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ORIGINAL ARTICLE

Evaluation of minimum pinch force while holding in fibromyalgia patients

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Abstract

Objective This study aimed to investigate the relationship between the minimum pinch force applied during object carrying and physical fatigue in patients with fibromyalgia. For this purpose, the study evaluated the association between the minimum and maximum pinch forces exerted while carrying a weight and both isokinetic muscle strength and the isokinetic fatigue index.

Methods One hundred eight (54 FMS/54 healthy) women participated. Pinch force was measured with a force sensor, and wrist flexor/extensor strength and fatigue index were evaluated using an isokinetic dynamometer at 180°/s.

Results Minimum pinch force did not differ significantly between groups, but maximum pinch force was higher in healthy subjects ($p=0.011$). Wrist flexor and extensor strength were substantially lower in FMS ($p<0.001$ for both). Fatigue index was lower in FMS, but differences were not statistically significant ($p=0.05$, $p=0.06$). In FMS patients, the minimum pinch force correlated with wrist flexor and extensor fatigue, but no correlation was found in controls.

Conclusions Our research shows that the minimum pinch force exerted by women with FMS is not different from that exerted by healthy women, but the maximum pinch force is lower. Muscle performance tests measured by isokinetic dynamometry may help assess physical fatigue in FMS patients.

Significance Although women with FMS can match their healthy peers in minimum pinch force, their lower maximum force may be the main cause of the fatigue they experience during daily activities.

Keywords Fatigue · Fibromyalgia · Muscle force · Pinch force

Introduction

Fibromyalgia is a chronic disease with characteristic symptoms of widespread pain and fatigue, accompanied by sleep disturbance, stiffness, and cognitive difficulties [1]. Although its pathophysiology is not fully understood, it is caused by atypical pain processing, dysfunction of skeletal muscle nociceptive components, and dysfunction of the hypothalamic–pituitary–adrenal axis [2]. Central sensitisation and fine-fibre neuropathy are also thought to be mechanisms involved in the pathophysiology [3]. Pain and fatigue are the cardinal symptoms of fibromyalgia. Pain and fatigue interact in a vicious cycle, causing patients to have difficulty with physical activity and reduced mobility [4].

Fatigue is a prevalent, persistent, and complex symptom with physical, emotional, and cognitive dimensions in fibromyalgia patients [5, 6]. Pain and fatigue during functional activities, difficulty initiating and maintaining a task, and slower task completion are commonly reported complaints in fibromyalgia patients [7–9]. Physical fatigue has been defined as a decrease in maximal muscle performance and increased exertion [4]. Previous studies have shown that men with fibromyalgia reported less fatigue than women and that men focused more on pain and women more on

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fatigue [5, 10]. Several studies evaluating motor performance in fibromyalgia patients have shown decreased grip strength in the hand [11, 12], impaired fine motor skills in the hand [13], low scores in functional capacity tests [14, 15], and decreased muscle performance in lower and upper extremity isokinetic muscle tests [15–18] compared with healthy subjects. Henriksson et al. reported that carrying and holding objects were particularly tiring for fibromyalgia patients [19]. Bardal et al. showed that fibromyalgia patients had an altered neuromuscular strategy during upper limb position control compared with healthy subjects [20]. Previous studies have focused on maximum muscle force, grip strength, or functional capacity measurements. A literature review did not identify any studies that assessed the minimum force required by people with fibromyalgia to perform a task. Therefore, we aimed to evaluate the minimum force fibromyalgia patients need to hold weight by squeezing it between the fingertips and objectively assess physical fatigue using isokinetic muscle performance tests.

In our study, we hypothesised that fibromyalgia patients would need more force to perform an object-holding task than healthy subjects and would have higher levels of physical fatigue as assessed by isokinetic muscle performance tests. The primary aim of this study was to investigate whether the minimum force used by fibromyalgia patients to hold a weight by pinching was different from those used by age-matched healthy volunteers, and the secondary aim was to examine the relationship between the minimum force applied and the isokinetic fatigue index.

Materials and methods

Participants

Our study was designed as a cross-sectional clinical trial, approved by the local ethics committee (Cemil Taşcıoğlu City Hospital ethics committee, approval code: 247) which conformed with the Declaration of Helsinki and registered with ClinicalTrials.gov (NCT06825195). Patients diagnosed with fibromyalgia according to the diagnostic criteria revised by the American College of Rheumatology (ACR) in 2016 were invited to the study according to the inclusion and exclusion criteria [21]. Healthy volunteers without exclusion criteria were invited to participate in the study. The research procedure was explained to the participants, and an informed consent form was signed. Inclusion criteria were patients diagnosed with fibromyalgia, aged 18–60 years; exclusion criteria were patients with a change in fibromyalgia treatment within the last 1 month, pathologies that may cause non-FMS pain in the dominant upper extremity, or neuromuscular diseases. Patients with metabolic disorders such as diabetes mellitus and thyroid dysfunction, vitamin B12 deficiency, autoimmune diseases, chronic viral hepatitis, malignancy or a history of chemotherapy, and chronic alcoholism were also excluded from the study. The presence of these conditions was ruled out through a thorough medical history, review of current medications, and evaluation of prior laboratory findings.

