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ORIGINAL ARTICLE

Influence of a long-term WB-EMS intervention on parameters of body composition and physical performance among individuals of different age decades between 19 and 81 years

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ABSTRACT

Lifelong fitness training plays an essential role in building and maintaining health. Whole-body electromyostimulation (WB-EMS) is a time-efficient training method that could be used as an adequate training intervention for different persons due to the intensive, involuntary contraction of the musculature and the resulting increases in muscular performance. Therefore, the aim of the study was to investigate if WB-EMS has positive effects on body composition and physical performance parameters of individuals of different age decades. Subjects from age decades 20-80 years participated in a 24-week WB-EMS training intervention. PRE and POST diagnostics of trunk extension and flexion, knee extension and flexion, hand grip strength, skeletal muscle mass (SMM) and body fat were performed on three consecutive days and the daily maximum values were summarized as the total mean value and were used for the descriptive data interpretation. Strength parameters were summarized in an unweighted additive index, the muscular change index (MCI). Regarding the results obtained by using the MCI, remarkable increases were observed in participants from all decades (20: +12.02%; 30: +6.59%; 40: +6.85%; 50: +3.96%; 60: +10.95%; 70: +20.26%; 80: +20.86%). Therefore, WB-EMS seems to be a time-efficient and adequate form of training that can be conducted to enhance muscular performance at different ages.

Keywords: Performance analysis of sport, Physical fitness, Strength training, Whole-body electromyostimulation, Lifespan.

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INTRODUCTION

Regular fitness and health training plays an important role in building and maintaining health throughout the lifespan. In addition to aerobic performance, the systematic development of strength performance is essential, as age-appropriate strength training has positive effects on the development of athletic and everyday motor performance as well as on the health and psychosocial well-being of adolescents and young adults (Büsch et al., 2017). As individuals age, they engage in physical exercise to prevent various diseases and enhance their general physical performance. A lack of exercise due to long periods of sitting at work as well as a general reduction in physical activity in everyday life can have a negative impact on health and can be seen as an independent risk factor for the development of chronic diseases (Finger et al., 2017a, 2017b). From the age of 30, the physical loss of muscle mass is about 3-8% per decade, which increases further from the age of 60 (Volpi et al., 2004). This involuntary loss of muscle mass, strength and function (which is called sarcopenia), is a strong risk factor for diseases in the elderly. Furthermore, reduced muscle mass considerably increases the risk of falls and injury, which may subsequently lead to functional dependence or permanent disability due to immobility and long-term rehabilitation processes, and thus to restrictions in daily life (Tinetti & Williams, 1997; Wolfson et al., 1995). Increased immobility and decreased physical activity are frequently accompanied by changes in body composition that result in an increase in fat mass, which can often lead to increased insulin resistance and advanced metabolic diseases in the elderly (Holloszy, 2000; Melton et al., 2000). An active lifestyle and regular physical activity have been proven to prevent this age-related loss of muscle mass and health impairments (Macaluso & Vito, 2004; Peterson et al., 2011). However, the training should be performed several times a week at a moderate to high intensity, which is often not possible due to physical limitations or a lack of motivation or opportunities to perform strength-oriented training (Kemmler & Stengel, 2012). Even if one´s physical constitution allows them to partake in strength training, factors such as time or training support are aspects that, regardless of age, are often cited as a reason not to train, even in younger generations. A potential solution to these problems could be whole-body electromyostimulation (WB-EMS) training due to its efficient and effective training characterization.

WB-EMS has been established as a time-efficient form of training for several years in various settings and for different groups of people; it causes the simultaneous stimulation of all the large muscle groups (through at least six applied current channels) with an effective stimulus that induces adaptations (Kemmler et al., 2020). In WB-EMS, the electrodes applied to the skin deliver an impulse to the underlying muscles, which causes an involuntarily contraction. One of the major advantages of this involuntary way of contraction is reduced joint stress. In contrast to conventional strength training, no weights have to be moved over one or more muscle-joint systems to trigger a training stimulus. All main muscle groups (8-12 with an electrode area of up to 2.8 m^2) as well as the deeper lying muscles can be stimulated simultaneously to the individual maximum, resulting in a shorter training duration and frequency (Stengel et al., 2015). Therefore, applying WB-EMS once a week for 20 minutes is common in commercial settings (the frequency can be increased to two sessions per week) (Kemmler et al., 2022). Training content can be adapted to the performance level of individuals from strictly static to slightly dynamic exercises and complex movement executions. This allows the best possible individualization based on the physical constitution of the individual being trained. For this reason, WB-EMS is also used as medical WB-EMS by qualified professionals as a therapeutic intervention in the healthcare sector (Berger et al., 2022). Despite the low training duration and frequency, the effectiveness of WB-EMS has been extensively proven with regard to various aspects. Among other things, increases in muscular strength capabilities, enhancements in body composition, and increases in motor performance have been observed in individuals of different ages (Berger, Ludwig, Becker, Backfisch et al., 2020; Götz et al., 2022; Kemmler et al., 2022; Kemmler et al., 2021; Ludwig et al., 2020).

