Impact of Whole-Body Electromyostimulation and Resistance Training on the Level of Functional Fitness in Elderly Women

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ABSTRACT

Objective: This study aimed to investigate the effect of whole-body electromyostimulation (WB-EMS) and resistance training (RT) on the level of functional fitness in a group of elderly women.

Participants: 63 women (60-65 years) were randomly divided into 2 experimental groups (19 in WB-EMS, 22 in RT) and one control group (22 women). Both experimental groups underwent a ten-week lasting interventional program, the control group was asked to maintain their usual daily regimen and lifestyle.

Methods: Senior fitness test battery (SFT) determined the level of functional fitness in participants, and the dual-energy X-ray absorptiometry (DXA) assessed the body composition.

Results: The RT group reported a statistically significant difference between pre-and post-test in values of the Chair Stand test ($p = 0.04$), 8 Foot up and Go ($p = 0.03$), in the Back Scratch test left side ($p = 0.02$) and the Chair Sit and Reach test right side ($p = 0.05$). The WB-EMS interventional program had a positive statistically significant effect only on the level of flexibility of the lower limbs measured by the Chair Sit and Reach test left side ($p = 0.05$).

Conclusions: The results of all individual components of functional fitness measured by SFT in both experimental groups (WB-EMS, RT) show an improving tendency. Comparing WB-EMS and RT groups, better results were confirmed in the RT group.

Study limitations: Extending the length of intervention programs could have a more significant effect on the level of functional fitness in elderly women.

Keywords: ageing, functional fitness, Senior fitness test, DXA, resistance training, WB-EMS

INTRODUCTION

The world population is ageing. It is projected that adults over 65 years will be doubled in 2050 (United Nations, 2021). Despite the longer life expectancy, it is necessary to maintain a high quality of life to be included in society. It includes the ability to move freely and be self-sufficient. One of the most evident facts of ageing is the loss of muscle mass and, thus, the associated loss of muscle strength. (Romero-Arenas et al., 2013). Severe loss of muscle mass, together with decreased muscle strength and/or decreased functional fitness, is defined as sarcopenia (Cruz-Jentoft et al., 2019). Sarcopenia has an estimated prevalence of 10 % in adults over 60 years, rising to > 50 % in adults older than 80 years (Shafiee et al., 2017). Women are more susceptible to the occurrence of sarcopenia due to lower initial levels of muscle strength and also due to hormonal changes during menopause (Brady et al., 2014).

A crucial element for maintaining self-sufficiency in activities of daily living is functional fitness. Functional fitness is multifactorial and is influenced by genetic predispositions, disease manifestations and their consequences, previous lifestyle, environmental influences, and psychological state (Kolar, 2009).

One of the effective methods to prevent sarcopenia is physical exercise. Physical exercise has the potential to improve physical function and thus the quality of life of the elderly. There is indisputable scientific evidence for the benefits of physical activity and exercise in the prevention and treatment of many chronic diseases such as sarcopenia, among many others (Chodzko-Zajko et al., 2009; Pedersen & Saltin, 2015). More specifically, resistance training is an effective method for preventing the manifestations of sarcopenia - loss of muscle mass and muscle strength or fitness in the elderly (Dent et al., 2018; Fragala et al., 2019; Papa et al., 2017). Resistance training is an exercise method that operates with a gradual increase in load that involves muscular work against an external load (Papa et al., 2017). For the optimal adaptation of the musculoskeletal system, it is recommended to perform resistance training 2–3 times a week, including 1–3 sets of 8–12 repetitions for each exercise. It is recommended to focus on the main muscular parts of the body (Izquierdo et al., 2021).

