

Six Weeks of Whole-Body Vibration Exercise Improves Pain and Fatigue in Women with Fibromyalgia

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Abstract

Objective: The aim of this study was to investigate the effectiveness of a 6-week traditional exercise program with supplementary whole-body vibration (WBV) in improving health status, physical functioning, and main symptoms of fibromyalgia (FM) in women with FM.

Methods: Thirty-six (36) women with FM (mean \pm standard error of the mean age 55.97 ± 1.55) were randomized into 3 treatment groups: exercise and vibration (EVG), exercise (EG), and control (CG). Exercise therapy, consisting of aerobic activities, stretching, and relaxation techniques, was performed twice a week (90 min/day). Following each exercise session, the EVG underwent a protocol with WBV, whereas the EG performed the same protocol without vibratory stimulus. The Fibromyalgia Impact Questionnaire (FIQ) was administered at baseline and 6 weeks following the initiation of the treatments. Estimates of pain, fatigue, stiffness, and depression were also reported using the visual analogue scale.

Results: A significant 3×2 (group \times time)-repeated measures analysis of variance interaction was found for pain ($p = 0.018$) and fatigue ($p = 0.002$) but not for FIQ ($p = 0.069$), stiffness ($p = 0.142$), or depression ($p = 0.654$). Pain and fatigue scores were significantly reduced from baseline in the EVG, but not in the EG or CG. In addition, the EVG showed significantly lower pain and fatigue scores at week 6 compared to the CG, whereas no significant differences were found between the EG and CG ($p > 0.05$).

Conclusion: Results suggest that a 6-week traditional exercise program with supplementary WBV safely reduces pain and fatigue, whereas exercise alone fails to induce improvements.

Introduction

Fibromyalgia (FM) syndrome is considered a chronic rheumatic condition of unknown etiology characterized by widespread noninflammatory musculoskeletal pain with tenderness on palpation in a minimum of 11 of the 18 tender points for at least 3 months.¹ Numerous symptoms may also be associated with this syndrome, including fatigue, anxiety, depression, nonrestorative sleep, muscular stiffness, or irritable bowel syndrome.

The management of FM is based on symptomatic multidisciplinary treatment through pharmacologic and nonpharmacologic strategies. Among all nonpharmacologic

treatments, exercise, cognitive behavioral therapy, and education have the strongest evidence for efficacy.² Numerous researchers support the benefits of aerobic exercise,²⁻⁷ strength training,^{2,6,8} health education,^{3,9} and relaxation techniques⁷ on health status, physical functioning, and main symptoms of FM.

Whole-body vibration (WBV) is a mode of exercise that has recently been utilized to improve muscle strength, bone density, and balance in healthy adults¹⁰ and aging populations.^{11,12} In this therapy, the subject performs exercises on a platform that generates vertical vibrations with a frequency and amplitude of 20–50 Hz and 2.0–10.5 mm, respectively.

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The rationale for investigating the effects of WBV in patients with FM is based on the following evidence. First, vibratory stimulation has been shown to induce pain relief in acute and chronic pain.¹³ However, this was a local vibration applied to the forearm, face, and skull rather than a WBV, effects that have not been studied in patients with FM. Second, WBV has been shown to increase strength in untrained¹⁴ and postmenopausal women.¹⁵ Third, some studies have reported increased growth hormone secretion with WBV.^{16,17} It is possible that this WBV-induced endocrine effect could enhance the effectiveness of the exercise therapy.¹⁸ Therefore, it is reasonable to expect that patients with FM could benefit from the salutary effects of WBV by improving health status, physical functioning, and main symptoms of FM. However, the effects of WBV on patients with FM have not been previously studied.

The purpose of this study was to investigate the effectiveness of a 6-week traditional exercise program with supplementary WBV in improving health status, physical functioning, and main symptoms of FM in women with FM. It was hypothesized that women with FM undergoing the traditional exercise program with supplementary WBV would improve health status, physical functioning, and main symptoms of FM more so than women undergoing exercise only. We considered pain, fatigue, stiffness, and depression as the main symptoms of FM.

