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# Analysis of the Muscular Activity, Peak Torque in the Lower Limbs, and Static Balance after Virtual Rehabilitation in Women with Fibromyalgia: A Randomized Controlled Study

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## Abstract

***Objective:*** To analyze the effect of the exergaming on muscular activity at rest and on maximum voluntary isometric contraction by electromyography (EMG) at peak torque, widespread pressure hyperalgesia identified using a tender point count, and static balance in fibromyalgia.
***Materials and Methods:*** Thirty-five women were divided into two groups: Wii™ (virtual rehabilitation, $n=16$) and control (stretching exercises, $n=19$), through simple randomization. The volunteers were evaluated by means of EMG, dynamometry by load cell, baropodometry, and algometry before interventions and reevaluated after the 10th and 20th sessions. The subjects participated fully in three 1-hour treatment sessions per week of 20 sessions.
***Results:*** The Wii group showed significant benefits for the peak torque of dorsiflexion movement after 20 sessions and for movement plantarflexion after 10 sessions. The control group showed bilateral improvement in muscular activity in the tibialis anterior muscle after 20 sessions. Both groups showed a significant decrease in tender point count, suggesting improved hyperalgesia after 10 sessions and 20 sessions. No significant improvement was found in static baropodometry in the two evaluated groups.
***Conclusion:*** Exergaming have the potential to increase the peak torque for dorsiflexion and plantarflexion movement in women with fibromyalgia. It also produces a decrease in tender point count equal to that with flexibility exercises and does not produce changes in the static balance.

**Keywords:** Fibromyalgia, Exercise, Rehabilitation, Exergaming

## Introduction

Fibromyalgia is characterized by generalized pain, specific sites of musculoskeletal tenderness, fatigue, sleep disturbances, headaches, cognitive maladies,[1] muscle weakness, postural balance disorder,[2] changes in gait pattern,[3] and a greater prevalence of falls.[4] For many patients, these symptoms persist for years and lead to frequent health care use.[5] Its etiopathogenesis is unclear, and there is no specific therapy.[6] Investigations with nonpharmacological therapies focused on physical rehabilitation have increased in recent years as alternative therapies for the treatment of fibromyalgia.[7]

Nowadays, exergaming is being used by physiotherapists as a physical rehabilitation technique. Exergaming involves physical exertion and is directly related to the exercise in the game.[8] It lets patients exercise while playing games, with repetitive therapeutic tasks completed under the mantle of a compelling fantasy, providing effective treatment.[9] This technique has been utilized for the treatment of various movement disturbances, including spastic cerebral palsy,[10] stroke,[11] and Parkinson's disease,[12] with positive results. It is also useful for improving walking speed in older women[13] and the functionality of shoulders in cancer patients.[14] It also optimizes balance for healthy older adults[15] and increases functional capacity and quality of life for hemodialysis patients.[16]

Recent studies have reported that the effects of exergaming on fibromyalgia resulted in additional benefits such as improvements in lower-body strength, cardiorespiratory fitness,[17] autonomic control,[18] exercise capacity, cardiovascular adaptation, and the pain threshold[19] and also decreases the

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impact of fibromyalgia and reduces fatigue of the lower limbs.[19] A recent systematic review and meta-analysis showed positive results in favor of aerobic exercises, flexibility exercises, strength training, stretching, and body awareness therapies for fibromyalgia treatment,[20] but the effectiveness of exergaming remained unknown.

The purpose of the present study was to analyze the effect of the exergaming on muscular activity at rest and on maximum isometric contraction, peak torque, widespread pressure hyperalgesia as measured by a tender point count, and static balance in women with fibromyalgia.

## Materials and Methods

### Study design

The current study presented complementary data from another study already published by the same research group.[19] This is a controlled, single-blind clinical trial conducted between November 2012 and December 2013 in the Laboratory of Movement Analysis of the Department of Physiotherapy, Federal University of Alfenas. The study was approved by the Research Ethics Committee of the Federal University of Alfenas (Protocol no. or CAAE no. 113.376) in accordance with the Helsinki Declaration and registered in the Registration Platform of Clinical Trials (RBR-4pmzpq). To ensure blinding, the researcher who performed the various evaluations of the results was not the same as the examiner who applied the interventions. Furthermore, all volunteers were informed of the procedures used in the study, and after agreeing to participate, each signed an informed consent agreement.

