Impact Of Whole-Body Electromyostimulation and Resistance Training Programme on Strength Parameters and Body Composition in Group of Elderly Women at Risk of Sarcopenia

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ABSTRACT

Objective: The purpose of the study is to compare the effect of ten-week lasting whole-body electromyostimulation (WB-EMS) and the circuit resistance training programme (RT) on body composition and strength parameters in women at risk of sarcopenia.
Methods: The WB-EMS programme was carried out once a week and included ten exercise sessions, the RT was carried out twice a week and included 20 sessions. 17 elderly women participated in the study, nine in a WB-EMS intervention group (age: 63.11 ± 1.52 years; weight: 70.07 ± 9.07 kg; height: 165.11 ± 6.4 cm; BMI 25.81 ± 3.96 kg/m2), eight in a RT group (age: 62.13 ± 1.69 years; weight: 73.58 ± 3.87 kg; BMI 27.34 ± 2.58 kg/m2). To assess body composition, dual-energy X-ray absorptiometry (DXA) was used. To determine the level of strength parameters, hand dynamometry and isokinetic dynamometry of knee flexors and knee extensors were used.
Results: Body composition assessment was performed by dual-energy X-ray absorptiometry and strength parameters were evaluated using isometric dynamometry (knee flexors and extensors strength). After completing ten weeks of intervention, significant differences were observed for lean muscle mass (RT group, $\text{Leanmass}_{\text{pre-test}}$ 43316.91 ± 1856.77 vs. $\text{Leanmass}_{\text{post-test}}$ 43939.56 ± 1869.84, p = 0.0307). No significant differences were found between the pre-test and post-test in the WB-EMS group ($\text{Leanmass}_{\text{pre-test}}$ 39472.56 ± 3370.04 vs. $\text{Leanmass}_{\text{post-test}}$ 38835.56 ± 3306.84, p = 0.5995). The isokinetic dynamometry analysis showed significant differences for the extensors and the peak torque on the right side in the RT group (Extensors Peak $\text{Torque}_{\text{pre-test}}$ 98.00 ± 13.55 vs. Extensors Peak $\text{Torque}_{\text{post-test}}$ 38835.56 ± 3306.84, p = 0.0160; Flexors Peak $\text{Torque}_{\text{pre-test}}$ 54.25 ± 11.14 vs. Flexors Peak $\text{Torque}_{\text{post-test}}$ 59.75 ± 11.13, p = .0059).
Conclusions: The most obvious finding that emerges from this study is that resistance training has shown a greater effect than whole-body electromyostimulation.

Keywords: ageing; dynamometry; strength; physical activity; WB-EMS

INTRODUCTION

Ageing is associated with many changes in physical involution, which dramatically affects the health status and quality of life of the elderly. One of the diseases related to the ageing process is sarcopenia (Peterson et al., 2011; Romero-Arenas, 2013) described as an age-related reduction in the volume of the appendicular skeletal muscle mass, also including the loss of muscle strength and functionality that usually accompany the loss of muscle mass (Fried et al., 2001; Marcell, 2003). Along with muscle mass loss, the level of muscle strength also decreases. Furthermore, older women are more sensitive to the incidence of sarcopenia due to lower initial muscle mass and muscle strength levels. Strong evidence of changes in hormonal production related to advancing age was found. Anabolic hormone levels decrease with age. The level of estrogen decreases after menopause in women. Also, insulin-like growth factors (IGF-1) decrease with age. These changes contribute to impaired protein synthesis (Brady et al., 2014; Ribeiro et al., 2017). Increasing levels of cortisol, insulin resistance, and the amount of fat tissue also contribute to reducing muscle mass (Marcell, 2003; Raguso et al., 2006). With ageing and an increase in fat mass, insulin resistance often develops, which is accompanied by decreased glucose tolerance. Insulin exposure contributes to increased muscle protein. Insulin resistance may therefore be associated with loss of muscle protein and catabolism, and can gradually lead to sarcopenia (Guillet & Boirie, 2005). Furthermore, there is a decrease in bone density (Daly et al., 2013). Sarcopenia with all of these factors has an influence on quality of life in the elderly, a higher risk of falls and fractures, and subsequently loss of self-sufficiency (Rhodes, 2000). Unfortunately, the ability and desire to exercise regularly decrease with increasing age. It leads to the acceleration of involution processes and thus to a reduced quality of life (Cruz-Jentoft et al., 2019; Kemmler et al., 2014; von Stengel & Kemmler, 2018).

Physical activity, specifically resistance training with respect to the health status of ageing adults, can significantly affect the ageing process and lead to the prevention of sarcopenia (Breen & Phillips, 2013; Forbes et al., 2012; Pedersen & Saltin, 2006; Taylor, 2014). Previous research that deals with the influence of physical activity on strength parameters and body composition in older age mentions resistance training or its combination with balance and flexibility exercises, endurance exercises, or walking. The studies also deal with water exercises and alternative variants of resistance training (Ilmar Danilo Santos et al., 2019; Kemmler et al., 2016; Kemmler & von Stengel, 2012; Lopez et al., 2018; Peterson et al., 2011; Ribeiro et al., 2017).

