ORIGINAL ARTICLE

Annals of Agricultural and Environmental Medicine
www.aaem.pl

Impact of an original exercise programme using vibrating exercise equipment on balance, risk of falls, and foot load in elderly women

Aneta Bac[1,A-F], **Urszula Żmudzińska**[1,B,F], **Joanna Gradek**[2,B,F], **Katarzyna Sobczyk**[2,B,F], **Anna Ścisłowska-Czarnecka**[1,C,E-F], **Magdalena Markowska**[1,B,F], **Renata Woźniacka**[1,C,F], **Katarzyna Filar-Mierzwa**[1,A-C,E-F]

[1] *Motor Rehabilitation, University of Physical Culture, Kraków, Poland*
[2] *Physical Education and Sport, University of Physical Culture, Kraków, Poland*
A – Research concept and design, B – Collection and/or assembly of data, C – Data analysis and interpretation, D – Writing the article, E – Critical revision of the article, F – Final approval of the article

Bac A, Żmudzińska U, Gradek J, Sobczyk K, Ścisłowska-Czarnecka A, Markowska M, Woźniacka R, Filar-Mierzwa K. Impact of an original exercise programme using vibrating exercise equipment on balance, risk of falls, and foot load in elderly women. Ann Agric Environ Med. doi:10.26444/aaem/211263

Abstract

Introduction and Objective. Old age is a period of life in which occur involutionary processes that concern all systems of the body. Physiotherapists are constantly looking for new solutions that would allow them to better and more effectively physically activate seniors and thus prevent, among others, falls and their consequences. The literature shows that one of the tools used in working with the elderly is vibration training, therefore, the aim of the study is to check the effectiveness of the authors' original exercise programme using vibrating exercise equipment on selected indicators in elderly women.
Materials and Method. The study participants comprised 47 elderly women (60–71 years), randomly divided into three groups: ES – undergoing the authors' original exercise programme with vibrating exercise equipment, E – subjected to the authors' exercise programme without any equipment, and group C – no intervention. For evaluation of selected indicators, the following were used: baropodometric platform (foot load), Single Leg Stance test (balance and risk of falls) and the Biosway platform (balance and risk of falls).
Results. Statistically significant changes were observed before and after the therapy for the ES group in relation to the Single Leg Stance test (eyes closed) and Limit of Stability results. For comparisons between groups after the therapy, such significance was observed for the load on the left forefoot (ES versus C), Single Leg Stance test (ES versus C) and the Limits of Stability test (ES versus E and ES versus C).
Conclusions. The author-designed exercise programme using vibrating exercise equipment proved to be more effective in improving selected indicators compared to exercises without vibration and to the control group.

Key words

balance, risk of falls, older women, foot load, vibrating exercise equipment.

INTRODUCTION

Currently, a progressive process of aging among societies can be observed. Old age is a period of life in which involution processes concerning all systems of the body occur, including those anatomical and functional. As a result, with age, the efficiency of postural and motor systems responsible for postural stability gradually decreases, which translates into, among others, an increased risk of falls [1–3]. Falls are mainly the consequence of balance disorders, but their frequency may also be influenced by other factors, such as reduced strength and muscle mass, visual capacity, the distribution of load on the feet, or cognitive disorders [4, 5]. Physiotherapists working with the elderly are constantly looking for new solutions that would allow them to better and more effectively physically activate their patients, thus preventing falls and minimising their consequences [6]. The main goal of physical activity among seniors is to improve fitness, muscle strength, flexibility, psychomotor coordination, balance and foot loading which, in turn, reduces the risk of falls [7, 8]. The literature shows that one of the tools that effectively improves the above-mentioned indicators is vibration training [9–12]; however, the authors of such publications mainly focus on body vibration using vibration foam rollers or platforms. The rollers used to generate vibrations are devices in the shape of a foam cylinder with a built-in vibrating element. With them, the physiotherapist performs a massage of the trunk and limbs, while the platform, under which the patient is standing, generates vibrations in his/her body under the control of the physiotherapist. A disadvantage of such devices is the need to use them under the supervision of a physiotherapist or their high cost of purchase, and therefore the inability of the patient to use these solutions for home rehabilitation. However, recently, accessories have appeared on the market that could be a good proposition for seniors to conduct vibration training both under the supervision of a physiotherapist and at home. These accessories are vibrating exercise equipment, which the patient holds in his/her hands during exercises. This vibrating exercise equipment comprises rings that consist of a handle with a vibration suppressing element, to which a spiral hose is attached, inside which there are four movable steel balls. When the rings