### Participants

The sample was composed of women with a diagnosis of fibromyalgia distributed according to the CONSORT Flowchart, as described by Carvalho et al.[19] The criteria for participation included a minimum age of 18 years and diagnosis of fibromyalgia in accordance with the parameters of the American College of Rheumatology (ACR). For the diagnosis, the history of pain must be at least of moderate severity (score $\geq 5$), generalized (i.e., in $\geq 7$ regions), associated with fatigue, cognitive symptoms and sleep interruption, and with a duration of symptoms of $\geq 3$ months and absence of another disorder that could explain the condition. Also accepted were those with only three to six regions affected by the pain if the symptoms were more severe (score $\geq 9$).[21,22]

The exclusion criteria for this trial included the presence of an acute or chronic medical condition or disease (e.g., cardiovascular or respiratory disease, metabolic, musculoskeletal, orthopedic, or neurological condition), inflammatory diseases (e.g., systemic lupus erythematosus, rheumatoid arthritis) that could interfere with the full execution of some types of physical exercises.[23,24] Men were excluded due to a prevalence twice as low as in women and to avoid a heterogeneous sample.[5] The selected participants were randomized into two groups, the group using Wii™ for the exercises (Wii group [WG], $n=16$) and the control group (CG) ($n=19$), through simple randomization using Microsoft Excel (version 2010).

### Assessment procedures

All participants were evaluated before starting interventions (E0) by means of muscle tension and activity (electromyography [EMG]), peak torque, static baropodometry, and generalized pressure hyperalgesia identified by counting tender points (algometry). The evaluations were repeated after the 10th (E1) and 20th (E2) sessions, according to previous study.[14]

Surface electromyography (SEMG) was captured from selected muscles: medialis gastrocnemius muscle, lateralis gastrocnemius muscle, right and left anterior tibial muscle,[25] left upper trapezius, right upper trapezius,[26] right paraspinal muscles, and left paraspinal muscles.[27] The skin of all of the evaluated muscles was cleaned with cotton and alcohol 70%, and a pair of self-adhesive disposable Meditrace surface electrodes were placed on the muscles according to the European recommendations for surface electromyography (SENIAM). The electrodes were circular Ag/AgCl, active type, and bipolar, with a distance between electrodes of 2 cm differential and a ratio of common-mode rejection of −80 dB. Biological signals were obtained using an 8-channel module (EMG System of the Brazil Ltda, São José dos Campos, Brazil), consisting of a signal conditioner and a band-pass filter with cutoff frequencies at 20–1000 Hz, [M1] an amplifier gain of 1000, and a common-mode rejection ratio higher than 120 dB [M2]. The data were processed using specific software for acquisition and analysis (EMG Analysis V1.01; Motion Lab Systems, Inc., Baton Rouge, LA). Initially, the EMG signal was stored on a computer using the software and analyzed in routines using MATLAB R2011b software (MathWorks, Natick, MA). The raw EMG signal was rectified in full wave and averaged every 0.01 seconds. Finally, the obtained signal was normalized through the ratio between its values and the average value of the EMG signal obtained during rest and maximum voluntary isometric contraction (MVIC) of the respective muscles in dorsal decubitus. For comparison purposes, the initial and final 3 seconds of each collection were discarded and the 4 seconds of the 10 seconds of EMG collection were analyzed. From those 4 seconds, the square root of the mean of the values, or root mean square, of each muscle was determined.

For the peak torque MVIC assessment of the tibialis anterior and gastrocnemius muscles, the volunteer was positioned supine, with legs extended. Then, a load cell with a capacity of 200 kgf was fixed by a steel cable (200 cm) to the foot of the volunteer and to a stable and level surface on fixed metal wall bars. This load cell was attached to the EMG. Data collection was performed simultaneously with EMG for the MVIC of each mentioned muscle.

