Effects of Whole-Body Electromyostimulation on Resting Metabolic Rate, Body Composition, and Maximum Strength in Postmenopausal Women: the Training and ElectroStimulation Trial

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Abstract

Kemmler, W, Schliffka, R, Mayhew, JL, and von Stengel, S. Effects of whole-body electromyostimulation on resting metabolic rate, body composition, and maximum strength in postmenopausal women: the Training and ElectroStimulation Trial. *J Strength Cond Res* 24(7): 1880–1887, 2010–We evaluated the effect of whole-body electromyostimulation (WB-EMS) during dynamic exercises over 14 weeks on anthropometric, physiological, and muscular parameters in postmenopausal women. Thirty women (64.5 ± 5.5 years) with experience in physical training (>3 years) were randomly assigned either to a control group (CON, $n = 15$) that maintained their general training program (2×60 min·wk^{-1} of endurance and dynamic strength exercise) or to an electromyostimulation group (WB-EMS, $n = 15$) that additionally performed a 20-minute WB-EMS training (2×20 min·10 d^{-1}). Resting metabolic rate (RMR) determined from spirometry was selected to indicate muscle mass. In addition, body circumferences, subcutaneous skinfolds, strength, power, and dropout and adherence values. Resting metabolic rate was maintained in WB-EMS (-0.1 ± 4.8 kcal·h^{-1}) and decreased in CON (-3.2 ± 5.2 kcal·h^{-1}, $p = 0.038$); although group differences were not significant ($p = 0.095$), there was a moderately strong effect size (ES = 0.62). Sum of skinfolds (28.6%) and waist circumference (22.3%) significantly decreased in WB-EMS whereas both parameters (1.4 and 0.1%, respectively) increased in CON ($p = 0.001$, ES = 1.37 and 1.64, respectively), whereas both parameters increased in CON (1.4 and 0.1%, respectively). Isometric strength changes of the trunk extensors and leg extensors differed significantly ($p \leq 0.006$) between WB-EMS and CON (9.9% vs. -6.4%, ES = 1.53; 9.6% vs. -4.5%, ES = 1.43, respectively). In summary, adjunct WB-EMS training significantly exceeds the effect of isolated endurance and resistance type exercise on fitness and fatness parameters. Further, we conclude that for elderly subjects unable or unwilling to perform dynamic strength exercises, electromyostimulation may be a smooth alternative to maintain lean body mass, strength, and power.

Key Words body composition, exercise, RMR, muscle, aging

Introduction

The change of body composition and the corresponding decline of functional capacity from maturity to senescence, even in healthy subjects, are of clinical significance. In the USA each year, about 10% of the nondisabled adults 75 years and older lose independence to perform the basic activities of daily living because of disability (16). After the menopausal transition, body composition changes considerably in elderly women. These changes include a clinically relevant increase of body fat together with a reduction of muscle mass (15,35); both factors correlate with morbidity and mortality in this age cohort (9). Parallel to these body composition changes, strength decreases by 15% per decade after the age of 60 years (12). However, although exercise studies (1,10,32) have observed favorable changes of body composition and strength parameters, because of physical limitations or a simple aversion, a large number of elderly subjects seem to be either unable or unwilling to perform (intense) exercise programs (19,25).

In this context, whole-body electromyostimulation (WB-EMS) may be a smooth alternative to demanding conventional exercise programs (40). Although the favorable effect of *local* electromyostimulation on (neuro) muscular parameters has been previously determined in athletes (4,5,13,26),

healthy younger (13,17,18), and elderly subjects (2,27,28,38), the overall effect of WB-EMS on body composition and strength in elderly subjects is scarce. Also important, the feasibility and acceptance of this exercise technology is unknown in this cohort.

Thus, in this pilot study, we determine the effect of WB-EMS on body composition, strength parameters, feasibility, and acceptance in a group of postmenopausal women. Our hypothesis was that WB-EMS exercise favorably affects body composition and strength in this cohort.

