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Effects of Combined Stretching and Strengthening Exercises on Muscle Thickness and Physical Performance in Fibromyalgia

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ABSTRACT

Background: To evaluate muscle thickness in patients with fibromyalgia syndrome (FMS) and to investigate the effects of stretching and strengthening exercises on muscle thickness, strength, pain, and physical performance.

Methods: In this prospective, randomized, controlled, single blind study, sixty female patients diagnosed with FMS were randomly assigned into two groups: the exercise group followed with a home exercise program of stretching and strengthening exercises and outdoor walking 5 days a week for 12 weeks, while the control group followed with only outdoor walking 5 days a week for 12 weeks. Ultrasound (US) was used to measure the anterior thigh muscle thickness of the quadriceps femoris. Pain levels were assessed using the numerical rating scale (NRS), disease activity using the fibromyalgia impact questionnaire (FIQ), grip strength using a dynamometer, and physical performance using the five-times sit-to-stand test (FTSST) and the 6-meter walk test (6MWT). Assessments were conducted at baseline and after 12 weeks.

Results: After 12 weeks, NRS, FIQ, FTSST, and right grip strength, left and right anterior thigh muscle thickness were significantly improved ($p<0.05$) in both groups. The exercise group showed significant improvements in 6MWT and the left-hand grip strength ($p<0.001$, $p<0.001$). Comparisons between groups at 12 weeks revealed that the exercise group had significantly better outcomes on the NRS, FIQ, 6MWT, FTSST, left and right grip strength, and left and right anterior thigh muscle thickness ($p < 0.001$).

Conclusion: Stretching and strengthening exercises effectively enhance muscle thickness and physical function while alleviating pain and disease symptoms in patients with FMS.

Keywords: Fibromyalgia, ultrasonography, muscle thickness, stretching exercises, strengthening exercises.

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INTRODUCTION

Fibromyalgia syndrome (FMS) is the second most common rheumatological disorder after osteoarthritis in the general population, affecting approximately 2% of individuals, predominantly females aged 40–60 years [1–3]. It is characterized by widespread pain, often accompanied by fatigue, weakness, sleep disturbances, depression, anxiety, and various cognitive and somatic disorders. Despite its prevalence, the etiology and pathophysiology of FMS remain poorly understood [4].

Research has highlighted significant physiological alterations in patients with FMS. These include reduced muscle blood flow and oxygenation, as well as decreased levels of phosphocreatine, adenosine triphosphate, and adenosine diphosphate in sensitive muscle regions. Concurrently, elevated adenosine monophosphate levels, increased creatine, and evidence of muscle fibril damage have been reported [5]. Furthermore, during exercise, blood flow to the muscles is notably reduced in FMS patients compared with healthy individuals, suggesting a potential link between FMS symptoms and skeletal muscle dysfunction [6].