Patients and Methods

Subjects

Participants were recruited by referral from family physicians and through public announcements distributed in local associations of FM in Barcelona (Spain). One hundred and four (104) women were interested in the study, and those with diagnosis of FM, according to the American College of

Rheumatology criteria,¹ for at least 3 years were considered for the study. Women were excluded if they had any orthopedic limitation, cardiovascular, pulmonary, or metabolic disease that would preclude exercise, or when participating in any other study (Fig. 1). Written informed consent was obtained from each subject prior to participation in the study according to procedures approved by the Committee on Biomedical Ethics of the Jordi Gol Gurina Foundation (Spain).

Study Design

A 2-factor mixed experimental design was employed in this study. Women were randomized into 3 treatment groups: exercise and vibration (EVG), exercise (EG), and control (CG) (Fig. 1). Measurements were taken at baseline and at 6 weeks following the initiation of the treatments. To minimize the residual effects of the last bout of exercise, the sixth-week questionnaire was administered 48 hours following the last session of the treatment. Prior to the initiation of the study, an individualized interview was performed with each patient in order to obtain the following information: (1) complete medical history, (2) current medications, (3) physical activity habits, (4) preferred types of exercises, and (5) socioeconomic status. In addition, patients were instructed to report any changes in medication regimens.

Self-report Health Status, Physical Functioning, and Main Symptoms of FM

Health status, physical functioning, and main symptoms of FM were assessed using the validated Spanish version of the Fibromyalgia Impact Questionnaire (FIQ).¹⁹ The FIQ is a valid, reliable, and sensitive tool^{19–22} widely used in research and clinical settings.^{3–5,8,19,20,23,24} This questionnaire measures physical function (activities of daily living), work, and general well-being. It contains 100-mm visual analogue

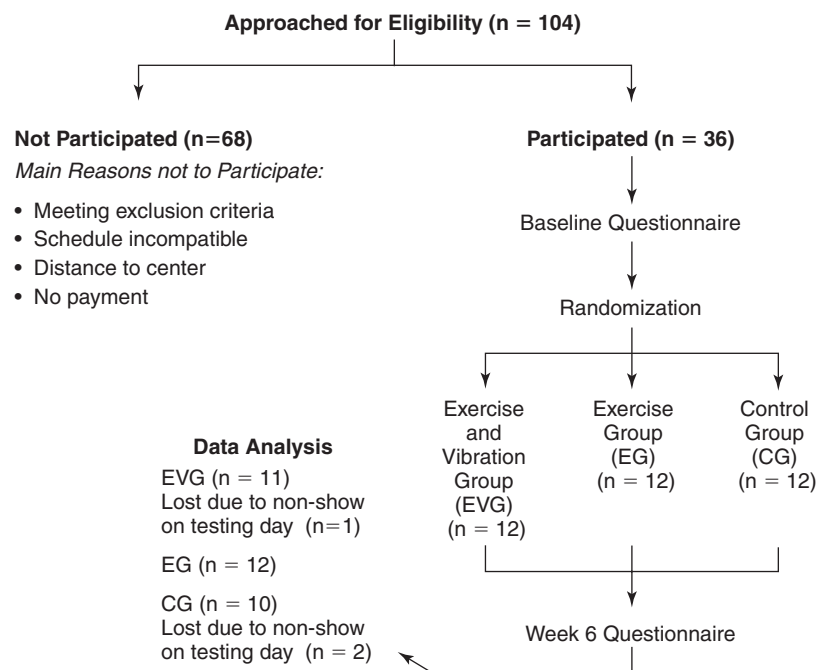


FIG. 1. Study design. EVG, exercise and vibration group; EG, Exercise Group; CG, Control Group.

scales (VAS) for pain, sleep, fatigue, stiffness, anxiety, and depression.^{19,20} An overall FIQ score is obtained by normalization of physical function, work, and well-being into a 0–10 scale, which are added to the total scores of VAS. We chose to singly document VAS scores for pain, fatigue, stiffness, and depression, as these are among the most common symptoms related to FM.²⁵ For all our dependent variables, a higher score indicates a greater level of difficulty or illness. Questionnaires were administered to all patients on the same day, time, and by the same investigator to ensure equal instructions and thus minimize potential confounding variables. In addition, administration and analysis of the questionnaires were performed by an investigator who was blind to the treatment groups.