Fifty-nine women with fibromyalgia and 56 healthy volunteers were invited to participate in the study. All patients underwent electromyographic (EMG) evaluation of sensory and motor conduction velocities of the median and ulnar nerves to assess for the presence of carpal tunnel syndrome. Five fibromyalgia patients were excluded from the study because the EMG examination of five fibromyalgia patients revealed carpal tunnel syndrome. One healthy volunteer could not be included in the analysis because her records were deleted due to a technical error, and one healthy volunteer was excluded from the study because she could not comply with the test. The study was completed with data from 54 fibromyalgia patients and 54 healthy volunteers. Anthropometric and clinical characteristics of participants are shown in Table 1.

Table 1 Clinical and anthropometric characteristics of the participants: The clinical and anthropometric characteristics of the participants are shown in Table 1. Abbreviations—kg: kilogram, BMI: Body Mass Index, FIQ: Fibromyalgia Impact Questionnaire

		Healthy controls (54)	**Fibromyalgia patients (54)**	***p*-value**
Age (years) (min–max)		43 (31–58)	46 (32–65)	0.06^{t}
BMI (kg/m^2)		26.3 ± 4.73	25.9 ± 4.30	0.90^{m}
Handedness	Right	53	51	0.618^{f}
	Left	1	3	
Duration of disease (months)		-	42.78 ± 55.07	
FIQ		-	55.53 ± 14.45	
Fatigue score		-	6.48 ± 2.93	

^{t} İndependent samples *t*-test

^{m} Mann-Whitney *U* test

^{f} Fisher's exact test

Methods

In this cross-sectional study, a blinded examiner measured isokinetic wrist and fingertip pinch strength on the same day for each subject. The Fibromyalgia Impact Questionnaire (FIQ) was also administered to FMS patients on the same day. The primary outcome variable was fingertip pinch force, and the secondary outcome variables were wrist isokinetic performance, disease severity (FIQ), and fatigue severity.

Fingertip Pinch Force Assessment

The pinch force between the dominant hand's 1st and 2nd fingers was tested. Hand dominance was determined by self-report. To do this, the patient was first asked to hold the force sensor (Homemade at Adelaide University, Australia) weighing 633 g between two fingers with minimum pinch force without letting it fall to the floor, and the minimum pinch force was measured. The patient was then asked to hold the same weight between two fingers with maximum pinch force, and the maximum pinch force was measured.

The participant was seated comfortably upright with a supported back in a quiet and spacious environment. The dominant upper extremity was positioned with the shoulder abducted 20 degrees, the elbow flexed 90 degrees, the forearm supported, and the wrist neutral (Fig. 1). During holding, the 3rd, 4th, and 5th fingers were asked to be in extension at the metacarpophalangeal joint, and the distal and proximal interphalangeal joints were asked to be slightly flexed. It has been shown that in this position, muscle activity during compression between the 1st and 2nd fingers may increase, and the target compression force may be reached more quickly [22]. Subjects were instructed about the device and the test procedure and asked to perform a familiarisation trial. During the familiarisation period, the participant was given the force sensor that would be used for the measurement and was asked to hold it in the palms of their hands and weigh it to get used to the weight of the device. Then, the participant was asked to hold and carry the same weight by squeezing it from the force sensor plates. At this stage, they were allowed to squeeze it as much as they wanted. When the participant reported that they were familiar with the weight and were ready, the test phase began.

After a five-minute rest period, the participant's eyes were covered with a black eye patch for the test measurements. Between the dominant hand's 1st and 2nd finger pulp, the participant was asked to squeeze and hold the force sensor plates with minimal force for 10 s without dropping them. This measurement was repeated three times at 30-s intervals. After a one-minute rest, she was asked to hold the same sensor with maximum compression force three times at 30-s intervals.

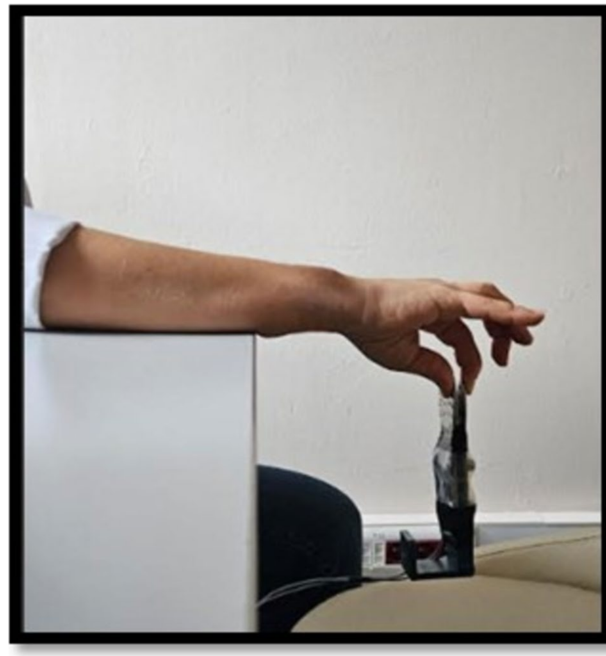


Fig. 1 Position of the participant during Fingertip Pinch Force Assessment Forearm supported, 1st and 2nd fingers on metal plates, 3rd, 4th and 5th fingers slightly extended during the assessment

