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Training and Detraining Effects of Step Aerobics on Strength and Functional Mobility in Healthy Middle-Aged and Older Women

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Abstract

The main purpose of the present study was to investigate the effects of 10 weeks of systematic steps aerobic practice on strength and functional mobility in three groups of women of different ages. One hundred and twenty women between the ages of 50 and 70 years were selected. This sample was divided into three experimental groups; 50-60 years (E-50); 60-70 years (E-60); and 70-80 years (E-70), and a control group (C). The experimental groups participated in step aerobics sessions of 60 minutes duration, using moderate volume of jumps, three times per week for 10 weeks. The C group was instructed to continue their habitual diet and physical activity. All tests (countermovement jump (CMJ), "Timed Up and Go" (TUG Test) and 30-second Chair Stand test (CST) were carried out before the 10 weeks of step aerobics (PRE), immediately after it (POST) and after 10 weeks of rest (DETRAINING). Step aerobics produced significant enhancements in the three age groups in jumping (ES:0.70-2.96; p<0.001;15-20%), functional mobility (ES:0.60-4.2; p<0.001;16-23%) and strength-endurance performance (ES: 2.55-3.78; p<0.00001; 30-40%). There were no significant changes in the C group in any of the variables of performance analyzed. Furthermore, the 10 weeks of detraining after the 10-week step aerobics program resulted in significant decreases in jumping (ES:0.60-0.70; p< 0.01;7-11%), functional mobility (ES:0.41-1.95; p<0.01;9-11%) strength-endurance (ES:1.01-2.74; p< 0.001;9-21%) performance in all training groups. The step aerobics program proposed appears to be an optimal stimulus for improving jumping, functional mobility, and strength-endurance performance during short-term training periods in middle-aged and elderly women.

Keywords: Women; Aerobic Dance Training; Strength Performance

Abbreviations: CMJ: Countermovement Jump; TUG: Timed Up and Go; CST: Chair Stand Test; PRE: Pretesting; POST: Post-Testing; DETR: Detraining-Testing; ICC: Intraclass Correlation Coefficient; AFAA: Athletics and Fitness Association of America.

Introduction

Lower body maximal strength and, particularly, maximal power output, decline with ageing [1,2]. The progressive decline in muscle strength and power, especially in the lower limbs, has important functional consequences. Reduced muscle power and strength have been identified as key factors, which may jeopardize the maintenance of mobility and independence for older individuals [3]. On the other hand, the power of the lower extremities has been related to stepping ability and gait velocity in elderly adults [4,5]. It has been demonstrated that increases in lower body strength led to reduced falls [6,7] and improved gait stability [8].

In this sense, strategies to reverse or mitigate this detrimental loss of muscle strength and power are therefore essential [3]. In addition to this reduction in physical capacity, muscle atrophy results in older people from a gradual process of fiber denervation with loss of some fibers and atrophy of others [9]. In particular, fast-twitch fibers show more denervation and atrophy than slow-twitch fibers, and this atrophy, particularly of the fast-twitch fibers, is most likely due to a combination of the effects of ageing and physical activity levels which have declined to a chronically low intensity [10]. Regular physical activity improves cardiorespiratory and muscular fitness, controls body mass and reduces the risk of premature chronic diseases in the adult population.

These can be obtained by completing 20 to 60 minutes of continuous or intermittent aerobic physical activity at an intensity ranging from 50 to 85% of the VO2max, for 3 to 5 days per week [11,12]. Concretely, bench stepping is one such practice of a healthy physical activity that would improve the level of physical fitness [13,14]. Bench stepping is a popular form of exercise that implies the execution of choreography to the rhythm of music, utilizing the movements of arms and legs while stepping up and down from the bank [13]. In order to reduce the risk of injury and improve effective muscular and cardio-respiratory development, the Athletics and Fitness Association of America (AFAA), recommends that the bench stepping should be carried out with a cadence of 118 to 128 beats min-1 on a bank between 15 and 20 cm in height [15].