Despite these findings on WB-EMS, to the authors' knowledge, no study exists whereby the authors explored the effectiveness of WB-EMS in individuals from all decades and genders and applied the identical stimulation protocol and training content, as these often remarkably differ from each other (Berger, Ludwig, Becker, Backfisch et al., 2020). For this reason, the aim of the present pilot study was to examine whether 24 weeks of WB-EMS training has a positive influence on different body composition and muscular performance parameters in untrained individuals of different ages.

MATERIALS AND METHODS

Participants

The study was conducted by using a quasiexperimental trial with a pretest–post-test design. This study was conducted between July 2021 and February 2022 in two centres at the RPTU Kaiserslautern, Germany, and the Friedrich–Alexander University Erlangen–Nürnberg, Germany. The aim of the study was to examine whether 24 weeks of WB-EMS training has a positive influence on different body composition and muscular performance parameters in untrained individuals of different ages. For this purpose, one male and one female person from each age decade between 20-80 years were integrated into the study. The search for test persons was carried out by means of e-mails, flyers and personal contacts. For each decade group, a variance of 1 year was tolerated, so persons in the 20 years age decade could be 19-21 years old, for example. In total 14 subjects between 19 and 81 years of age participated in this study. The inclusion criteria were an age between 19 and 81 years, no previous WB-EMS experience and no internal and orthopaedic limitations. The subjects did not engage in regular exercise for at least 24 months prior to the start of the study. Regular exercise was defined as moderate to intense activities lasting more than 20 minutes at a time and performed at least once a week for several weeks. Before the study began, the participants were informed of the relative and absolute contraindications according to the current guidelines for WB-EMS applications, and the potential exclusion criteria were verified (Kemmler et al., 2019). Hence, only subjects who were completely healthy and had no contraindications to exercise or specifically to WB-EMS were included. Furthermore, the subjects were asked to maintain their habitual lifestyle as much as possible and to not participate in any other sport in addition to the weekly guided WB-EMS training sessions. Before the start of the study, the subjects were informed in detail about the content of the experiment and signed a data protection and consent form. Due to health complications that were not associated with WB-EMS, only 12 people were able to complete the study.

Measures

Before and after the 24-week intervention (T1 and T2) three measurements were recorded on three consecutive days at similar times. These multiple measurements were carried out to minimize the probability of day-dependent variations and resulting inaccurate results. On each of the test days, all measurements were performed 3 times in a row with one minute rest in between, and the maximum value was included in the evaluation. The three measurement days were combined into one mean value, so each recorded data point consisted of several individual values (Backman et al., 1997).

Body composition was measured by using bioelectrical impedance analysis (BIA; InBody770, Biospace CO., Seoul, Korea). The parameters recorded were weight, body fat (BF), and skeletal muscle mass (SMM). Prior to the study, key information about the participants such as their age, gender, medication intake, and illnesses were requested. In addition, none of the test participants wore electrical or metal implants and none were pregnant. None of the participants had symptoms of infection at the diagnosis time; this was examined because infection can alter metabolic processes and blood flow, which could have an influence on the measurement results of the BIA (González-Correa & Caicedo-Eraso, 2012). Regarding the measurement preparation, the participants did not eat any food in the last two hours before the diagnostics and 500 ml of water should be drunk during this period. It was ensured that all the measurements took place at a similar time of day and that the room temperature was always around 22 degrees Celsius to keep the body's blood circulation as constant as possible.

A warmup consisting of a 5 min cycle on an ergometer at 100 W was performed to prepare the organism for the upcoming performance diagnostics. Subsequently, for subjects under 60 years of age, the concentric force of their knee flexion and extension of the nondominant side was measured in a sitting position by using IsoMed 2000 (D&R Ferstl GmbH, Hemau, Germany). Two sets of 12 repetitions each were performed with a 1 min rest in between the sets. The angular velocity was set to 60 °/s. The force of the hip- and knee extension and flexion of the subjects that were 60 years and older was determined in a closed kinetic chain setting by using Contrex LP (Physiomed Elektromedizin AG, Laipersdorf). A bilateral concentric leg extension (and flexion) was performed in a sitting, slightly supine position (15°), that was supported by chest and hip straps. The ROM was selected between 30 and 90° (knee angle), with the ankle flexed 90° and positioned on a flexible sliding foot-plate. The standard default setting of 0.5 m/s was used. After the warm-up and familiarization with the movement pattern, participants were asked to conduct five concentric repetitions (flexion and extension) with maximum voluntary effort. The participants completed two maximum trials with two minutes of rest in between; the higher value was used for data analysis. The use of different devices was due to the fact that the participating persons of the age decades 20-50 and 60-80 were tested at different universities. Different devices for diagnosing the maximum strength of the lower extremities were available at the bases, which, however, does not limit the comparability of the percentage change in performance in the further course.