Treatment Groups

Both EVG and EG underwent the same traditional exercise program twice per week for a total of 6 weeks. Following each traditional exercise session, EVG and EG were separated into 2 different rooms. EVG underwent a protocol with WBV, whereas the EG performed the same protocol without vibratory stimulus. The vibratory apparatus in the EG was turned on yet did not produce vibrations, which is a strategy that has been utilized by other authors.¹³ We informed both EVG and EG that they would receive a perceptible and imperceptible vibratory stimulus, respectively, thus maintaining the potential of a placebo effect consistent in both groups. Women in the CG performed neither the traditional exercise program nor the protocol with WBV. All 3 groups were instructed to continue with their pharmacologic care.² All exercise sessions were conducted by the same instructor, who had experience in working with FM. The protocol with WBV was supervised by experienced investigators. The 2 per week frequency of sessions was adopted to avoid the risk of exacerbating symptoms and to ensure adherence.

Although our traditional exercise program was similar to that from other studies,^{3–5,7,9} the inclusion of WBV in patients with FM is the unique aspect of this investigation. Six (6) weeks was chosen as the duration of our intervention because, based on previous research, this is sufficient time for WBV-induced adaptations to occur^{26–28} while inadequate duration for a traditional exercise program to improve pain, fatigue, stiffness, and depression in patients with FM.^{3,7} This approach allowed us to investigate the impact of WBV in enhancing the effectiveness of a traditional exercise program.

Traditional Exercise Program

The traditional exercise program was designed using the recommendations of Jones and Clark.²⁹ The program consisted of 15 minutes of a warmup, 30 minutes of aerobic exercise, 25 minutes of stretching exercises, and 20 minutes of relaxation. Major emphasis was given to aerobic exercise because this is the most beneficial type of exercise for the population investigated.² Aerobic activities consisted of 30 minutes of walking on flat ground at an intensity of 65%–85% of the theoretical maximal heart rate ($220 - \text{age (years)}$). The intensity was monitored by instructing the patients to take their pulse rate during the exercises. For adaptation purposes, during the first week, target heart rate was set at the lower range. Games and dances with low impact were pre-

sented at weeks 3 and 5 to avoid monotony. Patients danced salsa music for 30 minutes, performing two repetitions of 15 minutes each with a recovery of 3 minutes in between. Patients performed dancing tasks with a partner, whereas dancing games were performed in groups of 3–10 patients. Stretching exercises consisted of 5 different static whole-body stretches. Patients performed 5 repetitions of each whole-body stretch, holding the position for 30 seconds with a recovery of 30 seconds in between. Stretches involved (a) hamstrings, calves, Achilles tendons, back, and shoulders (downward-facing dog stretch); (b) gluteals, lower back, upper back, shoulders, arms, and chest (lying spinal twist stretch); (c) hamstrings, calves, shoulders, chest, and arms (forward-bend shoulder stretch); (d) Achilles tendons, calves, hamstrings, adductors, cervical spine, shoulders, and forearms (lying supine with open and straight legs with 90° of hip flexion and 100° of shoulder abduction with extended wrists); and (e) Achilles tendons, calves, hamstrings, back, and shoulders (sit-and-reach stretch). Stretches were individualized to teach each patient to locate her stop point and avoid overstretching. Relaxation exercises included diaphragmatic respiration, progressive muscular relaxation, contraction–relaxation, and imagery techniques. The total duration (over 12 sessions) of aerobic exercise, stretching, and relaxation was 9 hours, 6 hours, and 4 hours, respectively.

