

Article

Effects of Twelve Weeks of Virtual Square Stepping Exercises on Physical Function, Fibromyalgia's Impact, Pain and Falls in Spanish Women with Fibromyalgia

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Abstract

Severe fatigue, difficulty falling asleep, body stiffness, cognitive impairment, and widespread pain are some of the primary symptoms experienced by individuals with fibromyalgia (FM), leading to reduced physical function, increased frailty, and elevated fall risk. The present study aimed to evaluate the effects of the Virtual Square Step Exercise (V-SSE) program on physical function, frailty, FM impact, pain, fear, and risk of falling, and fall incidence in women with FM. A randomized controlled trial was conducted with 61 sedentary Spanish women with FM. Participants were randomly assigned to two groups: V-SSE and the control group. The V-SSE group completed an exercise program based on the V-SSE for 12 weeks (3 sessions/week), while the control group maintained their usual lifestyle and treatment. Physical function was assessed using the Timed Up and Go (TUG), Four-Step Square (FSST), 6-Minute Walking Test (6MWT), and others. Frailty was assessed with the Short Physical Performance Battery (SPPB). FM impact, pain, falls, and fear of falling were evaluated via questionnaires. Significant intergroup differences were only found in the 30 m Walking Test ($p = 0.023$; E.S. = 0.539), due to worsening in the control group. Although significant improvements were found in other variables in the V-SSE group, Dual Sit to Stand ($p = 0.038$), FM impact ($p = 0.010$), pain ($p = 0.003$) and falls ($p = 0.037$), these did not remain statistically significant after adjusting for multiple comparisons, nor were they corroborated in the intergroup comparison. A 12-week program based on the V-SSE was not effective in improving physical function, frailty, FM impact, pain, falls, fear, and risk of falling in Spanish women with FM.

Keywords: rehabilitation; rheumatology; physical activity; FMS; balance; prevention



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1. Introduction

Fibromyalgia (FM) is a complex disorder of pain processing in the central nervous system, characterized by a generalized hypersensitivity to pain [1,2]. Although its main symptoms, such as widespread pain, body stiffness, fatigue, sleep disturbances, depression, anxiety, and cognitive difficulties, have been widely documented, its precise etiology has not yet been determined [3–5]. However, genetic, environmental, and psychological factors are recognized as being involved in its development [2,5], as well as the influence of modifiable factors such as lifestyle, stress, or physical exercise on the intensity and evolution of symptoms [3,6].

The impact of FM extends beyond its symptoms. People with FM often have a decreased level of physical activity, low perceived physical fitness, kinesiophobia, and impaired physical function. These factors are associated with increased frailty, imbalance, fear of falling, and increased risk of falls [7–9]. The incidence of falls per year in people with FM is five times higher (2.5 vs. 0.5) than in people without FM [10], although this incidence is much lower in those who are physically active [7]. Along with all the above, FM significantly affects quality of life, limits activities of daily living, and negatively influences mood, as well as the perception of self-confidence and self-efficacy of individuals with this disease [2].

As it is a complex disorder that affects the whole person, the strategies implemented for the management of its symptoms and the areas affected by each patient require a multidisciplinary approach tailored to individual requirements, including pharmacological and non-pharmacological treatments [3,6,11,12]. Among non-pharmacological treatments, programs that include regular physical activity have been found to help improve FM symptoms, reducing pain, depressive symptoms, muscle stiffness, and sleep disturbances [6,13–15]. International scientific literature supports the inclusion of structured programs that combine regular physical activity with complementary strategies such as health education to improve symptom management and promote adherence to programs and healthy lifestyles. In Spain, the Al-Andalus project generated relevant data on physical condition, quality of life, and health-related factors in women with fibromyalgia, supporting the justification and development of physical education interventions tailored to this population [16–18]. In Brazil, the Amigos de Fibro program has been developed, validated for use in primary care, and shown to have positive effects on symptom management and emotional well-being in patients [19,20]. In addition, in countries such as Canada and Sweden, clinical trials with similar approaches have also been conducted to maintain the functional capacity and well-being of patients with FM, as well as to better control symptoms [21,22]. Finally, the revised recommendations of the European League Against Rheumatism (EULAR) highlight the importance of education, physical exercise, and a multidisciplinary approach as key tools in the fibromyalgia treatment [23].

In contrast, symptom severity has been associated with poorer overall physical fitness, as well as poorer performance on tests related to physical function, increased fear of falling, and the number of falls in women with FM [24]. However, the response of people with FM to exercise is not always positive, and inadequate intensity or duration, too high increases in workload, inadequate recovery times, or lack of adaptation of participants can lead to negative effects, such as a temporary increase in pain and fatigue [25,26]. People with FM, as well as people with other pain-related pathologies, often have longer recovery times than the general population, so it is recommended to begin any physical activity program with low intensities and increase the training load progressively [25,27]. Moderate-intensity aerobic exercise, multicomponent exercise, supervised strength training, mind–body practices (such as yoga and tai-chi), and dual (physical–cognitive) tasks can contribute to holistic improvement in people with FM. These programs can help increase

physical and cognitive function, improve mental health and sleep, reduce pain, and reduce the risk of falls, among other benefits [25–30]. However, the effects are often low to moderate in magnitude, so there is a need to continue to explore and optimize exercise programs that enhance these outcomes [2,15]. These findings support the design of safe, feasible exercise programs tailored to patients' needs, providing guidance to clinical care professionals on the implementation of effective strategies for the non-pharmacological treatment of fibromyalgia. Despite this, there is still a need to develop interventions that integrate physical and cognitive components in a structured manner, highlighting the importance of innovative programs such as Virtual Square Stepping Exercise (V-SSE).

This study is part of a larger research project to evaluate the effects of the Virtual Square Step Exercise (V-SSE) program in middle-aged and older Spanish women with FM. The first phase, the findings of which have already been published, examined the impact of the intervention on quality of life (QoL), self-perceived health, life satisfaction, mental health, and cognitive function, without finding it to be effective in improving these variables [31]. The present study, with the same participation sample, aimed to analyze the effects of 12 weeks of training based on a virtual version of the Square-Step Exercise (V-SSE) method on physical function, the impact of FM, frailty, pain, falls, fear of falling, and risk of falling.

V-SSE is an exercise program consisting of memorizing a series of movement patterns in progression of difficulty and executing them on a thin mat 2 m long and 1 m wide, divided into 25 cm² squares [32,33]. In the scientific literature, it has been found that SSE can improve physical function in its participants [10]. In particular, some researchers have found improvements in agility, lower limb strength, walking speed, reaction time, balance, fall efficacy scale, and fear of falling in the elderly population [10,32–35]. Besides, a recent systematic review evaluated the effects of SSE on physical and cognitive function, mental health, and body composition in healthy older adults, concluding that SSE has the potential to improve these [36]. However, no studies have evaluated the effects of SSE on physical function, frailty, FM impact, pain, falls, fear of falling, and risk of falls in women with FM, which is the focus of this study in a virtual version of the SSE.

The baseline hypothesis of this study was that 12 weeks of training based on the V-SSE method produces significant positive changes in physical function, FM impact, frailty, pain, falls, and fear of falling in middle-aged and older Spanish women with fibromyalgia.

2. Materials and Methods

2.1. Design

This study followed the format of a single-blind randomized controlled trial with participants individually assigned to either the intervention or control group. The methodological guidelines were established in accordance with the CONSORT Statement [37]. The research team did not find a way to blind the participants, and, during the intervention, they were aware of the group to which they had been assigned. However, the participants' group assignment was blinded to the evaluators. The allocation of participants to the groups (control and experimental) was randomized (1:1) by a researcher outside the clinical trial by assigning a code to the participants. Research Randomizer (<https://www.randomizer.org/>) was the software used for this assignment [31].

