

Changes in knee extension and flexion force, EMG and functional capacity during strength training in older females with fibromyalgia and healthy controls

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Objective. To investigate the effects of strength training on neuromuscular functions in elderly females with fibromyalgia (FM). **Methods.** Thirteen females with fibromyalgia [group FMt; mean age (s.d.) 60.2 (2.5) years] and 11 healthy controls [group HCt; 64.2 (2.7) yr] carried out supervised strength training twice a week for 21 weeks. Thirteen FM patients [group FMc; 59.1 (3.5) yr] served as non-training controls. Maximal isometric force and electromyographic (EMG) activity of the right quadriceps femoris in knee extension and flexion actions, maximal 10-m walking speed, and 10-step stair-climbing time were measured. Tender points were assessed by palpation, subjectively perceived symptoms with a visual analogue scale, and the self-reported physical function capacity by Health Assessment Questionnaire (HAQ).

Results. The mean (s.d.) increases in maximal extension force during the training period in groups FMt and in HCt were 32 (33)% ($P < 0.001$) and 24 (12)% ($P < 0.001$) respectively and those of flexion were 13 (20)% ($P < 0.05$) and 24 (17)% ($P < 0.01$). Explosive force of the extensors increased in both FMt and in HCt. The integrated EMGs of the vastus lateralis and medialis muscles increased in both FMt and HCt. Muscle forces and EMGs in group FMc remained at the basal level. Walking speed, stair-climbing time and the HAQ index improved in group FMt. The changes in the number of tender points and in perceived symptoms were in favour of the training group FMt.

Conclusions. The data support the hypothesis that elderly female FM patients have normal neuromuscular function. Supervised strength training also suits elderly FM patients, has positive effects on perceived symptoms and improves functional capacity without complications.

KEY WORDS: Fibromyalgia, Strength training, Neuromuscular adaptation, Women.

Fibromyalgia (FM) is a chronic non-inflammatory pain syndrome. [1–6]. The prevalence of FM is about 2% and increases with age [7]. Effects of physical training on FM have been studied mainly using aerobic exercise [8–9]. The role of strength training in the rehabilitation of FM patients is not well understood [8, 10–14]. Younger females with FM were similar to healthy women in their ability to improve their maximum strength, voluntary muscle activity and perceived symptoms by strength training [15].

Elderly FM patients usually have a long history of FM symptoms, which may hinder their ability to perform ordinary daily activities and may accelerate loss of condition in comparison with subjects undergoing healthy ageing. Our aims were to investigate, in elderly females with fibromyalgia and healthy control subjects, the effects of systematic strength training on (i) strength and voluntary neural activity of the unilateral knee extensor and flexor muscles, (ii) physical functional capacity, and (iii) subjectively perceived symptoms.

Materials and methods

Subjects

The healthy female controls (group HCt, $n = 10$) were recruited by flyers, and about 100 elderly female FM patients were sent an

informative letter via the Rheumatoid Arthritis Association of Central Finland and our out-patient clinic. About 60 patients agreed to participate in the study, but 20 volunteers were excluded on the basis of the answers. Forty volunteers were examined by a rheumatologist (PH). At this stage 14 patients were excluded because of unwillingness to cope with the study protocol or for medical reasons. The 26 patients who were included in the study fulfilled the 1990 American College of Rheumatology classification criteria for FM [1] and other inclusion criteria: age 55+ yr, no other disease except FM, no injuries and no experience of regular strength training exercise. The healthy subjects fulfilled the same criteria except for the FM diagnosis. The patients were allowed to use their individually tailored FM medications. All subjects were physically able to participate in normal daily activities. After inclusion, the FM patients were randomly allocated by draw to a training (FMt, $n = 13$) and a control (FMc, $n = 13$) group. All patients gave their informed consent in writing before inclusion and the Ethics Committee of the University of Jyväskylä approved the study.

Study design

All subjects had measurements taken twice before the training period (week -2 and week 0). Thereafter, FMt and HCt were

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Received 25 October 2002; revised version accepted 28 July 2003.

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assessed every 7th week (at weeks 7 and 14), and all study groups were assessed at the end of the trial at week 21.

Muscle strength measurements

The maximal voluntary isometric force and force-time variables of the right knee extensors (KE) and flexors (KF) were measured using a protocol similar to that used in our earlier study [14, 16]. Briefly, at least three trials were recorded, and the highest peak force [in newtons (N)] was taken for the analysis. The force-time analysis included the calculation of average force produced during the initial phase of the contraction up to 500 ms [17].

Electromyographic recordings

EMG activity during the KE and KF actions of the right knee was recorded from the vastus lateralis (VL), vastus medialis (VM) and biceps femoris muscles using an EMG method similar to one reported earlier [14, 16, 18]. EMG was analysed for the maximal peak force phase (500–1500 ms) of the isometric contraction and for the first 500 ms time period [17].

Measurements of physical functional capacity

Maximal walking speed (m/s) for 10 m and the time (s) taken to climb 10 stairs without hand-rails were measured with photocells. The fastest time out of three attempts in each trial was taken for the analyses. Self-reported physical functional capacity was assessed using the Stanford Health Assessment Questionnaire (HAQ) [19].

Tender points and subjectively perceived symptoms

Tender points were assessed by an experienced rheumatologist using palpation. Subjectively perceived pain, sleep quality, fatigue and general well-being were assessed with a 100 mm Visual Analogue Scale (VAS) [20] and mood by the Finnish short version of the Beck's Depression Index [21] before and at the end of the study period.