Static trunk extension and flexion (isometric force test) were measured by using the Back Check 607 (Dr. Wolff GmbH, Arnsberg, Germany). Participants were standing with their arms dangling and knee joints slightly bent. They were secured in the iliac crest area with one dorsal and one ventral pad in the sagittal plane. Two pads with force transducers were placed without pressure on the sternum and between the shoulder blades to record isometric forces. Maximum isometric force was measured in both directions. Tests were performed three times (30-second rest between), with the maximum value used for analysis (Weissenfels et al., 2019). Hand force of the dominant hand was measured using the Jamar hydraulic hand dynamometer (JLW Instruments, Chicago, USA). The measurement was performed seated with an elbow positioned at 90° flexion, forearm supported, shoulder at 0° of flexion and wrist in a neutral position.

Procedures

The training sessions took place once a week over a period of 24 weeks for 20 minutes each using the Miha Bodytec II device (Miha Bodytec, Augsburg, Germany). A creeping pulse of 0.4 seconds was set, as training was carried out with beginners. The other pulse parameters were based on the settings commonly used (pulse time: 6 s, pulse pause: 4 s, frequency: 85 Hz, pulse width: 350 µs) (Kemmler, 2022; Kemmler et al., 2022). During the WB-EMS training, the subjects wore a special EMS underwear provided by the device manufacturer. An electrode vest was used to stimulate the lower back, latissimus, upper back, abdomen, and chest. In addition, a waist belt, which stimulates the gluteal muscles, and electrode belts around the upper arms and thighs were applied. The training was standardized and consisted of six different exercises, which were performed during the impulse. The training exercises performed are shown in Table 1, the exercise sequence was performed twice. An impulse familiarization session was completed prior to the start of the first training session. Intensity control of WB-EMS was performed using subjective load (RPE scale), which is the most accurate way to control the intensity in WB-EMS (Berger et al., 2019). An intensity between six (strenuous) and seven (very strenuous) on the RPE scale was aimed and regularly checked. Impulse intensity was requested and adjusted several times during the training (Kemmler et al., 2016).

Table 1. Training exercises in the intervention.

Exercise	Repetitions
Lateral lunges with elbow flexion	3 per side
Squats with elbow flexion	6
Standing one-legged superman	6 per side
Squats with arms extended above head followed by latissimus pulldown movement	6
Lunge followed by trunk rotation, extended arms in 90 degree flexion, hands holding 3 kg medicine ball	6 per side
Standing crunches with diagonal trunk rotation, extended arms in elongation of the upper body, hands holding 3 kg medicine ball	6 per side

The aim of creating and selecting the training content was to intensively challenge all participating individuals, while at the same time enabling the implementation of the training content across all age decades. The limited number of exercises played an essential role in this process, as a clear selection of exercises avoids a possible overload and enables an adequate execution. Figure 1 shows an example of lunges followed by a trunk rotation, arms being extended at 90 degrees of flexion, and a 3 kg medicine ball being held.

Figure 1 Example of one of the performed exercises with a 3 kg medicine ball.

Analysis

No inferential statistical analysis was performed due to the small number of subjects. The descriptive data enables a decade-specific analysis and was used to interpret the present pilot study. Furthermore, to provide a decade-specific overview of the strength increases, the percentage changes in trunk extension and -flexion, knee extension and -flexion and hand force were combined into an unweighted additive index, which is consecutively referred to as the muscular change index (MCI).

RESULTS

One woman that was 61 years old lost interest in participating in the study and quit after 4 months. In addition, another woman 69 years old was hospitalized for 3 months during follow-up assessments and was thus lost to follow-up. Attendance was close to 100% for the participants from all decades. Compliance with the impulse intensity prescription was high. All participants stated RPEs of at least 6 (strenuous) during the WB-EMS session. No adverse effects related to WB-EMS application were determined or reported by the participants.

Table 2 shows the descriptive values of all recorded parameters at T1 and T2 as well as the percentage change from T1 to T2 as % Delta. The data of knee extension and knee flexion were separated due to different measurement systems being used on the individuals aged 20-50 and 60-80, but they were combined when determining the percentage change between the measurement times. Furthermore, a gender-specific representation was included to identify potential descriptive differences between the genders.

Table 2. Descriptive of all parameters including percentual changes between the measurements.