The Bioethics and Biosafety Committee of the University of Extremadura approved the full project. In addition, the project was registered (application number: 378330) in the Australian and New Zealand Clinical Trials Register [31].

2.2. Participants

The study was conducted on adult Spanish women with FM. To recruit the sample, local and national FM associations were contacted between December 2021 and April 2022. Associations from four Spanish provinces agreed to participate in the study, and 89 potential participants were recruited from Cáceres, Elche, Madrid, and Palencia. Table S1 shows the inclusion and exclusion criteria that were applied in the study [38–40]. Ten women were excluded because they did not meet the selection criteria, while eight women declined to participate in the intervention program. The study started with 71 women, who were randomly assigned to two groups: the experimental group (36 women) and the control group (35 women). However, 6 women (3 per group) decided not to continue with the intervention program for personal reasons and were excluded. Finally, 4 participants from the control group decided not to assist in the post-intervention evaluation tests and were excluded from all analyses. Therefore, the study had a final sample of 61 women with FM: experimental group (33 women) and control group (28 women). The flowchart was shown in our previous study [31]. The sample calculation for the main project variable, using G*Power 3.1.9.2 software, estimated that 26 participants per group would be necessary to detect significant differences in the pre–post intervention measurements through Student's *t*-test for paired samples; for this test, a statistical power of 90% was reached, calculated in a post hoc analysis for an alpha and beta risk of 0.05 and 0.2, respectively. For Student's *t*-test for independent samples, the sample calculation estimated a total of 98 women to find statistically significant intergroup differences; for this test, a statistical power of 60% was reached and should be considered when interpreting the results found in the intergroup comparisons of our study [31].

2.3. Twelve-Week Intervention Program

Experimental group (V-SSE): Participants in this group followed a training program based on Virtual SSE for 12 weeks, with three sessions per week. Before starting the intervention, each participant was provided with a special SSE mat, with dimensions of 250×100 cm and divided into 40 squares of 25 cm^2 . They also received a booklet containing 200 movement patterns organized into three levels of difficulty: beginner (with two sub-levels), intermediate, and advanced (with three sub-levels each) [10,31,41]. Along with these materials, specific instructions for performing the exercises were provided. The program consisted of a structured progression with 200 patterns, from the most basic movement (such as the simple walking pattern) to more complex movements (with several direction changes). The sessions were delivered to small groups of 2 to 6 people, in common rooms provided by the participating associations. In these spaces, participants were provided with training mats, workbooks, internet access, and a screen to connect to an SSE expert, who guided the sessions remotely via videoconference. The development of the sessions was detailed earlier in the first study of this project [31].

Control group: Participants in the control group were encouraged to maintain their usual lifestyle and treatment received by the public health system. The usual treatment of these participants, prior to the intervention program, did not include any exercise-based activity or physical activity. This remained the case throughout the 12-week intervention. Although these participants did not undergo the SSE intervention program, at the end of the project, the mats and booklets were made available to their associations so that they could complete the program if they so wished.

2.4. Questionnaires and Assessment Tests

Sociodemographic questionnaires and anthropometric measures were used to characterize the sample, including age, height, weight, BMI, hip and waist circumferences,

waist-to-hip ratio, years since diagnosis of the disease, and years since the onset of first symptoms, among others.

Initial tests and questionnaires were conducted one week before beginning the intervention program. These were repeated one week after the end of the 12-week intervention. The tests were carried out by Sports Science Graduates. These tests were carried out at the centers of each of the partner associations.

Physical Function Assessment

Balance: Dynamic and static balance were assessed. Static balance was assessed using two variants (open eyes: ICC = 0.99; closed eyes: ICC = 0.95) of the *One Leg Stance* (OLS) test. Participants were required to perform two attempts per leg. All attempts were timed, and the best result was recorded. This test is a predictor of falls in older people [10,42]. Dynamic balance was assessed using the *Four Square Steps Test* (FSST; ICC = 0.98). Participants performed two timed attempts, and the best of these was recorded. This test has also been recognized as a predictor of falls in older people [9,10,43].

Agility: Agility was assessed using the *Timed Up and Go* (TUG) test. The time (in seconds) it took participants to get up from a chair, walk to a cone 3 m away, make a 180° turn around it, walk the 3 m back to the chair, and sit down was taken. In women with FM, this test is valid and reliable (ICC = 0.93) [44]. In addition, we timed the time participants took to perform two other variants: *Dual TUG* (participants performed the TUG, while counting down aloud from 50 to 0, counting from 2 to 2) and *imagined TUG* (*i-TUG*; participants were asked to imagine themselves doing the run, and the time taken to do this imagined run was recorded). With real time and imagined time, the variable delta TUG (Δ TUG) was determined; a higher value in this parameter is related to a higher risk of falling [45].

Frailty: The *Short Physical Performance Battery* (SPPB) was used for this purpose. This battery consists of three tests: balance (*Tandem Stance*), walking speed (*4 m walking test*), and lower limb strength (*5 repetitions Sit to Stand*) [10]. From the three tests, a score between 0 and 12 points is determined, with 0 indicating the worst condition and scores below 10 indicating low physical fitness, risk of falls, and frailty [46].

Gait Speed: Gait speed was assessed using the *30 m Brisk Walking Test* (*30 m BWT*; ICC = 0.93) [47]. Participants had to cover 30 m, walking as fast and safely as possible. Two attempts were made with one minute in between, and the fastest one was recorded.

Cardiorespiratory fitness: The *6 min walking test* (6 MWT; ICC = 0.92) was used for this purpose. The participants had to walk as far as possible for 6 min. For this purpose, a rectangle of 45.7 m was set up, and the participants had to walk around it as many times as possible [44].

Flexibility: This was assessed by two tests: *Functional Reach Test* (ICC = 0.92) [48] and *Chair Sit and Reach* (*Sit & Reach*; ICC = 0.94) [44]. The first test assessed the functional scope of the participants, while the second assessed the flexibility of the lower limbs. Two measurements were taken for both tests, and the best result was recorded [10].

Lower limb strength: This was assessed with the *30 s Sit to Stand test* (*Sit to Stand*; ICC = 0.91) [10,44], recording the number of times participants managed to sit down and stand up for 30 s. In addition, a dual variant (*Dual Sit to Stand*, counting down 2 by 2 from the number 100) and an imagined variant (*i-Sit to Stand*, participants mentally visualized themselves doing the test and counted the repetitions they mentally performed in 30 s) were performed [9].

Handgrip strength: The isometric handgrip strength (ICC = 0.95) [44] was evaluated with a digital dynamometer (TKK 5101 Grip-D; Takey, Tokyo, Japan) [49]. Participants performed two attempts per hand, and the best result was recorded [9].

Fibromyalgia's Impact, Pain, Falls, Fear of Falling, and Risk of Falling Assessment

Fibromyalgia Impact Questionnaire Revised (FIQ-R): The FM's impact on the participants' daily lives was assessed using the FIQ-R. Using 21 items, this tool asks participants about the symptoms and problems resulting from the FM. It is scored from 0 to 100, where 0 indicates the least impact and 100 indicates the greatest. In addition, three domains can be assessed with this tool: *Functions* (constructed by 9 items and scores between 0 and 30, from lowest to highest impact), *Global Impact* (constructed by 2 items and scores from 0 to 20, from lowest to highest impact) and *Symptoms* (constructed by 10 items of the FIQ-R, with scores from 0 to 50, from lowest to highest impact). This tool is valid and reliable (Cronbach alpha = 0.93) [9,50].

Falls: Participants were asked to indicate the number of falls they had experienced in the previous four months.

Fear of falling: The *Fall Efficacy Scale-International (FES-I)* (ICC = 0.96) was used to assess participants' fear of falling. The FES-I asks participants how worried they are about falling when performing 16 activities of daily living. It can take a score between 16 and 64. Scores ≥ 24 are considered to indicate fear of falling [9,51,52].