Force sensor signals were recorded using PowerLab (AD Instruments Co, Oxford, UK), a data acquisition system with a sampling rate of 10 kHz. The recorded data were analysed using LABCHART7® software version V7.3.3 (ADInstruments, Oxford, UK). For minimum pinch force measurements, the smallest of the three measurements was defined as the 'minimum pinch force', and the 'mean minimum pinch force' was calculated by averaging these three measurements. For maximum pinch force measurements, the highest of the three measurements was defined as 'maximum pinch force', the average of these three measurements was taken, and the 'mean maximum pinch force' was calculated. Figure 2 shows images of minimum and maximum wave patterns. Pinch force was reported as a ratio to weight to eliminate interpersonal variability. It was also calculated: normalised minimum pinch force = minimum pinch force × 100/maximum pinch force; normalised mean minimum pinch force = mean minimum pinch force × 100/mean maximum pinch force. The participants' pinch force was expressed in newtons.

Isokinetic Muscle Performance Assessment Protocol

Flexor and extensor isokinetic assessments of the dominant wrist (torque, fatigue, work) were performed using a Cybex Humac Norm 2 isokinetic dynamometer. The tests were performed blindly under the supervision of a physician who was experienced in using isokinetic dynamometers, and the

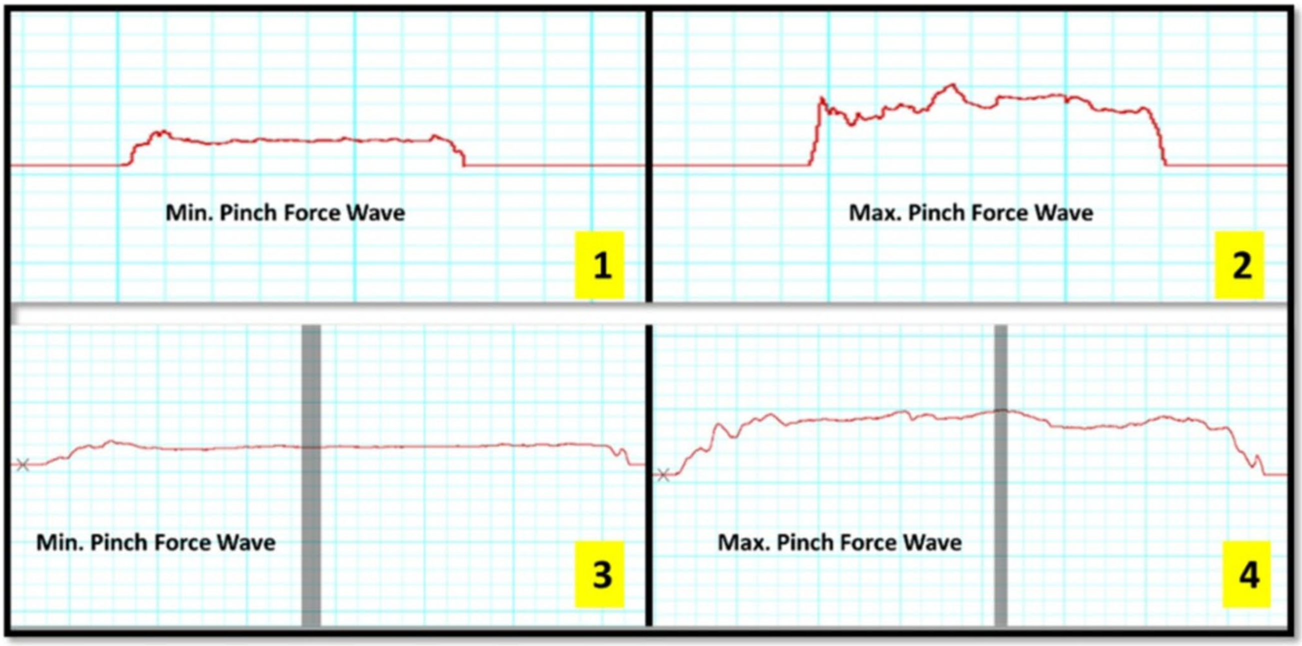


Fig. 2 Minimum and maximum force patterns: **1** Minimum pinch force wave. **2** Maximum pinch force wave evaluations were made at the lowest point of the minimum force wave and the highest point of the maximum force wave. In 3 and 4, these regions are shown as a hatched area

same level of verbal encouragement was given to all participants. Participants were seated in the test chair upright with the trunk supported and the hip and knee flexed at 90 degrees. The dominant limb was positioned with the forearm supported and fully supinated with the elbow flexed approximately 90 degrees (Fig. 3). To test wrist flexion–extension, the dynamometer's rotation axis was aligned with the diagonal axis of the distal radius and ulna. To minimise the