Parameter	Group	T1	T2	% Delta T1 – T2
Weight [%]	Overall	79.44 ± 17.06	79.25 ± 17.36	-0.34 ± 2.92
	Male	82.52 ± 19.38	81.84 ± 19.51	-0.92 ± 3.42
	Female	75.13 ± 14.03	75.63 ± 15.16	0.47 ± 2.15
Body Fat [%]	Overall	28.59 ± 6.67	27.69 ± 6.22	-2.91 ± 4.62
	Male	29.46 ± 6.80	28.47 ± 6.51	-3.27 ± 5.52
	Female	27.38 ± 7.03	26.6 ± 6.36	-2.40 ± 3.53
SMM [kg]	Overall	31.61 ± 8.17	32.01 ± 8.21	1.3 ± 1.5
	Male	32.03 ± 7.89	32.26 ± 7.76	0.85 ± 1.79
	Female	31.03 ± 9.45	31.65 ± 9.73	1.92 ± 0.7
Trunk Extension [kg]	Overall	66.79 ± 22.64	71.97 ± 21.94	8.85 ± 9.31
	Male	78.01 ± 21.92	83.29 ± 19.97	7.86 ± 6.45
	Female	51.10 ± 12.65	56.13 ± 13.73	10.23 ± 13.11
Trunk Flexion [kg]	Overall	47.22 ± 14.95	54.44 ± 18.21	16.59 ± 22.08
	Male	49.44 ± 14.22	59.18 ± 19.78	18.96 ± 20.56
	Female	44.12 ± 17.01	47.8 ± 15.2	13.28 ± 26.12
Knee Extension 20-50 years [Nm]	Overall	157.25 ± 68.99	172.88 ± 62.43	*Overall*
	Male	149.08 ± 72.18	161.33 ± 56.24	15.35 ± 12.71
	Female	165.42 ± 75.62	184.42 ± 74.66	*Male*
Knee Extension 60-80 years [N]	Overall	2064.83 ± 969.74	2352.58 ± 838.72	15.69 ± 15.53
	Male	2275.89 ± 1069.26	2578.67 ± 865.16	*Female*
	Female (n = 1)	1431.67	1674.33	14.87 ± 9.04
Knee Flexion 20-50 years [Nm]	Overall	102.79 ± 34.94	109.08 ± 37.37	*Overall*
	Male	9833 ± 41.61	103.00 ± 46.02	7.92 ±6.96
	Female	106.75 ± 32.78	115.17 ± 32.28	*Male*
Knee Flexion 60-80 years [N]	Overall	517.58 ± 203.86	565.75 ± 192.49	5.70 ± 6.01
	Male	612.22 ± 92.73	659.78 ± 60.74	*Female*
	Female (n = 1)	233.67	283.67	11.03 ± 7.65
Hand Force [N]	Overall	41.66 ± 13.63	43.11 ± 13.29	4.06 ± 7.61
	Male	43.15 ± 13.90	45.09 ± 12.61	5.67 ± 6.93
	Female	39.58 ± 14.54	40.33 ± 15.17	1.80 ± 8.74

Note. Values are presented as means (± SD). % Delta is shown for all age decades.

Table 3 shows the percentage changes of the individual parameters in relation to the decades 20-80. As stated above, the 60 and 70 decade group contained only one male each.

Table 3. Percentual changes of the parameters for each decade.

Decade	Weight [%]	BF [%]	SMM [%]	Trunk Extension [%]	Trunk Flexion [%]
20.00	2.16	1.22	1.93	15.47	10.19
30.00	-3.17	-7.66	1.25	5.41	-0.33
40.00	1.11	0.45	1.36	9.50	2.57
50.00	0.99	-4.90	2.90	3.14	1.93
60 (n = 1)	-1.11	-3.59	0.33	10.04	33.71
70 (n = 1)	-3.72	-1.84	-2.40	15.33	56.93
80.00	-0.71	-3.84	1.37	6.88	39.87
All	-0.64	-2.88	0.96	9.40	20.70

Decade	Knee Extension [%]	Knee Flexion [%]	Hand Force [%]	MCI [%]
20.00	14.91	11.65	11.32	12.02
30.00	21.95	5.43	-0.69	6.59
40.00	11.96	6.84	6.02	6.85
50.00	7.76	0.21	5.94	3.96
60 (n = 1)	2.25	2.48	5.37	10.95
70 (n = 1)	14.69	5.70	3.72	20.26
80.00	27.04	19.31	-2.78	20.86
All	14.37	7.37	4.13	11.64

Note. BF = Body Fat; SMM = Skeletal Muscle Mass; MCI = Muscular Change Index.

DISCUSSION

WB-EMS is considered an intensive, effective and time-saving training method in many areas of application and for different groups of people. The present study observed the influence of a 24-week WB-EMS training on body composition and physical performance parameters. To the authors' knowledge, this is the first study that exemplarily examined the effectiveness of WB-EMS in individuals from all decades with ages ranging from 19 to 81 years, which enables comparability regarding the examined parameters. Furthermore, the same training content and stimulation protocols were applied to all participants, which has not been the case in previous studies with subjects of such a broad age spectrum.