Risk of falling: The *Activities-Specific Balance Confidence Scale (ABC Scale)* was used to assess participants' risk of falling. With 16 items, the ABC Scale asks participants about their confidence in their balance in everyday life situations. This scale takes values from 0% confidence to 100% confidence. People with a confidence of less than 67% are considered to be at high risk of falling [24,53,54].

2.5. Statistical Analysis

The statistical analyses in this study were performed with Jamovi open source statistical software version 2.3.28.0 (Sydney, Australia). Normality and homogeneity of the data were tested with the Shapiro–Wilk test and Levene's test. Control and V-SSE groups were characterized by descriptive analysis, in which the mean and standard deviation (sd) of each of the variables at baseline are presented. To assess possible differences within each group (pre versus post intervention), a paired-sample *t*-test was used. Subsequently, to compare differences between groups (control versus V-SSE) in terms of pre–post change, a *t*-test for independent samples was applied on intragroup differences. Cohen's *d* was calculated to interpret the effect size (E.S.). For all analyses, a significance level of $p < 0.05$ was assumed. Subsequently, a Bonferroni adjustment for multiple comparisons was performed to control for Type I error caused by multiple statistical tests. The adjusted significance value was calculated by dividing the original alpha level by the number of comparisons made.

3. Results

Following the initial physical assessment, no significant between-group differences were observed in any of the variables related to physical function: balance (static: OLST; and dynamic: FSST), agility (TUG), frailty (SPPB), gait (30 m BWT), cardiorespiratory fitness (6MWT), flexibility (Functional Reach and Sit & Reach), lower limb strength (Sit to Stand) and handgrip (Table S2).

No intergroup differences were also found in the questionnaire-based study variables: FM Impact (FIQ-R and its domains: Functions, Global Impact, and Symptoms), pain (VAS for Pain), falls, fear of falling (FES-I) and risk of falling (ABC), as well as age, years since diagnosis, and years since appearance of symptoms. All of these are shown in Table 1.

After the twelve weeks of intervention, in the control group, significant pre–post changes were observed in the TUG (7.3 vs. 7.9, $p = 0.007$), SPPB (10.6 vs. 10.3, $p = 0.043$), 4 m walking test (2.6 vs. 3.0, $p = 0.003$), and 30 m walking test (18.6 vs. 20.7, $p = 0.006$), indicating a slight worsening in the performance of these tests. In the V-SSE group, a significant improvement was only observed in the number of repetitions performed in the

Dual Sit to Stand test (9.3 vs. 10.2, $p = 0.038$). However, after performing the Bonferroni correction, none of the changes found maintained statistical significance ($p = 0.002$). In the between-group comparison, significant differences were only detected in the 30 m walking test ($p = 0.028$, E.S. = 0.527), although these differences were also not confirmed after Bonferroni adjustment. Therefore, no significant improvements were found that could be attributable to V-SSE, and V-SSE was not found to be effective in improving physical function in our sample. All these results are presented in Table 2.

Table 1. Comparison of baseline questionnaire-based variables between control and Virtual Square Stepping Exercise groups.

Variables	Total (n = 61)		Control (n = 28)		Exercise (n = 33)		p
	Mean	(Sd)	Mean	(Sd)	Mean	(Sd)	
Age (years)	58.0	(9.8)	58.0	(11.0)	58.0	(7.0)	0.222
Years since diagnosis	13.2	(9.1)	14.0	(12.0)	12.0	(13.0)	0.771
Years with symptoms	20.8	(11.2)	20.0	(18.0)	21.0	(20.0)	0.503
FIQ-R: <i>Functions</i> (0–30)	15.6	(7.3)	16.1	(8.5)	15.3	(7.2)	0.857
FIQ-R: <i>Global Impact</i> (0–20)	10.6	(6.0)	10.9	(5.9)	10.2	(6.7)	0.843
FIQ-R: <i>Symptoms</i> (0–50)	31.8	(8.9)	31.9	(10.8)	31.6	(8.1)	0.970
FIQ-R (0–100)	57.8	(20.6)	58.8	(24.5)	58.0	(19.4)	0.849
VAS for Pain (0–10)	6.5	(1.9)	6.0	(1.8)	6.9	(1.9)	0.069
Falls (n)	2.1	(3.9)	1.4	(2.1)	2.1	(3.4)	0.117
Fear of Falling (16–64)	35.7	(11.0)	33.8	(10.4)	36.5	(12.0)	0.105
Risk of Falling (0–100)	55.6	(21.9)	53.2	(23.6)	60.8	(17.3)	0.116

n (number); Sd (standard deviation); p (p-value). Significant differences with Bonferroni's correction: $p < 0.006$; FIQ-R (Fibromyalgia Impact Questionnaire-Revised: 0 and 100 represents lowest and highest impact, respectively. Also, in all three dimensions, a higher score represents a higher impact); VAS (Visual Analogic Scale: 0, no pain; 10, maximum pain); Fear of Falling (16: not at all worried; 64: very worried); Risk of Falling (scores below 67 are associated with a high risk of falls).

Finally, no significant changes were observed between pre-test and post-test values for any of the questionnaire-based variables in the control group. In contrast, in the V-SSE group, significant differences between pre-test and post-test values were observed in the FIQ-R total score (58.0 vs. 54.1, $p = 0.010$), in the FIQ-R *Functions* dimension (10.2 vs. 9.6, $p = 0.028$), as well as in pain (6.9 vs. 5.5, $p = 0.003$) and in the number of falls (2.1 vs. 1.1, $p = 0.037$), with no significant changes observed in the rest of the variables. When applying the Bonferroni correction for multiple comparisons ($p = 0.006$), only the changes in VAS for pain remained statistically significant. In addition, these changes observed in the intragroup comparison were not confirmed in the intergroup comparison (Table S3). Therefore, V-SSE was not found to be effective in improving these variables in our sample. Pre–post intervention differences in the FIQ-R and its dimensions are shown in Figure 1. Figure S1 shows the pre–post differences in pain, number of falls, fear of falling, and risk of falling in both groups.

Table 2. Impact of the ‘Virtual Step Square Exercise’ program on physical function after 12 weeks in Spanish women with fibromyalgia.