Fig. 3 Position of the participant during isokinetic muscle strength measurements. Participants were seated upright with the trunk supported and the hip and knee flexed at 90 degrees. The dominant limb was positioned with the forearm supported and fully supinated, with the elbow flexed approximately 90 degrees. To test wrist flexion–extension, the dynamometer's rotation axis was aligned with the diagonal axis of the distal radius and ulna, and the examiner used a strap to stabilise the forearm with manual stabilisation. Each participant received the same verbal stimulus from the therapist: 'Move your arm as fast as you can'

contribution of elbow flexion and extension during the wrist flexion/extension test, the examiner used a strap to stabilise the forearm with manual stabilisation. Measurements were taken at a range of motion of 55 degrees of dorsal flexion and 35 degrees of palmar flexion [23]. Concentric isokinetic palmar flexion and dorsal flexion were performed for 5 min to warm up and then for testing. At a speed of 180 degrees/second, 15 repetitions of concentric testing were performed. Torque, velocity, and position measurements were taken throughout the range of motion. At the end of the test, peak flexor and extensor torques (Newton-metres (Nm)), fatigue index, and total work done (Joule) of the dominant wrist were recorded using the Humac Norm 2. The isokinetic fatigue index was calculated using the following formula based on torque averages:

Fatigue Index (%) = [(Mean torque of the first 3 repetitions – Mean torque of the last 3 repetitions)/Mean torque of the first 3 repetitions] × 100.

Fibromyalgia Impact Questionnaire (FIQ)

The FIQ was administered to the fibromyalgia patient group to determine the severity of the disease. The questionnaire assesses the impact on patients' activities of daily living, pain, fatigue, anxiety, and depression. The total score is calculated out of 100 points, with scores above 59 indicating severe disease activity and between 39 and 59 indicating moderate disease activity. In the questionnaire, fatigue severity is subjectively rated on a 10-point scale, with high scores associated with extreme fatigue [24].

Statistical Analysis and Sample Size Calculation

The primary outcome variable of this study was 'fingertip pinch force' and was planned to be measured in both FMS and healthy control groups. No examples in the medical literature can be used to calculate sample sizes for this variable. In the interim analyses performed in 10 control and 10 FMS patients during the study period, the effect size was determined to be 0.55. In the analyses to be performed with the two-tailed unpaired *t*-test, if the alpha error level is taken as 0.05 and the power of the study is accepted as 0.80, the minimum number of subjects required is calculated as 53 for each group. The sample size was calculated using G*Power ver3.1.9.4 software (Franz Faul University of Kiel, Germany).

The Kolmogorov–Smirnov test was used to analyse whether the data conformed to a normal distribution. If the data conformed to normal distribution, the means were compared by unpaired *t*-test. If the data were not normally distributed, the means of the two groups were compared using the Mann–Whitney *U* test. The distribution of categorical variables between groups was analysed using Fisher's exact test. Correlations between variables were analysed using Pearson's correlation test for data conforming to the normal distribution and Spearman's Rho correlation test for data not conforming to the normal distribution. The level of significance was accepted as $p < 0.05$. Analyses were performed using SPSS 23.0.

Results

The mean FIQ score for fibromyalgia patients was 55.53, while the mean fatigue severity was 6.48 (Table 1). While minimum pinch and mean minimum pinch force measurements showed no statistically significant difference between the FMS and healthy groups (*p* values 0.330 and 0.478, respectively), maximum pinch and mean maximum pinch forces were higher in the healthy group (*p* values < 0.001 and 0.002, respectively). No statistically significant difference was found between the two groups for normalised minimum pinch force and normalised mean minimum pinch force (*p* values 0.740 and 0.400, respectively). When pinch force was standardised against weight, no difference was found between the two groups for minimum and mean minimum pinch force. In contrast, the difference was maintained for maximum and mean maximum pinch force (*p* values 0.011 and 0.019, respectively) (Table 2).

The results of the participants' isokinetic muscle performance are shown in Table 3. The dominant side wrist peak flexor and extensor torques were lower in fibromyalgia patients compared to the healthy group (*p* values < 0.001 and < 0.001, respectively). When the values were standardised according to weight, the fibromyalgia patients' peak wrist flexor and extensor torques were lower than those of the healthy subjects (*p* values 0.001 and < 0.001, respectively). Total flexor and extensor work was higher in healthy volunteers than in fibromyalgia patients (*p* values 0.041 and 0.02, respectively). No difference was found between the two groups for the flexor and extensor fatigue index (*p* values 0.06 and 0.05).

The results of Spearman's correlation test when analysing the relationship between minimum pinch force and other variables are shown in Table 4 and Fig. 4. In the FMS group, there was a moderate positive correlation between weight-standardised minimum pinch force and weight-standardised peak wrist extensor torque, extensor and flexor fatigue index values (*r* and *p* values $r = 0.331$, $p = 0.014$; $r = 0.395$, $p = 0.003$; $r = 0.309$, $p = 0.023$, respectively).