Widespread pressure hyperalgesia and tender point count (algometry) were evaluated using a digital algometer (EMG System of the Brazil Ltda). The contact point of this algometer has a diameter of 10 mm. The evaluation was performed by the same examiner who tested the 18 bilateral tender points (suboccipital muscle, upper midpoint of the trapezius muscle, origin of the supraspinatus muscle, lower part of the sternocleidomastoid muscle, second costochondral junction, 2 cm distal to the lateral epicondyle, upper lateral part of the gluteal region, surface of the greater trochanter, and the medial fat pad of the knee). The device was applied in a gradual and constant manner, increasing by 1 kg/sec until the moment the subject reported pain. The total number of painful points was calculated for each patient.[28]

Baropodometry. To assess the plantar pressure and the body sway of the volunteer, a Footwork model baropodometer with an active surface of 400x400mm was used, with 2704 pickups connected to a computer cable. The collected data were subsequently analyzed using the equipment's software.

To collect data from the static analysis and body sway, the volunteer remained in an orthostatic position with both feet resting on the active surface of the equipment, separated by a 10-cm-wide ethylene vinyl acetate marker. This collection was performed for 10 seconds.

Total number of tender points. In this study, palpation and counting of specific tender points, as defined by the ACR, were performed to characterize fibromyalgia,[29] using a digital algometer coupled to the electromyograph (EMG System do Brazil).

### *Interventions*

The volunteers fully participated in the treatment for three 1-hour sessions per week, recommended by the American College of Sports Medicine,[30] of 20 sessions.

Exergaming. For the exergaming treatment, the Wii Remote Plus and the Wii Balance Board were used with a Nintendo® Wii system connected to a 42-inch LED TV. The participants were provided instruction and training on how to play and handle the videogame console before intervention with the exergaming.

Six Wii Fit™ Plus subgames were chosen. To perform active movement of the lower limb muscles, ''Jogging Plus'' was used, in which the participants performed a stationary run for 15 minutes. To perform active movement of the upper limbs for 9 minutes, the ''Bird's Eye Bullseye'' game was selected. To stimulate the control of expiratory and inspiratory movements and active control of the body's center of gravity, ''Yoga'' was used for 3 minutes. To perform controlled action of the trunk muscles associated with circular rhythmic movements and balance control, the ''Super Hula Hoop'' game was played for 9 minutes. To perform active and alternating movements of the lower limb muscles along with balance and unipodal discharge, ''Step game'' was used for 15 minutes. Finally, a stationary walk was performed with active and rhythmic movements of the muscles of the lower limbs using ''Rhythm Parade'' for 9 minutes. The order of the games was standardized so that everyone could perform the same sequence of games. The care with fatigue and the time of the matches were controlled according to the player's tolerance.[19]

Control group. The CG received a flexibility exercise that has been used in the treatment of fibromyalgia.[31,32] The chosen exercises included standing, sitting, and lying positions to stretch all of the muscle groups in an overall manner. Each position was maintained for four deep and prolonged exhales.[33] The selected positions were: 1, 15, 16, 19, 21, 35, 36, 38, and 40,[33] as described by Carvalho et al.[19]

Position 1: in orthostatism with scapular adduction and erect spine, arms extended and slightly back, wrists and fingers flexed in extension; contracted gluteal muscles and pelvis in retroversion, keeping knees and feet in parallel semiflexion. Variation two of this position, which is performed with hands in contact, was also used.[19,33] Position 15: in orthostatism with scapular adduction, hands supported on the nape, and erect spine; anterior trunk inclination and bent knees. Position 16: supine, knees bent, feet flat on the floor, and arms crossed, with scapular adduction and maintenance of the erect spine. Position 19: supine, with shoulders and elbows at 90 degrees of flexion, scapular adduction, lower limbs in hip flexion at 90 degrees, and knees in extension; dorsiflexion of the feet. Position 21: supine position, with arms positioned along the sides of the body, knees and hips semiflexed vertically and in external rotation, and soles of the feet in contact. Position 35: supine position with arms positioned in slight abduction and legs at 90 degrees of hip flexion with knees extended. Position 36: sitting position, erect spine, abduction and horizontal extension of the arms, and wrist extension at 90 degrees; lower limbs semiflexed with feet flat on the floor. Position 38: sitting position, upright column, upper limbs extended behind the body, and hands in contact; semiflexed lower limbs with feet flat on the ground. Position 40: seated position, abduction of shoulders and hands positioned behind the head with knees extended.[19,33]

### *Statistics*

The collected data were analyzed using SPSS software, version 20.0 (IBM Corp., Armonk, NY) with a significance level of 0.05.