	Control (n = 28)							Experimental (n = 33)							Group Comparison	
	Pre: Mean (Sd)		Post: Mean (Sd)		Diff. Mean (Sd)		<i>p</i>	Pre: Mean (Sd)		Post: Mean (Sd)		Diff. Mean (Sd)		<i>p</i>	Mean Diff. (SE)	<i>p</i>
Balance: OLSR Open (s)	26.8	(15.7)	29.5	(15.8)	2.7	(20.6)	0.837	23.0	(19.4)	23.4	(15.7)	0.4	(13.9)	0.429	−2.2	(4.7) 0.689
Balance: OLSR Close (s)	8.8	(12.2)	7.1	(6.7)	−1.7	(12.8)	0.742	6.0	(5.4)	5.3	(4.3)	−0.6	(4.6)	0.786	1.0	(2.6) 0.337
Balance: OLSL Open (s)	28.0	(14.8)	24.5	(15.2)	−3.5	(16.6)	0.851	20.2	(17.4)	21.1	(17.2)	0.8	(17.4)	0.393	4.3	(4.5) 0.172
Balance: OLSL Close (s)	8.6	(10.9)	6.5	(8.5)	2.1	(13.8)	0.777	5.4	(5.4)	5.2	(4.4)	−0.2	(4.7)	0.593	−1.9	(2.8) 0.235
Four Step Square (s)	6.7	(1.8)	6.6	(1.8)	−0.1	(1.5)	0.361	7.5	(3.6)	6.9	(1.9)	−0.6	(3.0)	0.125	−0.5	(0.6) 0.212
TUG (s)	7.3	(1.6)	7.9	(1.8)	0.6	(1.1)	0.007	7.9	(2.9)	8.0	(2.0)	0.1	(2.7)	0.545	−0.5	(0.5) 0.174
i-TUG (s)	5.6	(2.1)	5.6	(1.2)	−0.1	(1.9)	0.589	5.4	(2.2)	5.6	(1.6)	0.1	(2.4)	0.610	0.2	(0.6) 0.638
Δ-TUG	6.7	(6.8)	8.7	(6.8)	2.0	(6.1)	0.053	9.7	(9.9)	9.1	(5.6)	−0.6	(9.9)	0.360	−2.6	(2.1) 0.119
Dual TUG (s)	9.4	(2.8)	9.5	(3.0)	0.1	(2.5)	0.398	10.5	(5.1)	9.8	(3.4)	−0.8	(4.2)	0.147	−0.9	(0.9) 0.165
SPPB (0–12)	10.6	(1.0)	10.3	(1.0)	−0.3	(0.8)	0.047	10.7	(1.1)	10.9	(1.2)	0.2	(1.1)	0.210	0.5	(0.3) 0.062
SPPB: Tandem Stance (s)	10.0	(0.0)	10.0	(0.0)	0.0	(0.0)	0.327	9.6	(1.6)	9.8	(1.1)	0.2	(1.2)	0.144	0.2	(0.2) 0.157
SPPB: 5 rep Sit to Stand (s)	14.2	(5.0)	14.6	(3.9)	0.4	(3.4)	0.513	13.0	(4.6)	13.8	(5.5)	0.8	(4.9)	0.818	0.4	(1.1) 0.628
SPPB: 4 m Walking Test (s)	2.6	(0.6)	3.0	(0.6)	0.3	(0.5)	0.003	2.9	(0.7)	3.0	(0.8)	0.2	(0.7)	0.884	−0.2	(0.2) 0.142
30 m BWT (s)	18.6	(3.5)	20.7	(4.5)	2.1	(3.4)	0.006	21.7	(5.8)	21.6	(4.5)	−0.1	(4.6)	0.444	−2.2	(1.1) 0.028
6 min. Walking Test (m)	481.5	(94.3)	476.0	(80.7)	−5.5	(70.7)	0.709	455.5	(87.0)	454.4	(89.3)	−1.1	(79.1)	0.532	4.3	(20.1) 0.416
Functional Reach (cm)	33.8	(6.6)	34.8	(6.6)	0.9	(6.0)	0.421	33.3	(7.6)	33.3	(6.5)	0.0	(7.4)	0.495	−0.9	(1.7) 0.699
Sit & Reach Right (cm)	−2.9	(12.4)	−2.5	(12.8)	0.4	(11.9)	0.844	−6.1	(12.2)	−6.4	(12.8)	−0.3	(10.1)	0.566	−0.7	(2.9) 0.397
Sit & Reach Left (cm)	−2.9	(11.9)	−1.6	(13.2)	1.3	(7.5)	0.519	−5.4	(10.9)	−5.9	(11.9)	−0.5	(8.3)	0.641	−1.8	(2.5) 0.227
Sit to Stand (rep)	11.1	(3.0)	10.9	(2.6)	−0.2	(1.9)	0.618	10.4	(3.1)	10.8	(3.0)	0.4	(3.2)	0.240	0.6	(0.7) 0.188
i-Sit to Stand (rep)	13.7	(5.4)	13.3	(4.8)	−0.4	(4.5)	0.638	13.4	(5.7)	13.2	(4.4)	−0.3	(4.8)	0.626	0.1	(1.2) 0.456
Dual Sit to Stand (rep)	9.7	(2.7)	9.9	(2.8)	0.1	(1.6)	0.721	9.3	(3.4)	10.2	(2.7)	0.9	(2.7)	0.038	0.7	(0.6) 0.106
Handgrip Right (kg)	22.4	(4.6)	20.9	(6.5)	−1.5	(5.2)	0.146	21.7	(6.6)	21.1	(7.8)	−0.6	(6.6)	0.707	0.8	(1.5) 0.296
Handgrip Left (kg)	20.8	(5.0)	20.4	(5.7)	−0.3	(4.4)	0.685	20.7	(6.4)	20.5	(7.0)	−0.2	(5.4)	0.590	0.1	(1.3) 0.461

n (number); Sd (standard deviation); Diff. (difference); *p* (*p*-value. Significant differences with Bonferroni’s correction: $p < 0.002$); SE (standard error); OLSR (One Leg Stance Right); s (seconds); OLSL (One Leg Stance Left); TUG (Timed Up and Go); i (imagined); Δ (delta); m (meters); SPPB (Short Physical Performance Battery: 0, the worst physical performance; 12, the best); BWT (Brisk Walking Test); rep (repetitions); min. (minutes); cm (centimeters); kg (kilograms).

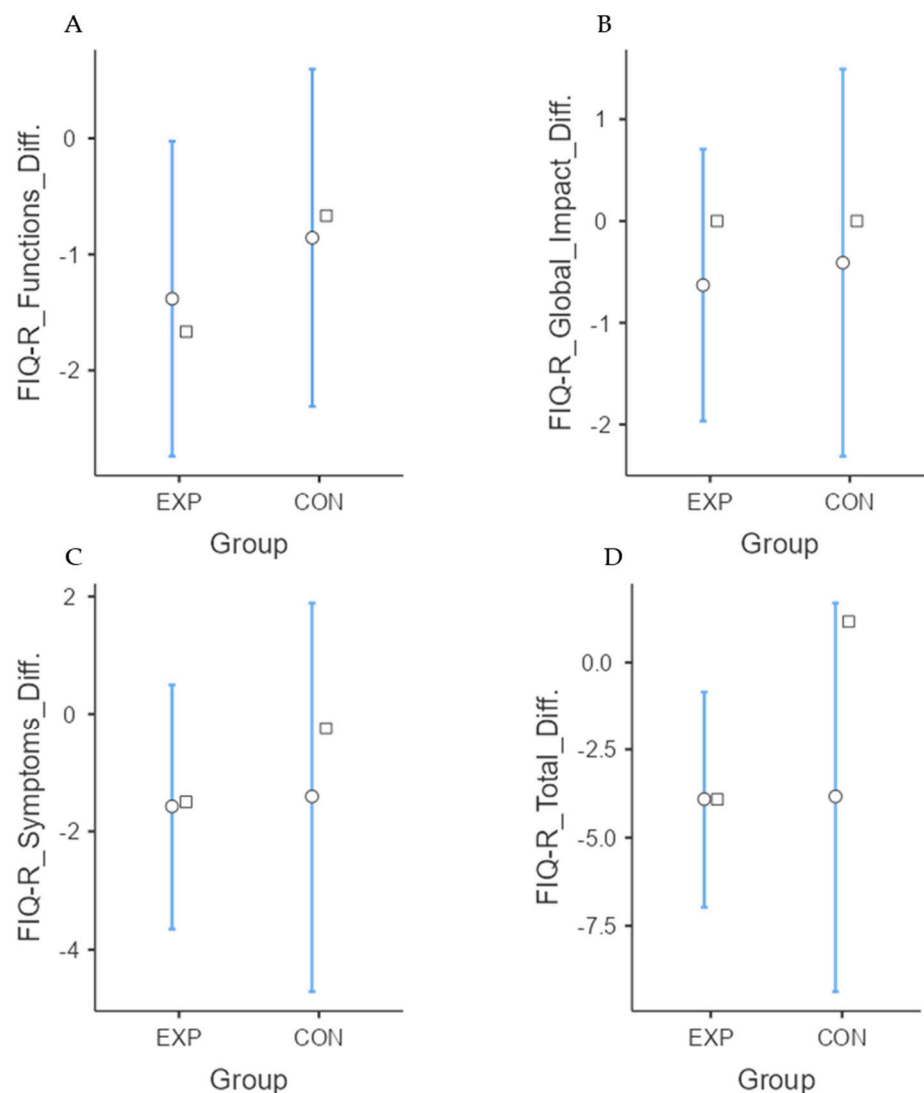


Figure 1. Differences in Fibromyalgia Impact Questionnaire Revised (FIQ-R) score and its dimensions: (A) Functions; (B) Global Impact; (C) Symptoms; (D) Total Score) before and after the intervention in both groups. The circle shows the mean score, and the square shows the median.