Our research deals with resistance training (RT) and the whole-body electromyostimulation method (WB-EMS). Resistance training appears to be effective in the prevention of sarcopenia in older adults (Cruz-Jentoft et al., 2019; Pedersen & Saltin, 2006; Taylor, 2014). Resistance exercise stimulates the release of anabolic hormones (Vingren et al., 2010) and leads to muscle hypertrophy and increased muscle strength (Kemmler et al., 2014; Kosek et al., 2006; Peterson et al., 2011; von Stengel & Kemmler, 2018). Studies have shown that resistance training improves the parameters of bone density of the femoral neck and lumbar spine (Huovinen et al., 2016; Marques et al., 2012). Socialisation during circuit resistance training leads to a higher level of motivation (Romero-Arenas et al., 2013). In addition to the above, the advantages of RT in older adults are mobility improvement, perceiving more energy, and self-confidence (Taylor, 2014).

Alternative forms of exercise provide health benefits to people who are unable or unwilling to engage in conventional types of exercise due to physical limitations or lack of motivation (Kemmler, et al., 2016; Kemmler & von Stengel, 2013). The WB-EMS method offers an alternative or additional training method to RT and has the potential to activate a higher number of motor units than classical resistance training. A favourable effect of WB-EMS on muscle strength of the upper and lower extremities was found (Pano-Rodriguez et al., 2020; von Stengel et al., 2015). Also, studies mentioned a positive effect on the amount of muscle mass (Kemmler et al., 2014) and on maintaining mineral bone density (von Stengel et al., 2015). The WB-EMS method seems to be a suitable method to prevent the risk of falling. The advantage of the WB-EMS method is the portability of the device and the time-efficiency (Kemmler et al., 2016; Langeard et al., 2017), care of the joints and tendons, which may be a suitable alternative for the ageing population with physical limitations (Kemmler et al., 2018; Kemmler et al., 2016). However, it is still a relatively costly method(Kemmler et al., 2016; Kemmler & von Stengel, 2012). WB-EMS seems to be an attractive alternative for people unable or unwilling to engage in traditional forms of resistance exercise.

Most studies have observed the effect of EMS training compared to a control group or exercise other than resistance training. The purpose of the study is to compare the effect of 10 weeks of WB-EMS and the circuit resistance training programme on body composition, bone density, and strength parameters in women at risk of sarcopenia.

METHODS

Participants

The elderly participants were recruited using the snowball technique from several sources. A cooperating organisation that provided physical activities for the elderly (rehabilitation centres, swimming pools, etc.) was addressed. Recruitment was also carried out on the website and Facebook profile of the Faculty of Sports Studies of Masaryk University Brno in the Czech Republic.

Inclusion criteria were: age 60-65 years, without regular physical activity and contraindications (epilepsy, cardiac pacemaker, severe circulatory system disease, abdominal or inguinal hernia, cancer, advanced arteriosclerosis, severe neurological disease, acute -bacterial or viral disease, diabetes mellitus, haemophilia, liver disease, tuberculosis, severe circulatory system disorders - eg unstable angina pectoris, untreated hypertension, uncontrolled heart rhythm disturbance, heart failure, valve stenosis, hypertrophic cardiomyopathy, reduced mobility, metal implants).

The 21 women aged 60 to 65 years met the inclusion criteria of the ten-week lasting interventional programmes. The participants were randomly divided into 2 groups – the whole body electromyostimulation group (WB-EMS) and the resistance training group (RT). All participants in this experimental study were asked to sign an informed consent form approved by the Ethics Committee of Masaryk University, Brno. The Ethics Committee application number was 0549/2019.

The WB-EMS group consisted of eleven women (nine women completed the intervention programme), and the RT group included ten women (eight women completed the intervention programme).

The participants were asked to maintain their usual daily regimen with the same amount of physical activity and a normal daily lifestyle. The descriptive characteristics (age, BMI, height, weight, number of men and women) of the study sample are shown in Table 1.

Table 1. Descriptive characteristics of the study sample

Variable	EMS-WB group		RT group	
	M	SD	M	SD
Age	63.11	1.52	62.13	1.69
BMI	25.81	3.96	27.34	2.58
Weight (kg)	70.07	9.70	73.58	3.87
Height (cm)	165.11	6.40	165	5.32
N	9		8	

Notes: M – mean, SD – standard deviation, BMI – body mass index, EMS-WB – Whole-body Electromyostimulation, N– number of tested participants

The participants were evaluated at the beginning (baseline) and at the end of the ten-week lasting of intervention (post-test). First, the DXA measurements were found out, followed by a hand and isokinetic dynamometry. All tests and measurements that lasted approximately 40 minutes were carried out by trained persons in laboratories of the Faculty of Sport Studies of Masaryk University Brno.