Although resistance training is an effective method to prevent the manifestation of sarcopenia (Papa et al., 2017; Romero-Arenas et al., 2013), it may not be suitable for everyone. One of the disadvantages is the time required for exercise, lack of motivation, as well as the inability of an individual to perform exercises due to decreased mobility or fatigue (Kemmler et al., 2016, 2017). Whole-body electromyostimulation has been shown to be an alternative method to the effects of resistance training (Kemmler et al., 2018, 2021). The WB-EMS method uses weak electrical impulses transmitted through electrodes on the skin, which have the potential to activate a large number of motor units in muscles (Kim & Jee, 2020). The WB-EMS basic training session provides a 20-minute training protocol using intermittent stimulation (4 s pulses, 4 s rest; 85 Hz, 350 ms). The recommended frequency of WB-EMS training is 1 per 7 days to 3 per 14 days. WB-EMS is a highly individualized and time-efficient exercise technology that does not burden the joints (Kemmler et al., 2021). In general, studies examine the effect of WB-EMS on body composition, muscle strength (Kemmler et al., 2018) and functional fitness (Jee, 2018) in young athletes and untrained elderly people (Kemmler et al., 2021).

The purpose of the study is to investigate the effect of whole-body electromyostimulation (WB-EMS) and resistance training (RT) on the level of functional fitness in a group of elderly women. Due to the nature of the intervention program, we assumed that both types of training would result in a statistically significant increase in the level of strength abilities of the upper and lower limbs, while no statistically significant improvement would be recorded in the other monitored parameters.

METHODS

Study sample

The study sample was recruited from several sources. The printed leaflets were available at various sports grounds and rehabilitation centres in the city of Brno, informative emails were sent through the University of the Third Age of Masaryk University, and the faculty's social networks and websites were also used. Women who contacted us on the basis of the offer subsequently received detailed information and filled in the entry form (name and surname, age, contact, contraindications, and other restrictions). Based on these data, they were included/excluded in the research.

Our sample consisted of 63 elderly women that met the inclusion criteria:

- age 60–65 years old, without regular physical activity (< 60 minutes of regular physical activity per week), and no health contraindications (epilepsy, cardiac pacemaker implant, severe circulatory system, abdominal or inguinal hernia, cancer, advanced arteriosclerosis, severe neurological, disease, acute bacterial or viral disease, diabetes mellitus, bleeding disorders (haemophilia), liver disease, tuberculosis, severe circulatory system disorders (e.g. unstable angina pectoris), untreated hypertension, uncontrolled heart rhythm disturbances, heart failure, valve stenosis, hypertrophic cardiomyopathy, reduced mobility and metal implants (due to using of DXA).

All participants were asked to sign an informed consent form approved by the Ethics Committee of Masaryk University, Brno. The Ethics committee application number was EKV-2021-010.

The study sample was randomly divided into three groups – one group underwent a whole-body electromyostimulation training program (WB-EMS), another group underwent resistance circuit training (RT) and a control group (CG). The interventional program lasted for ten weeks. Participants were asked to maintain their usual daily regimen with the same amount of physical activity during the interventional program. Table 1 presents the base anthropometric characteristics (age, body weight, body height, BMI, body fat) in all followed groups.

Table 1. Base anthropometric characteristics in all groups

Variable	***WB-EMS*** (n=19)	***RT*** (n=22)	***CG*** (n=22)
Age (years)	62.68 ± 1.66	62.64 ± 1.85	62.61 ± 1.52
Bodyweight (kg)	72.61 ± 13.43	75.54 ± 8.61	77.412 ± 16.92
Body height (m)	165.26 ± 5.19	167.86 ± 5.73	166.73 ± 5.34
Body mass index (kg·m)	26.59 ± 4.81	26.86 ± 3.23	27.80 ± 5.63
Body fat (%)	39.81 ± 4.69	39.85 ± 3.12	39.42 ± 4.89

Note: WB-EMS - whole-body electromyostimulation group, RT – resistance training group, CG – control group. n – number of participants

Measurements

All participants underwent two identical experimental tests and measurements before and after the ten weeks of the intervention program. Firstly, the body composition was assessed using dual-energy X-ray absorptiometry (DXA). Then, the senior fitness test battery (SFT) determined the level of functional fitness in older women. All tests and measurements lasted about 40 minutes and were performed by trained personnel. The body composition measurements (DXA) were carried out in a laboratory.