METHODS

Experimental Approach to the Problem

We performed a 14-week randomized controlled trial with postmenopausal women to address our hypothesis. To ensure that participants adequately perform the WB-EMS exercise regime, we included only women with a long experience of resistance training. Further, both subgroups performed the same basic exercise training described below; however, only the verum group performed an additional WB-EMS regime over 14 weeks (March 2008 to July 2008).

Endpoints representing our primary targets "body composition" and "maximum strength" were skeletal muscle mass indirectly assessed by spirometry (resting metabolic rate [RMR]), body fat assessed by skinfold measurement and bioimpedance analysis (BIA), abdominal fat determined by waist circumference, and isometric trunk, and leg strength.

The study design allows us to determine the additional effect of WB-EMS training on the above-mentioned endpoints in comparison to an isolated endurance and strength training program.

Subjects

Thirty postmenopausal women 55 years and older, living in the community of Erlangen-Nurnberg and pretrained during the Erlangen Fitness and Osteoporosis Study (EFOPS) (21) or Senior Fitness and Prevention Study (SEFIP) exercise studies (24) for >3 years were included in the Training and ElectroStimulation Trial (TEST). Both studies were trialsthat focused on general fitness with special regard to bone parameters with a combined high intensity endurance, resistance, and balance regime with 2 joint sessions and 2 home-training sessions per week.

Exclusion criteria (according to the manufacturer) were epilepsy, cardiac pacemaker, grave circulatory disorders, abdomen or groin hernia tuberculosis, cancer, grave neurologic disturbances, inflammable diseases, bleeding tendencies, medication, or diseases affecting muscle metabolism.

The study was approved by the ethics committee of the University of Erlangen (Ethik Antrag 3777). All study participants were informed of the experimental risk and gave written informed consent.

Figure 1 shows the participant flow during the TEST study. Subjects were stratified by age and randomly assigned to 2 intervention groups: WB-EMS ($n = 15$) or control (CG: $n = 15$). In addition to the endurance and strength training described below, the WB-EMS group performed WB-EMS training every 4–5 days (see below), whereas the CG were asked to maintain their previous exercise training. Table 1 gives the initial characteristics of the WB-EMS and control group.

Procedures

Intervention. Basic Exercise Program. The basic exercise program has been described elsewhere in detail (21–23); thus, only a brief description is given here. The exercise program consisted of 2 supervised group sessions (60–65 minutes) and 2 home-training sessions (20–25 minutes) per week. During these sessions, 20 minutes of aerobic dance (70–85% HRmax) were followed by multilateral jumps (4 × 15 reps) and either by 40 minutes of functional gymnastics and barbell exercises (3 exercises, 2 sets, 6–12 reps at 70–85% 1 repetition maximum [1RM]) or dynamic resistance training with strength machines (12 exercises, 1–3 sets, 6–12 reps at 70–85% 1RM).

Electromyostimulation. In addition to this basic exercise training, the WB-EMS group performed a guided and supervised WB-EMS training (miha bodytec, Augsburg,
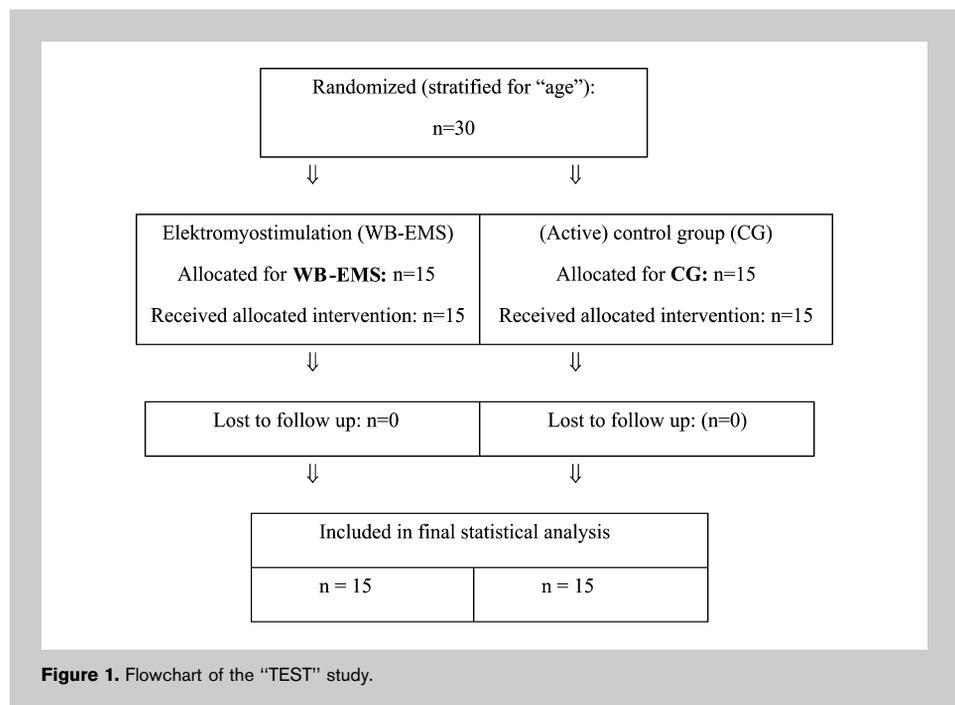