Measurements

Dual-energy X-ray absorptiometry (DXA) measures body composition and also bone density. DXA is commonly used to diagnose osteoporosis. This non-invasive method uses a very small dose (0,001–0,015 mSv) of ionising radiation. To measure body composition, the whole-body scanner was used. To measure bone density, the lumbar spine and upper part of the femur were monitored.

Hand Grip Dynamometry measures the level of maximum static short-term strength of the grip of hand flexors. The test is performed two times with the left hand and two times with the right hand. The better result of these two attempts is taken into account.

Measurement of the strength parameters of knee flexors/extensors

Concentric strength of the knee flexors/extensors was assessed at 60°/s using a Humac NORM isokinetic dynamometer. All participants were familiar with isokinetic measurements before the study /familiar testing measurement was done one week before the study. All participants were asked to avoid intense physical activity two days before the test. The maximum concentric strength of the knee flexors and extensors was measured from 0 to 90˚of knee flexion. The measurements of the isokinetic study protocol started with a warm-up (six min cycling at 1W/kg body weight, four min cycling at 1.5W/ kg body weight). Subsequently, the researcher explained and set the initial position (seat position with the backrest at 85°). Minimalizing compensation movements were secured with safety straps across the tested thigh, pelvis, and chest. The researcher clearly explained the instructions about the testing - each participant gave instructions to push as hard and fast as possible during the full range of motion. The isokinetic test consisted of three sets of four repetitions. The break between sets was three min and 30 s between the repetitions. The best attempt was recorded.

Intervention programme

Whole-Body Electromyostimulation Programme

The WB-EMS is a method in which weak but very frequent electrical impulses activate not only the superficial muscles but also those located in the deep layers of the body. Complex electro-myo-stimulation works with up to ten pairs of electrodes, each pair is located on the right and left half of the body. The impulse thus takes place in all muscles from one half of the body to the other, and not only in the places where the electrodes are placed. With total electromyostimulation, the duration of the training unit is 20 minutes, during which the muscles are four seconds in the tension phase (85 muscle contractions occur every second) and four seconds in the relaxation phase.

The WB-EMS occurred on the Miha Bodytec device. The WB-EMS Programme took place once a week for ten weeks. The first class lasted 60 minutes and included an entry review that covered information about the intervention programme process. The entry review was followed by a 12-minute class (pulse test and strengthening programme). The intensity of the electric pulses was set according to the actual possibilities of the tested persons. These values were loaded and were the initial values for the next courses. Other courses were held once a week, ideally on the same day, and lasted 20 minutes. The regeneration time (four days minimum between two courses) was obeyed. In the training sessions, exercises of similar character as resistance training were involved (Table 2).

Table 2. WB-EMS training protocol

Sequence	Exercise	Number of repetitions
0	Basic static position	
1	Half-squat	12
2	Trunk rotation (left and right)	8
3	Lunges (left side)	8
4	Lunges (right side)	8
5	Reverse fly (forearms up)	12
6	Chest fly (forearms up; concentric phase only)	6
7	Side lunges (left and right)	8
8	External arm rotation (left and right)	6
9	Back extension	6
10	Triceps kickback	6

Circuit resistance training programme

The minimum attendance with the possibility of replacing the training was set at 80%. The time interval between two trainings and the frequency two times a week had to be kept. One week before starting the intervention programme 2 introducing training sessions were held (manipulation with strengthening machines, correct technique of workouts, individual load setting according to a maximum of ten repetitions). For the first week of the intervention program, the load was calculated at 65 – 70%, for the second week, 70–75% RM.

Before the very beginning of the intervention, there was a training week for the probands, which consisted of two training units, during which the women got acquainted with the gym environment, with fitness machines, with their manipulation, and also with the demonstration of workouts used in training programmes. A preparatory class with training on the correct execution of the workouts and setting the individual load according to the 1RM (=one repetition maximum) was followed. We used 1RM modification of ten repetitions for the elderly, demonstrating the load they can lift ten times. From the resulting load, 65-70% RM max was calculated (for the first week of intervention), then 70-75% RM max (from the second week of intervention).

Each unit started with a warm-up including walking modifications, joint mobilisation exercises and dynamic stretching. The main part of the unit contained three circuits with ten positions (Table 3). Between each position, a short pause of about 1–1,5 minutes takes place. The pause among circuits lasted 3 to 5 minutes (for drinking, short regeneration, etc.). The unit was finished with static stretching.

Table 3. Resistance training protocol

Sequence	Exercise	Number of repetitions
1	Tabletop Leg Press	10–12
2	Bench Press	10–12
3	Back Lunges (left and right side)	10–12
4	Reverse Pec-deck	10–12
5	Wall Squats (with gymnastic ball)	10–12
6	Lat Pulldown	10–12
7	Leg Extensions	10–12
8	Triceps Pulldown	10–12
9	Lying Hamstring Curls	10–12
10	Biceps Cable Curl	10–12

Statistical analyses

For the analysis of the data obtained, Statistica 12 and Microsoft Excel software were used. Descriptive data are summarised as mean (M) ± standard deviation (SD). The assumption of normality was verified using the Shapiro-Wilk statistic. For reliability analysis, the paired sample t-tests compared the selected parameters between pre-test and post-test.