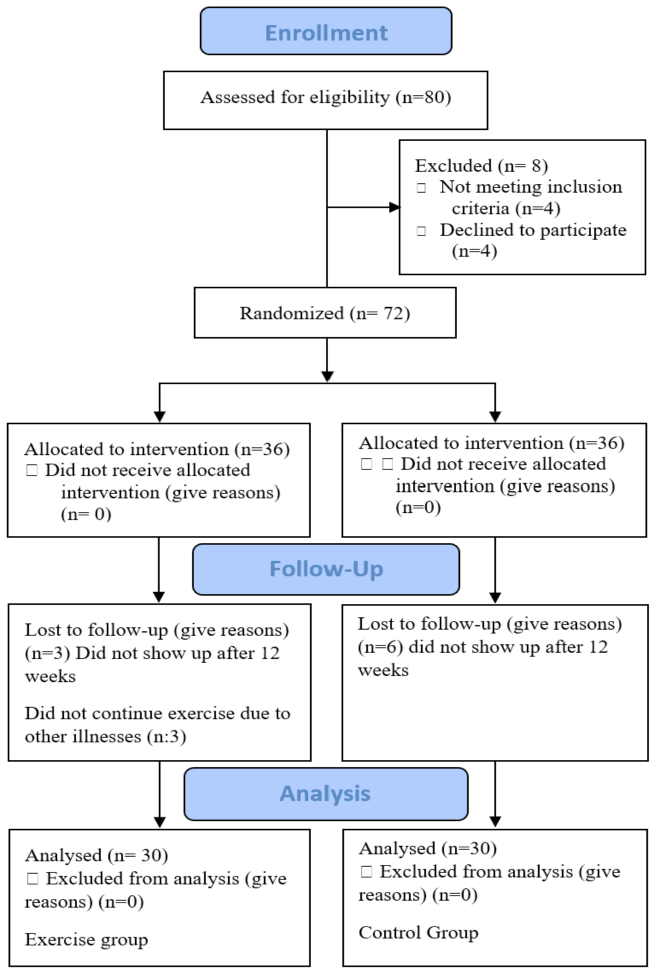
Exercise is supported by high-quality evidence and is considered an effective intervention for the management of FMS [7]. Many patients with FMS lead sedentary lifestyles and often exhibit reduced aerobic capacity. In line with the European League Against Rheumatism (EULAR) recommendations, exercise is strongly advised for individuals with FMS. Various modalities, including aerobic, strengthening, and stretching exercises, have been shown to provide clinical benefits [8]. Nevertheless, there is no clear consensus on the optimal type of exercise, and the superiority of one modality over another remains uncertain. It has been suggested that aerobic and strengthening exercises may mitigate metabolic alterations in muscle tissue and contribute to pain reduction. In contrast, stretching and relaxation exercises may alleviate pain by reducing soft-tissue tension [9]. Fatigue is the most common symptom after pain in FMS patients, leading to decreased physical activity levels and muscle function [10,11]. Given its potential to reduce both pain and fatigue, exercise plays a vital role in FMS management. However, the specific effects of different exercise types warrant further investigation.

Although exercise-based interventions are widely recommended for the management of fibromyalgia syndrome, the majority of previous studies have relied primarily on subjective outcome measures, with limited objective assessment of musculoskeletal adaptations. In particular, changes in muscle morphology in response to exercise remain insufficiently explored. Therefore, the present randomized controlled trial aimed to evaluate the effects of a home-based combined stretching and strengthening exercise program on anterior thigh muscle thickness, assessed by ultrasonography, as well as pain intensity, functional capacity, muscle strength, and disease-related outcomes in women with fibromyalgia syndrome. By incorporating objective ultrasonographic measurements with clinically relevant functional parameters, this study seeks to provide a more comprehensive evaluation of the musculoskeletal and functional effects of exercise therapy in this population.

MATERIALS AND METHODS

This is a prospective, randomized, controlled, single-blind study. 80 female patients aged 18 to 65 years who were diagnosed with FMS according to the 2016 American College of Rheumatology (ACR) classification criteria [12] were assessed for eligibility; 4 patients declined to participate, and 4 did not meet the inclusion criteria. Considering that there may be patients who may have to stop exercising or who we may not be able to reach at follow-up 72 of the patients were randomized, 3 patients in the exercise group and 6 patients in the control group could not be reached during the follow-ups and 3 patients in the exercise group could not continue exercising due to other illnesses (1 patient could not continue the exercises because of irregular blood pressure, 1 patient was operated due to acute appendicitis and 1 patient was resting due to upper respiratory tract infection). The study ended with 30 patients in each group, for a total of 60 patients, as seen in Figure 1. Exclusion criteria included neurological or orthopedic conditions that impair ambulation; advanced cardiac, renal, hepatic, or pulmonary disease that limits exercise capacity; malignancy; psychiatric disorders; inflammatory rheumatic disease; pregnancy or lactation.

Figure 1: CONSORT Flow Diagram



Patients were verbally informed, and written informed consent was obtained. The study was approved by the University Ethics Committee (2023-78) and was carried out in accordance with the principles of the Declaration of Helsinki. The protocol was registered with ClinicalTrials.gov (registration number NCT06253416).

Demographic and clinical characteristics of all patients were recorded at the Physical Medicine and Rehabilitation outpatient clinic by the same physician. The height (cm) was measured with a measuring tape, the weight (kg) was measured with a scale, and the Body Mass Index (BMI, kg/m2) of the patients was recorded.

