental patterns.

By applying this innovative system the trainer can learn a simple and quantifiable method for defining basic movement abilities, identifying asymmetries, which result in functional movement deficiencies.

- The main FMS tests are Deep Squat, Hurdle Step, In-line Lunge, Active Straight-leg Raise, Trunk Stability Push-up, Rotary Stability, Shoulder Mobility, Clearing tests.
- The scores range from zero to three, see the four basic scores below:

Test Scoring	Evaluation	Category
3	perform the movement without compensation	Excellent
2	complete the movement with compensation	Fair
1	unable to complete the movement	Poor
0	pain appears	Bad

Table 2 FMS evaluation

Clearing Tests	
+ (positive)	pain → score will be "0" for the associated test
- (negative)	no pain

Table 3 Clearing Test evaluation

- **0:** A score of zero is given if the pain is associated with the test. In this case, a medical examination of this painful area is recommended.
- **1:** A score of one is given if the client is unable to complete the movement pattern or is unable to assume the position to perform the movement.
- **2:** A score of two is given if the client is able to complete the movement but the exercise is accomplished with any compensation.
- **3:** A score of three is given if the client performs the movement properly without any compensation.

- The majority of the FMS tests need to be done on both sides with scoring the left and right sides as well. The lower score of the two sides is recorded and is counted toward the total scores. In addition, it is useful to make notes about the imbalances between the right and left sides.

Further details about FMS are contained in the XBody Training Protocols document.

5. Results

The FMS score of the two elderly subjects was 16 and 20 before starting the 32 weeks WB-EMS training program. After the first 16 training sessions, the score of FMS increased to 21 and 25. After the WB-EMS training program (including 32 training sessions), scores of 27 and 30 were measured by the operator. The two subjects' anthropometric characteristic showed similar decreases after the 32 weeks WB-EMS training program. The results are summarized in the following tables.

As it can be observed in case of subject A, the circumference of the arms was 28 cm, the circumference of quadriceps was 56 cm (right leg) and 57 cm (left leg), the circumference of the chest was 74 cm, the circumference of the waist was 85 cm and the circumference of the glutes was 98 cm. After performing the WB-EMS training program these measured parameters changed as the following: circumference of the arms was 26 cm, the quadriceps was 53 cm, the chest was 69 cm, the waist was 79 cm and the glutes was 95 cm. A decrease in body weight of subject A was also resulted, from 63.1 kg to 58.3 kg. Furthermore, the BMI (body mass index) decreased from 24 to 23 after the first 16 sessions on 9 Hz. Additionally, after the strengthening exercise period on 80 Hz, the further decrease was measured (22). The body composition measurements showed changes also. The BF % (body fat percentage) from 38% decreased to 33.9% and the MM% (muscle mass percentage) increased from 23.9% to 29%.

<table>
<tr><th colspan="8">Subject A - 162cm</th></tr>
<tr><th colspan="8">Baseline data</th></tr>
<tr><td colspan="4" rowspan="3">Before the first session</td><td rowspan="3">FMS</td><td colspan="3">Anthropometric Measures (cm)</td></tr>
<tr><td>Arms R/L</td><td>28</td><td>28</td></tr>
<tr><td>Quadriceps R/L</td><td>56</td><td>57</td></tr>
<tr><td>Weight (kg)</td><td>BMI</td><td>%Fat</td><td>%Muscle Mass</td><td rowspan="3">8</td><td>Chest</td><td colspan="2">74</td></tr>
<tr><td rowspan="2">63.1kg</td><td rowspan="2">24</td><td rowspan="2">38.0</td><td rowspan="2">23.9</td><td>Waist</td><td colspan="2">85</td></tr>
<tr><td>Glutes</td><td colspan="2">98</td></tr>
<tr><th colspan="8">1st period: Impulse frequency: 9 Hz, Continuous mode, Pulse width: 400 µs</th></tr>
<tr><td colspan="4" rowspan="3">16 sessions</td><td rowspan="3">FMS</td><td colspan="3">Anthropometric Measures (cm)</td></tr>
<tr><td>Arms R/L</td><td>27</td><td>27</td></tr>
<tr><td>Quadriceps R/L</td><td>55</td><td>55</td></tr>
<tr><td>Weight (kg)</td><td>BMI</td><td>%Fat</td><td>%Muscle Mass</td><td rowspan="3">12</td><td>Chest</td><td colspan="2">72</td></tr>
<tr><td rowspan="2">61.1kg</td><td rowspan="2">23</td><td rowspan="2">38.0</td><td rowspan="2">24.9</td><td>Waist</td><td colspan="2">83</td></tr>
<tr><td>Glutes</td><td colspan="2">95</td></tr>
<tr><th colspan="8">2nd period: Impulse frequency: 80 Hz, Burst mode, Pulse width 350 µs</th></tr>
<tr><td colspan="4" rowspan="3">16 sessions</td><td rowspan="3">FMS</td><td colspan="3">Anthropometric Measures (cm)</td></tr>
<tr><td>Arms R/L</td><td>26</td><td>26</td></tr>
<tr><td>Quadriceps R/L</td><td>53</td><td>53</td></tr>
<tr><td>Weight (kg)</td><td>BMI</td><td>%Fat</td><td>%Muscle Mass</td><td rowspan="3">16</td><td>Chest</td><td colspan="2">69</td></tr>
<tr><td rowspan="2">58.3</td><td rowspan="2">22</td><td rowspan="2">33.9</td><td rowspan="2">29.0</td><td>Waist</td><td colspan="2">79</td></tr>
<tr><td>Glutes</td><td colspan="2">95</td></tr>
</table>