Figure 1. Flowchart of the "TEST" study.

Germany, Figure 2) every 4–5 days. The WB-EMS equipment enables the simultaneous activation of 10 regions (upper legs, upper arms, bottom, abdomen, chest, lower back, upper back including the latissimus dorsi) with different intensities (Figure 2). Participants carried out 2 standardized WB-EMS programs during a 20-minute session (Table 2).

Fifteen dynamic exercises for all large muscle groups using a small range of movement were performed during WB-EMS training. Exercises were designed not to cause physical adaptations in this pretrained cohort. Current intensity of the WB-EMS was progressively increased during the interventional period.

Compliance with the WB-EMS regime was determined after 6 and 14 weeks. Participants were asked to appraise the average intensity of a WB-EMS session and the regional intensity of the WB-EMS on a rating scale (Ratings of Perceived Exertion [RPE]) between 1 (very low) and 7 (very high). Attendance was recorded by training logs managed by research assistants.

Testing Procedures
Tests were carried out before and after 14 weeks of exercise by the same researcher and at the same time of the day ($\pm$1 hour). All assessments were determined in a blinded fashion.

Height was determined with a stadiometer, and weight was measured with minimal clothing on digital scales. Body mass index was calculated as weight divided by height squared ($kg \cdot m^{-2}$). Circumferences were determined at several locations including the waist and hip. Body fat was assessed by skinfold measurement (Lange, Cambridge, MA, USA) at 11 anatomical sites (tragus, mouth, axilla, subscapularis, abdominal, supraillacus, suprapatella, biceps brachii, triceps brachii, and gastrocnemius). Tests were performed twice; the mean value of both tests were included in the analysis. The coefficient of variation was <5.3% for this procedure (multiple-tester reliability).

Resting metabolic rate was determined between 7:00 and 9:00 at a constant room temperature of 23° C before and after the 14-week intervention using indirect calorimetry after 12 or more hours of fasting. Participants were instructed not to participate in heavy physical activity or exercise 24 hours before the test and to visit the laboratory by car or public transport. Participants rested in a supine position quietly for 15 minutes before the data collection and for an additional 15 minutes during which the data were sampled. Subjects breathed freely through a face mask with expired air analyzed

TABLE 1. Baseline characteristics of the TEST cohort: EMS vs. CG.*†

Variable	WB-EMS ($n = 15$)	CG ($n = 15$)	p
Age (y)	65.6 ± 5.6	63.3 ± 5.4	n.s.
Height (cm)	160.8 ± 5.4	162.2 ± 6.6	n.s.
Weight (kg)	70.4 ± 12.0	64.9 ± 10.9	n.s.
Total body fat (%)‡	37.9 ± 4.8	35.0 ± 2.7	§
Age at menopause (y)$\parallel$	48.9 ± 5.2	47.9 ± 4.1	n.s.
Energy intake (kJ·d^{-1})¶	7,689 ± 1,722	7,824 ± 1,640	n.s.
Protein intake (g·d^{-1})¶	65 ± 17	71 ± 21	n.s.
Exercise volume (min·wk^{-1})$\parallel$	179 ± 58	147 ± 43	n.s.
VO$_2$peak (ml·kg^{-1}·min^{-1})#	27.1 ± 4.1	26.9 ± 4.2	n.s.
Multimorbidity (% per group)**	53.3	46.7	n.s.