Whole-Body Vibration

The protocol, given to both EVG and EG, consisted of static and dynamic tasks while standing on a WBV platform (PowerPlate,[®] Power Plate International B.V., Badhoevendorp, The Netherlands). Tasks mainly involved lower extremities and included (a) static squat at 100° of knee flexion; (b) dynamic squat between 90° and 130° of knee flexion; (c) maintained ankle plantar-flexion with legs in extension; (d) flexo-extension of the right leg between 100° and 130° of knee flexion; (e) flexo-extension of the left leg between 100° and 130° of knee flexion; and (f) squat at 100° of knee flexion shifting the body weight from 1 leg to the other. For all tasks, subjects held onto the supporting bar. The 6 exercises (30 seconds each) were repeated 6 times with a recovery of 3 minutes between repetitions. For adaptation purposes, only tasks (a), (b), and (c) (repeated 3 times) were performed during the first 2 sessions.

For the EVG, the WBV intensity was kept constant at 30 Hz of frequency and 2 mm of amplitude; whereas for the EG, the apparatus did not produce vibrations. The intensity of vibration was chosen based on previous literature. Thirty (30) Hz has been shown to induce maximal muscular electrical activity.³⁰ Lower frequencies (i.e., 20 Hz) were not used because they evoke muscular relaxation, whereas higher frequencies (i.e., 50 Hz) were not employed because they can generate severe soreness in untrained individuals.^{10,31} The duration of WBV was 4.5 minutes per session for the first 2 sessions, and 18 minutes for the remaining 10 sessions. Thus, the total duration after completion of 6 weeks (12 sessions) was 189 minutes.

Statistical Analysis

Descriptive statistics were used to summarize the demographic characteristics of the subjects and one-way analysis of variance (ANOVA) was used to compare the demographic variables among the 3 groups. To test the effects of the treat-

TABLE 1. DEMOGRAPHIC CHARACTERISTICS OF THE SUBJECTS

Variable	EVG (n = 11) Mean ± SEM	EG (n = 12) Mean ± SEM	CG (n = 10) Mean ± SEM
Age (yrs)	55.2 ± 3.4	53.7 ± 2.7	59.3 ± 2.3
Height (cm)	156.8 ± 2.2	156.8 ± 1.9	160.6 ± 1.6
Weight (kg)	68.8 ± 2.9	68.8 ± 3.2	74.1 ± 2.2
BMI (kg/m ²)	27.3 ± 0.4	27.6 ± 1.1	28.8 ± 0.9
Duration diagnosis (yrs)	10.1 ± 0.7	9.8 ± 0.8	10.5 ± 0.8
Baseline FIQ scores	64.6 ± 3.7	66.3 ± 3.2	66.3 ± 4.6

EVG, Exercise and Vibration Group; EG, Exercise Group; CG, Control Group; SEM, standard error of the mean; BMI, body mass index; FIQ, Fibromyalgia Impact Questionnaire.

ments on FIQ, pain, fatigue, stiffness, and depression, a 3 × 2 (group × time) mixed-design repeated-measures ANOVA was performed for each dependent variable. Simple main effects were evaluated if a significant interaction was elicited. Tukey's Honestly Significant Differences (HSD) procedure was used when a significant F-ratio with more than 1 degree of freedom was found. All data are presented as mean ± standard error of the mean). For all statistical tests, the α level was set at 0.05. Statistical analyses were performed with SPSS v.15.0. (SPSS, Inc. Chicago, IL).

Results

Of 104 women, 36 were recruited for this study, and randomly and evenly distributed to 3 treatment groups (Fig. 1). One (1) subject from the EVG and 2 from the CG did not complete the 6-week questionnaire due to a no-show on testing day. Since repeated-measures analysis only allows for inclusion of those subjects who completed all measurements, those subjects with missing values were excluded from the analysis. The demographics of the subjects in each group are summarized in Table 1. There were no

differences ($p > 0.05$) among the groups for any of the demographic variables.