Discussion

Our study investigated whether the minimum and maximum fingertip pinch force and the isokinetic performance of FMS patients' wrist flexor and extensor muscles differed from healthy subjects when carrying a fixed weight.

Table 2 1st and 2nd Finger Pinch Force Measurements: ^{t}Independent samples *t*-test, ^{m}Mann Whitney *U*, Min: minimum, Max: maximum, Std: standardised, N: Newton, kg: kilogram. The table shows the minimum and maximum pinch forces, their normalised values to each other, and the pinch forces proportional to weight to ensure standardisation between participants

	Healthy controls (54)	Fibromyalgia patients (54)	Effect size	*p*-values
Min. Pinch Force (N)	3.19 ± 1.74	2.90 ± 1.73	0.094	0.330 ^{m}
Mean Min. Pinch Force (N)	4.15 ± 2.26	3.75 ± 1.81	0.069	0.478 ^{m}
Max. Pinch Force (N)	36.52 ± 10.95	30.05 ± 8.74	**0.653**	**< 0.001** ^{t}
Mean Max. Pinch Force (N)	31.87 ± 9.03	26.75 ± 7.51	**0.617**	**0.002** ^{t}
Normalised min. Pinch Force (% Min/Max pinch force)	9.57 ± 6.08	10.16 ± 6.47	0.032	0.740 ^{m}
Normalised mean min. Pinch Force (% Mean min./Mean max. pinch force)	14.09 ± 8.53	14.91 ± 7.71	0.080	0.400 ^{m}
Std. Min. Pinch Force (N/kg)	0.05 ± 0.03	0.04 ± 0.03	0.070	0.468 ^{m}
Std. Mean Min. Pinch Force (N/kg)	0.06 ± 0.03	0.06 ± 0.03	0.060	0.539 ^{m}
Std. Max. Pinch Force (N/kg)	0.53 ± 0.17	0.45 ± 0.14	**0.498**	**0.011** ^{t}
Std. Mean Max. Pinch Force (N/kg)	0.46 ± 0.13	0.40 ± 0.13	**0.459**	**0.019** ^{t}

The statistical significance level is *p* 0.05, with significant values indicated in bold

Table 3 Isokinetic test resultsfor wrist flexorand extensor muscles: The table shows isokinetic muscle performance results for the wrist flexor and extensor muscles. The device's software automatically calculates total work and fatigue values. ^{t}Independent samples *t*-test, ^{m}Mann-Whitney *U* Test, PT: peak torque, TW: total work, Nm: Newton-meters, Std: standardised, kg: kilogram, J: Joule

	Healthy controls (54)	Fibromyalgia patients (54)	Effect size	*p*-values
Extensor PT 180°/s (Nm)	8.06 ± 2.29	6.00 ± 2.04	0.947	**< 0.001** ^{t}
Flexor PT 180°/s (Nm)	8.95 ± 3.09	6.29 ± 2.70	0.916	**< 0.001** ^{t}
Extensor TW 180°/s (J)	64.99 ± 38.62	49.03 ± 28.24	0.228	**0.02** ^{m}
Flexor TW 180°/s (J)	58.32 ± 45.86	41.61 ± 26.33	0.200	**0.041** ^{m}
Extensor Fatigue 180°/s	1.59 ± 21.25	− 6.82 ± 23.57	0.190	0.05 ^{m}
Flexor Fatigue 180°/s	6.91 ± 19.93	− 5.33 ± 34.48	0.182	0.06 ^{m}
Std. Extensor PT 180°/s (Nm/kg)	0.12 ± 0.34	0.09 ± 0.04	0.780	**< 0.001** ^{t}
Std. Flexor PT 180°/s (Nm/kg)	0.13 ± 0.04	0.09 ± 0.04	0.420	**< 0.001** ^{m}

As a result, we found that:

1. There was no difference between the minimum pinch forces of FMS patients and healthy subjects, but the maximum pinch forces of healthy subjects were higher. However, minimum pinch force and fatigue in the wrist flexor and extensor muscles were significantly correlated in patients but not in the control subjects.
2. FMS patients had lower dominant wrist extensor and flexor peak torques at 180 degrees/second than healthy subjects.
3. The total work produced by FMS patients' dominant wrist flexor and extensor muscle groups at 180 degrees/second speed was lower than the healthy group.

Muscle force

Reduced muscle force and changes in muscle coordination in FMS patients have been reported in several studies [11, 17, 18, 20, 25]. Few studies evaluate upper extremity muscle performance in this patient group [15, 16, 26, 27]. Studies show a decrease in hand grip strength [11, 12, 26, 27] and one study shows that hand grip strength does not differ between FMS patients and healthy subjects [15]. Women with FMS reported difficulties with overhead activities (working with arms raised), carrying shopping bags, and holding tools [28]. Bardal et al. showed that FMS patients had different motor strategies than healthy volunteers when controlling the position of the upper limb [20].