✉ Address for correspondence: Aneta Bac, Motor Rehabilitation, University of Physical Culture, Al. Jana Pawła II 78, 31-571 Kraków, Poland
E-mail: aneta.bac@awf.krakow.pl

Received: 03.04.2025; accepted: 03.10.2025; first published: 14.10.2025

are moved forward and backward, the balls move freely, generating vibrations at a frequency of approx. 60 Hz, which are transferred from the hand to other parts of the body [13]. According to the manufacturers of the equipment, exercises using vibrating rings, among others, activate 97% of muscles, affect the body's balance, prevent falls, make the connective tissue more flexible, strengthen the cardiovascular system and stimulate metabolism. Vibrating exercise equipment is recommended for patients with, i.e. Parkinson's disease, diabetes, obesity, rheumatism or depression. However, the available literature lacks publications which confirm the effectiveness of vibrating exercise equipment.

The use of vibrating exercise equipment is simple and intuitive, which is why it can be a promising type of therapy used in various types of dysfunctions among the elderly. Additionally, it allows for the diversification of repeated exercise regimens, performing exercises independently at home by the patient, and can also have a positive effect on the commitment and willingness of most people to participate in rehabilitation, resulting in a better therapeutic effect. Therefore, due to the potential of the described equipment and the lack of scientific reports proving its usefulness, especially in the field of improving balance and foot load, the aim of the present study is to check the effectiveness of the author's original exercise programme using vibrating exercise equipment on balance, risk of falls and foot load in elderly women.

MATERIALS AND METHOD

Study participants comprised 47 elderly women aged 60–71 years (Tab. 1). The participants were randomly divided into three groups (by computer-assisted selection performed by the main author):

ES group – experimental (N = 15). This group of participants underwent the authors' exercise programme with vibrating exercise equipment.

E group – experimental (N = 14). This group of participants underwent the authors' exercise programme without any equipment.

C group – control (N = 18). This group had no intervention.

All participants declared that they would not undertake other sports activities during the project.

Inclusion criteria:
- age between 60 – 71 years;
- consent for participation in the study;
- no contraindications to physical activity;
- no cognitive impairment (MMSE score above 27 points);

Exclusion criteria:
- motor disability preventing independent activity;
- injuries to the musculoskeletal system up to 12 months prior to the beginning of the rehabilitation programme;
- neurological diseases causing balance disorders;
- poor mental state, e.g. depression;
- physical conditions preventing participation, e.g. severe respiratory or circulatory deficiency.

The study was performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments. The research project was approved by the Bioethics Committee of National Chamber of Physiotherapists (Approval No. 33/KIF/2023). This study was registered in the Australian and New Zealand Clinical Trials Registry (Registration No. ACTRN12623001240639).

Measurement Tools. For all women, both in the experimental and control groups, measurements were taken twice, before and after the exercise programme, i.e. six weeks later (foot load, balance and risk of falls). Body mass and height and cognitive ability were measured once for each participant before the exercise programme.

Mini-Mental State Examination (MMSE). Cognitive ability was determined using MMSE, which is a 30-item screening tool used to assess cognition, including orientation, attention, language and memory. A patient receives a 0 or 1 score for

Table 1. Overview of participants

Variable	Group ES				Group E				Group C			
	$\bar{x}$	Min	Max	SD	$\bar{x}$	Min	Max	SD	$\bar{x}$	Min	Max	SD
Age (years)	67.33	61	71	3.20	66.50	62	70	2.77	68.94	65	71	1.55
Comparison between groups						ES vs E=0.654 ES vs C=0.177 E vs C=0.261						
Body height (cm)	162.87	153	170	4.21	161.29	151	168	5.57	158.28	150	167	5.55
Comparison between groups						ES vs E=0.394 ES vs C=0.383 E vs C=0.139						
Body mass (kg)	72.40	55	100	12.66	65.43	43	84	11.04	68.33	54	94	11.44
Comparison between groups						ES vs E=0.127 ES vs C=0.340 E vs C=0.475						
BMI (kg/m²)	27.19	20.70	36.30	4.20	21.19	17.30	32.70	4.16	27.30	20.60	36.90	4.89
Comparison between groups						ES vs E=0.209 ES vs C=0.944 E vs C=0.206						

$\bar{x}$ – mean; SD – standard deviation; *p* – level of statistical significance each question. The interpretation of the scale is as follows: scores of 30–27, normal; 26–24, cognitive impairment; 23–19, mild dementia; 18–11, moderate dementia; 10–0, severe dementia [14].