In summary, although differences between the decades were observed (Table 3), all participants benefited from the intervention at least with respect to overall muscle strength increases. Substantial descriptive enhancements in trunk flexion and extension, knee flexion and extension, and skeletal muscle mass were examined, clearly demonstrating a positive effect of WB-EMS over a 6-month training period. Looking at the individual decades, it is noticeable that an increase in strength performance measured by the recorded parameters was observed over all decades (excepted trunk flexion in the 30-year-olds). If one considers the MCI (% changes in trunk flexion and extension, knee flexion and extension and hand force), increases of 12.02% in the decade 20, 6.59% in the decade 30, 6.85% in the decade 40, 3.96% in the decade 50, 10.95% in the decade 60, 20.26% in the decade 70 and 20.86% in the decade of the 80-year-olds were observed for the individual decades, which in total equals a mean of 11.64% across all decades. The results show that all age decades examined benefited from WB-EMS training in terms of strength gains generated. In comparison to each other, the biggest improvements were observed in the two highest age decades, which confirms a use as well as applicability of WB-EMS also at a high age.

Previous studies observed positive results with various participants, even in young age groups. For example, Ludwig et al. (2020) found significant increases in performance of the knee extensors and flexors, hip adductors, and trunk flexors after 10 weeks of WB-EMS training (once a week) with adolescent soccer players (Ludwig et al., 2020).]. Although adolescent participants were not included in the present study as the focus was on adult individuals, these previous findings demonstrate the wide-ranging potential applications of WB-EMS, even in adolescent athletes. These findings are supported by a study of Berger et al. (2020) in which an 8-week WB-EMS intervention was conducted with a 17-year-old road cycling athlete, resulting in reductions in subjectively perceived back pain, improvements in recorded postural parameters, and increases in the maximal strength capacity of trunk flexors and extensors (Berger, Ludwig, Becker, Kemmler & Fröhlich, 2020). A study by Dörmann et al. (2019), in contrast to the studies presented above which were conducted with male subjects, was carried out with a trained, female cohort aged 20.5 ± 2.3 years. The effects of WB-EMS training twice a week over a 4-week intervention period on the parameters of speed, jumping power and lower extremity strength were observed and compared with the effects of a similarly structured conventional strength training. The WB-EMS training intervention resulted in enhancements in sprint speed (≤ 6.3%), change of direction speed (≤ 5.7%), vertical jump height (≤ 13.2%), and maximum strength of knee extensors (≤ 13.5%) and flexors (≤ 18.2%) (Dörmann et al., 2019).

The youngest subjects that participated in the present study were 19-21 years old, with an increase of 15.47% in trunk extension, 10.19% in trunk flexion, 14.91% in knee extension, and 11.65% in knee flexion, 11.32% in hand force and an MCI of 12.02%, which is similar to performance increases reported in the studies described previously. Therefore, it can be summarized that already in comparatively young age an increase in the muscular capacity by WB-EMS can be observed.

In the middle age decades 30, 40 and 50, the 24-week WB-EMS intervention resulted in a similar development of the examined parameters, although the extent of the increase in their performance was much lower than that experienced by the younger individuals. Individuals from these decades represent the largest user group of conventional WB-EMS applications according to a survey by Rodrigues-Santana et al. (2022) (Rodrigues-Santana et al., 2023). However, the number of studies including non-athletic adults of this age range is rather low (Kemmler et al., 2021). During this period of life, one´s daily life is often predominantly spent in a sitting or standing position, which is considered an independent risk factor for the development of chronic diseases and often leads to poor posture and back pain (Finger et al., 2017b). WB-EMS has proven to be an efficient and effective method to alleviate back pain and is considered a successful method to improve it (Kemmler, 2022; Weissenfels et al., 2019). Even though back pain was not directly measured during the present study, in many cases a correlation between undeveloped back muscles and occurring back pain exists, which is why the observed increase in trunk muscle strength may also influence potential back pain (Kemmler, 2022; Weissenfels et al., 2018). In comparison to an investigation by Ludwig et al. (2019), whereby the authors examined subjects between 18 and 40 years of age, similar tendencies of performance increases were observed in the present study. Even if the results with increases of up to 17.1% of back flexion and 21.4% of back extension (depending on the WB-EMS training group) were clearly above the results generated here for the age decades 30-50, the subjects integrated were able to benefit from the intervention, showing increases of the MCI from 3.96-6.85% (Ludwig et al., 2019). Furthermore, appropriate strength training through WB-EMS seems to be a suitable method to enhance performance and counteracts the physiological loss of muscle mass after the age of 30. For the present study, improvements of 1.25 - 2.9% in SMM were observed for the decades 30-50 (Volpi et al., 2004).

