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Muscle performance in fibromyalgia syndrome

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Abstract The objective of the study was to examine the muscle performance, isokinetic muscle strength, muscle endurance ratio, and submaximal aerobic performance in fibromyalgia syndrome (FMS) patients, to evaluate the relation between muscle performance, pain severity, clinical findings, and physical activity level, and to compare the results with healthy control subjects. Twenty-four FMS patients and 15 control subjects participated in this study. Data were obtained about the symptoms, location and onset of pain, treatment, and associated symptoms. Patients and controls underwent an examination of isokinetic muscle strength of right quadriceps on a Cybex dynamometer, and submaximal aerobic performance tests (PWC-170) were done for all subjects. Maximal voluntary muscle strength of the quadriceps was significantly lower in patients compared with the control group. Endurance ratios showing the work capacity were not statistically different between two groups. Submaximal aerobic performance scores were higher in the control group. There was not a relation between the decreased muscle performance and clinical findings, including pain severity, number of tender points, and duration of the symptoms of FMS patients. We found a reduced quadriceps muscle strength and submaximal aerobic performance in patients with FMS, indicating that patients have impaired muscle function.

Key words Fibromyalgia · Muscle performance

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Introduction

Fibromyalgia syndrome (FMS) is a chronic, nonarticular rheumatic disorder characterized by widespread musculoskeletal pain, stiffness, fatigue, and a well-defined pattern of tender points and disturbed sleep [1]. It is one of the most commonly diagnosed problems in outpatient clinics. Despite the large population suffering from this condition, the underlying pathophysiological mechanism remains unknown. Although a wide variety of mechanisms have been proposed to explain the symptoms, none of them has been demonstrated to play a critical role [2, 3].

It has been recognized that patients with FMS are relatively deconditioned when compared with normal subjects. This finding could reflect an abnormal physiologic limitation of muscular exercise capacity because of an impairment in the capacity and utilization of oxygen [4]. A reduction of maximal voluntary isometric and isokinetic strength in the quadriceps muscle has been reported in previous studies and was supposed to be the result of a primary muscle dysfunction [5]. Recent studies appeared to confirm that the FMS patients exhibited significant reduction in voluntary muscle strength of quadriceps in the order of 20–30% when compared with healthy subjects [6]. Lindh et al. also showed a markedly reduced maximal voluntary contraction in knee extension of 25 FMS patients, suggesting an impaired control mechanism at a supraspinal level [7].

The aim of this study was to examine muscle performance: isokinetic muscle strength, muscle endurance ratio, and submaximal aerobic performance tests (PWC-170) in FMS patients, to evaluate the relation between muscle performance, pain severity, clinical findings, and physical activity level, and to compare the results with the healthy control subjects.

Materials and methods

Twenty-four FMS patients, whose clinical diagnosis was based on the 1990 American College of Rheumatology criteria [8] from the outpatient clinics of the University of Hacettepe, Department of Physical Medicine and Rehabilitation, and 15 healthy control subjects from the University personnel, who volunteered to take part in this study, were recruited.

All patients were interviewed and examined by the same physiatrist (P.B.) on the day of exercise testing to verify eligibility for study and record the signs and symptoms. The women who did not have any problems that might indicate risk for muscle performance tests were included in the study. Subjects with cardiovascular, metabolic, or endocrinological problems, or inflammation, effusion, or restriction on any joint, or who had undergone any orthopedic procedures, or who were taking medicine that has a risk of hemorrhage were excluded. Data about the symptoms, location and onset of pain, and pharmacological treatment were obtained. The number of associated symptoms such as swelling, morning stiffness, paresthesia, chronic headache, poor sleep, general fatigue, irritable bowel syndrome, stress, anxiety, dyspnea, pollakiuria, dysmenorrhea, tachycardia, and chest pain were also recorded for each subject (range 0–14 symptoms).