Both experimental groups, EVG and EG, adhered to the treatments 93% and 92%, respectively (100% adherence = all sessions attended). None of the subjects dropped out of the study. All patients reported they maintained the same medication prescription throughout the study (Table 2). This program neither exacerbated FM-related symptoms nor resulted in musculoskeletal injuries; however, 1 patient exhibited a mild anxiety attack on the first session of WBV. This patient responded normally for the remainder of the sessions.

Figures 2 and 3 illustrate the change in FIQ and pain, fatigue, stiffness, and depression, respectively, across time and treatment groups. As shown, significant 3 × 2 (group × time) repeated-measures ANOVA interactions were found for pain ($F_{(2,30)} = 4.60$; $p = 0.018$) and fatigue ($F_{(2,30)} = 7.50$; $p = 0.002$) but not for FIQ ($F_{(2,30)} = 2.93$; $p = 0.069$), stiffness ($F_{(2,30)} = 2.09$; $p = 0.142$), or depression ($F_{(2,30)} = 0.43$; $p = 0.654$). When examining the simple main effects of the significant interactions, pain and fatigue scores were significantly reduced from baseline in the EVG, but not in the EG or CG (Fig. 3). In addition, pain and fatigue scores after 6 weeks of treatment were

TABLE 2. COMORBIDITIES AND MEDICATIONS OF THE SUBJECTS

Characteristic	EVG (n = 11) n (%)	EG (n = 12) n (%)	CG (n = 10) n (%)
Comorbidities			
Gonarthrosis	6 (54.5%)	6 (50%)	5 (50%)
Spondyloarthrosis	7 (63.6%)	8 (66.6%)	6 (60%)
Disc degeneration	3 (27.2%)	3 (25%)	2 (20%)
Coxarthrosis	1 (9%)	1 (8.3%)	1 (10%)
Osteoporosis	2 (18.2%)	2 (16.7%)	2 (20%)
Cardiopathies	1 (9%)	1 (8.3%)	1 (10%)
Depression	6 (54.5%)	6 (50%)	6 (60%)
Hypertension	2 (18.2%)	2 (16.7%)	2 (20%)
Circulatory diseases	1 (9%)	1 (8.3%)	1 (10%)
Carpal tunnel	2 (18.2%)	2 (16.7%)	1 (10%)
Irritable bowel	1 (9%)	1 (8.3%)	1 (10%)
Medication			
Antidepressants	6 (54.5%)	6 (50%)	6 (60%)
Anxiolytics	5 (45.5%)	5 (41.7%)	4 (40%)
NSAIDs	4 (36.4%)	5 (41.7%)	4 (40%)
Analgesics	4 (36.4%)	4 (33.3%)	3 (30%)
Muscle relaxants	1 (9%)	2 (16.7%)	1 (10%)

EVG, Exercise and Vibration Group; EG, Exercise Group; CG, Control Group; NSAIDs, nonsteroidal anti-inflammatory drugs.

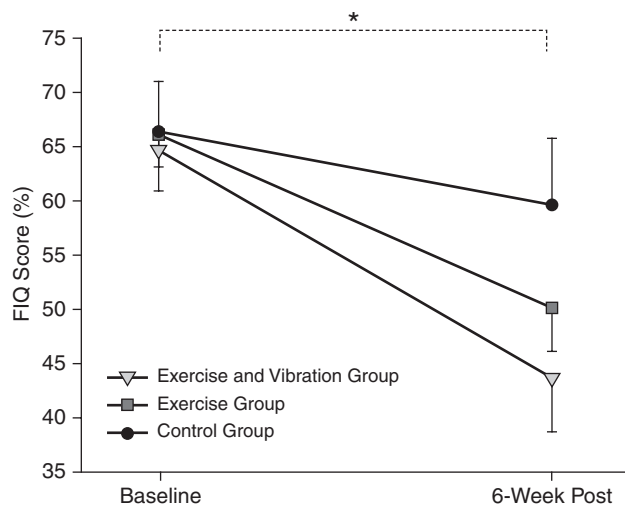


FIG. 2. Fibromyalgia Impact Questionnaire (FIQ) scores before and after 6 weeks of randomized treatments (mean \pm standard error of the mean). *Significant main effect of time ($p < 0.0001$).