Senior Fitness Test (SFT) was created to evaluate the individual components of functional fitness in older adults (Rikli & Jones, 2013). All Senior fitness subtests were performed in a gym:

- 30 Chair stand test: assessing the level of the strength of lower limbs,
- 6 Minute Walk test: assessing the level of endurance,
- 8 Foot up and Go test: assessing the level of agility, dynamic balance and reaction speed,
- Arm Curl test: assessing the level of the strength of upper limbs,
- Chair Sit and Reach test: assessing the level of flexibility of the lower limbs. The fingertips touching the toes is considered "0", overlapping is considered "+" and not touching "-".
- Back Scratch test: assessing the level of flexibility of the upper limbs. The tip of the middle fingers touching is considered "0", overlapping is considered "+" and not touching "-".

The dual-energy X-ray absorptiometry (DXA) assessed the body composition (BMI characteristics, muscle mass, body fat). This non-invasive method uses a very small dose (0,001–0,015 mSv) of ionising radiation. The body composition measurements were carried out in a laboratory using the whole-body scanner.

Interventional program

Whole-body electromyostimulation program

Whole-body electromyostimulation works on the principle of weak electrical impulses that stimulate motor units in muscles. The Miha Bodytec device is used, which consists of the main control panel and a training vest with electrodes that produce a weak electrical impulse to the muscles.

The WB-EMS group completed the exercise once a week and included 10 sessions. Those participants whose attendance was lower than 80 % were not included in the data analyses. The first training lasted 60 minutes when the tested persons were informed about the exercise method, and then the participants prepared for the first training. The intensity of the pulses was set up individually and was initial for the following exercise units. Following training sessions lasted 20 minutes and the basic whole-body exercise program was used. The program uses the traditional 4 s interval with gradual onset and 4 s interval of rest.

Table 2 describes the WB-EMS interventional training protocol in more detail.

Table 2. Whole-body electromyostimulation training protocol

WB-EMS unit	
Introductory part	Basic static position
Main part	
Workout 1	Half-Squat
Workout 2	Trunk Rotation (both sides)
Workout 3	Lunges (right leg to the front)
Workout 4	Lunges (left leg to the front)
Workout 5	Reverse Flies (forearms up)
Workout 6	Chest Flies (forearms up)
Workout 7	Side Lunges (both sides)
Workout 8	External Arms rotation
Workout 9	Back Extension
Workout 10	Triceps Kickback

Circuit resistance training program

The resistance training was carried out twice a week and included 20 sessions. Those participants whose attendance was lower than 80 % were not included in the data analyses. One week before the intervention, two trial training units took place, during which the test persons were instructed in the setting up of exercise machines and were shown the correct exercise technique. The individual load for individual exercises according to the ten-repetition maximum (RM) was set (= modification 1 RM for the elderly, the load they can lift 10 times). A load of 65–70 % 1RM was used for the first week of the intervention, and a load of 70–75 % 1RM was used from the second week of the intervention.

The training unit lasted 60 minutes. Table 3 describes the RT interventional training protocol in more detail.

Table 3. Resistance training protocol

Resistance training unit	
Introductory part	Warm-up Joint mobilization exercise, dynamic stretching
Main part	
Workout 1	Activation of the deep stabilization system
Workout 2	Bench press
Workout 3	Lunges back
Workout 4	Reverse Pec deck
Workout 5	Squats (with gymnastics ball supported by the wall)
Workout 6	Lat Pulldown
Workout 7	Leg Extension
Workout 8	Triceps Pulldown
Workout 9	Lying Leg Curls
Workout 10	Biceps Cable Curls
Final part	
	Static stretching

Data analysis

All analyses were conducted using Statistica 12.0 program. Data are presented as arithmetic group means, and the standard deviation (SD) of the mean. Data were examined for normality using a Kolmogorov-Smirnov test. Subsequently, two-way, repeated-measures ANOVA was undertaken for variables of the Senior Fitness Test between the groups. Statistical significance was set at $p \leq 0.05$.

RESULTS

Table 4 shows the basic descriptive characteristics (mean, standard deviation, minimal and maximal values) and the statistical significance values of individual Senior fitness tests measured before (pre-test) and after a ten-week lasting intervention program (post-test) in both interventions (WB-EMS, RT) and the control groups (CG).