The physical activity levels of the patients and control group were assessed using the questionnaire on physical activities. The participants reported the mean time spent doing each of eight moderate and vigorous activities, choosing from ten possible responses that ranged from 0 min to 11 h or more per week (zero, 1–4 min, 5–19 min, 20–39 min, 40–80 min, 1.5 h, 2–3 h, 4–8 h, 11 + h) during the past month and past year to assess a long-term mean physical activity. The specific activities listed were: walking, jogging, running, cycling, lap swimming, calisthenics, rowing, and tennis or squash. In addition, each respondent reported the number of flights or stairs he climbed daily and his usual walking pace. The reported time spent at each activity per week was multiplied by its typical energy expenditure requirements expressed in metabolic equivalents (METs) to yield a MET-hour score. One MET, which is the energy expended by sitting quietly, is equivalent to 3.5 ml of oxygen uptake/kg of body weight per minute for an adult. If more than one published intensity level was available for a given activity, the moderate or general MET value was chosen [9].

Patients underwent a standardized physical examination including an assessment of nine tender points on both sides of the body using manual palpation, including the occiput, low cervical area, trapezius muscle, supraspinatus muscle, second rib, lateral epicondyles, greater trochanter, gluteal, and knee [8]. A 10-cm visual analog scale (VAS) was used to assess pain at the moment of examination (0, no pain; 10, the worst pain possible).

All patients and control subjects underwent an examination of isokinetic muscle strength on a Cybex dynamometer, and submaximal aerobic performance tests (PWC-170) were done for all subjects.

A Cybex II isokinetic dynamometer (Lumex, New York) was used to determine maximum voluntary isokinetic muscle strength (MVIK), muscular endurance ratio, and peak torques on both extension and flexion of the right quadriceps muscle. The dynamometer was modified to eliminate torque overshoot and correct for gravity [10]. The subjects were seated in a specially constructed chair that enabled comfortable fixture. Each subject was instructed in the principles of isokinetic measurements before actual testing. To obtain reliable peak torque measurements, a set of five maximal warm-up repetitions at each speed was included in the test protocol. All tests were performed blind by the same laboratory technician, using the same degree of verbal encouragement in all subjects. The angular velocities used were 60°/s and 180°/s. Measurements were repeated three times at about 1-min intervals, and the highest torque value was obtained at each of the angular velocities. Contractional work was calculated between 75° and 15° of the knee flexion. The order of speed was from slower to faster. Torques and corresponding joint angles were recorded on a computer with specially designed interface and software, for calculating peak torque and contractional work.

The endurance ratio was defined as the number of repeated knee extensions needed for the contractional work in two successive knee extensions to be equal to or below 50% of the initial value. The Cybex II dynamometer automatically calculates the endurance ratio by dividing the work done in the last sample repetition by the work done in the first sample repetition, then multiplies this figure by 100.

Submaximal aerobic performance was estimated by an indirect-method, bicycle ergometer test (PWC-170). This submaximal exercise test has proven to be a very useful tool for evaluating the individual's circulatory capacity. It has been applied widely in trained or untrained adults and in children [11]. The test was performed on an upright-calibrated, stationary cycle ergometer, the subject being required to pedal continuously, for a total of not more than 9 min, during which time the work load was increased twice (at 3 min and 6 min), making three loads in all. According to the traditional procedure, the initial load had to be set at 1 W/kg body weight of the subject. Further increases were set according to heart rate response as recommended by a report by the Council of Europe [12]. Ideally the initial loading and subsequent increases were expected to produce an even progression from a heart rate of around 90–120 beats/min at the end of first load period to just below 170 beats/min at the end of the last load period. We measured the heart rate during the last 15 s of each load and the work load increase was regulated so that the heart rate achieved at the end of the test approached 170 beats/min. We determined the work load corresponding to a heart rate of 170 beats/min by extrapolation. As the subject's body weight is supported while cycling and cardiorespiratory endurance most usually entails carrying one's body weight, the score is expressed as divided by the subject's weight in kilograms.

Statistical methods

Baseline and other univariate comparisons were performed using unpaired *t*-tests. Pearson correlation coefficients were used to compare the isokinetic and submaximal performance test scores of participants with clinical parameters.