4. Discussion

This study presents the results of the first research that evaluated the effects of a 12-week training program based on Virtual Square Stepping Exercise (V-SSE) on physical function, FM impact, frailty, pain, falls, fear of falling, and risk of falling in Spanish women with fibromyalgia. In a previous work [31], the authors presented the analysis of the applicability and safety of the V-SSE in this same population, as well as its effects on quality of life, self-perceived health, life satisfaction, mental health, and cognitive function. In that study, despite observing that the V-SSE was applicable (with an adherence rate of over 85%) and safe (no injuries or incidents), no significant effects were found on the variables analyzed.

Similarly, the present study found, as main findings, that no statistically significant improvements were observed in indicators of physical function, frailty, FM impact, falls, fear of falling, and risk of falling after the V-SSE. Despite finding some positive trends in the experimental group, the statistical significance observed did not sustain after applying the multiple comparison correction. Furthermore, the intergroup analysis did not reveal statistically significant improvements either. These findings suggest that, in this study, the efficacy of V-SSE in improving these variables has not been proven.

In our study, no significant improvements in physical function were observed in women with FM after 12 weeks of V-SSE intervention. These results contrast with previous studies in the older population. Some researchers had reported positive effects of SSE on indicators related to physical function, such as balance, gait speed, agility, lower body strength and power, and flexibility [32–34,36,55–59].

A recent study in an older Spanish population evaluated the effects of 12 weeks of SSE on physical function, finding an improvement in dynamic balance (measured by FSST) and gait speed (30 m BWT) [34]. Following these findings, the authors suggested that SSE might be effective in improving stability and gait speed. Previously, Japanese and Korean researchers had observed improvements in static balance (using the OLSST) in the Japanese and Korean elderly population [35,59]. In contrast, our study found no significant improvements in either static or dynamic balance, using the same tests as those studies, as did other researchers in the Brazilian adult population [58,59], using the Berg Balance Scale, a battery that assesses static and dynamic balance. Therefore, the evidence on the effectiveness of SSE for balance improvement is not clear, and further research is needed, including more sensitive tools, such as inertial measurement units (IMUs) or force platforms. Regarding gait speed, according to the 30 m BWT, we found significant differences between the control group and the experimental group. Although this would be in line with the findings of Franco-García et al. [34], our finding was due to a worsening of the control group and not an improvement in the experimental group. Moreover, these differences were not statistically confirmed after adjustment for multiple comparisons. In the above studies in the elderly population [34,35], the improvements observed in balance and walking speed were not consolidated over time; in fact, in older Spanish women, the benefits were not maintained after one month of detraining [34]. In a previous study, the authors highlighted the importance of sustained physical activity over time for the beneficial effects of the SSE intervention to be long-lasting. These findings, together with the fact that people with FM have a longer period of adaptation to training, may suggest that our study should have been conducted over a longer period of exposure, extending beyond 14 weeks, as recommended in a recent systematic review [28].

In our study, we also found no effects on agility (assessed using the TUG), lower limb strength (assessed using the Sit to Stand), flexibility (using the Sit & Reach), aerobic capacity (using the 6 MWT), frailty (using SPPB), and handgrip strength. These findings coincided with those observed by Franco-García et al. [31], with similar assessment tests. Even though the V-SSE requires a process of memorization and execution of coordinative patterns, no improvements were found in the dual versions of the above tests, as in the study by Franco et al. [34]. Some authors have suggested that the original version of the SSE may be an insufficient physical stimulus to produce changes in the functional mobility, strength, and aerobic capacity of the participants, suggesting modifications in its implementation, including other adaptations, such as concurrent strength work to enhance its effects [31,36,58]. However, studies have been found in the scientific literature in which improvements in the above-mentioned physical function abilities have been observed in the elderly population [32,33,35,55,57–59]. Since there is no clear evidence that SSE can improve physical function capacities, it is necessary to further evaluate its effectiveness by providing new adaptations of the original program and exposure periods.

Our study, in addition to physical function, also looked at the effects on fear of falling, risk of falling, and number of falls, as well as FM impact and pain, as specific aspects of our population that are related to physical function. However, although we found a trend of improvement in these variables, we only found a significant reduction in pain within the experimental group, although this significant change was not confirmed in the intergroup comparison. Therefore, in contrast to previous studies that found significant

improvements in the above variables [32,56,59], our study did not reveal a significant effect, as in the Franco-García et al. study [34], where they also found no effect on fear of falling. The sample size, given that it did not reach sufficient statistical power for intergroup comparison, as well as the short duration of the intervention (12 weeks), may have meant that the trends found did not consolidate into statistically significant changes. However, the intensity of the program may also not have been a sufficient stimulus to induce changes in our population; thus, further research on the effectiveness of the V-SSE is necessary.

V-SSE is a tool that could be useful in improving physical function in women with FM, as well as reducing falls, fear of falling, risk of falling, pain, or the functional impact of the condition. It has been found to be applicable and safe in this population; however, at present, it has not demonstrated efficacy on its own in this population. Before V-SSE can be proposed as a training alternative, as has been proposed in other populations, for the improvement of the above variables, further research into possible modifications is necessary to demonstrate its efficacy. In the future, programs of longer duration should be implemented, the intensity of the exercises should be increased, or V-SSE should be combined with strength training. In addition, it is also necessary to explore face-to-face versions, given that there is a lack of face-to-face research with SSE in women with FM.

This research had some limitations that should be considered when interpreting our findings. Firstly, although our study had a sample size equal to or larger than other SSE studies, we did not have enough participants to be able to assume that the results of the intergroup comparisons were statistically reliable. However, we did reach a sufficient sample size to analyze the effects of the intervention in each of the groups, and it was not effective in improving the variables analyzed in our sample. In large part, the difficulties in recruitment were due to the COVID-19 pandemic, which generated a lot of fear and uncertainty among potential participants, and they used these reasons for not participating. We believe that the duration of our study, 12 weeks, although like other SSE programs, may have been insufficient to produce effects on our sample, given that some authors recommend interventions longer than 14 weeks in people with FM. Some physical measurements, such as balance, could have been carried out with more sensitive tools, although these were not available at the time of this intervention, and field tests were chosen for their ease and cost-effectiveness. We also did not consider the expectation bias of the participants, although we believe that this was not particularly relevant, given that no efficacy was found in the V-SSE group.

5. Conclusions

A 12-week Virtual Square Step Exercise (V-SSE) program was not effective in improving physical function, frailty, fibromyalgia impact, pain, falls, fear of falling, and risk of falling in Spanish women with FM.

Although improvements were observed within the experimental group in some variables, such as pain, impact of FM, and number of falls, these improvements were not confirmed as statistically significant after adjustment for multiple comparisons, nor in comparison with the control group.

These results suggest that, in its current form, the V-SSE program may not be sufficient to improve physical function in women with fibromyalgia.

Future studies should consider interventions of longer duration, integrated strength training, and with larger samples to more accurately assess the potential benefits of V-SSE in this population.