Table 4 Descriptive statistics of Senior Fitness Test in all groups

	WB-EMS (n = 19)	*RT* (n = 22)	*CG* (n = 22)
6 Min Walk (m)			
Pre-test (M±SD)	649.00 ± 67.45	675.00 ± 29.94	621.90 ± 65.27
Pre-test (Min/Max)	537.5/780	625/738	513/744
Post-test (M±SD)	657.28 ± 52.2	688.43 ± 32.33	655.35 ± 70.94
Post-test (Min/Max)	582/775	631/734	535/775
p-value	0.95	0.59	0.14
Chair stand (number)			
Pre-test (M±SD)	17.73 ± 4.24	17.18 ± 3.71	17.47 ± 4.35
Pre-test (Min/Max)	12/27	12/29	11/26
Post-test (M±SD)	19.52 ± 2,98	21.00 ± 4,85	19.09 ± 4.08
Post-test (Min/Max)	14/25	15/31	13/28
p-value	0.12	0.04 *	0.00 *
8 Foot up and Go (s)			
Pre-test (M±SD)	4.36 ± 0.49	4.00 ± 0.58	4.42 ± 0.59
Pre-test (Min/Max)	3.5/5.28	3.4/5.94	3.4/5.94
Post-test (M±SD)	4.02 ± 0.41	3.70 ± 0.34	4.28 ± 0.48
Post-test (Min/Max)	3.2/5.1	3.23/4.41	3.49/5.5
p-value	0.34	0.03 *	0.13

Arm Curl Right (number)			
Pre-test (M±SD)	21.68 ± 3.84	22.86 ± 3.58	24.52 ± 3.44
Pre-test (Min/Max)	15/28	19/31	15/31
Post-test (M±SD)	24.31 ± 2.90	26.95 ± 3.42	25.33 ± 2.90
Post-test (Min/Max)	19/29	22/34	19/30
p-value	0.22	0.10	0.13
Arm Curl Left (number)			
Pre-test (M±SD)	21.00 ± 3.17	22.90 ± 3.25	24.23 ± 3.14
Pre-test (Min/Max)	14/27	16/29	17/30
Post-test (M±SD)	23.73 ± 2.64	26.40 ± 3.67	24.85 ± 2.74
Post-test (Min/Max)	19/30	21/34	20/31
p-value	0.70	0.67	0.50
Back Scratch Right (cm)			
Pre-test (M±SD)	-2.47 ± 8.66	-0.52 ± 7.36	-1.69 ± 8.05
Pre-test (Min/Max)	-24/9	-22/11	-17/14
Post-test (M±SD)	-0.50 ± 7.50	0.22 ± 6.63	-1.26 ± 7.92
Post-test (Min/Max)	-16/9.5	-18/8	-18/9
p-value	0.06	0.69	0.16
Back Scratch Left (cm)			
Pre-test (M±SD)	-6.65 ± 8.63	-4.54 ± 7.65	-7.90 ± 7.96
Pre-test (Min/Max)	-25/5	-20/9	-20/7
Post-test (M±SD)	-5.52 ± 8.59	-3.90 ± 7.98	-6.85 ± 8.12
Post-test (Min/Max)	-23/5	-21/11	-21/9
p-value	0.22	0.02*	0.13
Chair Sit and Reach Right (cm)			
Pre-test (M±SD)	7.60 ± 8.31	6.86 ± 9.69	8.71 ± 8.55
Pre-test (Min/Max)	-10/21	-14/20	-16/22
Post-test (M±SD)	9.13 ± 8.65	6.90 ± 8.73	8.19 ± 8.21
Post-test (Min/Max)	-4/27	-13/21	-15/24
p-value	0.57	0.05*	0.07

Chair Sit and Reach Left (cm)			
Pre-test (M±SD)	6.34 ± 10.76	7.25 ± 10.61	9.09 ± 8.38
Pre-test (Min/Max)	-19/21	-16/23	-16/21
Post-test (M±SD)	8.73 ± 9.24	7.59 ± 8.89	7.59 ± 9.19
Post-test (Min/Max)	-8/28	-13/21	-15/24
p-value	0.05*	0.18	0.00 *