Numerous studies have focused on the cardiovascular and metabolic responses after step aerobics [13,16-19]. There is some information concerning the effectiveness of bench stepping to enhance lower limb strength in middle-aged women, which contrasts with the current interest in force training programs design for middle-aged and elderly people [20]. These authors demonstrated that an aggressive bench-step aerobics (BSA) program influenced the maximal force production in the lower body, but not to the extent of a heavy resistance training program. In a prior investigation, Koenig et al. [21] reported a significant decrease in quadriceps strength (i.e., knee extensions) and no change in hamstring strength (i.e., leg curls) following 10 wk of BSA. Differences in the two investigations may be partially explained by different exercise testing movements used in the study of Koenig et al. [21].

The increases in the 1-RM squat strength represent a total-body structural strength increase that has ramifications for everyday functional abilities, bone health, and physical performance. Hakkinen et al. [22] and Izquierdo et al. [23] have shown that maximal strength and the capacity to generate power are important components of an adequate physical condition, permitting one to carry out daily activities (i.e., to climb stairs, to reduce falls or to walk) that require submaximal efforts and increase functional independence and quality of life. Besides, it has been verified that with ageing, participants experience deterioration in the capacity to generate power and agility, factors that possibly contribute to the loss of mobility and to the risk of falls.

Therefore, the main purpose of the present study was to examine the effect of a 10-week periodized bench stepping program on jumping, functional mobility and strength-endurance in three different age groups of healthy women (50-60; 60-70; 70-80 years). It was hypothesized that experimental groups would improve in strength and jumping performance in different ways than the control group. A secondary purpose was to examine the impact of a 10-week cessation of training after the 10-week bench stepping program on jumping, functional mobility, and strength-endurance performance. The third purpose was if there were any diverging training/detraining effects between the three age groups.

Methods

Experimental Design

A randomized pre-post-detraining experimental study was carried out: 1-day pretesting (PRE), 10 weeks of bench stepping, 1-day post-testing (POST), and following 10 weeks of rest (DETR) of the 10 weeks of step aerobics. Participants completed several explosive-type actions to become familiar with the action required, as well as with the jump technique, and the functional mobility test. Subsequently, the participants were matched with respect to age, and then randomly allocated to either a bench stepping (bench stepping) training according to the age group, or a control group (C). The participants were tested by the same investigator, using the same protocol and at the same time of day at weeks 0, 10, and 20.

For the completion of all experimental protocols, the participants fasted for 3-4 hours before the testing and did not ingest stimulants for 8 hours (i.e., caffeine), they were allowed to hydrate at will and avoided practicing intense exercise during the previous 24 hours. All tests determining the values of strength endurance, vertical jumping performance and functional mobility were carried out at three-time points (pre, post and detraining-testing). The following tests were completed: height, body mass, countermovement jump (CMJ) performance, functional test ("Timed Up and Go" (TUG) and strength-endurance test (30-CST test). Additionally, care was taken to allow sufficient rest (15 minutes) between all tests to limit the effects of fatigue on subsequent tests.

All training sessions were supervised by a certified strength and conditioning coach. All participants were asked to maintain their normal daily routines and eating habits, avoid any strenuous physical activity during the duration of the experiment, not take nutritional supplements that might affect lean tissue mass or fat mass, and refrain from commencing new exercise programs for

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the duration of the study. Every participant in the experimental groups executed the step aerobics at 06.00 p.m.

Participants

This study involved a group of 120 women between the ages of 50 and 80 years (all of them menopausal) (Table 1). None of the participants had any background in regular step aerobics. The participants were participating in a gymnastic program and recreational activity that did not involve bench stepping and had been participating in that program for 3 years. The women were instructed to avoid following a diet or being involved with other exercise programs during the duration of the study (from March to May). Exclusionary criteria included: participants with potential medical problems or with a history of ankle, knee or back pathology within the 3 years preceding the study, participants with no medical or orthopedic problems that compromised their participation or performance in this study or any lower extremity reconstructive surgery in the past 2 years or unresolved musculoskeletal disorders. All participants were meticulously informed of the experiment procedures and the possible risks and benefits associated with their participation in the study while they were asked to sign an informed consent document before any of the testing. The study conformed, nevertheless, with the current national and international laws and regulations governing the use of human subjects (Declaration of Helsinki II) and was approved by the Ethics Committee of the involved institutions (IRB number: E2016000034) (Table 1).