For the calculation of the sample number, physical function by Fibromyalgia Impact Questionnaire was used as the variable, with a sample size of 16 volunteers as estimated for a power of 80%.[19] The initial data were evaluated with an analysis of variance (ANOVA) test, and the sample size was calculated using G*Power software version 3.1.7 (Franz Faul, Universitat Kiel, Germany) with the following parameters: *F* tests/ANOVA: repeated measures, with factors/effect size f estimated from variances. The normality of the data was verified using the Kolmogorov–Smirnov test, and its homoscedasticity (equality of variance) was verified with the Levene test. The variable anthropometric data and time of pain symptom were submitted to the Mann–Whitney *U* test.

Data from all 21 initial participants who underwent treatment throughout the entire study were used to conduct the intention-to-treat by multiple imputation analysis through SPSS software. The analysis of variance (repeated two-way ANOVA measures), followed by the Bonferroni post-test for multiple comparisons, was conducted when the data presented normal distribution. In addition, we used Mauchly's test of sphericity, and in the case of violation of this assumption, a Greenhouse–Geisser correction was performed.

To calculate the effect size in ANOVA, $f^2$ Cohen was used, and values from 0.02 to 0.15 (small effect), 0.15 to 0.35 (moderate effect), and above 0.35 (large effect) were adopted.[32]

## Results

The groups were considered similar according to demographic data and duration of symptoms (Table 1).

Initially, the groups had similar resting EMGs in the dorsal decubitus of all evaluated muscles. There was no significant muscular activity improvement after 10 sessions or 20 sessions (Table 2).

Before treatment (E0), the MVIC EMG in the analyses of muscles were similar in the two groups. The CG showed

Table 1. Sample Characterization (Mean ± Standard Deviation) and Comparison of Anthropometric Data and Time of Pain Symptom

| *Variable* | *WG* (n = *16*) | *CG* (n = *19*) | P* |
|---|---|---|---|
| Age (years) | 55.64 ± 9.16 | 47.70 ± 15.46 | 0.239 |
| BMI (kg/cm$^2$) | 30.28 ± 5.25 | 26.09 ± 5.01 | 0.083 |
| Weight (kg) | 75.90 ± 13.40 | 66.25 ± 12.90 | 0.063 |
| Height (m) | 1.58 ± 0.08 | 1.59 ± 0.60 | 0.317 |
| Pain time (years) | 9.91 ± 7.29 | 14.65 ± 12.14 | 0.594 |

*Mann–Whitney *U* test.
BMI, body mass index; CG, control group; WG, Wii group.

bilateral improvement in muscular activity in the muscle tibialis anterior after 20 sessions, with a high level of effect. The effect size was large in all of the evaluated muscles, except the right and left upper trapezius, where the effect size was low (Table 3).

The analysis of the values of MVIC demonstrated that both groups were similar at the beginning of the study (E0) in dorsiflexion and plantarflexion on the right and left sides. Significant intergroup improvements were found in the WG for dorsiflexion movement after 20 sessions on the right and left side and for movement plantarflexion after 10 sessions on the right and left side and 20 sessions on only the left side. No significant differences were found in the CG for this parameter (Table 4).

All of the variables analyzed with static baropodometry were similar before treatment (E0) in both groups, and no significant improvement was found in static baropodometry in the groups. In the intergroup analysis, the CG performed better than the WG in assessing the contact surface only after the 10th session; after this evaluation, both had similar results (Table 5).

In the intergroup analysis, before treatment, the pain threshold was similar in both groups. The WG showed a significant decrease in tender point count, suggesting improved hyperalgesia after 10 sessions and 20 sessions. The results of the evaluations also indicated that the CG showed improvement in the same time period. The magnitude of the effects was high (Table 5).