RESULTS

T-tests were used to analyse the relationship between pre and post-tests for each intervention group. The results obtained from the Dual-energy X-ray absorptiometry are presented in Table 4. Data from this table (Table 4) can be compared with the data in Table 5 which shows the difference between the interventional group (WB-EMS vs. RT).

Table 4. The average values of body composition measurements in the WB-EMS group

Variables	Pre-test (n=9)	Post-test (n=9)	*p* value pre vs. post-test
BMD-WB (g/cm3)	0.98 ± 0.06	0.97 ± 0.05	NS (0.3131)
T score	-1.6 ± 0.80	-1.7 ± 0.71	NS (0.4088)
LMI	14.50 ± 1.14	14.31 ± 1.13	NS (0.9741)
Lean Mass (g)	39472.56 ± 3370.04	38835.56 ± 3306.84	NS (0.5995)
Subtotal total (g)	65797.11 ± 9642.97	65439.89± 9899.86	NS (0.3305)
Subtotal fat	41.26 ± 5.05	41.84 ± 5.38	**0.0081***
Subtotal L+BMC (g)	38235.44 ± 3329.81	37609.78 ± 3270.23	**0.0153***

Notes: BMD - bone mineral density, WB - whole body, LMI - lean mass index; *$p < 0.05$; NS: not statistically significant

Table 5. The average values of body composition measurement in RT group

Variables	Pre-test (n=8)	Post – test (n=8)	*p* value pre vs. post-test
BMD-WB (g/cm3)	0.98 ± 0.06	0.98 ± 0.04	NS (0.1677)
T score	-1.6 ± 0.65	-1.7 ± 0.74	NS (0.1704)
LMI	16.01 ± 1.05	16.21 ± 1.10	NS (0.0744)
Lean Mass (g)	43316.91 ± 1856.77	43939.56 ± 1869.84	**0.0307***
Subtotal total (g)	69747.91 ± 3777.37	70496.51± 4066.68	**0.0388***
Subtotal fat	39.61 ± 2	39.42 ± 2.65	NS (0.3281)
Subtotal L+BMC (g)	42057.41 ± 1937.56	42667.11 ± 1975.92	**0.0274***

Notes: BMD - bone mineral density,WB - whole body, LMI - lean mass index;*$p < 0.05$; NS: not statistically significant

No significant differences were found between BMD-WB, T score, LMI and Subtotal fat in the RT group. As can be seen from Table 5, the RT group reported a significant difference, especially in the Lean Mass parameter which has highly important health consequences ($Leanmass_{pre\text{-}test}$ 43316.91 ± 1856.77 vs. $Leanmass_{post\text{-}test}$ 43939.56 ± 1869.84, $p = 0.0307$).

Tables 6 and 7 compare the summary statistics for the selected intervention programme (EMS-WB and RT).

Table 6. The average values of strength parameters from isokinetic dynamometry measurements in the WB-EMS group (knee flexors and extensors strength)

Variables	Pre-test (n = 9)	Post-test (n = 9)	*p* value pre vs. post-test
L Extensors Peak Torque (N/m)	89.33 ± 9.36	89.55 ± 15.37	NS (0.9492)
R Extensors Peak Torque (N/m)	96.66 ± 11.07	97.55 ± 15.95	NS (0.7901)
L Flexors Peak Torque (N/m)	49.88 ± 8.56	53.33 ± 10.44	NS (0.0599)
R Flexors Peak Torque (N/m)	47.22 ± 6.99	55.11 ± 11.87	**0.0142***
L Extensors Time to Peak Torque (s)	0.43 ± 0.07	0.43 ± 0.05	NS (0.9751)
R Extensors Time to Peak Torque (s)	0.46 ± 0.09	0.45 ± 0.11	NS (0.8122)
L Flexors Time to Peak Torque (s)	0.44 ± 0.09	0.46 ± 0.09	NS (0.3645)
R Flexors Time to Peak Torque (s)	0.43 ± 0.10	0.38 ± 0.05	NS (0.0505)
Handgrip (dominant hand) (kg)	24.87 ± 3.95	25.12 ± 3.26	NS (0.8426)

Notes: L - left side, R - right side;*$p < 0.05$; NS: not statistically significant

Strong evidence of improvement of strength was found when Flexors Peak Torque or right side was compared (Flexors Peak Torque$_{\text{pre-test}}$ 47.22 ± 6.99 vs. Flexors Peak Torque $_{\text{post-test}}$ 55.11 ± 11.87, *p= 0.0142*). This result is significant at the p = 0.05 level.