Single Leg Stance (SLS). A test is used to assess postural control and balance in a static position and is a basic tool for evaluating the risk of falls in older people. The patients were informed how to perform the test before it had begun. The patients stood on one leg, with their upper limbs resting on their hips. Time measurement began when the patient lifted one lower limb and ended when the patient supported him/herself with the upper or lifted lower limb. During the test, each patient was supported by a physiotherapist. The test was performed with eyes open and then with eyes closed. The patient stood on his/her dominant lower limb [15].

Baropodometric platform. A static foot load analysis was performed using a FreeMED platform, consisting of an active panel of 40 × 40 cm, which contained recording sensors, and additional passive panels of 2 x 100 cm, constituting an extension of the active panel [16]. During the static tests on the FreeMed ground reaction force platform, the foot load distribution was calculated. Each static test was performed in a free-standing position, with the arms hanging freely beside the torso and feet parallel to each other, slightly apart, barefoot. The results of the tests included: individually for the right and left feet – total load (%) and load by regions – forefoot and hindfoot (%).

Biosway platform. The Biodex platform is a device equipped with an appropriately configured platform and monitor. It also includes a foam covering to imitate unstable ground during one of the available tests. The device is used for assessing fall risk among seniors [17, 18].

All participants of the study performed three tests, each one at the beginning and each one at the end of the study:

- *Postural Stability Test (PST)* – emphasizes the patient's ability to maintain the centre of balance for 30s (the result is given in numbers without units, the lower number the better the result) [19].
- *Limits of Stability (LoS)* – assesses the participant's ability to maintain his/her centre of pressure outside the plane of support while keeping the feet on the ground (the result is given in %, the higher the %, the better the result) [20].
- *Modified Clinical Test of Sensory Interaction and Balance (m-CTSIB)* – assesses fall risk. The test consisted of four parts, each lasting 30 seconds: eyes open and eyes closed, hard surface; eyes open and eyes closed, soft surface (the result is given in numbers without units, the lower the number, the better the result) [21].

Rehabilitation programme. Both study groups were subjected to an identical original exercise programme consisting of three parts:

1) warm up (5 min) – consisted of exercises for the upper and lower limbs and the trunk in all planes;
2) proper (35 min) – comprised aerobic, balance and strength exercises;
3) cool down (5 min) – consisted of breathing, relaxation and stretching exercises.

Women from the first study group (ES) performed all exercises using vibrating exercise equipment. Both study groups participated in exercise sessions three times a week, for six weeks. Each session lasted approx. 45 min, and the intensity of exercise did not exceed 40–70% HRmax.

Statistical methods. The data are presented as mean values, minimal and maximal values and standard deviation. Normality of distributions was verified based on the Shapiro-Wilk test. Evaluation of homogeneity of variance was performed using the F test. In the case of meeting the assumptions of parametric tests, differences between the control group and the study group were checked using the Student's t-test, while when the assumptions were not met, using the non-parametric Mann-Whitney U test. Differences between the control group and the study groups were compared using one-way analysis of variance (ANOVA), and then for *post-hoc* evaluation, the Tukey test was used, in the case of data with a normal distribution (Barlett's test) and with homogeneous variance (Brown-Forsyth test). In the absence of parametric test assumptions, the Kruskall-Wallis test was used with *post-hoc* evaluation using Dunn's test. The significance level of $p \leq 0.05$ was adopted. Microsoft Excel 2007 and Statistica 10 (StatSoft) were used for statistical analysis of the results.

RESULTS

The first of the evaluated indicators was the static load on the feet of the examined patients. For the left foot, no statistically significant changes were observed before or after the applied therapeutic intervention for any of the evaluated groups. In the comparisons between groups, however, statistically significant differences were noted only between the group exercising with vibrating exercise equipment (ES) compared to the control group (C) after the applied therapy. For the right foot – similarly to the left – no statistically significant changes were observed before or after the applied therapeutic intervention for any of the evaluated groups. In the between group comparison, statistically significant differences were noted only between the group exercising with vibrating exercise equipment (ES) compared to the control group (C) before therapy. No statistically significant changes were observed after the applied therapeutic intervention for any of the evaluated groups (Tab. 2).