The most comprehensive literature base can be found for people with the age of 60 years and older (Kemmler et al., 2021). In many cases, older people are unable or unwilling to perform intensive strength training due to physical limitations or lack of motivation, even if it positively influences their daily activity and has preventive benefits such as reducing falls and the incidence of various diseases such as sarcopenia (Kemmler & Stengel, 2012). The elderly can remarkably benefit from the specific way of the WB-EMS application due to the involuntary contraction and potential training execution in a static or lying position without additional loads (Kemmler et al., 2015). In the present study, increases in strength were observed, MCI improved by 10.65 to 20.86%, which represents among the largest increases in performance in the present intervention. Similar percentage increases were observed for maximum isokinetic leg and hip extensor strength (MIES) and maximum isokinetic leg and hip flexor strength (MIFS) by von Stengel and Kemmler (2018). During this investigation, 118 males aged 27-89 years old trained with WB-EMS over a period of 14-16 weeks. Increases in MIES of 9.1 ± 7.3% and MIFS of 18.1 ± 11.0% were observed for the people 65-79 of age (Stengel & Kemmler, 2018). These performance increases generated by WB-EMS are consistent with a study by Kemmler et al. (2012), whereby considerable increases in the maximal trunk extension (+9.9%) and leg extension (+9.8%) were detected after 14 weeks of WB-EMS training in postmenopausal women aged 65 ± 5 years old (Kemmler et al., 2010). Even in female patients over 70 years old that were suffering from sarcopenia and not able to perform an adequate conventional strength training, a 12 week WB-EMS intervention occurring once a week resulted in a considerable increase in the maximum strength of their leg extension and -flexion. With this study, the universal and individually adjustable training design of the WB-EMS became clear, as the training was performed in a lying position with primarily static and slightly dynamic exercises, which nevertheless led to an enhancement in muscular performance (Kemmler et al., 2015). Therefore, in accordance with the current evidence, the present results confirm the beneficial possibility of using WB-EMS with an older population.

Apart from the positive results, methodological points that concern the general implementation and limit the transferability of the results to the general population must be mentioned. The intervention was conducted as a pilot study whereby one participant of each gender per age decade 20-80 was included in the intervention, no control group was observed. For reasons not related to WB-EMS, only one person in each of the decades 60 and 70 was able to complete the intervention. Furthermore, the sample collected was relatively small, only a total of 14 subjects were included in the evaluation. Correspondingly, from a biometrical point of view, we are unable to clearly answer the research question of whether age or gender modifies the effects of WB-EMS on outcomes related to strength and body composition—nevertheless, the overall strength changes (MCI) were enhanced in participants from all age groups. Further, the physical activity in everyday life was not controlled, integrating this as a covariate impossible, and its potential influence on the outcome parameters cannot be excluded. The use of different measurement systems at the different study centres further complicates the comparison of the recorded parameters; future studies should ideally test all participants with the identical diagnostics and devices.

Nevertheless, it could be shown that the investigated results are in accordance with the literature and that a positive influence of a WB-EMS intervention on all age decades 20-80 can be observed.

CONCLUSIONS

In summary, it can be concluded that positive effects of a 24-week WB-EMS intervention were observed across all age decades in the present pilot study. Apart from the increase in muscular performance and SMM, the training was performed by individuals from all age groups and genders with high adherence, acceptance and without any adverse effects, which clearly shows the universal applicability of the training. Older persons especially benefit from WB-EMS, as the involuntary stimulation of the musculature can be performed without high voluntary effort. However, regardless of age and gender, WB-EMS seems to be an adequate way to enhance performance over a long period of time.

AUTHOR CONTRIBUTIONS

Conceptualization: Joshua Berger; Data curation: Joshua Berger, Elena Janowicz and Markus Weineck; Formal analysis: Joshua Berger; Funding acquisition: Michael Fröhlich and Wolfgang Kemmler; Investigation: Joshua Berger, Elena Janowicz and Markus Weineck; Methodology: Joshua Berger, Oliver Ludwig and Michael Fröhlich; Project administration: Wolfgang Kemmler; Software: Oliver Ludwig; Supervision: Oliver Ludwig, Michael Fröhlich and Wolfgang Kemmler; Visualization: Joshua Berger and Elena Janowicz; Writing – original draft: Joshua Berger and Elena Janowicz; Writing – review & editing: Oliver Ludwig, Michael Fröhlich and Wolfgang Kemmler.

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No potential conflict of interest was reported by the author.

INSTITUTIONAL REVIEW BOARD STATEMENT

The study was conducted in accordance with the Declaration of Helsinki and approved by the ethics committee of the German University for Prevention and Health Management (02/17, 11.09.2017).

INFORMED CONSENT STATEMENT

Informed consent was obtained from all subjects involved in the study.

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The experiments comply with the current laws of the country in which they were performed.

REFERENCES

Backman, C. L., Harris, S. R., Chisholm, J. A. & Monette, A. D. (1997). Single-subject research in rehabilitation: a review of studies using AB, withdrawal, multiple baseline, and alternating treatments designs. Archives of physical medicine and rehabilitation, 78(10), 1145-1153. https://doi.org/10.1016/S0003-9993(97)90142-8

Berger, J., Becker, S., Backfisch, M., Eifler, C., Kemmler, W. & Fröhlich, M. (2019). Adjustment Effects of Maximum Intensity Tolerance During Whole-Body Electromyostimulation Training. Frontiers in Physiology, 10(920). https://doi.org/10.3389/fphys.2019.00920

Berger, J., Fröhlich, M. & Kemmler, W. (2022). WB-EMS Market Development-Perspectives and Threats. International Journal of Environmental Research and Public Health, 19(21), 14211. https://doi.org/10.3390/ijerph192114211

Berger, J., Ludwig, O., Becker, S., Backfisch, M., Kemmler, W. & Fröhlich, M. (2020). Effects of an Impulse Frequency Dependent 10-Week Whole-body Electromyostimulation Training Program on Specific Sport Performance Parameters. Journal of Sports Science and Medicine, 19(2), 271-281.