Table 7. The average values of strength parameters from isokinetic dynamometry measurements in RT group (knee flexors and extensors strength)

Variables	Pre-test (n = 8)	Post-test (n = 8)	*p* value pre vs. post-test
L Extensors Peak Torque (N/m)	95.12 ± 11.60	100.37 ± 15.08	NS (0.2273)
R Extensors Peak Torque (N/m)	98.00 ± 13.55	106.25 ± 12.29	**0.0160***
L Flexors Peak Torque (N/m)	55.50 ± 12.36	58.75 ± 12.30	NS (0.2663)
R Flexors Peak Torque (N/m)	54.25 ± 11.14	59.75 ± 11.13	**0.0059***
L Extensors Time to Peak Torque (s)	0.44 ± 0.07	0.47 ± 0.11	NS (0.3711)
R Extensors Time to Peak Torque (s)	0.42 ± 0.06	0.42 ± 0.05	NS (0.8551)
L Flexors Time to Peak Torque (s)	0.44 ± 0.09	0.46 ± 0.09	NS (0.3645)
R Flexors Time to Peak Torque (s)	0.46 ± 0.10	0.43 ± 0.03	NS (0.4692)
Handgrip (dominant hand) (kg)	25.62 ± 2.40	25.03 ± 3.30	NS (0.2946)

Notes: L-left side, R-right side; *$p < 0.05$; NS: not statistically significant

The statistical significance differences between pre and post-test are highlighted in Table 7. (R Extensors Peak Torque $_{\text{pre-test}}$ 98.00 ± 13.55 N.m vs. R Extensors Peak Torque $_{\text{post-test}}$ 106.25 ± 12.29 N.m, *p= 0.0160*; R Flexors Peak Torque Torque $_{\text{pre-test}}$ 54.25 ± 11.14 N.m vs. R Extensors Peak Torque $_{\text{post-test}}$ 59.75 ± 11.13 N.m, *p= 0.0059*).

DISCUSSION

The purpose of the study was to compare highly discussed whole-body electromyostimulation with a resistance training program in a group of women at risk of sarcopenia. Regular physical activity on a daily basis plays a vital role in the quality of life (Galloza et al., 2017; McPhee et al., 2016). The whole body electromyostimulation is becoming increasingly popular due to its effectiveness and also the time that is dedicated to training (Kemmler et al., 2017; Pano-Rodriguez et al., 2020; Teschler & Mooren, 2019). Also, it is important to mention that each 1 h increase in sitting time during the day can lead to an increase of 33% of the risk of sarcopenia in the 60-year group regardless of physical activity or lifestyle (Gianoudis et al., 2015). On the other hand, in the last few years, there has been a growing interest in resistance training as a key part of regular physical activity in the elderly (Lopez et al., 2018; Tsuzuku et al., 2018).

This paper presents a unique result of comparing the effect of whole-body electromyostimulation and resistance training. We decided to show the differences between body composition assessment and strength parameters. Strong evidence of an improvement in strength was found when the Flexors Peak Torque on the right side was compared (Flexors Peak $Torque_{pre-test}$ 47.22 ± 6.99 vs. Flexors Peak Torque $_{posttest}$ 55.11 ± 11.87, *p= 0.0142*) in the whole body electromyostimulation group. The statistical significance was also found in the resistance training group (R Extensors Peak Torque $_{pre-test}$ 98.00 ± 13.55 N.m vs R Extensors Peak Torque $_{post-test}$ 106.25 ± 12.29 N.m, *p = 0.0160*; R Flexors Peak Torque Torque $_{pre-test}$ 54.25 ± 11.14 Nm vs R Extensors Peak Torque $_{post-test}$ 59.75 ± 11.13 Nm, *p = 0.0059*).

Furthermore, a better practical use was found in a group of resistance training in values of in the Lean Mass parameter, which has highly important health consequences ($Leanmass_{pre-test}$ 43316.91 ± 1856.77 vs. $Leanmass_{post-test}$ 43939.56 ± 1869.84, *p= 0.0307*).

Regarding body composition, studies evaluated the value of lean mass in the elderly women and men who participated in resistance training. After the intervention, the studies determined a significant increase in lean mass in women compared to the control group (Fjeldstad et al., 2009; Marcos-Pardo et al., 2019; Romero-Arenas et al., 2013). In contrast to our results, a study comparing WB-EMS and high-intensity resistance training listed similar effects of both methods on body composition. After 16 weeks of intervention, a significant increase in lean body mass was recorded in both groups. No significant changes between groups occurred (Kemmler et al., 2016). Some studies examined the effect of WB-EMS on body composition in the elderly women. Both studies reported a significant increase in lean body mass compared to the control group (Kemmler et al., 2014; von Stengel et al., 2015).

Regarding the strength parameters, many studies focused on the effect of WB-EMS in elderly non-trained subjects. A recent study compared resistant training and the WB-EMS method on overall physical fitness in untrained elderly women. After ten weeks of intervention, a statistically significant increase in the strength of the upper and lower extremities was determined in both groups. However, greater improvements were recorded in the WB-EMS group (Pano-Rodriguez et al., 2020). Furthermore, another study involving non-sporting elderly women determined the significant effect of WB-EMS training on the strength of leg and trunk extensors after the 54-week intervention. The same parameters were maintained or decreased slightly in the control group (Kemmler et al., 2014).