Patients' pain levels were measured using the Numerical Rating Scale (NRS). The pain in the NRS is measured on a scale from 0 (no pain) to 10 (unbearable pain) by patients [13].

Grip strength was measured using a Jamar dynamometer (Saehan hydraulic hand dynamometer). The test was performed while the patients were sitting in a chair, with their elbows at 90 degrees of flexion, three times with each hand, with 30 seconds of rest between trials, and the mean (kg) of the three trials for each hand was calculated separately [14].

Physical performance was assessed using the five-times sit-to-stand test (FTSST) and usual gait speed with the 6-meter walk test (6MWT). At FTSST, subjects sit down without touching the back of the chair, then stand up fully 5 times as quickly as possible, and the time is measured in seconds [15]. The 6MWT, a 6-meter flat path, was marked on the hospital corridor, participants walked on the path, and walking time was measured in seconds [16].

Disease activity was evaluated with the Fibromyalgia Impact Questionnaire (FIQ). FIQ consists of ten items on a three-factor structure with functional, physical symptom, and mental symptom domains. Each item is scored from 0 to 10. Decreased scores indicate better disease activity. Sarmer et al. established the validity and reliability of the FIQ within the Turkish demographic [17].

Muscle thickness was measured with the ultrasound (US) (6-12 MHz: Philips purewave, multi-frequency linear probe), a valid and reliable method for assessing muscle morphology [18]. The anterior thigh muscle thickness was evaluated bilaterally on the quadriceps femoris using minimal probe pressure to avoid tissue compression. Measurements were obtained at the midpoint between the upper border of the patella and the anterior superior iliac spine, with patients in the supine position. To reduce measurement variability, all ultrasonographic assessments were performed by a single physician with five years of experience in musculoskeletal ultrasonography at baseline and at 12 weeks.

After the examination, patients were randomized into two groups by an independent researcher using a computer program. Outcome assessments were performed by the same physician who was blinded to group allocation. Due to the nature of the intervention, neither the patients nor the physiotherapist was blinded. The exercise group received a home exercise program consisting of stretching and strengthening exercises targeting major upper- and lower-extremity muscle groups using isotonic contractions. The exercise program was initially demonstrated by a physiotherapist and supported with visual materials. Participants were instructed to perform the exercises three days per week for 12 weeks, with each movement repeated 10 times. To enhance adherence, weekly telephone follow-ups were conducted, and participants were asked to record their activity on an exercise-tracking form. In addition, participants were invited to the hospital every four weeks (three visits in total) for supervised practice and reinforcement of proper technique. The program began with static stretching exercises, each held for 10 seconds and repeated ten times with 10-second rest intervals. This was followed by strengthening exercises targeting the upper and lower extremities using 0.5 kg weights, with each exercise performed for 10 repetitions and 10 seconds of rest between sets (Table 1). Exercises are shown in Figure 2. In addition to the exercise program, the exercise group was offered 30 minutes of outdoor walking 5 days a week for 12 weeks.

The control group was offered 30 minutes of outdoor walking 5 days a week without supervision for 12 weeks. Walking was performed at a self-selected moderate pace. They were advised to exercise regularly, only verbally. Participants received weekly telephone follow-ups from the physiotherapist and completed an exercise tracking form to monitor adherence.

Patients received no additional treatment other than the recommended exercise during the study period. The medications patients used for FMS have not been changed throughout the study.

The sample size was determined based on the results of a power analysis conducted with G*Power version 3.1. This analysis, considering a power of 0.85, α of 0.05, and an effect size of 0.70, was informed by values from previous research [11].