Table 1: Initial characteristics of the groups (means ± SD).

Group	Age (years)	Height (cm)	Body mass (kg)	BMI (Kg/m^2)	Body fat (%)
C (n = 45)	58.13 ± 3.1	165.4 ± 2.4	65.6 ± 4.2	23.98	27.2 ± 4.3
E-50 (n = 25)	55.4 ± 4.1	163.2 ± 7.1	66.6 ± 7.8	25.01	26.5 ± 2.8
E-60 (n = 25)	63.4 ± 3.2	162.7 ± 5.4	71.5 ± 8.9	27.01	27.5 ± 2.9
E-70 (n = 25)	73.4 ± 2.3	164.3 ± 4.9	73.2 ± 2.1	27.12	28.3 ± 2.1

Training

The participants took part in a linear, bench stepping-training program consisting of three sessions each week (Monday-Wednesday-Friday) for a period of 10-wk, in total of 30 sessions Each training session lasted 60 minutes, made up of the following parts: 15 minutes of standard warm-up (10 minutes submaximal running and several displacements, stretching exercises for 5 minutes), 40 minutes of bench stepping work and 10 minutes of cool-down period (stretching exercises). The first week was used for familiarization with the basic movements of the bench stepping. During each session the heart rate of each participant was registered by monitors (Sports Tester, Polar Electro, Kempele, Finland).

This registration was important to assure that the participants completed the session in the zone of adequate heart rate to the prescription carried out by the ACSM (60-70% of the heart rate of reserve) [12]. The sessions of bench stepping were given by the same instructor. The employed music was selected for the warming-up, main phase and return to a resting state. The routine was set to music paced at a cadence of 118 to 128 foot strikes a minute. The choreographed exercise bout included steps and combinations that allowed forwards/backward and lateral transitions on and off the bench. The control group (CG) did not receive treatment and was instructed to maintain their physical habits and regular sports practice. The training was performed in a closed sports hall area with a stable temperature of 26ºC and 65% of humidity on a synthetic surface.

Anthropometric Characteristics

Height was measured using a wall-mounted stadiometer (Seca 222, NY, USA) and recorded to the nearest centimeter. Body mass was measured to the nearest 0.1 kg using a medical scale. The participants were carefully familiarized with the test procedure during several sub-maximal and maximal actions a few days before measurements were taken while the tests were also being done previously with control training purposes.

Countermovement Jump

A countermovement jump (CMJ) was utilized in order to assess jump performance. The CMJ test was performed using a force platform (Bioware, Kistler, Switzerland). Jump height was determined using the calculated displacement of the mass center measuring the applied force and the body mass. During the CMJ, the participant was instructed to rest his/her hands on his/her hips while performing a downward movement followed by a maximum-effort vertical jump. All participants were instructed to land in an upright position and to bend their knees following landing. Five trials were completed with 45-60 seconds of rest between trials and the best-performance trial was used for the subsequent statistical analysis. The intraclass correlation coefficient (ICC) was 0.92 (0.88-0.94).

Functional Mobility Test

The "Timed Up-and-Go" test (TUG test) assesses functional mobility and dynamic balance. The TUG test is an objective, fast and easy-to-apply test [24]. This test measures the minimum time

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that an individual can raise from a seated position without pushing off with the arms, walk 3 meters, turn, and returned to the initial seated position, as fast as possible. The score represents the time elapsed from the starting signal until the participant returns to the seated position on the chair. The TUG test was administrated using a chair without arms, with a seat height of 46 cm. The chair, with rubber tips on the legs, was placed against a wall to prevent it from moving during the test. The test began with the participant seated in the middle of the chair, back straight, feet approximately shoulder-width apart and placed on the floor at an angle slightly back from the knees, with one foot slightly in front of the other to help maintain balance when standing. Arms were crossed at the wrists and held against the chest. At the signal "go" the participant rose to a full stand (body erect and straight), walked 3 meters, turned and then returned to the initial seated position. The TUG test is a reliable (intraclass correlation coefficient = 0.84-0.92) and valid measure of lower extremity agility in laboratory settings [24]. Three trials were completed with 90 seconds of rest among trials and the best performance trial was used for the subsequent statistical analysis. The intraclass correlation coefficient (ICC) was 0.88 (0.86-0.92).