Table 4 Results of Subject A

In case of subject B, the circumference of the arms was 27 cm, the circumference of the quadriceps was 54 cm, the circumference of the chest was 74 cm, the circumference of the waist was 84 cm and the glutes was 98cm. After performing the WB-EMS training program, these measured parameters changed as the following: circumference of the arms was 25 cm, quadriceps was 52 cm, the chest was 70 cm, the waist was 78 cm and glutes was 93 cm. The body weight of subject B also decreased from 57.2 kg to 53.9 kg. Furthermore, the BMI (body mass index) decreased from 20 to 19 after the strengthening exercise period at 80 Hz. The body composition measurements showed changes also. The BF % (body fat percentage) from 32.6% decreased to 30.2 % and the MM% (muscle mass percentage) increased from 28.8% to 31.2%.

Subject B - 167cm							
Baseline data							
Before the first session				FMS	Anthropometric Measures (cm)		
					Arms R/L	27	27
					Quadriceps R/L	54	54
Weight (kg)	BMI	%Fat	%Muscle Mass	10	Chest	74	
57.2kg	20	32.6	28.8		Waist	84	
					Glutes	98	
1st period: Impulse frequency: 9 Hz, Continuous mode, Pulse width: 400 µs							
16 sessions				FMS	Anthropometric Measures (cm)		
					Arms R/L	26	26
					Quadriceps R/L	53	53
Weight (kg)	BMI	%Fat	%Muscle Mass	15	Chest	72	
55.6kg	20	32.0	29.4		Waist	82	
					Glutes	96	
2nd period: Impulse frequency: 80 Hz, Burst mode, Pulse width 350 µs							
16 sessions				FMS	Anthropometric Measures (cm)		
					Arms R/L	25	25
					Quadriceps R/L	52	52
Weight (kg)	BMI	%Fat	%Muscle Mass	18	Chest	70	
53.9	19	30.2	31.2		Waist	78	
					Glutes	93	

Table 5 Results of Subject B

6. Discussion and conclusion

The purpose of this study was to examine the effect of WB-EMS on sarcopenia. The hypothesis was that EMS-elicited contraction would be helpful in decreasing the effects of sarcopenia, thus it is an efficient way of increasing or maintaining muscle mass, strength, and functionality. From the two described cases it can be concluded that WB-EMS can be a great help to people with sarcopenia. The measurement showed a reduction in weight with positive body composition changes, namely the BF % decreased and the MM % increased in the case of both subjects. The increase in the FMS values indicates that the subjects gained strength and muscle mass and the functionality improved in both cases.