Results

The mean age of the FMS patients and the control subjects were 30.46 ± 6.43 years and 31.33 ± 7.91 years, respectively. The demographic data of the patient and control groups are shown in Table 1. The

Table 1 The demographic data (mean ± SD) of the patient and control groups (*MET-hours* sum of mean time per week spent in each activity, *BMI* body mass index)

	Patients (n = 24)	Controls (n = 15)
Age (years)	30.46 ± 6.43	31.33 ± 7.91
Women/men	24/0	15/0
Marital status		
Married	16	10
Divorced/separated	1	
Single	7	5
Work status		
Employed	15	15
Retired		
Homemaker	9	
Weight (kg)	61.53 ± 9.52	59.07 ± 5.85
Height (m)	1.60 ± 0.05	1.61 ± 0.05
BMI (kg/m^2)	24.16 ± 3.46	22.54 ± 2.13
Physical activity score (mean MET-hours)	17.15 ± 27	19.26 ± 1.8

weight, height, and physical activity scores were similar in the two groups.

The patients had generalized pain for a mean of 39.4 ± 18.35 months. Medication included analgesics in eight and antidepressants in three patients. The mean number of anamnestic symptoms was 12.75 ± 3.74. The most frequent symptoms were feeling unrefreshed in the morning (91.6%), general fatigue (87.5%), stress and/or anxiety (83%), and sleep disturbance (79.1%). It was also found that the cold, physical activity, and stressful events had an increasing effect on pain in FMS patients.

The mean VAS score was 7.19 ± 1.57 in the patient group. The patients had a mean of 13.46 ± 2.17 (range 11–18) tender points out of 18 sites examined. The results of the routine laboratory tests performed were normal in all subjects.

In order to obtain clinical relevance, a test protocol similar to that recommended by the manufacturer of the isokinetic device was chosen. For the same reason, peak torque was measured in foot-pounds (ft lb). Data were obtained using two test speeds: slow 60°, fast 190°.

Table 2 shows the mean values of peak isokinetic gravity-corrected torque in foot-pounds at 60°/s and 180°/s of the right quadriceps muscle and endurance ratios (percentage) in the Cybex II dynamometer. Maximal voluntary muscle strength of quadriceps at 60°/s and 180°/s, in both flexion and extension were lower in patients compared with the control group, but the difference was statistically significant only in extension at 60°/s ($P < 0.05$). The mean value of endurance ratios showing the work capacity was lower in the FMS group than in the control group, but the difference was not statistically significant ($P > 0.05$). Submaximal aerobic performance scores (PWC-170) were higher in the control group ($P < 0.05$; Table 2).

There was not a correlation between decreased muscle performance and clinical findings, including pain severity, number of tender points, number of associated symptoms, and duration of the symptoms ($P > 0.05$). We could not find a correlation between physical activity scores and clinical findings and muscle performance tests ($P > 0.05$).

Table 2 The isokinetic and submaximal aerobic performance tests (PWC-170) results of patient and control groups (mean ± SD)

	Patients (n = 24)	Control (n = 15)	P
Peak torque ext[a]			
60/s	72.75 ± 12.63	89.06 ± 7.44	$P < 0.05$
180/s	41.04 ± 8.5	43.8 ± 5.45	$P > 0.05$
Peak torque flex[a]			
60/s	39.6 ± 6.9	42.9 ± 4.2	$P > 0.05$
180/s	32.8 ± 11.9	34.3 ± 4.3	$P > 0.05$
Endurance ratio[b] (%)	37.8 ± 12.1	41.8 ± 5.44	$P > 0.05$
PWC (W/kg)	139 ± 0.34	234 ± 0.26	$P < 0.05$

[a] Peak torques in foot-pounds per 100 lbs of body weight
[b] Relative endurance at 180/s