Table 1: Twelve-week exercise program of the study groups

Component	Exercise Group	Control Group
Study duration	12 weeks	12 weeks
Walking program	Outdoor walking	Outdoor walking
Walking frequency	5 days/week	5 days/week
Walking duration	30 min/session	30 min/session
Walking intensity	Self-selected moderate pace	Self-selected moderate pace
Stretching exercises	Yes (cervical, shoulder, trunk, and lower limb muscles)	No
Stretching protocol	10 seconds × 10 repetitions, 10 seconds rest between repetitions	Not applicable
Strengthening exercises	Yes (upper and lower extremities)	No
Strengthening protocol	Isotonic exercises with 0.5 kg weights, 10 repetitions per exercise, 10 seconds rest	Not applicable

Exercise supervision	Demonstrated by a physiotherapist, supported with visual cards	Verbal recommendation only
Home program	Yes	No
Exercise frequency	3 days/week	Not applicable
Follow-up	Weekly telephone calls	Weekly telephone calls
Adherence monitoring	Exercise tracking form	Exercise tracking form
Re-assessment visits	Every 4 weeks (total 3 visits)	Every 4 weeks (total 3 visits)

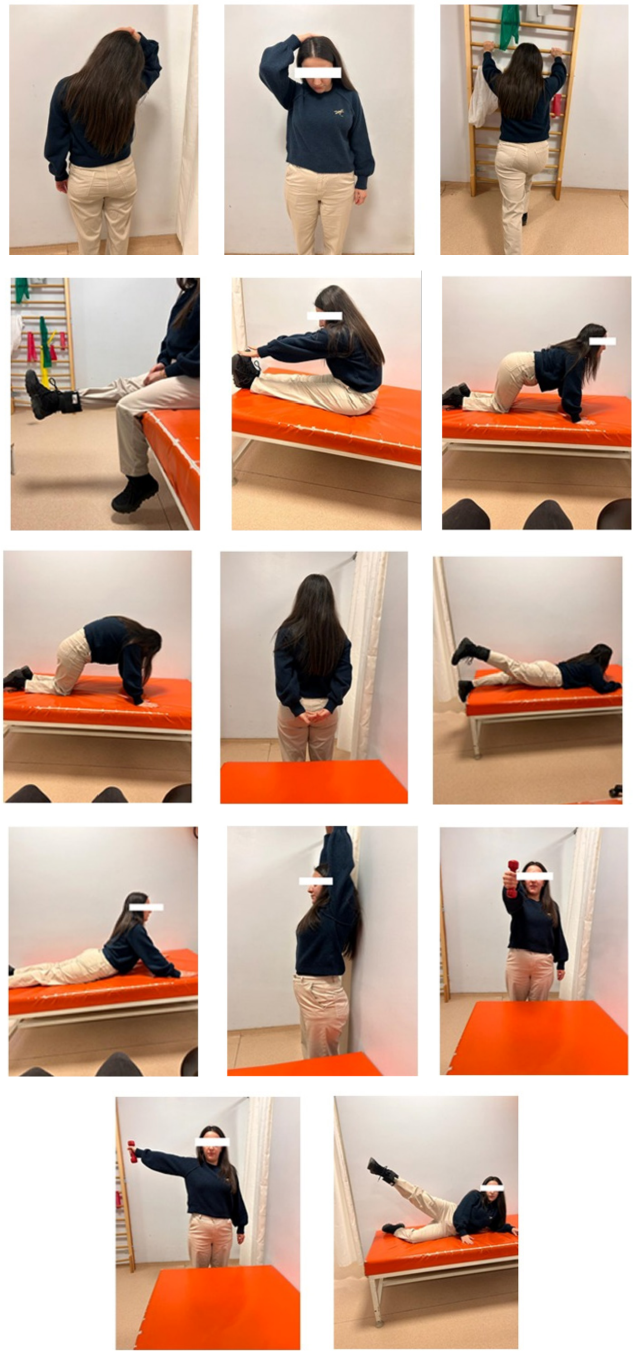


Figure 2: Stretching and strengthening exercises

Statistical Analysis

All data were analyzed using SPSS for Windows version 21.0. For variables exhibiting a normal distribution, Kolmogorov-Smirnov/Shapiro-Wilk tests were employed. In instances where data did not follow a normal distribution, the Mann-Whitney U test was used to compare numerical parameters between groups. Conversely, for normally distributed data between groups, the Independent sample t-test was applied. The Wilcoxon test assessed the statistical significance of temporal changes for parameters not following a normal distribution, while the paired-sample t-test was used for parameters that did. Statistical significance was set at a two-sided alpha level of 0.05.