30-Second Chair Stand Test

The chair stand test (30CST) assesses lower body strength and endurance. 30CST (the maximum number of times within 30 seconds that an individual can raise to a full stand from a seated position, without pushing off with the arms). The 30CST was administrated using a chair without arms, with a seat height of 40 cm. The chair, with rubber tips on the legs, was placed against a wall to prevent it from moving during the test. The test began with the participant seated in the middle of the chair, back straight, feet approximately shoulder width apart and placed on the floor at an angle slightly back from the knees, with one foot slightly in front of the other to help maintain balance when standing. Arms were crossed at the wrists and held against the chest. At the signal "go" the participant rose to a full stand (body erect and straight) and then returned to the initial seated position.

The participants were encouraged to complete as many full stands as possible within a 30-second time limit. The participant was instructed to be fully seated between each stand. While monitoring the participant's performance to assure proper form, the tester silently counted the completion of each correct stand. Following a demonstration by the tester, practice trials of 3 repetitions were given to check proper form, followed by the 30-second test trial. The score was the total number of stands executed correctly within 30 seconds (more than halfway up at the end of 30 seconds counted as a full stand). Incorrectly executed stands were not counted. The 30CST is a reliable (intraclass correlation coefficient = 0.84-0.92) and valid measure of lower extremity strength (r=0.71-0.78) in laboratory settings [25,26] and demonstrates an ability to climb steps as well as gait velocity and lower risk of falling [26]. Three trials were completed with 300 sec. of rest between trials and the best performance trial was used for the subsequent statistical analysis. The intraclass correlation coefficient (ICC) was 0.90 (0.86-0.94).

Statistical Analysis

Descriptive statistics (mean ± SD) for the different variables were calculated. Homogeneity of variance across groups was verified using Levene's test, whereas the normality of the distribution of the data was examined with the Kolmogorov-Smirnov test. To assess the training-related effects on height in CMJ and Chair stand test, 4 groups by 3 (times) factorial analysis of variance (ANOVA) were conducted. Any significant differences found by the ANOVA were followed by Bonferroni post hoc analysis. All data were analyzed using the Statistical Package for Social Sciences (Version 23.0; SPSS Inc., Chicago, IL, USA). The α level was set at $p \leq 0.05$.

Results

The adherence in this study was high with more than 95% of attendance to the sessions planned, suggesting that the proposed intervention of bench stepping was well tolerated by the women. As no injuries were observed during the experimental phase, this allowed us to hypothesize that this type of physical activity, in the conditions established, can be developed with a high degree of safety and satisfaction. At the beginning of the training program, significant differences were observed among the groups in the pre-training height in CMJ and strength test ($p < 0.001$). Moreover, no significant changes were observed in the control group in any of the variables tested at any point ($p > 0.05$).

CMJ

After the 10 weeks of step aerobics, statistically significant ($p < 0.00001$) increases were observed in CMJ height in all the experimental groups. Significant differences ($p < 0.001$) were also observed in the magnitude of the increase in CMJ height at 10 weeks, between the E-50 group (ES: 2.96; 15.49%) with the E-60 group (ES: 1.10; 19.59%) and E-70 group (ES: 0.70; 20.80%) (Table 2).

TUG

During the 10 weeks of step aerobics, statistically significant ($p < 0.001$) decrements were observed in the TUG test in all the experimental groups. Significant differences ($p < 0.001$) were observed in the magnitude of the increase in agility at 10 weeks, between the E-50 group (ES: 4.2; 23.55%) with E-60 group (ES: 1.10; 19.55%) and E-70 group (ES: 0.60; 16.25%) (Table 2).

30CST

During the 10 weeks of step aerobics, statistically significant ($p < 0.00001$) increases were observed in the 30CST in all the experimental groups. Significant differences ($p < 0.001$) were found in the magnitude of the increase in strength-endurance at

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10 weeks, between the E-50 group (ES: 2.55; 30.46%) with the E-60 group (ES: 3.78; 32.84%) and E-70 group (ES: 3.62; 40.66%) (Table 2).