Supplementary Materials: The following supporting information can be downloaded at: <https://www.mdpi.com/article/10.3390/sci7030117/s1>, Figure S1: Differences in VAS for Pain (A), Falls (B),

Fear of Falling (C) and Risk of Falling (D) before and after the intervention in both groups. The circle shows the mean score, and the square shows the median; Table S1: Inclusion and exclusion criteria; Table S2: Comparison of baseline variables related to physical function between control and Virtual Square-Stepping Exercise groups; Table S3: Impact of the ‘Virtual Step Square Exercise’ program on Impact of Fibromyalgia, Pain, Falls, Fear of Falling, and Risk of Falling after 12 weeks in Spanish women with fibromyalgia.

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Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki and approved by the Institutional Review Board (or Ethics Committee) of the University of Extremadura (approval number: 79/2018. 2018). This RCT was registered in the Australian and New Zealand Clinical Trials Registry (application number: 378330); <https://www.anzctr.org.au> (accessed on 29 November 2019).

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

Data Availability Statement: Data presented in this study are available upon request from the corresponding author. Data are not publicly available due to privacy and ethical restrictions.

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References

1. Filipovic, T.; Filipović, A.; Nikolic, D.; Gimigliano, F.; Stevanov, J.; Hrkovic, M.; Bosanac, I. Fibromyalgia: Understanding, Diagnosis and Modern Approaches to Treatment. *J. Clin. Med.* **2025**, *14*, 955. [\[CrossRef\]](#)
2. Sumbul, H.E.; Okyay, R.A.; Bekarysova, D.; Kocyigit, B.F. Global Research Trends on Fibromyalgia and Exercise: A Ten-Year Web of Science-Based Bibliometric Analysis. *Rheumatol. Int.* **2025**, *45*, 50. [\[CrossRef\]](#) [\[PubMed\]](#)
3. Häuser, W.; Ablin, J.; Fitzcharles, M.A.; Littlejohn, G.; Luciano, J.V.; Usui, C.; Walitt, B. Fibromyalgia. *Nat. Rev. Dis. Primers* **2015**, *1*, 15022. [\[CrossRef\]](#) [\[PubMed\]](#)
4. Tharwat, S.; Mosad, N.R.; Abdelmessih, K.E.; Moatamed, E.; Rihan, M.; Osama, N.; Sallam, N.; Elsayed, Y. Prevalence of Fibromyalgia among University Students and Its Impact on Their Health-Related Quality of Life: A Survey-Based Study from Egypt. *BMC Public. Health* **2023**, *23*, 2437. [\[CrossRef\]](#)

5. Sarzi-Puttini, P.; Giorgi, V.; Marotto, D.; Atzeni, F. Fibromyalgia: An Update on Clinical Characteristics, Aetiopathogenesis and Treatment. *Nat. Rev. Rheumatol.* **2020**, *16*, 645–660. [[CrossRef](#)]
6. Findeisen, K.; Guymer, E.; Littlejohn, G. Neuroinflammatory and Immunological Aspects of Fibromyalgia. *Brain Sci.* **2025**, *15*, 206. [[CrossRef](#)]
7. Martínez-Amat, A.; Hita-Contreras, F.; Latorre-Román, P.A.; De La Cabeza Gutierrez-López, M.; García-Pinillos, F.; Martínez-López, E.J. Association of the Weekly Practice of Guided Physical Activity with the Reduction of Falls and Symptoms of Fibromyalgia in Adult Women. *J. Strength Cond. Res.* **2014**, *28*, 3146–3154. [[CrossRef](#)]
8. Leon-Llamas, J.L.; Murillo-Garcia, A.; Villafaina, S.; Domínguez-Muñoz, F.J.; Morenas, J.; Gusi, N. Relationship between Kinesiophobia and Mobility, Impact of the Disease, and Fear of Falling in Women with and without Fibromyalgia: A Cross-Sectional Study. *Int. J. Environ. Res. Public Health* **2022**, *19*, 8257. [[CrossRef](#)]
9. Denche-Zamorano, Á.; Pereira-Payo, D.; Collado-Mateo, D.; Adsuar-Sala, J.C.; Tomas-Carus, P.; Parraca, J.A. Physical Function, Self-Perceived Physical Fitness, Falls, Quality of Life and Degree of Disability According to Fear and Risk of Falling in Women with Fibromyalgia. *J. Funct. Morphol. Kinesiol.* **2024**, *9*, 174. [[CrossRef](#)]
10. Carlos-vivas, J.; Pérez-gómez, J.; Delgado-gil, S.; Campos-lópez, J.C.; Granado-sánchez, M.; Rojo-ramos, J.; Muñoz-bermejo, L.; Barrios-fernandez, S.; Mendoza-muñoz, M.; Prado-solano, A.; et al. Cost-Effectiveness of “Tele-Square Step Exercise” for Falls Prevention in Fibromyalgia Patients: A Study Protocol. *Int. J. Environ. Res. Public Health* **2020**, *17*, 695. [[CrossRef](#)] [[PubMed](#)]
11. Vasileios, P.; Styliani, P.; Nifon, G.; Pavlos, S.; Aris, F.; Ioannis, P. Managing Fibromyalgia with Complementary and Alternative Medical Exercise: A Systematic Review and Meta-Analysis of Clinical Trials. *Rheumatol. Int.* **2022**, *42*, 1909–1923. [[CrossRef](#)]
12. Kundakci, B.; Kaur, J.; Goh, S.L.; Hall, M.; Doherty, M.; Zhang, W.; Abhishek, A. Efficacy of Nonpharmacological Interventions for Individual Features of Fibromyalgia: A Systematic Review and Meta-Analysis of Randomised Controlled Trials. *Pain* **2022**, *163*, 1432–1445. [[CrossRef](#)] [[PubMed](#)]
13. Alvarez, M.C.; Albuquerque, M.L.L.; Neiva, H.P.; Cid, L.; Rodrigues, F.; Teixeira, D.S.; Matos, R.; Antunes, R.; Morales-Sánchez, V.; Monteiro, D. Exploring the Relationship between Fibromyalgia-Related Fatigue, Physical Activity, and Quality of Life. *Int. J. Environ. Res. Public Health* **2022**, *19*, 4870. [[CrossRef](#)]
14. Masquelier, E.; D’haeyere, J. Physical Activity in the Treatment of Fibromyalgia. *Jt. Bone Spine* **2021**, *88*, 105202. [[CrossRef](#)]
15. Denche-Zamorano, Á.; Barrios-Fernandez, S.; Mendoza-Muñoz, M.; Carlos-Vivas, J.; Vega-Muñoz, A.; Collado-Mateo, D.; Olivares, P.R.; Adsuar, J.C. Fibromyalgia, Pain, and Physical Activity: A Bibliometric Analysis. *Int. J. Environ. Res. Public Health* **2023**, *20*, 1335. [[CrossRef](#)] [[PubMed](#)]
16. Soriano-Maldonado, A.; Ruiz, J.R.; Aparicio, V.A.; Estévez-López, F.; Segura-Jiménez, V.; Álvarez-Gallardo, I.C.; Carbonell-Baeza, A.; Delgado-Fernández, M.; Ortega, F.B. Association of Physical Fitness with Pain in Women with Fibromyalgia: The al-Ándalus Project. *Arthritis Care Res.* **2015**, *67*, 1561–1570. [[CrossRef](#)]
17. Córdoba-Torrecilla, S.; Aparicio, V.A.; Soriano-Maldonado, A.; Estévez-López, F.; Segura-Jiménez, V.; Álvarez-Gallardo, I.; Femia, P.; Delgado-Fernández, M. Physical Fitness Is Associated with Anxiety Levels in Women with Fibromyalgia: The al-Ándalus Project. *Qual. Life Res.* **2016**, *25*, 1053–1058. [[CrossRef](#)]
18. Estévez-López, F.; Gray, C.M.; Segura-Jiménez, V.; Soriano-Maldonado, A.; Álvarez-Gallardo, I.C.; Arrayás-Grajera, M.J.; Carbonell-Baeza, A.; Aparicio, V.A.; Delgado-Fernández, M.; Pulido-Martos, M. Independent and Combined Association of Overall Physical Fitness and Subjective Well-Being with Fibromyalgia Severity: The al-Ándalus Project. *Qual. Life Res.* **2015**, *24*, 1865–1873. [[CrossRef](#)]
19. Antunes, M.D.; Schmitt, A.C.B.; Marques, A.P. Amigos de Fibro (Fibro Friends): Development of an Educational Program for the Health Promotion of Fibromyalgia Patients. *Prim. Health Care Res. Dev.* **2022**, *23*, e44. [[CrossRef](#)]
20. Antunes, M.D.; Schmitt, A.C.B.; Marques, A.P. Amigos de Fibro (Fibro Friends): Validation of an Educational Program to Promote Health in Fibromyalgia. *Int. J. Environ. Res. Public Health* **2022**, *19*, 5297. [[CrossRef](#)]
21. Turcotte, K.; Oelke, N.D.; Whitaker, G.; Holtzman, S.; O’Connor, B.; Pearson, N.; Teo, M. Multi-Disciplinary Community-Based Group Intervention for Fibromyalgia: A Pilot Randomized Controlled Trial. *Rheumatol. Int.* **2023**, *43*, 2201. [[CrossRef](#)]
22. Mannerkorpi, K.; Nordeman, L.; Ericsson, A.; Arndorw, M. Pool Exercise for Patients with Fibromyalgia or Chronic Widespread Pain: A Randomized Controlled Trial and Subgroup Analyses. *J. Rehabil. Med.* **2009**, *41*, 751–760. [[CrossRef](#)]
23. Macfarlane, G.J.; Kronisch, C.; Dean, L.E.; Atzeni, F.; Häuser, W.; Flub, E.; Choy, E.; Kosek, E.; Amris, K.; Branco, J.; et al. EULAR Revised Recommendations for the Management of Fibromyalgia. *Ann. Rheum. Dis.* **2017**, *76*, 318–328. [[CrossRef](#)] [[PubMed](#)]
24. Denche-Zamorano, Á.; Pastor-Cisneros, R.; Tomas-Carus, P.; Adsuar-Sala, J.C.; Salas-Gómez, D.; Parraca, J.A. Relationship of Pain, Depression, Fatigue, and Sleep Problems with Functional Capacity, Balance, and Fear of Falling in Women with Fibromyalgia: Cross-Sectional Study. *Nurs. Rep.* **2024**, *14*, 2819–2836. [[CrossRef](#)] [[PubMed](#)]
25. Niu, G.; Zheng, X.; Deng, B.; Yang, Q.; Du, Y.S. Effects of Exercise Dosage on the Treatment of Fibromyalgia: A Meta-Analysis of Randomised Controlled Trials. *Musculoskelet. Care* **2024**, *22*, e1918. [[CrossRef](#)]
26. Bidonde, J.; Busch, A.J.; Schachter, C.L.; Webber, S.C.; Musselman, K.E.; Overend, T.J.; Góes, S.M.; Dal Bello-Haas, V.; Boden, C. Mixed Exercise Training for Adults with Fibromyalgia. *Cochrane Database Syst. Rev.* **2019**, *5*, CD013340. [[CrossRef](#)]