Berger, J., Ludwig, O., Becker, S., Kemmler, W. & Fröhlich, M. (2020). Effects of an 8-Week Whole-Body Electromyostimulation Training on Cycling Performance, Back Pain, and Posture of a 17-Year-Old Road Cyclist. International Journal of Athletic Therapy and Training, 26(2), 96-100. https://doi.org/10.1123/ijatt.2020-0016

Büsch, D., Prieske, O., Kriemler, S., Puta, C., Gabriel, H. W. & Granacher, U. (2017). Krafttraining im Kindes- und Jugendalter: Bedeutung, Wirkung und Handlungsempfehlungen. Swiss Sports & Exercise Medicine, 65(3), 34-42.

Dörmann, U., Wirtz, N., Micke, F., Morat, M., Kleinöder, H [Heinz] & Donath, L. (2019). The Effects of Superimposed Whole-Body Electromyostimulation During Short-Term Strength Training on Physical Fitness in Physically Active Females: A Randomized Controlled Trial. Frontiers in Physiology, 10, 728. https://doi.org/10.3389/fphys.2019.00728

Finger, J., Mensink, G., Lange, C. & Manz, K. (2017a). Arbeitsbezogene körperliche Aktivität bei Erwachsenen in Deutschland. https://doi.org/10.17886/RKI-GBE-2017-026

Finger, J., Mensink, G., Lange, C. & Manz, K. (2017b). Gesundheitsfördernde körperliche Aktivität in der Freizeit bei Erwachsenen in Deutschland. https://doi.org/10.17886/RKI-GBE-2017-027

González-Correa, C. H. & Caicedo-Eraso, J. C. (2012). Bioelectrical impedance analysis (BIA): a proposal for standardization of the classical method in adults. Journal of Physics: Conference Series, 407, 12018. https://doi.org/10.1088/1742-6596/407/1/012018

Götz, M., Heiss, R., Stengel, S. von [Simon], Roemer, F., Berger, J., Nagel, A., Uder, M. & Kemmler, W. (2022). Spatial Distribution of Muscular Effects of Acute Whole-Body Electromyostimulation at the Mid-Thigh and Lower Leg-A Pilot Study Applying Magnetic Resonance Imaging. Sensors, 22(24), 10017. https://doi.org/10.3390/s222410017

Holloszy, J. O. (2000). The biology of aging. Mayo Clinic Proceedings, 75 Suppl, S3-8; discussion S8-9. https://doi.org/10.1016/S0025-6196(19)30634-2

Kemmler, W. (Hrsg.). (2022). Ganzkörper-EMS und Rückenschmerz: Evidenzen und Limitationen einer innovativen Trainingstechnologie.

Kemmler, W., Fröhlich, M. & Eifler, C. (2022). Ganzkörper-Elektromyostimulation: Effekte, Limitationen, Perspektiven einer innovativen Trainingsmethode. Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-662-65206-0

Kemmler, W., Kleinöder, H [Heinz] & Fröhlich, M. (2020). Editorial: Whole-Body Electromyostimulation: A Training Technology to Improve Health and Performance in Humans? Frontiers in Physiology, 11. https://doi.org/10.3389/fphys.2020.00523

Kemmler, W., Kleinöder, H [Heinz], Fröhlich, M., Müller, S [Stephan] & Vatter, J. (2016). Safety first! Leitlinien zur optimierten Anwendung von Ganz-Körper-EMS. F&G Fitness und Gesundheit(4), 22-24.

Kemmler, W., Schliffka, R., Mayhew, J. L. & Stengel, S. von [Simon] (2010). Effects of whole-body electromyostimulation on resting metabolic rate, body composition, and maximum strength in postmenopausal women: the training and electrostimulation trial. Journal of Strength & Conditioning Research, 24(7), 1880-1887. https://doi.org/10.1519/JSC.0b013e3181ddaeee

Kemmler, W., Shojaa, M., Steele, J., Berger, J., Fröhlich, M., Schoene, D., Stengel, S. von [Simon], Kleinöder, H [Heinz] & Kohl, M. (2021). Efficacy of Whole-Body Electromyostimulation (WB-EMS) on Body Composition and Muscle Strength in Non-athletic Adults. A Systematic Review and Meta-Analysis. Frontiers in Physiology, 12(95). https://doi.org/10.3389/fphys.2021.640657