*EMS = electromyostimulation; CG = control group; WB-EMS = whole-body-electromyostimulation; n.s. = nonsignificant.
†Values are given as mean ± SD.
‡Skinfolds according to Durnin and Wormserley (11).
§$p < 0.05$.
$\parallel$Baseline questionnaire.
¶Four-day dietary protocol.
#Spirometry; treadmill test to a voluntary maximum.
**Two and more diseases.

Figure 2. Whole-body electromyostimulation equipment.

using an open spirometric system (Oxycon mobile, Conshohocken, PA, USA). Coefficient of variation determined in a recent pilot study was 4.1% for this procedure.

Maximum isometric strength of the trunk and leg extensors was measured with a Schnell M3 isometric tester using the test protocol suggested by Tusker (36). The coefficients of variation were <4.0% (3.1% for trunk extension to 3.9% for leg extension) for this procedure.

A detailed questionnaire was used to assess well-being, pain frequency, and intensity at different skeletal sites, prestudy exercise levels, normal daily activity levels, diseases, and medication. The follow-up questionnaires additionally contained sections to monitor disease incidences, changes in disease severity and intake of medication, life-style changes, or sport activities outside the TEST training program.

Statistical Analyses

The sample size calculation was based on our main endpoint RMR. To detect a 5% difference between the groups, 15 subjects per group were required for a 5% error probability with 80% statistical power (SD: 5%; Dropout rate: $n = 2$). Baseline values were reported as means and SDs. Normal distribution was checked using the Kolgomorov–Smirnov test, and homogeneity of variance was investigated with Levine's F-test. Normally distributed variable differences within groups were analyzed by paired t-tests, otherwise the Wilcoxon–rank test was used. Changes between baseline and 18 months follow-up were reported as absolute changes. Depending on the data, Mann–Whitney U test based on absolute changes or analyses of variance with repeated measurements were performed to check time–group interactions. Between-group differences were given as absolute difference along with 95% confidence interval (Table 3). All tests were 2-tailed, and statistical significance was accepted at $p \leq 0.05$. Effect sizes (ES) based on the absolute difference ($\pm SD$) between baseline and follow-up in the WB-EMS vs. the CG were calculated using Cohens' d (8). SPSS 16.0 (SPSS Inc, Chicago, IL, USA) was used for all statistical procedures.

RESULTS

Overall attendance rate of the basic exercise program did not change compared with prestudy attendance and was comparable between both groups ($\approx$80%; 22.3 $\pm$ 2.0 total sessions). Attendance rate of the WB-EMS training was 98%. No incidents of medical significance occurred during the training sessions.

Average exercise intensity per session was characterized as moderate to high (RPE: 4.4 $\pm$ 0.5) after 6 weeks and increased (4.9 $\pm$ 0.7) after 14 weeks of WB-EMS exercise. After 6 weeks, with 1 exception (chest: 3.4), regional EMS intensity was described as moderate for all other regions (3.9 $\pm$ 0.3, 3.7–4.1). The perceived exposure significantly increased after 14 weeks of WB-EMS training (4.7 $\pm$ 0.5; 4.2–5.4).

The effect of the WB-EMS program on primary and secondary study endpoints is given in Table 3. In summary, RMR significantly decreased in the CG (-5.3%, $p = 0.038$) and did not show relevant changes in the electromyostimulation group (-0.2%, $p = 0.991$). Despite a moderate ES (ES = 0.62), no significant differences ($p = 0.095$) between the groups were determined.