The Single Leg Stance test (SLS) was for the assessment of static balance and the risk of falls in all the women under study. Statistically significant changes were observed only for the group exercising with vibrating exercise equipment (ES). In the case of the test performed with open eyes, such significance was noted in comparison to the control group (C), and for the test with closed eyes, significance was also observed in the results obtained by women from the ES group before and after the therapy (Tab. 3).

In the case of the results obtained using the Biosway platform, statistically significant differences were noted for the Limits of Stability (LoS) test and the Modified Clinical Test of Sensory Interaction and Balance (m-CTSiB) performed with eyes open and on a soft surface. In the LoS test, these changes were observed both before and after therapy for the ES group, and in the between-group comparisons. In the comparisons between groups prior to the implemented therapy, statistically significant differences were visible

Table 2. Results of foot load for left and right feet before and after therapy

Variable	Group	Before therapy				After therapy				Comparison between measurements
		$\bar{x}$	Min	Max	SD	$\bar{x}$	Min	Max	SD	
LEFT FOOT										
Forefoot load (%)	ES	23.07	14.00	36.00	5.57	24.67	15.00	42.00		p=0.489
	E	22.79	13.00	35.00	6.28	22.36	12.00	34.00		p=0.866
	C	20.50	12.00	34.00	4.89	20.11	12.00	34.00		p=0.829
Comparison between groups		ES vs E p=0.899 ES vs C p=0.169 E vs C p=0.256				ES vs E p=0.380 ES vs C p=0.047* E vs C p=0.330				
Hindfoot load (%)	ES	23.40	16.00	37.00	6.53	26.33	15.00	36.00		p=0.188
	E	23.64	3.00	42.00	10.74	26.43	18.00	38.00		p=0.422
	C	26.61	2.00	37.00	8.77	28.83	19.00	38.00		p=0.391
Comparison between groups		ES vs E p=0.941 ES vs C p=0.423 E vs C p=0.396				ES vs E p=0.967 ES vs C p=0.237 E vs C p=0.316				
Total load (%)	ES	46.87	41.00	66.00	6.49	50.20	46.00	61.00		p=0.094
	E	46.43	30.00	64.00	9.80	48.86	39.00	62.00		p=0.445
	C	48.44	40.00	58.00	4.19	49.94	39.00	63.00		p=0.795
Comparison between groups		ES vs E p=0.887 ES vs C p=0.406 E vs C p=0.437				ES vs E p=0.490 ES vs C p=0.533 E vs C p=0.971				
RIGHT FOOT										
Forefoot load (%)	ES	25.67	13.00	37.00	6.91	21.80	17.00	28.00		p=0.061
	E	23.79	10.00	36.00	6.24	22.00	12.00	29.00		p=0.409
	C	21.28	12.00	32.00	4.99	21.06	13.00	34.00		p=0.900
Comparison between groups		ES vs E p=0.450 ES vs C p=0.043* E vs C p=0.216				ES vs E p=0.898 ES vs C p=0.652 E vs C p=0.6200				
Hindfoot load (%)	ES	27.87	10.00	39.00	7.56	27.87	8.00	43.00		p=1.000
	E	29.79	19.00	42.00	6.47	29.21	25.00	36.00		p=0.776
	C	30.28	25.00	40.00	3.83	30.00	21.00	40.00		p=0.862
Comparison between groups		ES vs E p=0.478 ES vs C p=0.245 E vs C p=0.796				ES vs E p=0.529 ES vs C p=0.347 E vs C p=0.638				
Total load (%)	ES	53.13	34.00	59.00	6.49	49.80	39.00	54.00		p=0.094
	E	53.57	36.00	70.00	9.80	51.21	39.00	61.00		p=0.455
	C	51.56	42.00	60.00	4.16	51.06	37.00	61.00		p=0.795
Comparison between groups		ES vs E p=0.887 ES vs C p=0.406 E vs C p=0.437				ES vs E p=0.460 ES vs C p=0.533 E vs C p=0.947				

$\bar{x}$ – mean; SD – standard deviation; *p*-level of statistical significance; *significantly different ($p \leq 0.05$).

between the ES and control group (C), as well as between the E group and the control (C). Post therapy, statistically significant changes were demonstrated between the ES group and the remainder (E and C). In the m-CTSiB test (eyes open, soft surface), statistically significant differences were observed only in the between-group measurements prior to therapy for the ES group compared to the other groups (E and C) (Tab. 4).