Kemmler, W. & Stengel, S. von [Simon] (2012). Alternative exercise technologies to fight against sarcopenia at old age: a series of studies and review. Journal of aging research, 2012, 109013. https://doi.org/10.1155/2012/109013

Kemmler, W., Teschler, M [Marc] & Stengel, S. von [Simon] (2015). Effekt von Ganzkörper-Elektromyostimulation - "A series of studies". Eine alternative Trainingstechnologie zur muskuloskelettalen Prävention bei älteren Menschen. Osteologie, 24(1), 20-29. https://doi.org/10.1055/s-0037-1622035

Kemmler, W., Weissenfels, A., Willert, S., Fröhlich, M., Ludwig, O., Berger, J., Zart, S., Becker, S., Backfisch, M., Kleinöder, H [Hans], Dörrmann, U., Wirtz, N., Wegener, B., Konrad, K. L., Eifler, C., Krug, J., Zinner, C., Müller, S [S.], Authenrieth, S., . . . Stengel, S. von (2019). Recommended Contraindications for the Use of Non-Medical WB-Electromyostimulation. German Journal of Sports Medicine/Deutsche Zeitschrift fur Sportmedizin, 70(11), 278-282. https://doi.org/10.5960/dzsm.2019.401

Ludwig, O., Berger, J., Becker, S., Kemmler, W. & Fröhlich, M. (2019). The Impact of Whole-Body Electromyostimulation on Body Posture and Trunk Muscle Strength in Untrained Persons. Frontiers in Physiology, 10(1020). https://doi.org/10.3389/fphys.2019.01020

Ludwig, O., Berger, J., Schuh, T., Backfisch, M., Becker, S. & Fröhlich, M. (2020). Can A Superimposed Whole-Body Electromyostimulation Intervention Enhance the Effects of a 10-Week Athletic Strength Training in Youth Elite Soccer Players? Journal of Sports Science and Medicine, 19(3), 535-546. https://doi.org/10.3389/fphys.2019.00920

Macaluso, A. & Vito, G. de (2004). Muscle strength, power and adaptations to resistance training in older people. European journal of applied physiology, 91(4), 450-472. https://doi.org/10.1007/s00421-003-0991-3

Melton, L. J., Khosla, S., Crowson, C. S., O'Connor, M. K., O'Fallon, W. M. & Riggs, B. L. (2000). Epidemiology of sarcopenia. Journal of the American Geriatrics Society, 48(6), 625-630. https://doi.org/10.1111/j.1532-5415.2000.tb04719.x

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

Rodrigues-Santana, L., Hugo, L., Pérez-Gómez, J., Hernández-Mocholí, M. A., Carlos-Vivas, J., Saldaña-Cortés, P., Contreras-Barraza, N. & Adsuar, J. C. (2023). The effects of whole-body muscle stimulation on body composition and strength parameters: A PRISMA systematic review and meta-analysis. Medicine, 102(8), e32668. https://doi.org/10.1097/MD.0000000000032668

Stengel, S., Bebenek, M., Engelke, K. & W, K. (2015). Whole-Body Electromyostimulation to Fight Osteopenia in Elderly Females: The Randomized Controlled Training and Electrostimulation Trial (TEST-III). Journal of Osteoporosis, Volume 2015, Article ID 643520. https://doi.org/10.1155/2015/643520

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, 13, 2495. https://doi.org/10.2147/CIA.S185018

Tinetti, M. E. & Williams, C. S. (1997). Falls, injuries due to falls, and the risk of admission to a nursing home. The New England journal of medicine, 337(18), 1279-1284. https://doi.org/10.1056/NEJM199710303371806

Volpi, E., Nazemi, R. & Fujita, S. (2004). Muscle tissue changes with aging. Current opinion in clinical nutrition and metabolic care, 7(4), 405-410. https://doi.org/10.1097/01.mco.0000134362.76653.b2

Weissenfels, A., Teschler, M [Marc], Willert, S., Hettchen, M., Fröhlich, M., Kleinöder, H [Heinz], Kohl, M., Stengel, S. von [Simon] & Kemmler, W. (2018). Effects of whole-body electromyostimulation on chronic nonspecific low back pain in adults: a randomized controlled study. Journal of pain research, 11, 1949. https://doi.org/10.2147/JPR.S164904

Weissenfels, A., Wirtz, N., Dörmann, U., Kleinöder, H [Heinz], Donath, L., Kohl, M., Fröhlich, M., Stengel, S. von [Simon] & Kemmler, W. (2019). Comparison of Whole-Body Electromyostimulation versus Recognized Back-Strengthening Exercise Training on Chronic Nonspecific Low Back Pain: A Randomized Controlled Study. BioMed Research International. https://doi.org/10.1155/2019/5745409

Wolfson, L., Judge, J., Whipple, R. & King, M. (1995). Strength is a major factor in balance, gait, and the occurrence of falls. The journals of gerontology. Series A, Biological sciences and medical sciences, 50 Spec No, 64-67. https://doi.org/10.1093/gerona/50A.Special_Issue.64