Body weight significantly decreased in both groups (WB-EMS: 1.9 $\pm$ 1.7 kg, $p = 0.001$ vs. CG: 0.9 $\pm$ 1.5 kg, $p = 0.025$); however, changes in body weight over the training was not significantly different between WB-EMS and CG ($p = 0.122$, ES = 0.62) after 14 weeks.

Sums of skinfolds were significantly reduced in the WB-EMS ($p = 0.001$) by 8.6%. A nonsignificant increase of this parameter was observed in the CG (1.4%), whereas difference between groups was significant ($p = 0.001$; ES = 1.37). Corresponding data were obtained for BIA measurement ($p = 0.001$; ES = 1.22).

Waist and hip circumferences were also significantly ($p = 0.001$) reduced in the WB-EMS, both by $\approx$2.3%. In the CG, waist circumference increased nonsignificantly ($p = 0.106$) by 1.0%, whereas hip circumference significantly ($p = 0.008$) decreased by 1.3%. Significant between-group differences were determined for waist circumference ($p = 0.001$, ES = 1.64).

Maximum isometric strength of the trunk and leg extensors of the WB-EMS group significantly improved by 9.9% ($p = 0.015$) and 9.6% ($p = 0.001$), respectively. Both parameters decreased nonsignificantly in the CG (trunk extensors: -6.4%, $p = 0.054$; leg extensors: -4.5; $p = 0.106$). Whole-body electromyostimulation and CG significantly ($p < 0.01$) differed on these parameters after 14 weeks (ES = 1.53 and 1.43, respectively).

Because we observed a low incidence of pain intensity and frequency at baseline, the lack of significant differences among WB-EMS and CG for these parameters were not unexpected after 14 weeks of intervention.

TABLE 2. Whole-body electromyostimulation-protocol of the TEST study.

Program 1	Program 2
Stimulation frequency: 85 Hz	Frequency: 7 Hz
Impulse duration: 4 s	Impulse duration: continuously
Impulse break: 4 s	
Impulse increase: 0 s	
Pulse breadth: 350 μs	Pulse breadth: 350 μs
Impulse type: bipolar	Impulse type: bipolar
Duration: 10 min	Duration: 10 min

TABLE 3. Changes of primary and secondary endpoints in the WB-EMS and control group.*†‡

	EMS (n = 15) (MV ± SD)	CG (n = 15) (MV ± SD)	Absolute difference mean (95% CI)	p	Effect size
RMR (kcal·h^{-1})					
Baseline	61.6 ± 10.6	60.0 ± 9.7			
14 wk	61.6 ± 9.5	56.8 ± 9.2			
Difference	−0.1 ± 4.8	−3.2 ± 5.2	−3.2 (−7.0 to 0.6)	0.095	0.62
Sum of 11 skinfold (mm)					
Baseline	267.8 ± 68.8	227.4 ± 30.3			
14 wk	244.6 ± 54.6	230.2 ± 32.1			
Difference	−23.2 ± 20.1	2.8 ± 17.7	26.1 (11.9–40.2)	0.001	−1.37
Waist circumference (cm)					
Baseline	86.5 ± 10.9	80.8 ± 7.1			
14 wk	84.4 ± 54.6	81.6 ± 6.6			
Difference	−2.0 ± 1.5	0.8 ± 1.9	2.8 (1.6–4.1)	0.001	−1.64
Hip circumference (cm)					
Baseline	106.3 ± 10.2	101.0 ± 6.6			
14 wk	103.6 ± 9.5	99.7 ± 6.2			
Difference	−2.5 ± 1.8	−1.3 ± 1.6	1.2 (−0.1 to 2.5)	0.065	−0.70
Isometric maximum strength trunk–extensors (N)					
Baseline	116.3 ± 23.8	119.5 ± 40.0			
14 wk	127.8 ± 44.2	112.0 ± 32.2			
Difference	11.5 ± 12.8	−7.6 ± 12.2	−19.2 (−32.4 to −6.0)	0.006	1.53
Isometric maximum strength leg extensors (N)					
Baseline	827 ± 209	889 ± 191			
14 wk	908 ± 229	849 ± 214			
Difference	80 ± 77	−40 ± 90	−121 (−184 to −57)	0.001	1.43

*WB-EMS = whole-body electromyostimulation; RMR = resting metabolic rate.
†Significance (p) is listed for between-group differences only; further information is given in the corresponding Result section.
‡n.s. = nonsignificant.