In addition, studies reported the favourable effect of resistance training on strength parameters. A study comparing the effect of WB-EMS and high intensity resistance training in middle-aged untrained men concluded that leg extensor strength increased significantly in both groups with no significant differences between the groups (Kemmler et al., 2016). Significant improvement in absolute values of maximal dynamic strength and muscle volume on knee extensor strength was determined by a study involving elderly women who underwent 12 weeks of resistance training intervention (Correa et al., 2013).

It was not possible to investigate the significant relationships between the selected parameters and the intervention further because the sample size was too small. Therefore, a further study with more emphasis on the duration of the intervention and with an increase in sample size is suggested. The higher number of participants and the longer duration of the exercise programme would contribute to objective results. Also, we did not monitor and influence the eating habits of the participants, which could have influenced the results of the intervention.

CONCLUSION

In conclusion, the most obvious finding that emerges from this study is that resistance training has shown a greater effect than whole-body electromyostimulation in values of the Lean Mass parameter, which has highly important health consequences. Strong evidence of an improvement in strength was found when the Flexors Peak Torque on the right side was in the WB-EMS group. The statistical significance was also found in the resistance training group. In addition to the observed parameters, the exercise programmes also had an effect on the social factor of the participants. The participants noted that through the exercise programmes they were in contact with their peers, learned the correct technique of exercises and experienced new types of exercises. Some of the participants continue practising physical activity and also, they continue meeting on other occasions. We consider the study to be rigorous in optimising physical activity recommendations of the elderly and in spreading awareness of the possibilities of exercise of the elderly.

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REFERENCES

Brady, A. O., Straight, C. R., & Evans, E. M. (2014). Body Composition, Muscle Capacity, and Physical Function in Older Adults: An Integrated Conceptual Model. *Journal of Aging and Physical Activity*, *22*(3), 441–452. https://doi.org/10.1123/JAPA.2013-0009

Breen, L., & Phillips, S. M. (2013). Interactions between exercise and nutrition to prevent muscle waste during ageing: Interventions for muscle anabolism in the elderly. *British Journal of Clinical Pharmacology*, *75*(3), 708–715. https://doi.org/10.1111/j.1365-2125.2012.04456.x

Correa, C. S., Baroni, B. M., Radaelli, R., Lanferdini, F. J., Cunha, G. D. S., Reischak-Oliveira, Á., Vaz, M. A., & Pinto, R. S. (2013). Effects of strength training and detraining on knee extensor strength, muscle volume and muscle quality in elderly women. *AGE*, *35*(5), 1899–1904. https://doi.org/10.1007/s11357-012-9478-7

Cruz-Jentoft, A. J., Bahat, G., Bauer, J., Boirie, Y., Bruyère, O., Cederholm, T., Cooper, C., Landi, F., Rolland, Y., Sayer, A. A., Schneider, S. M., Sieber, C. C., Topinkova, E., Vandewoude, M., Visser, M., Zamboni, M., Writing Group for the European Working Group on Sarcopenia in Older People 2 (EWGSOP2), and the Extended Group for EWGSOP2, Bautmans, I., Baeyens, J.-P., … Schols, J. (2019). Sarcopenia: Revised European consensus on definition and diagnosis. *Age and Ageing*, *48*(1), 16–31. https://doi.org/10.1093/ageing/afy169

Daly, R. M., Rosengren, B. E., Alwis, G., Ahlborg, H. G., Sernbo, I., & Karlsson, M. K. (2013). Gender specific age-related changes in bone density, muscle strength and functional performance in the elderly: A-10 year prospective population-based study. *BMC Geriatrics*, *13*(1), 71. https://doi.org/10.1186/1471-2318-13-71

Fjeldstad, C., Palmer, I. J., Bemben, M. G., & Bemben, D. A. (2009). Whole-body vibration augments resistance training effects on body composition in postmenopausal women. *Maturitas*, *63*(1), 79–83. https://doi.org/10.1016/j.maturitas.2009.03.013

Forbes, S. C., Little, J. P., & Candow, D. G. (2012). Exercise and nutritional interventions for improving aging muscle health. *Endocrine*, *42*(1), 29–38. https://doi.org/10.1007/s12020-012-9676-1

Fried, L. P., Tangen, C. M., Walston, J., Newman, A. B., Hirsch, C., Gottdiener, J., Seeman, T., Tracy, R., Kop, W. J., Burke, G., & McBurnie, M. A. (2001). Frailty in Older Adults: Evidence for a Phenotype. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences*, *56*(3), M146–M157. https://doi.org/10.1093/gerona/56.3.M146

Galloza, J., Castillo, B., & Micheo, W. (2017). Benefits of Exercise in the Older Population. *Physical Medicine and Rehabilitation Clinics of North America*, *28*(4), 659–669. https://doi.org/10.1016/j.pmr.2017.06.001