7. Bibliography

[1] A., A., Préfaut, C. ., Gouzi, F. ., Couillard, A., Coisy-Quivy, M., Hugon, G., … Hayot, M. (2011). Skeletal muscle effects of electrostimulation after COPD exacerbation: A pilot study. *European Respiratory Journal*, *38*(4), 781–788. https://doi.org/10.1183/09031936.00167110

[2] Bax, L., Staes, F., & Verhagen, A. (2005). Does neuromuscular electrical stimulation strengthen the quadriceps femoris? A systematic review of randomised controlled trials. *Sports Medicine*, *35*(3), 191–212. https://doi.org/10.2165/00007256-200535030-00002

[3] Bouletreau P; Patricot MC; Saudin F; Guiraud M; Mathian B.; (1987). Effects of intermittent electrical stimulations on muscle catabolism in intensive care patients. Retrieved from https://www.ncbi.nlm.nih.gov/pubmed/3501482

[4] Dirks ML, Wall BT, Snijders T, Ottenbros CL, Verdijk LB, van L. L. (2014). Neuromuscular electrical stimulation prevents muscle disuse atrophy during leg immobilization in humans.

[5] Gerovasili, V., Stefanidis, K., Vitzilaios, K., Karatzanos, E., Politis, P., Koroneos, A., … Nanas, S. (2009). Electrical muscle stimulation preserves the muscle mass of critically ill patients: a randomized study. *Critical Care*, *13*(5), R161. https://doi.org/10.1186/cc8123

[6] Gruther, W., Kainberger, F., Fialka-Moser, V., Paternostro-Sluga, T., Quittan, M., Spiss, C., & Crevenna, R. (2010). Effects of neuromuscular electrical stimulation on muscle layer thickness of knee extensor muscles in intensive care unit patients: A pilot study. *Journal of Rehabilitation Medicine*, *42*(6), 593–597. https://doi.org/10.2340/16501977-0564

[7] Karatzanos, E., Gerovasili, V., Zervakis, D., Tripodaki, E. S., Apostolou, K., Vasileiadis, I., … Nanas, S. (2012). Electrical muscle stimulation: An effective form of exercise and early mobilization to preserve muscle strength in critically Ill patients. *Critical Care Research and Practice*, *2012*. https://doi.org/10.1155/2012/432752

[8] Kemmler, W., & Von Stengel, S. (2012). Alternative exercise technologies to fight against sarcopenia at old age: A series of studies and review. *Journal of Aging Research*, *2012*(February). https://doi.org/10.1155/2012/109013

[9] Maffiuletti, N. A., Roig, M., Karatzanos, E., & Nanas, S. (2013). Neuromuscular electrical stimulation for preventing skeletal-muscle weakness and wasting in critically ill patients: a systematic review. *BMC Medicine*, *11*(1), 137. https://doi.org/10.1186/1741-7015-11-137

[10] Meesen RL, Dendale P, Cuypers K, Berger J, Hermans A, Thijs H, L. O. (2010). Neuromuscular electrical stimulation as a possible means to prevent muscle tissue wasting in artificially ventilated and sedated patients in the intensive care unit: A pilot study.

[11] Routsi, C., Gerovasili, V., Vasileiadis, I., Karatzanos, E., Pitsolis, T., Tripodaki, E. S., … Nanas, S. (2010). Electrical muscle stimulation prevents critical illness polyneuromyopathy: a randomized parallel intervention trial. *Critical Care*, *14*(2), R74. https://doi.org/10.1186/cc8987

[12] Vivodtzev, I., Debigar??, R., Gagnon, P., Mainguy, V., Saey, D., Dub??, A., … Maltais, F. (2012). Functional and muscular effects of neuromuscular electrical stimulation in patients with severe COPD: A randomized clinical trial. *Chest*, *141*(3), 716–725. https://doi.org/10.1378/chest.11-0839

[13] Vivodtzev, I., Pépin, J. L., Vottero, G., Mayer, V., Porsin, B., Lévy, P., & Wuyam, B. (2006). Improvement in quadriceps strength and dyspnea in daily tasks after 1 month of electrical stimulation in severely deconditioned and malnourished COPD. *Chest*, *129*(6), 1540–1548. https://doi.org/10.1378/chest.129.6.1540

[14] Williams, N., & Flynn, M. (2014). A review of the efficacy of neuromuscular electrical stimulation in critically ill patients. *Physiotherapy Theory and Practice*, *30*(1), 6–11. https://doi.org/10.3109/09593985.2013.811567

[15] Barberi, L., Scicchitano, B. M., & Musarò, A. (2015). Molecular and cellular mechanisms of muscle aging and sarcopenia and effects of electrical stimulation in seniors. European Journal of Translational Myology, 25(4), 231. https://doi.org/10.4081/ejtm.2015.5227