Discussion

In this study we found a qualitatively impaired muscle function of the FMS patients and a generalized deconditioning, which might be due to fatigue, muscle damage, or psychological factors rather than pain. Patients with FMS were found to have reduced isokinetic peak torque especially at the low speed of quadriceps muscle when compared with healthy subjects. Although there is a trend for quadriceps muscle whereby peak torque decreases with increasing velocity [13], the decrease was lower in our FMS patients than in the control group. This can be explained by a reduced energy supply in initiating a standardized period of activation that might be due to pain, fear of pain, fatigue, or psychological status. The lower values of submaximal aerobic performance test in our FMS patients may also be related to this condition. Because in the submaximal bicycle ergometer test the individual is her own control, a gradually decreasing heart rate at a standard work rate stimulates the individual's efforts to maintain a given heart rate level, and these heart rate levels determine the test results. In our study, ergometer test results as an indirect estimation of submaximal aerobic performance were similar to the results of Norregaard et al. [6]. They found lower physical performance scores during an ergometer test in FMS patients than in control subjects and the maximal increase in heart rate was lower than the predicted values. The FMS patients in their study also exhibited a significant reduction in voluntary muscle strength of the knee and elbow flexors and extensors by 20–30%[6].

Jacobsen et al. [14] have shown that fibromyalgia patients have a lower isokinetic and isometric maximum voluntary muscle strength than expected. The maximum voluntary isokinetic and isometric strength of the quadriceps of FMS patients was reduced by 45% compared with that of the healthy controls, and the isokinetic strength deficit was proportional to the severity of the syndrome. They suggested that FMS patients with a large number of tender points had a significant reduction in isokinetic knee extension peak torque. In our study we could not find a statistically significant correlation between these parameters. Norregaard et al. [15] determined low quadriceps muscle strength in FMS patients, and they found a relationship between strength and muscle area in 15 FMS patients compared with 14 healthy controls. There are also other reports of reduced maximal voluntary force in both primary FMS and work-related myalgia [16, 17]. Studies comparing the muscle function in patients with FMS and chronic regional muscular pain have similar results with a reduction in isometric muscle strength and endurance greater in FM than in patients with regional muscular pain [18].

Lindh et al. [7] showed a markedly reduced maximal voluntary contraction of quadriceps muscle with normal muscular endurance values, but a superimposed electrical twitch on a maximal contraction revealed that all motor units were not recruited. They suggested possible mechanisms explaining such an inability might involve motivational factors, reflex inhibition due to pain or fear of pain, and an impaired central drive for activation [7]. Simms et al. [19] studied muscle energy metabolism in 13 FMS patients by using phosphorus magnetic resonance spectroscopy and found no difference between FMS and sedentary controls. Although we didn't analyze peak VO_2 values for maximal aerobic capacity, PWC-170 is a submaximal aerobic performance test and indirectly shows it. The deconditioned status of FMS patients is supported by the study of Benett et al. [20], who measured the aerobic capacity (VO_2 max.) of 25 patients. More than 80% of the patients were below the average of fitness compared with age- and gender-matched subjects of the general population. McCain et al. [21] evaluated the effects of cardiovascular fitness training on the manifestations of FMS and found a 25% improvement after a 20-week program over baseline cardiovascular fitness scores assessed by PWC-170. Sietsema et al. [22] demonstrated no abnormality in the overall rate and pattern of utilization of oxygen during muscular exercise in patients with FMS.

In the isokinetic test results of our study, the muscular endurance ratio was not found to be different from healthy subjects, similar to the studies of Elert et al. [16] and Lindh et al. [7]. As the level of muscular performance in the endurance test are related to maximal voluntary isokinetic contraction, the endurance can be assumed to be lower in FMS patients. Our results can be explained by the previous studies of Lindh et al. [7], in which they found a reduced degree of capillarization in the muscle biopsies of vastus lateralis muscles, as an indication of impaired adaptation to endurance activities in FMS patients. In contrast to our results, Jacobsen et al. [17] found a lower dynamic muscular endurance in FMS patients when compared with chronic myofascial pain syndrome, but they did not use a healthy control group.

In conclusion we found a reduced quadriceps muscle strength and submaximal aerobic performance in patients with FMS, indicating that patients have impaired muscle function compared with healthy control subjects. Physical inactivity, other than pain and psychological factors, may be responsible for these findings. Further studies are needed to investigate the mechanism of reduced muscle performance and the effects of aerobic exercise in this patient group.

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