DISCUSSION

To the best of our knowledge, the present study is the first clinical trial that determined the feasibility and, with 1 limitation the effectiveness of WB-EMS on body composition and strength in a postmenopausal cohort. Thus, we could verify our hypothesis up to the point that WB-EMS has a significantly positive impact on overall and abdominal fat and on strength parameters. However, lean body mass (LBM) indirectly determined via RMR showed a nonsignificant effect ($p = 0.095$; ES: 0.62) after adjuvant WB-EMS.

Compared with other studies with comparable duration (3), dropout rate was low, and attendance was excellent in the WB-EMS group. However, one has to realize that our WB-EMS program was related to rather individualized training sessions with 1 instructor and 2 participants. Thus, it may be rather the exclusiveness of the exercise program than its mode that leads to this exceptional high commitment.

Judging the overall effectiveness of WB-EMS in this cohort of pretrained and physically adapted subjects is difficult. The focus of this study was to determine the effect of an adjuvant WB-EMS program on a variety of body composition and strength parameters in a pilot study design. This may have limited us in several ways. First, we recruited a cohort of pretrained women that were capable of realizing the prescribed perceived exertion rate for the WB-EMS program. This proceeding may be suboptimum concerning the development of our endpoints; however, comparable to conventional exercise protocols, it was essential that exercise intensity (i.e., current intensity) was high enough to overwhelm individuals' strain threshold. Secondly, exercise and control groups maintained their conventional exercise training to not disrupt the training continuity, especially of the control group. Although both groups performed the same basic exercise protocol with identical attendance, there may be a synergistic effect that favored the results of the WB-EMS group. Thirdly, we did not perform high-end body composition measurements (i.e., computed tomography [CT] or dual energy X-ray absorptiometry [DXA]) to minimize the bureaucratic expenditure. Hence, greater changes in body composition might have occurred than were able to be determined by the precision of our measurements.

Despite the aforementioned limitations, after 14 weeks of intervention, we determined positive WB-EMS effects on all anthropometrical and muscular endpoints. Although we did

not establish a sedentary control group for reasons discussed above, differences between groups reached statistical significance for fitness (strength parameters) and total and abdominal fatness (sums of skinfolds and waist circumference) parameters.

Concerning our primary endpoint, however, the WB-EMS effect on RMR did not reach statistical significance. Resting metabolic rate was selected as our primary endpoint for 2 reasons. Primarily, from a methodological point of view, RMR represents a key determinant of the magnitude of fat-free mass (FFM) (33). Thus, changes of RMR may indicate changes of FFM. Although FFM is a heterogenic compartment (muscle, organs, bone, and connective tissue), exercise-induced changes of FFM can be almost exclusively dedicated to changes of muscle mass.

Further, with 60–70% of the subjects, RMR is the largest component of daily energy expenditure (34), meaning that exercise strategies to decrease or maintain body weight or body fat should focus on FFM. Thus, although compared with DXA, Magnetic resonance imaging, or quantitative computed tomography (QCT), RMR may be a suboptimum parameter to determine muscle mass per se; RMR assessment additionally gives an insight into basic energy consumption of these postmenopausal women.

A central cause for the failure of the study to determine a significant effect on RMR may have been a less than adequate statistical power, resulting in a higher deviation of the mean difference than expected (8% vs. 5%). Several reasons may contribute to this higher variance. (a) A low reliability of the RMR assessment may have been present. This factor, however, can be neglected because the CV of our RMR measurement was comparable with corresponding studies (37). (b) Changes of confounding factors with impact on RMR during the intervention period were determined by interview or questionnaire; however, no subject reported major corresponding changes. (c) Also, all subjects followed the prescribed protocol, which meant no subject participated in heavy physical activity or exercise 24 hours before the test or visited the laboratory by other means than car or public transport such as bicycling or walking.