DISCUSSION

Vibration training is one of the newest tools used for working with seniors, but reports on its effectiveness in improving various indicators (including balance and muscle strength) are not clear. Such inconsistency may result, for example, from the different sizes of the studied groups (from a dozen to almost 100 participants), duration of the intervention (from single sessions to 10 weeks), varying intensity of vibration application (from single application to once or twice a week), or the large age range in the studied groups. Additionally, although the authors focus on the effect of vibrations on both independent, healthy elderly people and those burdened with various diseases, they assess very different indicators, among which there are no reports on the effect of this form of therapy on foot loading in senior women, which is very important in the context of the risk of falls.

In the available literature, the influence of vibrations generated by vibrating platforms is discussed. Liu et al. [9] examined 15 healthy women around the age of 60 who underwent vibration training combined with static and dynamic squats. The authors assessed the strength of the lower limb muscles and showed that the training they

Table 3. Single Leg Stance test results before and after therapy

One Leg Stance	Group	Before therapy				After therapy				Comparison between measurements
		$\overline{x}$	Min	Max	SD	$\overline{x}$	Min	Max	SD	
Eyes open (min)	ES	1:42:20	0:08:18	6:00:00	1:49:10	2:53:30	0:15:10	12:01:29	3:09:23	p=0.218
	E	1:05:30	0:00:00	2:10:21	0:34:24	1:23:23	0:02:24	2:47:27	0:42:33	p=0.244
	C	1:17:11	0:05:04	4:49:29	1:12:20	1:10:04	0:02:01	3:57:04	3:57:04	p=0.761
Comparison between groups		ES vs E p=0.255 ES vs C p=0.434 E vs C p=0.595				ES vs E p=0.094 ES vs C p=0.047* E vs C p=0.504				
Eyes closed (min)	ES	0:08:05	0:02:26	0:29:26	0:07:22	0:28:24	0:03:50	0:28:24	0:22:54	p=0.003*
	E	0:05:45	0:00:00	0:13:15	0:03:23	0:09:57	0:02:01	0:09:57	0:10:11	p=0.157
	C	0:09:13	0:02:44	0:14:32	0:03:26	0:13:32	0:01:42	0:09:32	0:13:39	p=0.425
Comparison between groups		ES vs E p=0.288 ES vs C p=0.401 E vs C p=0.579				ES vs E p=0.013 ES vs C p=0.006 E vs C p=0.854				

$\overline{x}$ – mean; SD – standard deviation; *p*-level of statistical significance; *significantly different ($p \leq 0.05$).