While previous studies have focused on the maximum muscle force that FMS patients can exert, our study aimed to evaluate the minimum force exerted. We showed that women with FMS exert the same intensity of force to perform the same task as healthy women, but the maximum force that women with FMS can exert to perform the same task is lower than that of healthy women. In addition, unlike previous studies, we measured fingertip pinch force to assess the most distal point of the upper extremity and to exclude entrapment neuropathies that may alter participants' fingertip sensitivity and pinch force by EMG. One reason for the lower maximum fingertip pinch force in FMS patients may be the altered muscle strategies in upper extremity motor control mentioned in the study by Bardal et al. [20]. We also found a moderate positive relationship between minimum pinch force and wrist extensor muscle strength in FMS patients, but not in healthy subjects. This finding supports that FMS patients have altered muscle strategies for upper extremity control compared with healthy subjects. These results from our study may explain the difficulty in upper extremity use reported subjectively by patients in previous studies [19, 28].

Manual dexterity has a significant impact on occupational performance and daily living activities. Manual dexterity includes gross motor skills, such as holding objects in the hand, and fine motor skills, such as manipulating objects with the fingertips [29]. It has been suggested that FMS patients have impaired fine motor skills [13, 30], and this impairment may be associated with chronic pain [31].

Our study shows that the minimum force FMS patients use to perform the same activity is the same, but the maximum force they can apply is lower than that of healthy subjects. This may lead to difficulties in maintaining fine motor skills and may explain the 'clumsiness' reported by patients.

Fatigue

Fatigue is a persistent symptom that occurs in almost all patients with fibromyalgia, is independent of exercise and activity, interferes with daily life and functionality, and is difficult to control [32]. Pain and fatigue during functional activities, difficulty starting and maintaining a task, and slower task completion are commonly reported complaints [7–9]. General fatigue assessment can be done with questionnaires based on patient self-report and no fibromyalgia-specific fatigue assessment tool [6]. Our study found no correlation between the fatigue score, a FIQ subunit, and isokinetic muscle performance tests. One reason for this may be that subjective fatigue reported by patients includes physical, emotional, and cognitive fatigue. Of these components, muscle performance tests may better represent only physical fatigue. Physical fatigue can be assessed more objectively with tests of muscle performance and functional capacity [14].

There are conflicting results from studies evaluating fatigue using isokinetic muscle performance tests in FMS patients. Güler et al. found that isokinetic wrist flexor and extensor fatigue index in FMS patients were similar to those in healthy subjects [16]. Our study showed no difference between the two groups in the fatigue index calculated during the isokinetic test, similar to Güler et al. However, we showed that the total work was lower in FMS patients than healthy subjects, similar to Maquet et al. The lower total work in FMS patients indicates that the resistance of the muscles to fatigue is lower than in control subjects (fatigue develops more easily), which may explain the lower maximum compression force between the two fingers during handling.

Table 4 Variables associated with the minimum pinch force standardised by weight: The table shows the relationship between minimum pinch force, peak wrist flexor and extensor torque, fatigue score, isokinetic fatigue index and total work scores in FMS and healthy subjects. Spearman correlation coefficient, N: number, Std: standardised, Min: minimum, PT: peak torque, N: Newton, kg: kilogram, FIQ: Fibromyalgia Impact Questionnaire, FMS: Fibromyalgia Syndrome

Group	Variables		Std. Extensor PT/kg	Std. Flexor PT/kg	FIQ	Fatigue Scores	Fatigue Extensor 180°/s	Fatigue Flexor 180°/s	Total Work Extensor180°/s	Total Work Flexor 180°/s
Healthy	Std. Min. Pinch Force (N/kg)	*r*	0.101	0.058			−0.015	0.023	0.036	−0.068
		p	0.467	0.676			0.911	0.868	0.794	0.624
		N	54	54	-	-	54	54	54	54
FMS	Std. Min. Pinch Force (N/kg)	*r*	**0.331***	0.159	−0.217	−0.220	**0.395****	**0.309***	−0.089	−0.051
		p	**0.014**	0.251	0.115	0.109	**0.003**	**0.023**	0.521	0.715
		N	**54**	54	54	54	**54**	**54**	54	54

The statistical significance level is p 0.05, with significant values indicated in bold

Fig. 4 **a, b, c** Scatter plots of factors associated with minimum pinch force. The scatter plots show the relationship between minimum and maximum pinch force (**a**), peak wrist flexor and extensor torques (**b**), and flexor and extensor fatigue index (**c**) for FMS and healthy subjects. Lines show the fit for each subgroup. Red dots and lines represent healthy subjects, and black dots and lines represent FMS patients. Std, standardised, Min, minimum; Max, maximum; PT, peak torque; N, Newton; kg, kilogram