significantly lower in the EVG compared to the EG and CG; the differences between the EG and CG, however, were not statistically different ($p > 0.05$) (Fig. 3).

Discussion

The purpose of this study was to investigate the effectiveness of a 6-week traditional exercise program with supplementary WBV in improving health status, physical functioning, and main symptoms of FM. Although WBV has been shown to produce positive results in a variety of populations,^{10–12,14,15,26,27} this is the first study to investigate the effects of WBV on women with FM. We found that a 6-week traditional exercise program with supplementary WBV safely reduced pain and fatigue, whereas the effect of exercise alone was not evident in any of the parameters.

The characteristics of our population are similar to those reported in other FM studies.^{3–6,8,9} The mean baseline FIQ score in our patients is slightly higher than that reported in several FM studies,^{3–5,8,9} but similar to others.^{6,7} Importantly, our 0% dropout and 92%–93% treatment adherence rates are highly unusual in interventions including patients with FM, and distinguish this investigation from other FM studies.^{5,7,9}

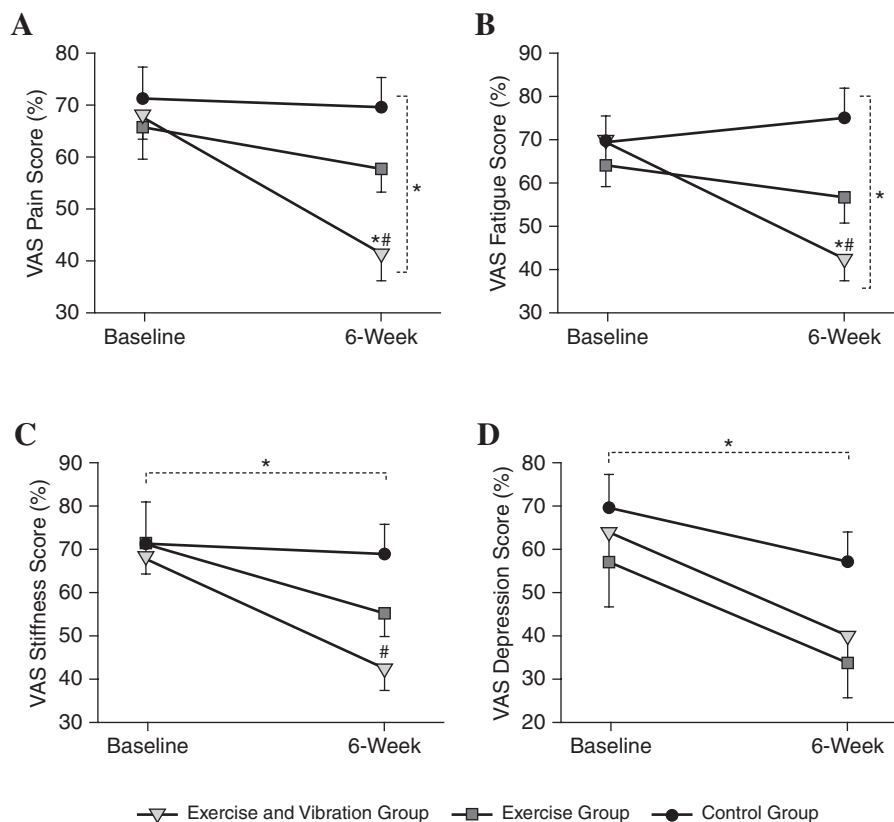


FIG. 3. Pain, Fatigue, Stiffness, and Depression scores before and after 6 weeks of randomized treatments (mean \pm standard error of the mean). (A) *Significant 3×2 mixed-design repeated-measures analysis of variance (ANOVA) interaction ($p = 0.018$). #Significantly different from Control Group ($p = 0.004$). §Significantly different from Baseline within treatment group ($p < 0.0001$). (B) *Significant 3×2 mixed-design repeated-measures ANOVA interaction ($p = 0.002$). #Significantly different from Control Group ($p = 0.001$). §Significantly different from Baseline within treatment group ($p < 0.0001$). (C) *Significant main effect of time ($p = 0.002$). #Significant main effect from Control Group ($p = 0.047$). (D) *Significant main effect of time ($p = 0.001$). VAS, Visual Analogue Scale.

Because subjects were not reimbursed, this high adherence rate may be suggestive of patient's satisfaction with the intervention.

Our results clearly suggest the positive effects of the traditional exercise program plus supplementary WBV intervention on pain and fatigue, whereas the effect of exercise alone is not apparent in any of the variables. The results from the EG are consistent with those obtained by Gowans et al.,⁴ who found no improvements in estimates of pain, fatigue, stiffness, and depression using FIQ after 6 weeks of a similar exercise program plus education therapy. Similarly, Wiggers et al.⁷ showed no improvements in pain, fatigue, sleep, and depression at week 7 of aerobic exercise therapy, and King et al.⁹ reported no changes in FIQ scores after 12 weeks of a comparable exercise therapy. In contrast, Redondo et al.²⁴ found improvements in FIQ and fatigue scores (but not in pain, stiffness, and depression) following an 8-week program consisting of cycling, strength, and stretching exercises (5 sessions per week). Our findings for EG do not differ from those of other studies utilizing similar intervention duration, exercise protocols, and the same assessment techniques.^{3,7}