27. Casanova-Rodríguez, D.; Ranchal-Sánchez, A.; Rodríguez, R.B.; Jurado-Castro, J.M. Aerobic Exercise Prescription for Pain Reduction in Fibromyalgia: A Systematic Review and Meta-Analysis. *Eur. J. Pain.* **2025**, *29*, e4783. [\[CrossRef\]](#)
28. Sousa, M.; Oliveira, R.; Brito, J.P.; Martins, A.D.; Moutão, J.; Alves, S. Effects of Combined Training Programs in Individuals with Fibromyalgia: A Systematic Review. *Healthcare* **2023**, *11*, 1708. [\[CrossRef\]](#)
29. Chen, J.; Han, B.; Wu, C. On the Superiority of a Combination of Aerobic and Resistance Exercise for Fibromyalgia Syndrome: A Network Meta-Analysis. *Front. Psychol.* **2022**, *13*, 949256. [\[CrossRef\]](#) [\[PubMed\]](#)
30. Cheng, C.A.; Chiu, Y.W.; Wu, D.; Kuan, Y.C.; Chen, S.N.; Tam, K.W. Effectiveness of Tai Chi on Fibromyalgia Patients: A Meta-Analysis of Randomized Controlled Trials. *Complement. Ther. Med.* **2019**, *46*, 1–8. [\[CrossRef\]](#)
31. Denche-Zamorano, Á.; Pereira-Payo, D.; De, J.; Ríos-Calonge, L.; Tomás-Carús, P.; Collado-Mateo, D.; Adsuar, J.C. Effects of Twelve Weeks of Virtual Square Stepping Exercises on Quality of Life, Satisfaction with the Life, Mental Health, and Cognitive Function in Women with Fibromyalgia: A Randomized Control Trial. *Women* **2025**, *5*, 17. [\[CrossRef\]](#)
32. Shigematsu, R.; Okura, T.; Nakagaichi, M.; Tanaka, K.; Sakai, T.; Kitazumi, S.; Rantanen, T. Square-Stepping Exercise and Fall Risk Factors in Older Adults: A Single-Blind, Randomized Controlled Trial. *J. Gerontol. Ser. A Biol. Sci. Med. Sci.* **2008**, *63*, 76–82. [\[CrossRef\]](#) [\[PubMed\]](#)
33. Shigematsu, R.; Okura, T.; Sakai, T.; Rantanen, T. Square-Stepping Exercise versus Strength and Balance Training for Fall Risk Factors. *Aging Clin. Exp. Res.* **2008**, *20*, 19–24. [\[CrossRef\]](#) [\[PubMed\]](#)
34. Franco-García, J.M.; Pérez-Gómez, J.; Castillo-Paredes, A.; Redondo, P.C.; Rojo-Ramos, J.; Mayordomo-Pinilla, N.; Villafaina, S.; Gómez-Álvaro, M.C.; Melo-Alonso, M.; Carlos-Vivas, J. Effects of Twelve Weeks of Square Stepping Exercises on Physical and Cognitive Function and Plasma Content of SMP30: A Randomised Control Trial. *Geriatrics* **2025**, *10*, 22. [\[CrossRef\]](#)
35. Shigematsu, R.; Okura, T. A Novel Exercise for Improving Lower-Extremity Functional Fitness in the Elderly. *Aging Clin. Exp. Res.* **2006**, *18*, 242–248. [\[CrossRef\]](#)
36. Franco-García, J.M.; Carlos-Vivas, J.; Castillo-Paredes, A.; Mayordomo-Pinilla, N.; Rojo-Ramos, J.; Pérez-Gómez, J. Impacts of Square Stepping Exercise on Physical-Cognitive Function, Biomarkers, Body Composition and Mental Health in Healthy Senior Aged 60 and Above: A Systematic Review. *Healthcare* **2024**, *12*, 2325. [\[CrossRef\]](#)
37. Turner, L.; Shamseer, L.; Altman, D.G.; Weeks, L.; Peters, J.; Kober, T.; Dias, S.; Schulz, K.F.; Plint, A.C.; Moher, D. Consolidated Standards of Reporting Trials (CONSORT) and the Completeness of Reporting of Randomised Controlled Trials (RCTs) Published in Medical Journals. *Cochrane Database Syst. Rev.* **2012**, *11*, MR000030. [\[CrossRef\]](#)
38. Wolfe, F.; Clauw, D.J.; Fitzcharles, M.A.; Goldenberg, D.L.; Häuser, W.; Katz, R.L.; Mease, P.J.; Russell, A.S.; Russell, I.J.; Walitt, B. 2016 Revisions to the 2010/2011 Fibromyalgia Diagnostic Criteria. *Semin. Arthritis Rheum.* **2016**, *46*, 319–329. [\[CrossRef\]](#)
39. Cardinal, B.J.; Esters, J.; Cardinal, M.K. Evaluation of the Revised Physical Activity Readiness Questionnaire in Older Adults. *Med. Sci. Sports Exerc.* **1996**, *28*, 468–472. [\[CrossRef\]](#)
40. Bull, F.C.; Al-Ansari, S.S.; Biddle, S.; Borodulin, K.; Buman, M.P.; Cardon, G.; Carty, C.; Chaput, J.P.; Chastin, S.; Chou, R.; et al. World Health Organization 2020 Guidelines on Physical Activity and Sedentary Behaviour. *Br. J. Sports Med.* **2020**, *54*, 1451–1462. [\[CrossRef\]](#) [\[PubMed\]](#)
41. Giannouli, E.; Morat, T.; Zijlstra, W. A Novel Square-Stepping Exercise Program for Older Adults (StepIt): Rationale and Implications for Falls Prevention. *Front. Med.* **2020**, *6*, 463375. [\[CrossRef\]](#)
42. Vellas, B.J.; Wayne, S.J.; Romero, L.; Baumgartner, R.N.; Rubenstein, L.Z.; Garry, P.J. One-Leg Balance Is an Important Predictor of Injurious Falls in Older Persons. *J. Am. Geriatr. Soc.* **1997**, *45*, 735–738. [\[CrossRef\]](#)
43. Dite, W.; Temple, V.A. A Clinical Test of Stepping and Change of Direction to Identify Multiple Falling Older Adults. *Arch. Phys. Med. Rehabil.* **2002**, *83*, 1566–1571. [\[CrossRef\]](#)
44. Carbonell-Baeza, A.; Álvarez-Gallardo, I.C.; Segura-Jiménez, V.; Castro-Piñero, J.; Ruiz, J.R.; Delgado-Fernández, M.; Aparicio, V.A. Reliability and Feasibility of Physical Fitness Tests in Female Fibromyalgia Patients. *Int. J. Sports Med.* **2015**, *36*, 157–162. [\[CrossRef\]](#) [\[PubMed\]](#)
45. Beauchet, O.; Fantino, B.; Allali, G.; Muir, S.W.; Montero-Odasso, M.; Annweiler, C. Timed up and Go Test and Risk of Falls in Older Adults: A Systematic Review. *J. Nutr. Health Aging* **2011**, *15*, 933–938. [\[CrossRef\]](#)
46. Santamaría-Peláez, M.; González-Bernal, J.J.; Da Silva-González, Á.; Medina-Pascual, E.; Gentil-Gutiérrez, A.; Fernández-Solana, J.; Mielgo-Ayuso, J.; González-Santos, J. Validity and Reliability of the Short Physical Performance Battery Tool in Institutionalized Spanish Older Adults. *Nurs. Rep.* **2023**, *13*, 1354–1367. [\[CrossRef\]](#)
47. Andersson, M.; Moberg, L.; Svantesson, U.; Sundbom, A.; Johansson, H.; Emtner, M. Measuring Walking Speed in COPD: Test-Retest Reliability of the 30-Metre Walk Test and Comparison with the 6-Minute Walk Test. *Prim. Care Respir. J.* **2011**, *20*, 434–440. [\[CrossRef\]](#) [\[PubMed\]](#)
48. Duncan, P.W.; Weiner, D.K.; Chandler, J.; Studenski, S. Functional Reach: A New Clinical Measure of Balance. *J. Gerontol.* **1990**, *45*, M192–M197. [\[CrossRef\]](#)
49. Ruiz-Ruiz, J.; Mesa, J.L.M.; Gutiérrez, A.; Castillo, M.J. Hand Size Influences Optimal Grip Span in Women but Not in Men. *J. Hand Surg.-Am. Vol.* **2002**, *27*, 897–901. [\[CrossRef\]](#)