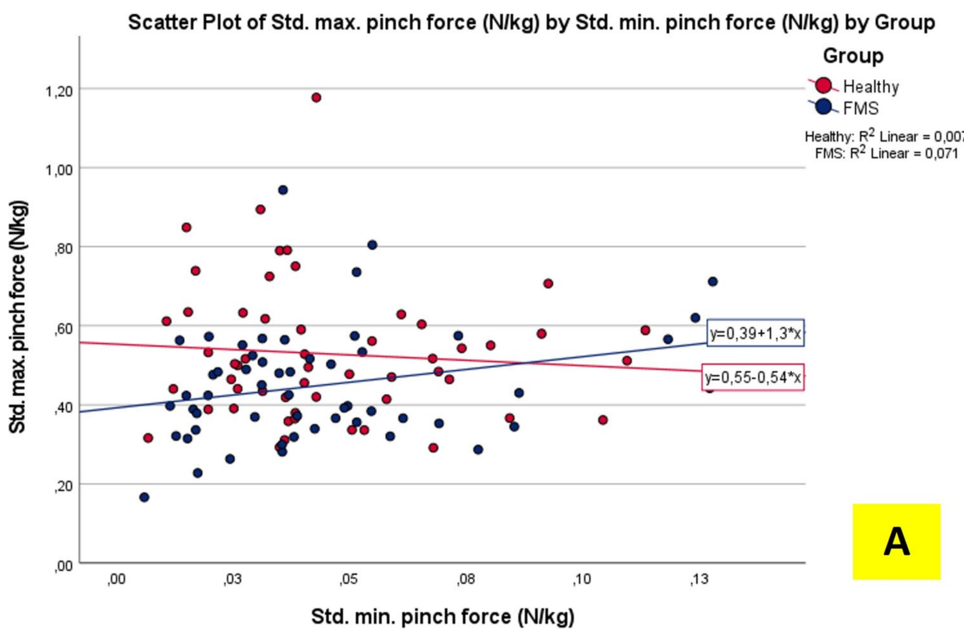
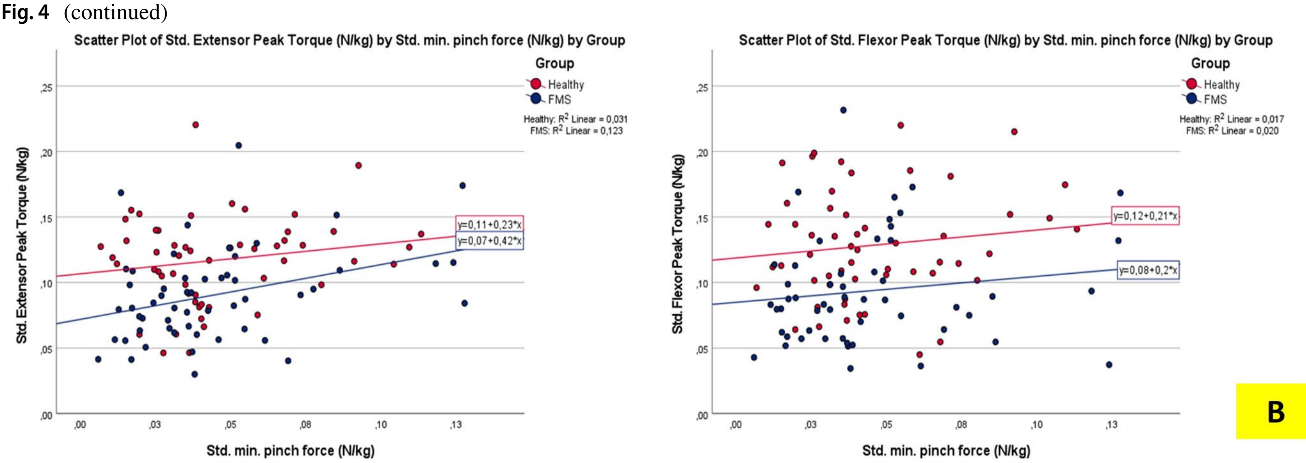


Fig. 4 (continued)



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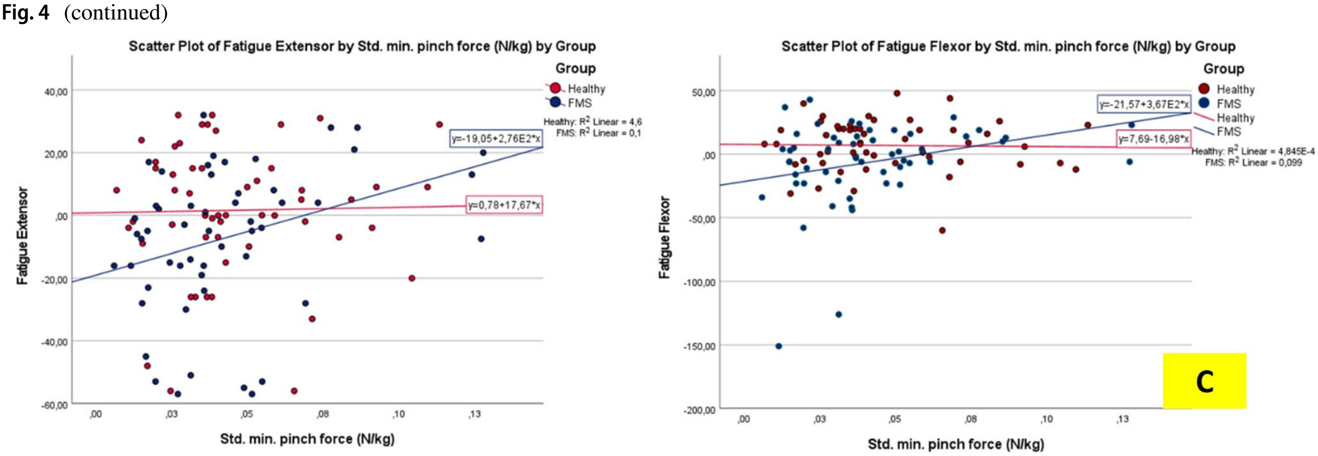