Table 4. PST, LoS and m-CTSiB results before and after therapy

Variable	Group	Before therapy				After therapy				Comparison between measurements
		$\overline{x}$	Min	Max	SD	$\overline{x}$	Min	Max	SD	
Postural Stability Test (PST)	ES	0.45	0.20	1.00	0.22	0.39	0.00	0.70	0.20	p=0.491
	E	0.44	0.00	1.00	0.22	0.49	0.20	2.00	0.45	p=0.710
	C	0.48	0.20	0.80	0.18	0.44	0.30	1.90	0.14	p=0.500
Comparison between measurements		ES vs E p=0.893 ES vs C p=0.653 E vs C p=0.463				ES vs E p=0.476 ES vs C p=0.372 E vs C p=0.700				
Limits of Stability (LoS) [%]	ES	42.40	31.00	51.00	6.03	55.40	41.00	73.00	10.49	p=0.000*
	E	42.14	32.00	50.00	8.11	45.21	25.00	58.00	9.37	p=0.362
	C	49.94	34.00	62.00	8.29	45.00	30.00	59.00	8.52	p=0.087
Comparison between measurements		ES vs E p=0.923 ES vs C p=0.010* E vs C p=0.016*				ES vs E p=0.010* ES vs C p=0.003* E vs C p=0.947				
m-CTSiB – Eyes open, hard surface	ES	0.63	0.41	1.21	0.21	0.54	0.00	0.85	0.22	p=0.277
	E	0.67	0.28	1.15	0.24	0.64	0.36	1.12	0.24	p=0.690
	C	0.64	0.38	0.82	0.14	0.67	0.35	0.91	0.17	p=0.537
Comparison between groups		ES vs E p=0.593 ES vs C p=0.910 E vs C p=0.570				ES vs E p=0.270 ES vs C p=0.073 E vs C p=0.675				
m-CTSiB – Eyes closed, hard surface	ES	0.84	0.52	1.64	0.30	0.80	0.00	1.64	0.39	p=0.786
	E	0.84	0.32	2.20	0.47	0.86	0.29	1.90	0.43	p=0.901
	C	0.77	0.35	1.26	0.26	0.76	0.35	1.05	0.21	p=0.816
Comparison between measurements		ES vs E p=0.994 ES vs C p=0.533 E vs C p=0.637				ES vs E p=0.708 ES vs C p=0.672 E vs C p=0.377				
m-CTSiB – Eyes open, soft surface	ES	1.17	0.80	1.73	0.22	1.14	0.00	1.62	0.42	p=0.824
	E	1.37	0.81	2.04	0.33	1.73	0.00	1.32	0.25	p=0.599
	C	1.49	1.08	2.26	0.29	1.38	0.35	1.38	0.22	p=0.316
Comparison between measurements		ES vs E p=0.001* ES vs C p=0.001* E vs C p=0.261				ES vs E p=0.209 ES vs C p=0.157 E vs C p=0.532				
m-CTSiB – Eyes closed, soft surface	ES	2.67	1.78	4.96	0.87	2.15	0.00	4.10	0.95	p=0.130
	E	2.77	2.13	4.12	0.64	2.66	1.91	3.98	0.62	p=0.662
	C	2.58	0.64	3.35	0.49	2.50	0.35	3.64	0.53	p=0.600
Comparison between measurements		ES vs E p=0.730 ES vs C p=0.719 E vs C p=0.354				ES vs E p=0.099 ES vs C p=0.247 E vs C p=0.474				

m-CTSiB – Modified Clinical Test of Sensory Interaction and Balance; $\overline{x}$ – mean; SD – standard deviation; *p*-level of statistical significance; *significantly different ($p \leq 0.05$)

described improved this strength compared to people training without vibration, although they indicated that increasing the vibration frequency did not increase the therapeutic effect. In a different study conducted by de Bruin et al. [10], its authors confirmed the earlier report on the positive effects of vibration training. They examined 17 elderly people (including 10 women) who underwent vibration training on a platform combined with dance therapy. The entire training intervention lasted eight weeks; during the first three weeks, the subjects were exposed to vibrations of different frequencies three times a week, and for the remaining five weeks after training on the platform, they were subjected to dance therapy. The indicators assessed following therapy included: static balance, risk of falls and cognitive abilities. According to the authors, all indices improved after the intervention compared to the control group.

Lam et al. [22] reached slightly different conclusions after examining 62 elderly people. In order to check the effect of vibration training on a platform combined with strength and balance exercises on mobility and balance, the authors divided the subjects into three groups: with vibration training, without vibration training, and a group exercising recreationally and engaging only the upper limbs in the exercises. The proposed programme lasted eight weeks, and the subjects exercised three times a week. In the conclusions from this study, the authors mentioned that the vibration training they conducted was as effective as the exercise programmes conducted without such training. Similar conclusions were also reached by Sievänen et al. [23] who assessed the risk of falls and physical capacity in 83 elderly people who underwent 10 weeks of vibration training on a platform. The study participants were divided into two groups, one of which underwent vibration training and the other, low-intensity exercises once a week. These authors also emphasized the similar effectiveness of exercises and vibration training in improving the assessed indicators.

The second tool used to generate vibrations in the human body discussed in the literature is vibrating rollers. As in the case of platforms, here too, the authors are not unanimous as to the effectiveness of such training. Yang et al. [12] examined 15 healthy, elderly women, in whom they assessed the impact of vibrations generated by foam rolling on blood pressure and physical performance. The women underwent massage once a week, and on the following days, they performed walking and static stretching exercises. The entire programme lasted three weeks, and in the conclusions, the authors noted a positive effect of exercises combined with vibration on both blood pressure and physical performance.

Chen et al., however, reached opposite conclusions [24]. These authors assessed the effect of static stretching combined with vibration generated by foam, among others, on physical performance in older women with pre-hypertension. The authors divided 13 study participants into three groups, one of which performed static stretching exercises, the second the same exercises combined with vibration foam rolling, and the third, static stretching exercises combined with foam rolling without a vibration component. In each group, the intervention was used once. After completion of the study, the authors found that in the vibration foam rolling group, the results obtained by the patients were worse compared to the remaining two groups.