RESULTS

As shown in Table 2, the groups were similar in age, height, weight, and BMI at baseline. In addition, no statistically significant differences were found between the groups in terms of NRS, FIQ, 6MWT, FTSST, left and right-hand grip strength, and left and right anterior thigh muscle thickness at baseline measurements. All patients in the exercise group (n:30) completed the exercise tracking form, while only 10 patients in the control group completed the exercise tracking form

Table 2: The comparison of demographic and clinical features of the participants at baseline

	Exercise Group n=30	Control Group n=30	p-value
Age (year)	46.17±7.82	48.1±9.03	0.379
Height (cm)	156.73±6.79	157.21±5.99	0.771
Weight(kg)	75.3 (66.05-83.95)	67.75 (64.40-74.62)	0.090
BMI (kg/m2)	29.52 (26.91-34.06)	27.74 (25.26-31.57)	0.101
NRS	8.5 (5.75-10)	9 (6.75-10)	0.375
Fibromyalgia Impact Questionnaire (FIQ)	74.21 (61.87-84.73)	74.2 (50.8-86.82)	0.620
6MWT (s)	12.16±2.55	11.30±2.33	0.180
FTSST (s)	13.53±2.85	14.59±3.70	0.217
Right-hand grip strength (kg)	20.07±7.07	23.23±7.21	0.092
Left-hand grip strength (kg)	18 (13.5-20.5)	20 (14.75-25.50)	0.239
Right anterior thigh muscle thickness(mm)	1.69±0.33	1.72±0.46	0.742
Left anterior thigh muscle thickness(mm)	1.49(1.36-1.98)	1.64 (1.31-2.02)	0.483

BMI Body mass index, NRS Numeric Rating Scale, 6MWT: 6-meter walk test, FTSST: five-times-sit- to-stand test. *n*: Number. Numerical data are given as mean±standard deviation or median (interquartile range) values. P<0.05 indicates statistical significance.

After 12 weeks, NRS, FIQ, FTSST, and right-hand grip strength, as well as left and right anterior thigh muscle thickness, were statistically significantly improved in both groups (Table 3). 6MWT and the left-hand grip strength increased only in the exercise group (p<0.001, p<0.001) after 12 weeks. At 12 weeks, NRS, FIQ, 6MWT, FTSST, left- and right-hand grip strength, and left- and right-anterior thigh muscle thickness results were statistically significantly improved in the exercise group compared to the control group (Table 3).

Table 3: The intergroup differences of temporal changes and temporal changes of clinical features between baseline and after 12 weeks among groups.

	Exercise Group n=30	Control Group n=30	p** value
NRS baseline NRS (12 weeks)	8.5 (5.75-10) 5.5 (4-6) p*<0.001	9 (6.75-10) 8 (6.75-8) p*=0.001	<0.001
FIQ baseline FIQ (12 weeks)	74.21 (61.87-84.73) 64.36 (53.58-71.84) p*<0.001	74.2 (50.8-86.82) 72.83 (50.8-84.78) p*=0.031	<0.001
6MWT baseline 6MWT (12 weeks)	12.16±2.55 9.93±1.99 p*<0.001	11.30±2.33 11.22±2.31 p*=0.342	<0.001
FTSST baseline FTSST (12 weeks)	13.53±2.85 10.84±2.41 p*<0.001	14.59±3.70 14.3 ±3.56 p*=0.012	<0.001
Right-hand grip strength (kg) baseline Right-hand grip strength (12 weeks)	20.07±7.07 22.17±6.40 p*<0.001	23.23±7.21 23.53±6.91 p*=0.026	<0.001
Left-hand grip strength (kg) baseline Left-hand grip strength (12 weeks)	18 (13.5-20.5) 19.5 (15.5-22.5) p*<0.001	20 (14.75-25.50) 20 (15.5-25.5) p*=0.066	0.001
Right anterior thigh muscle thick-ness(mm) baseline Right anterior thigh muscle thickness (12 weeks)	1.69±0.33 1.81±0.31 p*<0.001	1.72±0.46 1.74±0.46 p*<0.001	<0.001
Left anterior thigh muscle thick-ness(mm) baseline Left anterior thigh muscle thickness (12 weeks)	1.49(1.36-1.98) 1.57 (1.46-2.06) p*<0.001	1.64 (1.31-2.02) 1.66 (1.34-2.04) p*<0.001	<0.001