Thus, the most likely reason for the high intraindividual variation of the adaptability to WB-EMS (−5.3 to 8.4%) may be either the exercise compliance in the WB-EMS group or a high variation of the corresponding effect of WB-EMS on RMR in pretrained postmenopausal women (31). Concerning the first issue, although attendance was rather high in the WB-EMS group, it was difficult to decide whether subjects realized the prescribed exercise intensity during the WB-EMS training.

Regarding the development of RMR, it is interesting that the WB-EMS group maintained their rates, whereas RMR of the CG significantly dropped. Although a systematic error concerning the spirometric assessment may be a reason, the quality control parameters of this procedure did not support this idea. A more evident reason for the change of RMR may be individuals acclimatization induced by seasonal variations during the test and intervention phase from March to July (7).

Both groups reduced their body weight significantly, with only one subject per group listing an energy restricting diet as a reason. Comparable to the RMR, the reduction of body weight may be related to seasonal changes of nutritional habits and energy intake (39). Whether energy restriction was generally related to changes of RMR and body weight is difficult to conclude. In their review, Stiegler and Cunliffe (34) summarized the effect of energy restriction and combined exercise training (endurance and strength type, comparable to our basic exercise program). Dependent on protein intake, the authors determined that there was at least maintenance of the FFM. After progressive, high-intensity resistance training combined with an energy-restricted diet (800 kcal·d^{-1} with 40% proteins) in a cohort of overweighted subjects, Bryner et al. (6) determined a significant reduction of body weight (15%) combined with a marginal decrease of the FFM (−1.6%) and a significant increment of the RMR (3.6%). In parallel, the low-moderate reduction of body weight in our nonsedentary CG should not result in a significant decrease of the RMR.

Besides the significant reduction of body weight in the WB-EMS group, a significant decrease of subcutaneous body fat as assessed at 11 skinfold sites along with a significant reduction of the abdominal body fat as determined by waist circumference assessment (20,30) was shown in the presence of maintenance of RMR.

Reviewing the literature, there is a lack of studies determining the effect of whole-body myostimulation on body composition in the elderly. Although some studies demonstrated an increase in muscle mass after myostimulation (27,38), no study has yet assessed the effect on total or central body fat.

Concerning maximum strength changes, our WB-EMS group that performed an endurance and strength type basic program together with a WB-EMS program exhibited significant differences compared with a CG that performed an isolated strength and endurance exercise program. Most studies with untrained subjects confirmed our results (13,28,38). In one study, the isolated effect of local EMS on isokinetic quadriceps strength was compared with an isolated EMS program and a combined stair climbing and EMS program (28). Contrarily to our results, Paillard et al. (28) did not obtain significant differences concerning the strength changes between the groups. However, unlike our cohort, their exercise subjects were college "freshmen" producing a consider age differential.

One may argue that the difference between the isolated basic exercise group (CG) and the combined exercise and WB-EMS group did result from a higher training volume of the WB-EMS group. However, this argument may be confounded by dose-effect phenomenon in studies of strength type exercise (14,29).

In summary, in this group of pretrained elderly subjects, a high acceptance and feasibility of whole-body EMS training exercise was verified. Further, we provided evidence that

adjuvant WB-EMS exercise exceeds the effect of isolated strength and endurance type exercise for fitness and fatness parameters.

PRACTICAL APPLICATIONS

It is obvious that an increasing number of elderly subjects are unable or unwilling to perform (intense) conventional exercise training regimes. The findings of the study demonstrate that whole-body EMS program performed for 20 minutes every 4 days is effective and feasible. Thus, we consider the application of this novel exercise technology an appropriate alternative for elderly subjects to favorably improve body composition and physical strength important for healthy and independent aging. As a result, WB-EMS as a means of exercise training that focuses on body composition and strength parameters should be taken seriously into account by end users, physical therapists, and physical fitness instructors.

ACKNOWLEDGMENTS

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