Detraining

After the 10-week detraining period, significant decreases (p < 0.001) were observed in height in CMJ in all the experimental age groups (E-50 group (ES: 0.67; 7.73%), E-60 group (ES: 0.60; 10.06%) and E-70 group (ES: 0.70; 11.76%). Significant decreases (p < 0.001) were observed in 30CST in all the experimental groups (E-50 group (ES; 1.01; 9.28%), E-60 group (ES: 1.59; 15.64%) and E-70 group (ES: 2.74; 21.85%), whereas TUG test obtained significant differences only in E-50 group (ES: 1.95; 9.53%) and E-60 group (ES: 0.71; 11.70%) (Table 2). After detraining, significant differences (p < 0.0001) were observed among the groups in the magnitude of height decrement in CMJ, in the TUG test and 30CST (Table 2).

Table 2: Changes from pre-training to post-training and detraining assessments in the selected performance parameters for each group.

E-50								
	Pre	**Post**	**Detra**	**% PRE-POST**	**% POST-DETR**	**p-value**	**ES PRE-POST (90% CI)**	**ES POST-DETR (90% CI)**
CMJ (cm)	21.04±1.1*	24.30±2.8*†	22.42±4.2*‡	15.49	7.73	0.00001	2.96 (1.51-4.47)	0.67 (0.46-0.88)
TUG test (s)	5.35±0.3*	4.09±0.2*†	4.48±0.8*‡	23.55	9.53	0.00001	4.2 (2.0-6.4)	1.95 (1.04-2.86)
30-CST (rep)	25.18±3*	32.85±3*†	29.80±5*‡	30.46	9.28	0.00001	2.55 (1.26-3.81)	1.01 (0.73-1.40)
E-60								
	Pre	**Post**	**Detra**	**% PRE-POST**	**% POST-DETR**	**p-value**	**ES PRE-POST (90% CI)**	**ES POST-DETR (90% CI)**
CMJ (cm)	15.62±2.1*	18.68±3.1*†	16.80±2.3*‡	19.59	10.06	0.001	1.45 (0.91-1.83)	0.60 (0.43-0.76)
TUG test (s)	6.80±1.2*	5.47±0.9*†	6.11±1.1*‡	19.55	11.7	0.001	1.10 (0.60-1.58)	0.71 (0.50-0.91)
30-CST (rep)	23.05±2*	30.62±3*†	25.83±4*‡	32.84	15.64	0.00001	3.78 (1.93-5.63)	1.59 (0.96-2.31)
E-70								
	Pre	**Post**	**Detra**	**% PRE-POST**	**% POST-DETR**	**p-value**	**ES PRE-POST (90% CI)**	**ES POST-DETR (90% CI)**
CMJ (cm)	12.88±3.8*	15.56±2.6*†	13.73±3.2*‡	20.8	11.76	0.001	0.70 (0.50-0.91)	0.70 (0.50-0.91)
TUG test (s)	8.12±2.2*	6.8±1.8*†	7.54±2.8*‡	16.25	10.88	0.001	0.60 (0.43-0.76)	0.41 (0.33-0.54)
30-CST (rep)	17.83±2*	25.08±2*†	19.60±1*‡	40.66	21.85	0.00001	3.62 (1.86-5.38)	2.74 (1.39-4.09)
C								
	Pre	**Post**	**Detra**	**% PRE-POST**	**% POST-DETR**	**p-value**	**ES PRE-POST (90% CI)**	**ES POST-DETR (90% CI)**
CMJ (cm)	16.23±1.4	16.80±1.2	16.40±0.9	3.51	2.38	0.456	0.4 (0.32-0.52)	0.33 (0.25-0.41)
TUG test (s)	6.6±2.8	6.5±1.9	6.7±1.3	1.51	3.07	0.854	0.03 (0.02-0.04)	0.10 (0.08-0.12)
30-CST (rep)	22.15±2	22.8±3	21.8±2	2.93	4.38	0.346	0.32 (0.26-0.38)	0.33 (0.27-0.39)

Abbreviations: Detra: Detraining Test; UG test: "Up and go" Test; 30-CST: 30-sec Chair Stand Test; ES: effect size; CI: confidence interval; *Significant difference between the age groups (p < 0.0001) at pre, post and after detraining; †Significant differences from pre to post values (p < 0.001); ‡ Significant differences from post to detraining values (p < 0.001).