We found that the extensor and flexor fatigue index were moderately positively correlated with the weight-normalised minimum pinch force in the FMS patient group. This finding suggests that FMS patients exert more effort (use more force) to perform the same task as muscle fatigue develops. The absence of a similar relationship in healthy subjects suggests that muscle fatigue does not alter the minimum force required to perform a task in healthy subjects. Few studies have used isokinetic systems to assess muscle performance in people with FMS.

In an FMS cohort study, peak knee flexor and extensor torques measured at different angular velocities were lower than in healthy subjects [33]. Borman et al. found that peak knee extensor torque at 60 degrees/second was lower in FMS patients than in healthy subjects. However, peak knee flexor torque at 60 degrees/second and peak knee flexor and extensor torque at 180 degrees/second did not differ from healthy subjects [17]. Tavares et al. performed isokinetic muscle performance tests of the knee (peak flexor and extensor torque at 60 degrees/second, total work, power and fatigue index) and found no difference between the FMS and healthy groups [14]. Akyol et al. found that peak knee extensor torque at 60 degrees/second and peak knee extensor and flexor torque at 180 degrees/second were lower in FMS patients than in healthy subjects [15]. Maquet et al. reported that peak knee flexor and extensor torques were lower in FMS patients at 60 and 180 degrees/second [18]. A literature review found one study that evaluated isokinetic wrist muscle performance in FMS patients. In the study by Güler et al., wrist flexor and extensor strength were lower in FMS patients than in healthy subjects at 90 degrees/second, but there was no difference between the two groups at 180 degrees/second [16]. As isokinetic wrist strength measurement was not the primary outcome measure of our study, we only measured concentric isokinetic contractions of the wrist flexors and extensors at an angular velocity of 180 degrees/second to assess muscle fatigue.

Contrary to Güler et al., we found that the peak isokinetic wrist flexor and extensor torques of FMS patients were lower than those of healthy subjects, particularly the peak extensor torque standardised to kilograms. Analyses at this angular velocity are indicative of muscle endurance. Although isokinetic fatigue parameters were not different between the two groups, this finding suggests that FMS patients may be more susceptible to fatigue during low-resistance, repetitive activities.

Conclusions

FMS is a disorder characterised by widespread pain and fatigue, whose pathophysiology is not yet understood. Reduced motor performance and difficulties initiating and maintaining movement have been reported in these patients compared with healthy individuals. Studies have shown that these patients use altered motor control strategies to control movement compared with healthy individuals. These findings reveal a striking pattern: although women with FMS are able to exert a minimum pinch force comparable to that of healthy individuals during task performance, their maximum pinch force is significantly reduced. This limitation may play a critical role in the development of physical fatigue commonly reported by individuals with FMS. There is no specific test or method of measuring physical fatigue in people with FMS. Isokinetic dynamometer tests showed that FMS patients had lower muscle strength and endurance than healthy subjects. It was also observed that the minimum pinch force of FMS patients increased with increasing fatigue, so that they exerted more effort than the minimum effort required to maintain the same work. This and similar studies might lead to more widespread use of isokinetic systems in assessing FMS patients and may lead to the development of new measurement devices.

Limitation of study

The main limitation of our study is that only female patients were included, so our results cannot be applied to all fibromyalgia patients. Another limitation is that isokinetic assessments were only performed at 180 degrees/second. Isokinetic assessments at different angular velocities and repetitions may better reflect the performance of the muscle.

Author contributions DEZ, Sİ, EÇ, SA, ED, and TA evaluated subjects and monitored the daily operations of the study, including recruitment, data collection, and data management. DE, İK, KST, ÖK, SA, ED developed the study concept and design. DE, KST, ÖK, İK, SA, ED, TA, EÇ, and Sİ contributed to recruitment, data collection, and data analysis. All authors read and approved the final manuscript.

Data availability All data generated or analyzed during this study are included in this published article.

Declarations

Competing interests The authors declare no competing interests.

Ethics approval Our study was designed as a cross-sectional clinical trial, approved by the local ethics committee (Cemil Taşcıoğlu City Hospital ethics committee, approval code: 247) which conformed with the Declaration of Helsinki and registered with ClinicalTrials.gov (NCT06825195).

Disclaimer The results of the study are presented clearly, honestly, and without fabrication, falsification, or inappropriate data manipulation.

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