p*: p values for intragroup temporal changes, p<0.05, p**: p values for intergroup differences of temporal changes, p<0.05. NRS Numeric Rating Scale, 6MWT: 6-meter walk test, FTSST: five-times-sit- to-stand test. *n*: Number.

DISCUSSION

In this study, pain intensity, disease activity, physical performance (assessed by the FTSST), right-hand grip strength, and bilateral anterior thigh muscle thickness improved over 12 weeks in both groups, whereas improvements in 6MWT and left-hand grip strength were observed only in patients who performed stretching and strengthening exercises. Overall, the exercise program was associated with increased muscle thickness and strength, along with reduced pain and lower fibromyalgia disease activity scores.

In FMS, non-pharmacological interventions such as patient education, exercise therapy, and cognitive behavioral therapy constitute the cornerstone of management. Among these approaches, exercise therapy has consistently demonstrated strong evidence of effectiveness and is widely recommended, even surpassing pharmacological interventions in long-term management [19]. Therefore, the present study aimed to evaluate the effects of exercise on both muscle morphology and functional performance in patients with FMS.

In FMS, an increase in proinflammatory cytokines and a decrease in insulin-like growth factor 1 levels are observed. At the same time, patients experience restricted movement due to pain, fatigue, sleep disturbances, and loss of motivation. These factors contribute to a decrease in muscle mass and muscle strength, potentially leading patients into a vicious cycle that exacerbates symptoms. Therefore, it is crucial to detect muscle loss early and plan appropriate treatment to mitigate symptom progression.

There are various studies on exercise treatments for patients with FMS. Gómez-Hernández et al. (2020) [20] showed that the FIQ value decreased significantly when stretching exercises were added to aerobic exercises one day a week in patients with FMS. Assumpção et al. (2018) [21] reported that stretching exercises had the greatest effect in reducing pain and improving quality of life, whereas resistance exercises were most effective in improving depression and FIQ scores. Consistent with the literature, our findings indicate greater reductions in pain and FIQ scores among patients who performed stretching and strengthening exercises compared with those who performed aerobic exercise alone, supporting the combined use of these modalities to improve overall well-being.

Sevimli et al. (2015) [22] reported that stretching and strengthening exercises were compared with aquatic and aerobic exercises; pain levels improved significantly in all three groups, but the improvement in the aquatic exercise group was greater. Different from this study, aquatic exercise was not used in our study. Because it is difficult to use the pool regularly in the area where the patients are located, FMS is a chronic disease, and the exercise program that patients will apply requires continuity. Therefore, it would be appropriate to recommend an exercise treatment method that patients can access. Our findings suggest that such home-based programs may offer clinically meaningful benefits.

Sarcopenia has been reported to be more prevalent in patients with FMS compared to healthy adults [23]. The 6MWT is the most commonly used assessment for evaluating physical performance and sarcopenia in patients with FMS [24]. Silva et al. (2019) [25] reported that, only a significant improvement was found at 6MWT with strengthening exercises in patients with FMS. In the study by Alventosa et al. (2020) [26], the 6MWT improved at the end of 8 weeks in the low-intensity physical exercise group compared to the control group. In the study by Sañudo et al. (2010) [27], hand strength and function increased when muscle-strengthening and flexibility exercises were added to aerobic exercise. In line with these findings, only the exercise group in our study showed a significant improvement in 6MWT performance, suggesting that strengthening and stretching exercises may enhance functional capacity in this population.