There is also a report in the literature on vibration training performed using vibrating exercise equipment. Zurek et al. [25] assessed the effect of vibration training using vibrating exercise equipment on muscle bioelectric activity, range of motion, and pain intensity in older women with chronic low back pain. The authors examined 92 women aged 49 – 80 who were divided into two groups. The first group performed exercises using vibrating exercise equipment, and the second group conducted the same exercises but without such apparatus. The training sessions were carried out twice a week and lasted 10 weeks. After analysing the obtained data, the authors found that vibration training was as effective in improving the assessed indicators as exercises without vibration, but they recommend it as prospective strategy in increasing ROM and decreasing lumbar spine pain.

In the present study, the authors assessed the effect of vibrations obtained using vibrating exercise equipment in combination with a proprietary exercise programme on balance and foot load in elderly women. The studied women were divided into three groups: two groups exercising with and without vibrating exercise equipment, respectively, and a control group without any applied therapeutic intervention. The examined women exercised three times a week for six consecutive weeks, and each exercise session lasted 45 minutes. After analysing the results, it was found that it was the exercises using vibrating exercise equipment that proved to be the most effective in improving some of the assessed indicators, both in relation to the second study group and the control group. It was also noted that exercises using vibrating exercise equipment demonstrated the most effective effect on improving the load on the left forefoot (significant change compared to the control group), balance, and the risk of falls (significant change compared to the control group in the test with eyes open and a statistically significant change after therapy in the test with eyes closed) and reducing the risk of falls assessed (significant change both after therapy and in comparison to the remaining groups).

Assessing the impact of vibrating exercise equipment and the vibrations generated by them on the human body, without a doubt, requires further research. However, the results obtained in the current study underline the potential of these devices/tools – especially the Single Leg Stance Test – and encourage further research on the relationships between vibrations obtained using vibrating exercise equipment on the nervous and musculoskeletal systems of elder individuals.

Limitations of the study. The study is not without limitations. Increasing the duration of training would be a good guideline for future studies. In further research, the sample size could also be increased and also involve men as well as women. A good complement to the research would also be assessment regarding the long-term effects of the applied therapeutic interventions, as well as evaluation concerning the impact of the proposed exercises on other areas of functioning in everyday life.

CONCLUSION

The original exercise programme using vibrating exercise equipment proved to be more effective in improving forefoot loading as well as balance, and in reducing the risk of falls compared to exercises performed without a vibration component, and in contrast to the control group.

Acknowledgments

The study was financed in within the 2019–2022 programme of the Minister of Science and Higher Education in Warsaw under the title *Regional Initiative of Excellence*, in the amount of PLN 11,919,908 (Project No. 022/RID/2018/19).