Note: WB-EMS – whole-body electromyostimulation group, RT – resistance training group, CG – control group. n – number of participants, M - Mean, SD – standard deviation, SFT – Senior fitness test, p-value – statistical significance, * p ≤ 0.05

The results demonstrate that both interventional programs (WB-EMS and RT) had a positive effect on the level of functional fitness. As can be seen from the data in Table 4, the RT group reported a statistically significant difference between pre-and post-test in values in the Chair Stand test assessing the level of the strength of lower limbs (p = 0.04), 8 Foot up and Go test assessing the level of agility, dynamic balance and reaction speed (0.03). Also, in the Back Scratch test (left side) evaluating the flexibility of the upper limbs and the Chair Sit and Reach Test (right side) evaluating the flexibility of the lower limbs we found statistically significant results (p = 0.02 in the Back Scratch test left side, p = 0.05 in the Chair Sit and Reach test right side).

The results reveal that the WB-EMS interventional program had a positive statistically significant effect only on the level of flexibility of the lower limbs measured by the Chair Sit and Reach test left side (p = 0.05). In all other SFT subtests in the WB-EMS group, same as in the RT group, we can observe an improving trend.

The statistically significant results indicated an increase in the level of the measured variables we also found in the control group in the Chair Sit and Reach test left side (p = 0.00) and in the Chair Stand test (p = 0.00).

It is interesting to follow the SD, minimal and maximal values reached in pre-and post-tests. SD values decreased almost in all subtests in the WB-EMS group (except the test Chair Sit and Reach right). This fact testifies to the equalization of the performance of individual tested persons. In contrast to the WB-EMS group, individual differences increased for the RT group after completing IP; SD rose for 3 subtests (6 Min Walk Test; Arm curl left; Back Scratch left). The same trend occurred in CG (6 Min Walk Test; Back Scratch left; Chair Sit and Reach left).

DISCUSSION

Old age is a period in a person's life in which many changes occur in the human organism. Consequently, these changes often have a negative effect on the quality of life and the level of self-sufficiency in the elderly. One of the means for maintaining them at a sufficient level is physical activity. However, due to health reasons, not all older adults can engage in regular physical activities in that positive way could affect the above-mentioned parameters. For this reason, one of the interventional programs chosen in our study was the whole-body electromyostimulation (WB-EMS) which is also suitable for the elderly with various types of health restrictions (e.g., after surgery, injury, physical disabilities…). The second type of IP was, already more used, resistance training.

So, the study was aimed at investigating the effect of WB-EMS and resistance RT on the level of functional fitness in a group of elderly women. We supposed that for both types of IP, there would be a statistically significant improvement in the level of strength parameters of the lower and upper limbs (measured by tests: Arm curl and Chair stand). Based on the results, we reject the established hypothesis.

In comparison to WB-EMS and RT groups, better results were confirmed in the RT group. Despite the fact, that the development of agility, dynamic balance and reaction speed were not the main aim of the IP, the RT group achieved precisely the best result in the 8 Foot up and Go test ($p = 0.03$). This positive result could be caused by the learning effect in the post-test measurements or the application of dynamic stretching exercises more demanding on the balance abilities in the warm-up.

The training units of the RT group focused on hypertrophy and increasing the level of strength. Due to the principle of specificity, the second most visible improvement appeared in the tests assessing the strength of the lower extremities measured by the Chair Stand test ($p = 0.04$). The resistance training included specific exercises for the Chair Stand Test (squats with a gymnastic ball, lunges back) which probably increased the effect of training on SFT. Although leg extensions and lying leg curls are not specific exercises to increase the effectiveness of squats and the Chair Stand Test, their inclusion may have a favourable effect on the level of flexor and knee extensor strength that is essential to the Chair Stand Test.

Also, in the parameter of the flexibility of lower and upper limbs in the RT group, we monitored the statistically significant enhancement. Although, as with the 8 Foot up and Go test, the IP was not aimed at developing the level of flexibility, the joint mobilization exercises (preparation before circuit training) included as a necessary part of the unit, may have influenced the result. The significant change in flexibility can also be caused by sufficient frequency and intensity of static stretching at the end of the exercise unit. Static stretching is effective enough to compensate for the unfavourable effects of resistance training on flexibility levels (Marques et al., 2009) and also to faster the regenerative processes after this type of training load.