Gianoudis, J., Bailey, C. A., & Daly, R. M. (2015). Associations between sedentary behaviour and body composition, muscle function and sarcopenia in community-dwelling older adults. *Osteoporosis International*, *26*(2), 571–579. https://doi.org/10.1007/s00198-014-2895-y

Guillet, C., & Boirie, Y. (2005). Insulin resistance: A contributing factor to age-related muscle mass loss? *Diabetes & Metabolism*, *31*, 5S20-5S26. https://doi.org/10.1016/S1262-3636(05)73648-X

Huovinen, V., Ivaska, K. K., Kiviranta, R., Bucci, M., Lipponen, H., Sandboge, S., Raiko, J., Eriksson, J. G., Parkkola, R., Iozzo, P., & Nuutila, P. (2016). Bone mineral density is increased after a 16-week resistance training intervention in elderly women with decreased muscle strength. *European Journal of Endocrinology*, *175*(6), 571–582. https://doi.org/10.1530/EJE-16-0521

Ilmar Danilo Santos, L., Antonio Gomes de, R.-N., Jose Carlos, A.-S., Albernon Costa, N., Alan Bruno Silva, V., Bruna Caroline Oliveira, A., Iohanna Gilnara Santos, F., & Marzo Edir Da, S.-G. (2019). Effects of Different Methods of Resistance Training on Indicators of Daily Physical Fitness in Physically Active Elderly Women. *International Journal of Sports and Exercise Medicine*, *5*(7). https://doi.org/10.23937/2469-5718/1510136

Kemmler, W., Bebenek, M., Engelke, K., & von Stengel, S. (2014). Impact of whole-body electromyostimulation on body composition in elderly women at risk for sarcopenia: The Training and ElectroStimulation Trial (TEST-III). *AGE*, *36*(1), 395–406. https://doi.org/10.1007/s11357-013-9575-2

Kemmler, W., Kohl, M., Freiberger, E., Sieber, C., & von Stengel, S. (2018). Effect of whole-body electromyostimulation and / or protein supplementation on obesity and cardiometabolic risk in older men with sarcopenic obesity: The randomized controlled FranSO trial. *BMC Geriatrics*, *18*(1), 70. https://doi.org/10.1186/s12877-018-0759-6

Kemmler, W., Teschler, M., Weissenfels, A., Bebenek, M., von Stengel, S., Kohl, M., Freiberger, E., Goisser, S., Jakob, F., Sieber, C., & Engelke, K. (2016). Whole-body electromyostimulation to fight sarcopenic obesity in community-dwelling older women at risk. Resultsof the randomized controlled FORMOsA-sarcopenic obesity study. *Osteoporosis International*, *27*(11), 3261–3270. https://doi.org/10.1007/s00198-016-3662-z

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*, 1–8. https://doi.org/10.1155/2012/109013

Kemmler, W., & von Stengel, S. (2013). 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. *Clinical Interventions in Aging*, 1353. https://doi.org/10.2147/CIA.S52337

Kemmler, W., Weissenfels, A., Teschler, M., Willert, S., Bebenek, M., Shojaa, M., Kohl, M., Freiberger, E., Sieber, C., & von Stengel, S. (2017). Whole-body electromyostimulation and protein supplementation favorably affect sarcopenic obesity in community-dwelling older men at risk: The randomized controlled FranSO study. *Clinical Interventions in Aging*, *Volume 12*, 1503–1513. https://doi.org/10.2147/CIA.S137987

Kosek, D. J., Kim, J., Petrella, J. K., Cross, J. M., & Bamman, M. M. (2006). Efficacy of 3 days/wk resistance training on myofiber hypertrophy and myogenic mechanisms in young vs. Older adults. *Journal of Applied Physiology*, *101*(2), 531–544. https://doi.org/10.1152/japplphysiol.01474.2005

Langeard, A., Bigot, L., Chastan, N., & Gauthier, A. (2017). Does neuromuscular electrical stimulation training of the lower limb have functional effects on the elderly?: A systematic review. *Experimental Gerontology*, *91*, 88–98. https://doi.org/10.1016/j.exger.2017.02.070

Lopez, P., Pinto, R. S., Radaelli, R., Rech, A., Grazioli, R., Izquierdo, M., & Cadore, E. L. (2018). Benefits of resistance training in physically frail elderly: A systematic review. *Aging Clinical and Experimental Research*, *30*(8), 889–899. https://doi.org/10.1007/s40520-017-0863-z

Marcell, T. J. (2003). Review Article: Sarcopenia: Causes, Consequences, and Preventions. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences*, *58*(10), M911–M916. https://doi.org/10.1093/gerona/58.10.M911

Marcos-Pardo, P. J., Orquin-Castrillón, F. J., Gea-García, G. M., Menayo-Antúnez, R., González-Gálvez, N., Vale, R. G. de S., & Martínez-Rodríguez, A. (2019). Effects of a moderate-to-high intensity resistance circuit training on fat mass, functional capacity, muscular strength, and quality of life in elderly: A randomized controlled trial. *Scientific Reports*, *9*(1), 7830. https://doi.org/10.1038/s41598-019-44329-6