Although differences between EVG and EG in pain and fatigue were not statistically different, the significant difference between EVG and CG, but not between EG and CG, could illustrate that exercise plus supplementary WBV is more effective in improving pain and fatigue than exercise alone. Furthermore, the EVG, but not the EG or the CG, exhibited an improvement in pain and fatigue from baseline to week 6.

There are some limitations to this study. The small sample size can be considered a limitation of the study; however, the presence of statistically significant interactions for pain and fatigue with a large effect size are indicative of a meaningful treatment effect. Nevertheless, it is likely that with inclusion of more subjects, a statistically significant interaction for FIQ could have been found. Moreover, in terms of the experimental design, the absence of a fourth treatment group consisting of WBV without exercise impeded the examination of the WBV effect solely; thus, it is unknown to what extent an intervention exclusively based on WBV elicits improvements in health status, physical functioning, and main symptoms of FM. However, WBV alone was not considered as a single therapy, but instead in combination with exercise, because the salutary effects of exercise in this population are well recognized and should not be neglected. This study was attempted to improve the efficacy of exercise as opposed to devising a potential substitute for exercise. Nevertheless, whether WBV strengthens the effect of the exercise therapy, produces improvements independently, or both, needs further investigation.

The significance of this study is threefold. First, we showed that a traditional exercise program with supplementary WBV safely reduces pain and fatigue, the most important symptoms in patients with FM, whereas exercise alone fails to induce significant changes. Second, the results of WBV are observed after only 6 weeks of intervention. Because patients with FM typically report an insufficient available time to invest with an exercise therapy, or complain about not attaining positive results in a quick manner, the WBV may be considered a novel strategy in the management of FM. Third, the present study opens a new line of investigation; further research should be

focused on exploring the mechanisms by which WBV produces these positive results, and determining other potential benefits associated with WBV (i.e., muscle strength, hormonal changes, sleep quality). Also, a longer study with greater sample size and objective measures appears timely. Since the present study did not describe the long-term effects or the rate of change, further investigations with multiple follow-ups are also warranted.

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Author's Disclosure Statement

There was no conflict of interest.

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