Muscle thickness measurement is a more objective evaluation tool than functional tests. Magnetic resonance imaging, dual-energy X-ray absorptiometry, computerized tomography, ultrasonography, and bioelectrical impedance analysis can be used to evaluate muscle mass, but these are expensive and not easily performed in outpatient clinics. The US is cheap, quick, reliable, and easily applied in daily routine. For this reason, we performed muscle thickness measurements using US at both the beginning and the end of the 12-week period. There are a few studies in which muscle thickness is evaluated using US in patients with FMS. A study conducted by Umay et al. (2020) [28] found that muscle thickness decreased in patients with FMS compared with healthy subjects, and that a decrease in quadriceps femoris muscle thickness was associated with poorer quality of life. Kuzu et al. (2022) [29], reported that the thickness of the neck extensor muscle was evaluated with US, and the muscle thickness decreased in patients with FMS, and there was an inverse correlation with FIQ. Furthermore, in another study by Mesci et al. (2023) [30], muscle thickness decreased in patients with FMS and was associated with handgrip strength. Consistent with the literature, our study demonstrated increased anterior thigh muscle thickness following 12 weeks of exercise therapy, accompanied by improvements in functional outcomes and pain levels. These findings support the potential role of structured exercise in improving muscle morphology and alleviating disease-related symptoms in FMS.

Consistent with previous studies, reduced muscle thickness has been reported in patients with FMS. More importantly, muscle thickness in patients with FMS increased following 12 weeks of exercise therapy and was accompanied by favorable changes in functional outcomes, muscle strength, and pain levels. These findings may help interrupt the cycle of pain, immobilization, and muscle strength decline commonly observed in FMS and support the notion that regular, structured exercise can positively affect overall disease activity and symptoms in this population.

The primary management approach for patients with FMS is exercise therapy. According to the EULAR recommendations, exercise is definitely recommended in patients with FMS. Currently, there is no definitive recommendation on exercise choice, and the superiority of one modality over another remains unclear. One of the main problems with exercise therapy is patients' poor compliance with treatment. Exercise-related muscle pain and low physical capacity at the beginning of treatment cause patients to stop exercising. For this reason, an exercise protocol is required that patients can easily implement on their own. In our study, since no exercises caused trauma to the patients, no exercise-related complications developed, and all patients completed the study safely, we concluded that the exercises were safe.

FMS is a chronic disease that leads to loss of function in women of younger age. In a study conducted by Marañón et al. (2009) [31] in 301 FMS patients, it was found that health costs doubled in patients with high disease activity and that this increase was associated with functional capacity and depression. And it was even stated that it could lead to permanent working disability. Improvements in functionality, muscle strength, and muscle thickness support individual and social development among women of productive age. For this reason, we believe that it would be beneficial to recommend stretching and strengthening exercises to women with FMS.

Limitations

This study has several limitations. First, only female patients were included, which limits the generalizability of the findings. Second, adherence to the home exercise program was assessed using self-reported tracking forms, and completion rates differed between groups, potentially influencing the magnitude of the observed effects. In addition, the follow-up period was limited to 12 weeks; longer-term supervised interventions may provide further insight into sustained muscular and functional adaptations. Baseline physical fitness, nutritional status, and activity levels were not assessed, and a standardized exercise program was applied to all participants without individualization, precluding evaluation of differential exercise responses.

CONCLUSION

In this study, stretching and strengthening exercise therapy was associated with improvements in physical performance, muscle strength, and muscle thickness, as well as reductions in pain intensity and disease activity in patients with fibromyalgia syndrome. These findings suggest that accessible, home-based exercise programs may be an effective non-pharmacological strategy for managing FMS.

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Institutional Review Board Statement

This study was reviewed and approved by the Human Institutional Ethics Committee of Hitit University (2023-78), and the study was carried out in accordance with the principles of the Declaration of Helsinki. The protocol was registered with ClinicalTrials.gov (registration number NCT06253416).

Informed Consent Statement

Before enrolling, all participants completed an informed consent form.

Data Availability Statement

The data associated with the paper are not publicly available but are available from the corresponding author on reasonable request.

Declaration of Generative AI

The authors declare that no generative AI tools were used in the preparation of this manuscript.

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No other persons who satisfied the criteria for authorship but are not listed

Conflicts of Interest

The authors declare no conflicts of interest.

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