## Discussion

The data in this study suggest that the exergaming training program is an effective intervention for the treatment of fibromyalgia. The main finding of this trial was that intervention based on exergaming significantly improved muscle strength in lower limbs and decreased hyperalgesia. In addition, the CG, as an active group that performed an exercise modality, also improved in some variables, such as reducing the tender point count and increasing dynamic balance.

As already reported in other studies,[17–19] exergaming is capable of acting on the symptoms of fibromyalgia, but what would be the response to the use of these games for strength, electrical activity, and number of tender points?

Studies suggest that fibromyalgia patients have more reduction in muscle strength in the limbs,[34–36] considerably more reduction in functional performance, and more thickness of the muscles of the upper and lower extremities as measured by ultrasonography than in healthy controls.[36] The current evidence demonstrates that strength training is

Table 2. Mean (Standard Deviation) Rest Electromyography in the Dorsal Decubitus of Evaluated Muscles in the Control and Wii Groups in Three Moments of Evaluation, Baseline (E0), after 10 Sessions (E1), and after 20 Sessions (E2)

| | | | *Evaluations, mean (SD)* | | | *ANOVA,* P | | | |
|---|---|---|---|---|---|---|---|---|---|
| *Muscle* | *Member* | *Group* | *E0* | *E1* | *E2* | *Time-group* | *Time* | *Group* | *f*$^2$ |
| Lateralis Gastrocnemius | R | CG | 2.34 (0.37) | 2.52 (0.31) | 2.36 (0.35) | 0.265 | 0.689 | 0.490 | 0.270 |
| | | WG | 2.28 (3.09) | 2.28 (0.30) | 2.47 (0.30) | | | | |
| | L | CG | 2.40 (0.34) | 2.59 (0.28) | 2.39 (0.34) | 0.150 | 0.825 | 0.451 | 0.323 |
| | | WG | 2.52 (0.27) | 2.44 (0.26) | 2.44 (0.26) | | | | |
| Medialis Gastrocnemius | R | CG | 2.09 (0.24) | 2.18 (0.25) | 2.14 (0.31) | 0.289 | 0.370 | 0.892 | 0.259 |
| | | WG | 2.10 (0.15) | 2.05 (0.14) | 2.25 (0.28) | | | | |
| | L | CG | 2.17 (0.31) | 2.31 (0.33) | 2.38 (0.53) | 0.150 | 0.377 | 0.381 | 0.323 |
| | | WG | 2.28 (0.26) | 2.15 (0.22) | 2.81 (0.94) | | | | |
| Anterior Tibialis | R | CG | 2.84 (0.82) | 3.04 (1.00) | 2.44 (0.42) | 0.202 | 0.433 | 0.100 | 0.296 |
| | | WG | 2.49 (0.30) | 2.49 (0.28) | 2.54 (0.35) | | | | |
| | L | CG | 2.33 (0.59) | 2.54 (0.68) | 2.37 (0.48) | 0.561 | 0.795 | 0.588 | 0.175 |
| | | WG | 2.31 (0.39) | 2.31 (0.35) | 2.36 (0.33) | | | | |
| Paraspinal | R | CG | 2.46 (0.49) | 2.46 (0.30) | 2.23 (0.33) | 0.096 | 0.480 | 0.787 | 0.362 |
| | | WG | 2.47 (0.28) | 2.26 (0.22) | 2.48 (0.26) | | | | |
| | L | CG | 2.74 (0.44) | 2.55 (0.28) | 2.48 (0.73) | 0.075 | 0.202 | 0.382 | 0.415 |
| | | WG | 2.59 (0.23) | 2.43 (0.24) | 3.18 (1.13) | | | | |
| Upper Trapezius | R | CG | 2.80 (0.94) | 2.73 (1.16) | 2.65 (0.55) | 0.995 | 0.775 | 0.234 | 0.010 |
| | | WG | 2.50 (0.60) | 2.39 (0.98) | 2.35 (0.35) | | | | |
| | L | CG | 2.86 (0.74) | 2.70 (0.33) | 2.77 (0.66) | 0.848 | 0.639 | 0.373 | 0.095 |
| | | WG | 2.72 (0.46) | 2.62 (0.58) | 2.55 (0.45) | | | | |

Bonferroni test: * vs. Ev0; ** vs. Ev 1, $P < 0.05$; effect size ($f^2$).
COP, center of pressure; COP-AP, anteroposterior displacement of the COP; COP-ML, mediolateral displacement of the COP; L, left; R, right; SD, standard deviation.