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Discussion

A novel approach in this study was to examine the effect of low-impact step aerobics for a period of 10 weeks, in three different age groups of healthy women (50-80 years) in order to maximize the CMJ, the functional mobility (TUG test) and strength-endurance performance (30-second test). The primary finding of this investigation indicates that low bench stepping (i.e., stretch touch, lunges, grapevine, hops, knee lifts) using a moderate volume of exercises, produced significant enhancements in the three experimental groups of women in jumping, functional mobility, and strength-endurance performance. In addition, there were no changes in the control group in any of the variables tested at any time point.

Conceptually, the present data would indicate that following a low-impact bench stepping in previously untrained healthy women of 50-70 years, appears to be an optimal stimulus for improving vertical jump, functional mobility, and strength-endurance performance during short-term (10 weeks) training periods. In addition, 10 weeks of detraining following a 10-week bench stepping program resulted in similar decreases in CMJ, TUG test and 30CST in all training groups, whereas the performance in the vertical jump, functional mobility and strength-endurance performance were reduced by 40-50%. In the last decade, numerous investigations have investigated step aerobics and its effect on health and performance [27]. The majority of these studies have focused on analyzing the cardiovascular and metabolic responses brought about during a session or after the step aerobics [13,14,16-19]. Thus, [18] showed that the consumption of oxygen increased at 1.6 ml·kg-1·min-1 when the cadence of the music increased from 120 to 128 heat min-1.

Besides, Kin-Isler et al. [28] analyzing the lipoprotein and lipid profile of the blood in sedentary young women, and they observed after 8 weeks of step aerobics that the levels of cholesterol and triglycerides were reduced significantly. The results obtained in the present study confirm our hypothesis and show how the systematic practice of step aerobics supposes a sufficient stimulus to increase the muscular force and vertical jump performance in sedentary women that did not have the habit of doing this type of physical practice. Muscle strength and power are shown to be related to functional performance of daily living activities, such as walking, climbing stairs, and rising from a chair [1,29]. Therefore, the step aerobics program used in the current study may be effective for improving and/or maintaining the functional capacity of older people.

Further, Evans and Campbell [10] have suggested that muscle strength and power may be related to the risk of falling. It could be hypothesized that the implementation of a step aerobics program similar to that used in the present study might be effective in the prevention of falls by the elderly; however, this requires investigation in future clinical research. Clearly step aerobics programs should be designed to increase not only muscle power but also strength, because this factor has the greatest impact on the performance of activities of daily living, as well as avoiding falls. An interesting finding was that all age groups increased 30CST after step aerobics. Several studies have shown enhancements in middle-aged and older participants in maximal and fast force production [1,10], in explosive jumping performances [1,11] and isotonic muscle power output in lower extremities [2].

What is clear is that the step aerobics program used in this study resulted in meaningful increases in 30CST both in young and old women. Thus, one may speculate that the muscle force stimulus experienced by previously physically inactive women during step aerobics can be effective for 30CST development. A major part of the improvements in untrained participants during the initial weeks in power-type strength training is probably due to adaptations of the neural system (i.e., increased motor unit firing frequency, improved motor unit synchronization, increased motor unit excitability, increased efferent motor and neural drive or a reduction of the antagonist and improved co-activation of the synergist muscles) [30].

The gains in 30CST (ES: 2.55-3.62; 30-40%) were accompanied by significant increases in the height of the jump (ES: 0.70-2.96; 15-20%). 30CST and CMJ tests were significantly higher in the group of the oldest women (60-70 years) after the training period. The three age groups of women: 50-60; 60-70 and 70-80 years adapted to the training intervention with significant and relatively large increases in strength endurance and power output. It is well known that muscular strength and power decrease with increasing age [1,11,20].