50. Luciano, J.V.; Aguado, J.; Serrano-Blanco, A.; Calandre, E.P.; Rodriguez-Lopez, C.M. Dimensionality, Reliability, and Validity of the Revised Fibromyalgia Impact Questionnaire in Two Spanish Samples. *Arthritis Care Res.* **2013**, *65*, 1682–1689. [[CrossRef](#)]
51. Yardley, L.; Beyer, N.; Hauer, K.; Kempen, G.; Piot-Ziegler, C.; Todd, C. Development and Initial Validation of the Falls Efficacy Scale-International (FES-I). *Age Ageing* **2005**, *34*, 614–619. [[CrossRef](#)]
52. Lomas-Vega, R.; Hita-Contreras, F.; Mendoza, N.; Martínez-Amat, A. Cross-Cultural Adaptation and Validation of the Falls Efficacy Scale International in Spanish Postmenopausal Women. *Menopause* **2012**, *19*, 904–908. [[CrossRef](#)]
53. Ishimoto, Y.; Wada, T.; Kasahara, Y.; Kimura, Y.; Fukutomi, E.; Chen, W.; Hirosaki, M.; Nakatsuka, M.; Fujisawa, M.; Sakamoto, R.; et al. Fall Risk Index Predicts Functional Decline Regardless of Fall Experiences among Community-Dwelling Elderly. *Geriatr. Gerontol. Int.* **2012**, *12*, 659–666. [[CrossRef](#)]
54. Montilla-Ibáñez, A.; Martínez-Amat, A.; Lomas-Vega, R.; Cruz-Díaz, D.; la Torre-Cruz, M.J.D.; Casuso-Pérez, R.; Hita-Contreras, F. The Activities-Specific Balance Confidence Scale: Reliability and Validity in Spanish Patients with Vestibular Disorders. *Disabil. Rehabil.* **2017**, *39*, 697–703. [[CrossRef](#)]
55. Shigematsu, R.; Okura, T.; Nakagaichi, M.; Nakata, Y. Adherence to and Effects of Multidirectional Stepping Exercise in the Elderly: A Long-Term Observational Study Following a Randomized Controlled Trial. *J. Phys. Fit. Sports Med.* **2013**, *2*, 127–134. [[CrossRef](#)]
56. Fisseha, B.; Janakiraman, B.; Yitayeh, A.; Ravichandran, H. Effect of Square Stepping Exercise for Older Adults to Prevent Fall and Injury Related to Fall: Systematic Review and Meta-Analysis of Current Evidences. *J. Exerc. Rehabil.* **2017**, *13*, 23. [[CrossRef](#)] [[PubMed](#)]
57. Teixeira, C.V.L.; Gobbi, S.; Pereira, J.R.; Ueno, D.T.; Shigematsu, R.; Gobbi, L.T.B. Effect of Square-Stepping Exercise and Basic Exercises on Functional Fitness of Older Adults. *Geriatr. Gerontol. Int.* **2013**, *13*, 842–848. [[CrossRef](#)]
58. Pereira, J.R.; Gobbi, S.; Teixeira, C.V.L.; Nascimento, C.M.C.; Corazza, D.I.; Vital, T.M.; Hernandez, S.S.S.; Stella, F.; Shigematsu, R. Effects of Square-Stepping Exercise on Balance and Depressive Symptoms in Older Adults. *Mot. Rev. Educ. Física* **2014**, *20*, 454–460. [[CrossRef](#)]
59. Cha, H.J.; Kim, K.B.; Baek, S.Y. Square-Stepping Exercise Program Effects on Fall-Related Fitness and BDNF Levels in Older Adults in Korea: A Randomized Controlled Trial. *Int. J. Environ. Res. Public Health* **2022**, *19*, 7033. [[CrossRef](#)] [[PubMed](#)]

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