TABLE 3. MEAN (STANDARD DEVIATION) MAXIMUM VOLUNTARY ISOMETRIC CONTRACTION ELECTROMYOGRAPHY IN THE EVALUATED MUSCLES IN THE CONTROL AND WII GROUPS IN THREE MOMENTS OF EVALUATION, BASELINE (E0), AFTER 10 SESSIONS (E1), AND AFTER 20 SESSIONS (E2)

| | | | *Evaluations, mean (SD)* | | | *ANOVA,* P | | | |
|---|---|---|---|---|---|---|---|---|---|
| *Muscle* | *Member* | *Group* | *E0* | *E1* | *E2* | *Time-group* | *Time* | *Group* | $f^2$ |
| Lateralis Gastrocnemius | R | CG | 6.17 (2.95) | 5.26 (1.78) | 6.79 (2.68) | 0.058 | 0.751 | 0.383 | 0.401 |
| | | WG | 6.69 (2.24) | 7.35 (2.45) | 6.54 (2.02) | | | | |
| | L | CG | 6.41 (3.17) | 5.46 (2.04) | 6.30 (2.51) | 0.151 | 0.371 | 0.382 | 0.323 |
| | | WG | 5.93 (1.47) | 6.95 (2.39) | 7.35 (1.40) | | | | |
| Medialis Gastrocnemius | R | CG | 6.41 (3.23) | 6.13 (2.72) | 5.90 (1.81) | 0.333 | 0.846 | 0.143 | 0.243 |
| | | WG | 7.11 (2.32) | 7.81 (3.21) | 8.25 (3.05) | | | | |
| | L | CG | 5.71 (2.90) | 5.14 (2.53) | 6.21 (1.86) | 0.240 | 0.430 | 0.253 | 0.278 |
| | | WG | 6.12 (2.20) | 7.24 (3.01) | 6.96 (2.20) | | | | |
| Anterior Tibialis | R | CG | 10.74 (4.09) | 9.08 (3.46)* | 13.06 (2.79)** | 0.076 | 0.040 | 0.293 | 0.381 |
| | | WG | 11.56 (3.95) | 12.32 (3.66) | 13.41 (3.20) | | | | |
| | L | CG | 9.81 (3.46)* | 9.81 (3.46)* | 13.57 (2.30)** | 0.398 | <0.001 | 0.968 | 0.222 |
| | | WG | 8.62 (3.76) | 11.18 (3.56) | 13.00 (2.91) | | | | |
| Paraspinal | R | CG | 7.08 (2.20) | 7.67 (2.25) | 8.34 (1.72) | 0.133 | 0.067 | 0.582 | 0.335 |
| | | WG | 7.54 (1.42) | 6.77 (1.19) | 7.65 (1.87) | | | | |
| | L | CG | 7.32 (2.39) | 7.50 (2.19) | 8.11 (1.89) | 0.050 | 0.787 | 0.456 | 0.441 |
| | | WG | 7.73 (1.29) | 7.09 (1.22) | 6.50 (2.07) | | | | |
| Upper Trapezius | R | CG | 11.16 (6.47) | 9.34 (3.94) | 8.69 (3.50) | 0.829 | 0.124 | 0.856 | 0.100 |
| | | WG | 10.26 (3.33) | 9.22 (3.49) | 8.93 (2.99) | | | | |
| | L | CG | 10.57 (4.85) | 10.04 (4.56) | 9.69 (4.41) | 0.848 | 0.606 | 0.958 | 0.095 |
| | | WG | 10.69 (4.27) | 9.60 (3.64) | 10.24 (2.96) | | | | |

Bonferroni test: * vs. Ev0; ** vs. Ev 1, $P < 0.05$; effect size ($f^2$).