This is supported by the current study in which the group of the oldest women produced only 68% as much 30CST and 57% in the CMJ test as that of the group of the youngest women before the step aerobics. The difference between youngest and oldest was not altered by the training as the oldest group of women (70-80 years) could only produce 78% of the 30CST of the youngest group (50-60 years) at the post-training testing. Despite increasing age, there was a decrease in all measured performance variables, the three groups produced relatively large increases in 30CST over the 10 weeks of step aerobics, and this is consistent with previous research on resistance training involving both young [31] and old [20,22] participants.

In our study older women in training groups showed lower baseline values than the youngest group, and it is known that, when they start to exercise regularly, less fit people achieve higher gains in comparison with well-trained individuals measured by most of the indices of physical fitness [32]. This may be one of the explanations for the higher changes in older women in the present study. Therefore, it can be concluded that within the training parameters of intensity, frequency, and duration used in the current study, the oldest women group adapt at a similar rate to that of the youngest group. Power of lower extremities has been related to stepping ability and gait velocity in middle-aged

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and elderly adults. Increases in lower body strength have led to reducing falls and improving gait stability. Strategies to reverse or mitigate this detrimental loss of muscle strength and power are therefore essential [5].

The gains in strength were accompanied by significant increases in the height of the jump (CMJ) (from 15.49 to 20.80%). To the best of our knowledge, there are no prior studies in the literature that have evaluated the effect of step aerobics on vertical jumps in middle-age and older women. Only, in the studies of Kin-Isler and Kosar [33] and Kraemer et al. [34] the vertical jump performance in a group of women less than 35 years old after step aerobics has been measured. In both studies, the authors concluded no improvements in vertical jump performance after following an 8-week bench stepping program consisting of three training sessions per week of 40 minutes per session. However, in the study of Kraemer et al. [34], they observed that the experimental group improved the CMJ performance when they realized the step aerobics with a supplementary load (from 30% to 60% of body mass).

The authors argued that the bench stepping programs with overload provide a more sensitive stimulus of adaptation to improve vertical jump performance. In the study of Kraemer et al. [34]. in the progression of the BSA program, additional power-type movements (e.g., jumps, deep knee bend jumps, and greater step height) were included. These data demonstrate that BSA alone can enhance power development in the lower body. Several factors may influence the power development observed with BSA. Previous investigations have shown vertical impact forces ranging from 1.4 to 1.87 times body weight during BSA [35]. Vertical impact forces may increase if complex movements are performed, greater step rates are used, and if higher steps are used [36]. Thus, these data demonstrate that a substantial impact force component is placed on the lower body musculature in a plyometric manner over longer durations. The aggressive stretch-shortening cycle nature of the BSA modality demonstrates an effective means for increasing muscular power in women. It is quite possible that the BSA programs provided more loading than the typical vertical jump test due to mechanical forces in the dynamic stretch-shortening cycle [36].

The differences found between the present investigation and the two studies previously cited can be argued over the type of sample selected. The women in our study were aged between 50 and 80 years, while in the studies of Kin-Isler & Kosar [33] and Kraemer et al. [34], they were ~35 y ~23 years, respectively. This difference in age could allow us to speculate the possibility that step aerobics had a significant influence on vertical jump performance (CMJ) without external load. Besides, it seems probable that the different duration of the treatments, the prior levels of force, the prior status of training (fitness) of the participants or the different designs of the studies (loads, intensity, volume, frequency, or types of exercises) may account for the mean discrepancies in the results among studies. It is known that when they start to exercise regularly, less fit people achieve higher gains in comparison with well-trained individuals measured by most of the indices of physical fitness. This may be one of the explanations for the higher changes in older women than in the studies of Kin-Isler & Kosar [33] and Kraemer et al. [34]. Further research should be conducted to examine the effects of different types of step aerobics on strength and power performance in different ages.

The progressive decline in muscle strength and power, especially in the lower limbs, has important functional consequences [37]. Reduced muscle power and strength have been identified as one of the key factors, which may jeopardize the maintenance of mobility and independence for older individuals [3]. Power and force of lower extremities have been related to stepping ability and gait velocity in elderly adults [4,5]. Increases in lower body strength have been demonstrated to lead to reduced falls [38] and improved gait stability and agility [39]. Strategies to reverse or mitigate this detrimental loss of muscle strength and power are therefore essential.