Marques, E. A., Mota, J., & Carvalho, J. (2012). Exercise effects on bone mineral density in older adults: A meta-analysis of randomized controlled trials. *AGE*, *34*(6), 1493–1515. https://doi.org/10.1007/s11357-011-9311-8

McPhee, J. S., French, D. P., Jackson, D., Nazroo, J., Pendleton, N., & Degens, H. (2016). Physical activity in older age: Perspectives for healthy ageing and frailty. *Biogerontology*, *17*(3), 567–580. https://doi.org/10.1007/s10522-016-9641-0

Pano-Rodriguez, A., Beltran-Garrido, J. V., Hernandez-Gonzalez, V., & Reverter-Masia, J. (2020). Effects of Whole-Body Electromyostimulation on Physical Fitness in Postmenopausal Women: A Randomized Controlled Trial. *Sensors*, *20*(5), 1482. https://doi.org/10.3390/s20051482

Pedersen, B. K., & Saltin, B. (2006). Evidence for prescribing exercise as therapy in chronic disease. *Scandinavian Journal of Medicine and Science in Sports*, *16*(S1), 3–63. https://doi.org/10.1111/j.1600-0838.2006.00520.x

Peterson, M. D., Sen, A., & Gordon, P. M. (2011). Influence of Resistance Exercise on Lean Body Mass in Aging Adults: A Meta-Analysis. *Medicine & Science in Sports & Exercise*, *43*(2), 249–258. https://doi.org/10.1249/MSS.0b013e3181eb6265

Raguso, C. A., Kyle, U., Kossovsky, M. P., Roynette, C., Paoloni-Giacobino, A., Hans, D., Genton, L., & Pichard, C. (2006). A 3-year longitudinal study on body composition changes in the elderly: Role of physical exercise. *Clinical Nutrition*, *25*(4), 573–580. https://doi.org/10.1016/j.clnu.2005.10.013

Rhodes, E. C. (2000). Effects of one year of resistance training on the relation between muscular strength and bone density in elderly women. *British Journal of Sports Medicine*, *34*(1), 18–22. https://doi.org/10.1136/bjsm.34.1.18

Ribeiro, A. S., Schoenfeld, B. J., Fleck, S. J., Pina, F. L. C., Nascimento, M. A., & Cyrino, E. S. (2017). Effects of Traditional and Pyramidal Resistance Training Systems on Muscular Strength, Muscle Mass, and Hormonal Responses in Older Women: A Randomized Crossover Trial. *Journal of Strength and Conditioning Research*, *31*(7), 1888–1896. https://doi.org/10.1519/JSC.0000000000001653

Romero-Arenas, S. (2013). Impact of Resistance Circuit Training on Neuromuscular, Cardiorespiratory and Body Composition Adaptations in the Elderly. *Aging and Disease*, *04*(05), 256–263. https://doi.org/10.14336/AD.2013.0400256

Romero-Arenas, S., Blazevich, A. J., Martínez-Pascual, M., Pérez-Gómez, J., Luque, A. J., López-Román, F. J., & Alcaraz, P. E. (2013). Effects of high-resistance circuit training in an elderly population. *Experimental Gerontology*, *48*(3), 334–340. https://doi.org/10.1016/j.exger.2013.01.007

Taylor, D. (2014). Physical activity is medicine for older adults: Table 1. *Postgraduate Medical Journal*, *90*(1059), 26–32. https://doi.org/10.1136/postgradmedj-2012-131366

Teschler, M., & Mooren, F. C. (2019). (Whole-Body) Electromyostimulation, Muscle Damage, and Immune System: A Mini Review. *Frontiers in Physiology*, *10*, 1461. https://doi.org/10.3389/fphys.2019.01461

Tsuzuku, S., Kajioka, T., Sakakibara, H., & Shimaoka, K. (2018). Slow movement resistance training using body weight improves muscle mass in the elderly: A randomized controlled trial. *Scandinavian Journal of Medicine & Science in Sports*, *28*(4), 1339–1344. https://doi.org/10.1111/sms.13039

Vingren, J. L., Kraemer, W. J., Ratamess, N. A., Anderson, J. M., Volek, J. S., & Maresh, C. M. (2010). Testosterone Physiology in Resistance Exercise and Training: The Up-Stream Regulatory Elements. *Sports Medicine*, *40*(12), 1037–1053. https://doi.org/10.2165/11536910-000000000-00000

von Stengel, S., Bebenek, M., Engelke, K., & Kemmler, W. (2015). Whole-Body Electromyostimulation to Fight Osteopenia in Elderly Females: The Randomized Controlled Training and Electrostimulation Trial (TEST-III). *Journal of Osteoporosis*, *2015*, 1–7. https://doi.org/10.1155/2015/643520 von Stengel, S., & Kemmler, W. (2018). Trainability of leg strength by whole-body electromyostimulation during adult lifespan: A study with male cohorts. *Clinical Interventions in Aging*, *Volume 13*, 2495–2502. https://doi.org/10.2147/CIA.S185018

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