beneficial and can treat fibromyalgia, bringing positive results through reduction of pain, number of tender points, depression, and anxiety.[37,38] Our study demonstrated that exergaming is a useful tool for improving muscle strength in lower limbs by increasing the peak torque. Kisiel-Sajewicz et al.[39] reported that parameters such as MVIC can provide information on brain dynamics, with the motor cortex, corticospinal, supraspinal, propriospinal, motoneuron, and motor axon areas having a central function for the muscle contraction. Therefore, these central structures can interfere with peripheral muscle contraction mechanisms, consequently altering the muscle strength. Other justifications for our findings may be that exercise with exergaming might have promoted changes in brain dynamics such as increased power in the beta-3 frequency band that could be related to increased cerebral blood flow as described in another study.[18]

The body of literature describes strengthening exercises, aerobic exercises,[40] water exercises,[41] and balneotherapy[42] reducing pain and improving tender point counts in adults with fibromyalgia.[40,41] Our positive results for reducing the tender point counts in both groups was possible in less time as compared with other therapies.[41]

One study demonstrates that fibromyalgia patients might have different fiber recruitment or a possible atrophy of type II fibers, suggesting that they are not able to reach muscle relaxation.[43] The current study justifies this result because we were not successful in modifying the EMG values at rest in either treatment used in our protocol.

Fibromyalgia was associated with a specific EMG pattern indicating premature discontinuation of the muscle contraction. Therefore, maximal voluntary muscle contraction tests may be of limited value for assessing function.[44] This

TABLE 4. MEAN (STANDARD DEVIATION) VALUES OF MAXIMAL VOLUNTARY ISOMETRIC CONTRACTION (KGF) OF THE DORSIFLEXOR AND PLANTAR FLEXOR MUSCLES OF THE CONTROL AND WII GROUPS IN THREE MOMENTS OF EVALUATION, BASELINE (E0), AFTER 10 SESSIONS (E1), AND AFTER 20 SESSIONS (E2)

| | | | *Evaluations, mean (SD)* | | | *ANOVA,* P | | | |
|---|---|---|---|---|---|---|---|---|---|
| *Movement* | *Member* | *Group* | *E0* | *E1* | *E2* | *Time-group* | *Time* | *Group* | $f^2$ |
| Dorsiflexion | R | CG | 3.91 (3.08) | 3.98 (3.35) | 1.95 (5.56) | 0.042 | 0.682 | 0.030 | 0.447 |
| | | WG | 6.77 (5.60) | 7.60 (6.71) | 10.80 (8.60)[a] | | | | |
| | L | CG | 4.64 (3.07) | 4.06 (2.94) | 2.99 (4.50) | 0.023 | 0.328 | 0.050 | 0.487 |
| | | WG | 6.43 (5.77) | 7.32 (6.23) | 11.13 (8.53)[a] | | | | |
| Plantarflexion | R | CG | 9.09 (4.46) | 7.98 (4.48) | 6.96 (7.50) | 0.010 | 0.168 | 0.041 | 0.543 |
| | | WG | 12.52 (10.27) | 18.10 (9.87)[a] | 17.12 (12.27)[a] | | | | |
| | L | CG | 8.60 (3.48) | 8.43 (4.19) | 11.43 (15.23) | 0.758 | 0.669 | 0.138 | 0.119 |
| | | WG | 12.35 (8.64) | 15.51 (9.01)[a] | 14.60 (14.04) | | | | |

Bonferroni test: [a]Wii vs. Control, $P < 0.05$; effect size ($f^2$).

Table 5. Mean (Standard Deviation) Baropodometry Static and Dynamic and Hyperalgesia of Both Groups at Three Moments, Baseline (E0), after 10 Sessions (E1), and after 20 Sessions (E2)