Even if the other tested parameters did not show statistically significant results, we can observe the improving tendency. The study conducted by Todde et al. (2016) applying resistance training, confirmed the statistical improvement of all tests, except the 8-Foot Up and Go Test, despite the low specificity of the training units, especially in terms of flexibility. Participants achieved high heart rate values during the training, which could be a decisive factor leading to maximum training efficiency.

The results of our research slightly differ from the results of the research led by Liuet et al. (2009), whose intervention program consisted of progressive resistance training. Their conclusions indicated an increase in the level of muscle strength of the upper and lower extremities. The improvement of the remaining functional parameters was minimal. A statistically significant improvement of some functional parameters, a slight improvement and stagnation indicate a positive effect of this intervention on the level of functional fitness. Recommendations for improving the level of functional fitness suggest repeating resistance training three times a week with an individual load intensity of 80% of the one-repetition maximum (1RM) (Papa et al., 2017). Ferguson (2014) also states that high-intensity training performed 2–3 times per week is the best method to reduce the prevalence of sarcopenia.

The results show the WB-EMS group increased significantly only the level of flexibility of the lower limbs measured by the Chair Sit and Reach test left side ($p = 0.05$). The other abilities revealed only a positive trend of increasing the level of the monitored parameter. However, it must be remembered that due to the natural decrease in the level of functional fitness with increasing age, stagnation or slight enhancement of parameters of functional fitness could be assessed as a positive result.

The synthesis of the findings does not show that many studies focused on the effect of WB-EMS on the level of functional fitness in the elderly, which could be a question for further, long-term research. Kemmler et al. (2021) mediated a meta-analysis dealing with the effect of WB-EMS on various parameters, which showed a statistically significant change in muscle mass, lower extremity strength, and back extensor strength. However, it did not show a positive effect on body fat, which is affected by caloric intake. We also know from the synthesis of knowledge that long-term training with progressive overload continues to have a positive effect on the level of functional fitness and reduction of sarcopenia, and individuals can improve this rate with some speed and to some extent. Sufficient volume and progressive overload are needed for strength adaptation and muscle tissue hypertrophy. Even after the interruption of physical activity, the adaptation does not completely disappear. Individuals after three years without physical activity, who trained for two years in the form of resistance training, had more strength after these five years than before the start of strengthening (Smith et al., 2003).

The statistically significant results indicated an increase in the level of the measured variables we surprisingly found also in the control group, more precisely in the Chair Sit and Reach test left side ($p = 0.00$) and in the Chair Stand test ($p = 0.00$). The results could be influenced by the season in which the measurements and interventional program took part. The interventional programs were held in spring or in autumn when older adults are engaged in gardening walking or cycling in nature. As already mentioned in the text above, also the learning effect or the level of motivation could positively influence the results. Despite the random division of the tested persons into groups, we have to state that the control group achieved very good results already in the pre-test. Due to this fact, in future research, we think about the division based on other criteria.

CONCLUSION

To conclude, this study tried to determine the effect of a ten-week lasting RT and WB-EMS interventional program on the level of functional fitness in a group of elderly women.

The results of all individual components of functional fitness measured by SFT in both experimental groups (WB-EMS, RT) show an improving tendency. Comparing WB-EMS and RT groups, better results were confirmed in the RT group. Some of the followed parameters indicate statistically significant improvement (p <0.05) – the level of the strength of the upper and lower extremities, the level of agility, dynamic balance and reaction speed and the level of flexibility of the upper and lower limbs in the group of RT. In the group WB-EMS, we found statistically significant results only in the level of mobility of one side of the upper extremities. We also consider the fact that both groups improved in all other tests to be very positive. Apart from the importance of maintaining the level of physical fitness in older adults at a sufficient level, the positive impact of physical activity on some other anthropometrical (e.g., maintaining the amount of muscle mass as a prevention of osteoporosis) and physiological aspects (e.g., lowering of blood pressure) must not be omitted. The following study could be focused on determining the effect of these two interventional programs on bone mineral density and T-score values in women at risk of sarcopenia.

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