To the best of our knowledge, there is no study concerning the effectiveness of step aerobics to enhance lower limb strength in women from 40 to 80 years. The results obtained in the present study confirm our hypothesis and show how the systematic practice of step aerobics supposes a sufficient stimulus to increase muscular power, and consistently, improve the stepping ability and gait velocity in sedentary women. In this sense, Shigematsu et al. [40] showed how a group of 38 women (72-87 years) after 12 weeks of aerobic dance training, improved the capacity of dynamic and static equilibrium. Nevertheless, that study did not include the utilization of banks. Thus, it would be interesting for future investigations to measure the influence of step aerobics on equilibrium ability.

In the three age groups, 30CST and CMJ performance were significantly lower after 10 weeks of detraining than at end of the 10-week training program. Previous studies also show that detraining leads to a decrease in strength and a loss of training effect within a few weeks [41]. Our findings that lower extremity strength and CMJ performance decreased after 10 weeks of detraining is not consistent with previous studies of elderly people [10,41]. Possible explanations of the discrepancy among the results of the studies could be that the initial training level of the population was greater or that we used a shorter duration and lower intensity of training than those used in other studies [41,43] and our participants may have been less physically active than those in some other studies [43].

The fact that detraining induced decreases in the functional performance of the neuromuscular system may be related to the frequency of the preceding training, the type and duration of the training, and the activities of daily living during the detraining period [41,43]. Thus, the initial levels of physical activity and functional capacity may account in part for the decline in strength

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after detraining our participants. Exercise programs should be safe enough for the exercisers to avoid injuries and musculoskeletal consequences. This is especially important in programs designed for middle-aged, elderly and old sedentary women. In the present study, the injury rate was 7%, 12% and 15% in the age groups 50-60, 60-70 and 70-80 years respectively.

The rates are relatively low, considering the training mode (i.e., low-impact exercises). Any interruptions in training due to musculoskeletal symptoms and injuries were short, suggesting that the disorders and injuries were not serious (e.g., stiffness, cramps, muscle strains). The training program was supervised due to the fact that the participants - middle-aged, elderly and old mostly sedentary women - are risk groups for injuries [44]. The cornerstones of the training were throughout the intervention sufficient warming-up before training, muscle stretching after training, slow-progressing intensity, variation in training sessions, and finally, no competitive elements were included in the training program. The relatively low incidence of training-induced injuries and the unchanged or decreased level of musculoskeletal symptoms during the training indicate the feasibility of the step aerobics program.

The step aerobics program proposed appears to be an optimal stimulus for improving jumping, functional mobility and strength-endurance performance during short-term training periods in middle-aged and elderly women. This step aerobics program was safe enough for the exercisers to avoid injuries and musculoskeletal consequences especially because was designed for middle-aged, elderly and old women. Several limitations should be mentioned in this study. As in some studies conducted to analyze the performance of elderly and old women, the sample size is always limited. Even though this study includes a moderate sample size (n=120), it would be highly recommended additional research with a larger sample of different sports, ages, gender, and strength standards should be conducted before the applicability of the current results can be generalized. Another limitation was no nutritional guidelines were marked for the participants during the study.

Future research should address the relative efficiency of training isolated for strength and then alter the program to train solely for agility versus the simultaneous strength and jumping training used in the current study. The feasibility of this type of training program, including aspects such as training motivation, training adherence, training-induced injuries, musculoskeletal symptoms, and the impact of perceived health and fitness, should also be investigated using reliable and validated measurement methods.

Conclusions

In conclusion, the results of the present study showed that systematic step aerobics during a period of 10 weeks in three age groups of women, can increase the dynamic force and power of the lower extremities. Furthermore, the training program caused favorable changes in the functional performance measured through the functional mobility test. These results indicate that the reductions in the neuromuscular performance associated with ageing can be diminished with an appropriate intervention of step aerobics.

Practical Application

Medical staff and practitioners must consider that a period of 10 weeks of bench-stepping intervention in women of different ages can increase the dynamic force and power of the lower extremities. This type of training could present changes in the functional performance measured through the functional mobility test, associated with age.

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