| | | *Evaluations, mean (SD)* | | | *ANOVA,* P | | | |
|---|---|---|---|---|---|---|---|---|
| *Variables* | *Group* | *E0* | *E1* | *E2* | *Time-group* | *Time* | *Group* | $f^2$ |
| COP-ML right (cm) | CG | 0.42 (0.34) | 0.34 (0.37) | 0.60 (0.41) | 0.933 | 0.062 | 0.961 | 0.063 |
| | WG | 0.46 (0.39) | 0.29 (0.11) | 0.61 (0.42) | | | | |
| COP-ML left (cm) | CG | 0.27 (0.17) | 0.27 (0.17) | 0.38 (0.20) | 0.777 | 0.092 | 0.238 | 0.115 |
| | WG | 0.35 (0.20) | 0.33 (0.17) | 0.49 (0.21) | | | | |
| COP-AP right (cm) | CG | 1.49 (0.68) | 1.39 (0.69) | 1.36 (0.68) | 0.770 | 0.415 | 0.494 | 0.119 |
| | WG | 1.77 (0.69) | 1.38 (0.452) | 1.43 (0.79) | | | | |
| COP-AP left (cm) | CG | 1.85 (0.62) | 1.33 (0.69) | 1.93 (0.77) | 0.447 | 0.098 | 0.981 | 0.207 |
| | WG | 2.00 (0.80) | 1.53 (0.64) | 1.60 (1.09) | | | | |
| COP-area left ($cm^2$) | CG | 0.46 (0.32) | 0.57 (0.78) | 0.56 (0.38) | 0.483 | 0.889 | 0.997 | 0.199 |
| | WG | 0.67 (0.58) | 0.49 (0.42) | 0.43 (0.38) | | | | |
| COP-area right ($cm^2$) | CG | 0.75 (0.81) | 0.38 (0.39) | 0.41 (0.22) | 0.937 | 0.056 | 0.965 | 0.045 |
| | WG | 0.73 (0.76) | 0.35 (0.19) | 0.45 (0.41) | | | | |
| COP-body area ($cm^2$) | CG | 1.29 (1.01) | 1.06 (1.09) | 1.03 (0.55) | 0.419 | 0.089 | 0.646 | 0.217 |
| | WG | 1.80 (1.39) | 0.84 (0.57) | 1.14 (0.96) | | | | |
| COP-ML body (cm) | CG | 1.073 (0.49) | 0.96 (0.55) | 0.91 (0.24) | 0.676 | 0.203 | 0.968 | 0.143 |
| | WG | 1.18 (0.79) | 0.82 (0.391) | 0.93 (0.36) | | | | |
| COP-AP body (cm) | CG | 1.51 (0.61) | 1.43 (0.94) | 1.50 (0.47) | 0.558 | 0.357 | 0.907 | 0.160 |
| | WG | 1.66 (0.67) | 1.23 (0.42) | 1.43 (0.66) | | | | |
| Number of points | CG | 16.70 (1.64) | 13.80 (3.29)* | 10.35 (1.66)*,** | 0.282 | <0.001 | 0.535 | 0.261 |
| | WG | 16.73 (2.00) | 12.00 (3.06)* | 10.45 (3.58)* | | | | |

Bonferroni test: * vs. Ev0; ** vs. Ev 1, $P < 0.05$; effect size ($f^2$).
COP, center of pressure; COP-AP, anteroposterior displacement of the COP; COP-ML, mediolateral displacement of the COP.

conclusion helps to elucidate why no significant data improvement was found in the EMG analyses of the WG.

Although recent studies and meta-analyses report benefits of exergaming in different types of individuals in terms of improving balance,[45] our results did not confirm the effectiveness of Wii for the management of fibromyalgia in this regard. In contrast, the CG showed improvement in dynamic balance due to better support during gait, and this is due to the intrinsic characteristics provided by stretching exercises that contribute to increased mobility.[46]

In another clinical trial, it was determined that aerobic exercises resulted in more significant improvements as compared with stretching exercises. The evaluation of the 18 tender points through palpation and the pain threshold were among the variables that were evaluated. A pain scale was used to measure these variables after the 10th and 20th weeks of treatment.[46] In this study, it was noted that exergaming produced more substantial responses than the control (chain muscle stretching technique).

Limitations of this study were the number of sessions, which proved to be insufficient to promote improvements in static baropodometry. The number of volunteers is also a factor in limiting the statistical significance of this study. Another limitation of the study is that even though there is no significant difference between the anthropometric variables, the actual data present wide variations such as age and duration of pain.

## Conclusion

The primary outcome was that exergaming have the potential to increase the peak torque for dorsiflexion and plantarflexion movement in women with fibromyalgia. In addition, the secondary results were that the exergaming produces a decrease in tender point count equal to that from flexibility exercises and does not produce changes in the static balance.

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No competing financial interests exist.

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