REFERENCES

1. Alsubaie SF. The postural stability measures most related to aging, physical performance, and cognitive function in healthy adults. Biomed Res Int. 2020;5301534. doi:10.1155/2020/5301534
2. Filar-Mierzwa K, Długosz-Boś M, Marchewka A, et al. Effect of different forms of physical activity on balance in older women. J Women Aging. 2021;33(5):487–502. doi:10.1080/08952841.2020.1718579
3. Wong RMY, Chong KC, Law SW, et al. The effectiveness of exercises on fall and fracuture prevention among community elderlies: a systematic review and meta-analysis. J Orthop Trans. 2020;24:58–65. doi:10.1016/j.jot.2020.05.007
4. Colón-Emeric CS, McDermott CL, Lee DS, et al. Risk assessment and prevention of falls in older community-dwelling adults: a review. JAMA. 2024;331(16):1397–1406. doi:10.1001/jama.2024.1416. PMID: 38536167
5. Linhares DG, Borba-Pinheiro CJ, Castro JBP, et al. Effects of multicomponent exercise training on the health of older women with osteoporosis: a systematic review and meta-analysis. Int J Environ Res Public Health. 2022;19(21):14195. doi:10.3390/ijerph192114195
6. Długosz-Boś M, Filar-Mierzwa K, Stawarz R, et al. Effect of three months Pilates training on balance and fall risk in older women. Int J Environ Res Public Health. 2021;18:3663. https://doi.org/10.3390/ijerph18073663
7. Bangsbo J, Blackwell J, Boraxbekk CJ, et al. Copenhagen Consensus statement 2019: physical activity and ageing. Br J Sports Med. 2019;53:856–858.
8. Criss MG, Wingood M, Staples WH, et al. APTA geriatrics' guiding principles for best practices in geriatric physical therapy: an executive summary. J Geriatr Phys Ther. 2022;45(2):70–75. doi:10.1519/JPT.0000000000000342
9. Liu Y, Fan Y, Chen X. Effects of whole-body vibration training in static and dynamic semi-squat patterns on the lower limb muscle activity. Sci Rep. 2023;13(1):14432. doi:10.1038/s41598-023-40985-x
10. de Bruin ED, Baur H, Brülhart Y, et al. Combining stochastic resonance vibration with exergaming for motor-cognitive training in long-term care; a sham-control randomized controlled pilot trial. Front Med (Lausanne). 2020;7:507155. doi:10.3389/fmed.2020.507155
11. Souto Braz RR, Campos SL, Villela DW, et al. Effectiveness of whole-body vibration combined with multicomponent training on the risk of falls and quality of life in elderly women with osteoporosis: study protocol for a randomized controlled clinical trial. Biology (Basel). 2022;11(2):266. doi:10.3390/biology11020266
12. Yang WC, Chen CH, Chu LP, et al. Acute effects of vibration foam rolling with light and moderate pressure on blood pressure and senior fitness test in older women. Int J Environ Res Public Health. 2021;18(21):11186. doi:10.3390/ijerph182111186
13. https://www.smovey.info.
14. Folstein MF, Folstein SE, McHugh PR. Mini-mental state: a practical method for grading the cognitive state of patients for the clinician. J Psychiatr Res. 1975;12:189–198. doi:10.1016/0022-3956(75)90026-6
15. Vellas BJ, Wayne SJ, Romero L, et al. One-leg balance is an important predictor of injurious falls in older persons. J Am Geriat Soc. 1997;45(6):735–738. doi:10.1111/j.1532-5415.1997.tb01479.x
16. Correale L, Pellino VC, Marin L, et al. Comparison of an inertial measurement unit system and baropodometric platform for measuring spatiotemporal parameters and walking speed in healthy adults. Motor Control. 2020;18:1–11. doi:10.1123/mc.2020-0060
17. Biodex Medical Systems, Inc. Biosway portable balance system operation manual; 2009. http://www.biodex.com/sites/default/files/950460man10202revd.pdf
18. Wrisley DM, Whitney SL. The effect of foot position on modified clinical test of sensory interaction and balance. Arch Phys Med Rehabil. 2004:85:335–338. doi:10.1016/j.apmr.2003.03.005
19. McIlroy WE, Maki BE. Preferred placement of the feet during quiet stance: development of a standardized foot placement for balance testing. Clin Biomech. 1997;12(1):66–70. doi:10.1016/s0268-0033(96)00040-x
20. Clark S, Rose D, Fujimoto K. Generalizability of the limits of stability test in the evaluation of dynamic balance among older adults. Arch Phys Med Rehabil. 1997;78(10):1078–84. doi:10.1016/s0003-9993(97)90131-3
21. Shumway-Cook A, Woollacott MH. Motor control: Theory and practical applications. Philadelphia: Lippincott Williams&Wilkins, 2001.
22. Lam FM, Chan PF, Liao LR, et al. Effects of whole-body vibration on balance and mobility in institutionalized older adults: a randomized controlled trial. Clin Rehabil. 2018;32(4):462–472. doi:10.1177/0269215517733525
23. Sievänen H, Piirtola M, Tokola K, et al. Effect of 10-week whole-body vibration training on falls and physical performance in older adults: a blinded, randomized, controlled clinical trial with 1-year follow-up. Int J Environ Res Public Health. 2024;21(7):866. doi:10.3390/ijerph21070866
24. Chen CH, Hsu CH, Chu LP, et al. Acute effects of static stretching combined with vibration and nonvibration foam rolling on the cardiovascular responses and functional fitness of older women with prehypertension. Biology (Basel). 2022;11(7):1025. doi:10.3390/biology11071025
25. Zurek G, Kasper-Jędrzejewska M, Dobrowolska I, et al. Vibrating exercise equipment in middle-age and older women with chronic low back pain and effects on bioelectrical activity, range of motion and pain intensity: a randomized, single-blinded sham intervention study. Biology (Basel). 2022;11(2):268. doi:10.3390/biology11020268