Strength training

The subjects trained twice a week for 21 weeks. All sessions (60–90 min in duration) were supervised. Each training session included two dynamic exercises for the leg extensor muscles and five or six other exercises for the other main muscle groups of the body. During the first 4 weeks the training included three sets with 15–20 repetitions for each set with light loads of 40–60% of 1 RM (one repetition maximum). Training continued during the next 7 weeks with four sets and 8–12 repetitions per set with loads of

60–70% of 1 RM. From week 12 onwards the sessions included three to five sets with 5–10 repetitions with loads of 70–80% of 1 RM. About 20% of the training for the leg muscles was performed as 'explosive' strength training, so that each repetition with light loads (40–50%, two sets, 8–12 repetitions) was performed as rapidly as possible. All subjects were allowed to continue their normal daily activities as earlier, to use their normal medication and to visit medical professionals if needed.

Statistical analysis

Standard statistical methods were used to calculate the mean and s.d. To determinate the effects of training, the data were analysed by multivariate analysis of variance with repeated measures (ANOVA) and probability-adjusted (Bonferroni) *t* tests were used for pairwise comparisons when appropriate. The differences between the groups at the baseline and the relative changes with training were tested using analysis of variance (ANOVA; one-way, with Bonferroni correction) with the criterion of $P < 0.1$. Otherwise the $P < 0.05$ criterion was used. The SPSS statistical program (SPSS, Chicago, IL, USA) was applied.

Results

All subjects, except one from the HCt group (personal reasons), were able to complete the scheduled training. Physical characteristics of the subjects are shown in Table 1.

Maximal isometric forces and integrated EMGs

The groups did not differ from each other at the baseline. During the 21-week training period maximal KE force increased by 24 (s.d. 12)% ($P < 0.001$) in group HCt and by 32 (33)% ($P < 0.001$) in group FMt. The maximum mean integrated electromyogram (IEMG) of the VL and VM muscles increased in groups HCt ($P < 0.001$) and FMt ($P < 0.001$), but remained unaltered in group FMc (Fig. 1). The change in KE force in group FMt ($P < 0.1$) and the EMG activity of the VL + VM in groups HCt ($P < 0.05$) and FMt ($P < 0.05$) was larger than that recorded for group FMc.

The maximal KF force in groups HCt and in FMt increased by 24 (17)% ($P < 0.01$) and 13 (20)% ($P < 0.05$) respectively. In group HCt, the training period also led to an improvement in the maximum IEMG activity of the biceps femoris [19 (26)%, $P < 0.05$]; the change of 26 (51)% in group FMt did not reach statistical significance. Nevertheless, the increase of maximal KF flexion force in both training groups was larger than that in group FMc (HCt vs FMc, $P < 0.01$; FMt vs FMc, $P < 0.1$). Neither of the experimental groups showed significant changes in the antagonist coactivation of the biceps femoris during KE during the control or training period.

TABLE 1. Demographic and anthropometric characteristics of the training (FMt) and control (FMc) patients with fibromyalgia and healthy training controls (HCt): mean (s.d.)

	FMt (n=13)		FMc (n=13)		HCt (n=10)	
	Before	After	Before	After	Before	After
Years since diagnosis	8.5 (4.3)		6.6 (4.1)			
Tender points	16.5 (1.8)	14.6 (2.5)**	15.6 (1.9)	15.8 (1.6)		
Age (yr)	60.2 (2.5)†		59.1 (3.5)††		64.2 (2.7)	
Weight (kg)	66.4 (8.8)	66.2 (8.5)	69.7 (9.7)	68.9 (10.6)	70.5 (6.1)	70.7 (5.3)
Height (cm)	159 (3.7)	161 (6.1)	162 (5.3)	162 (5.2)	160 (5.7)	160 (5.9)
Body fat (%)	35.4 (3.1)†	35.2 (3.3)	37.8 (3.1)	37.0 (4.0)	38.7 (1.6)	37.5 (1.7)*

* $P < 0.001$ between before and after; ** $P < 0.05$ between before and after; † $P < 0.01$ between FMt and HCt at baseline; †† $P < 0.001$ between FMc and HCt at baseline.

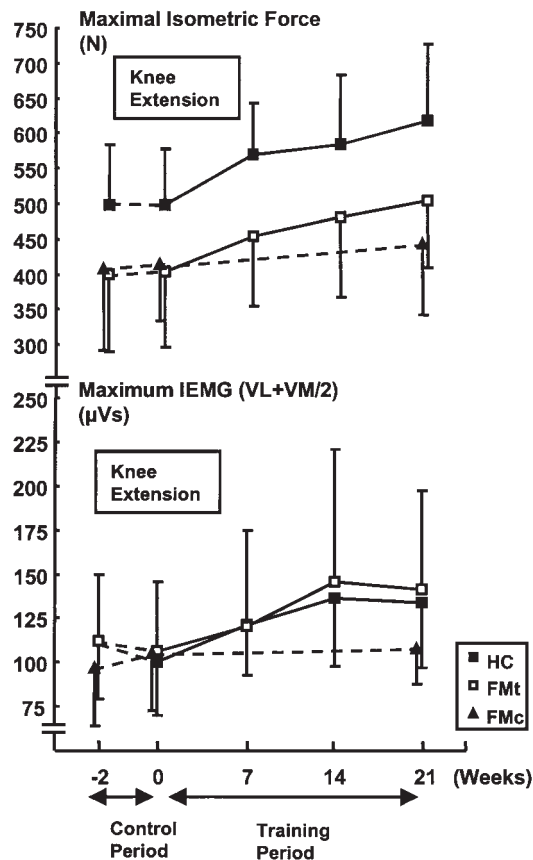


FIG. 1. Maximal isometric unilateral force [N; mean (s.d.)] and the mean maximum IEMG activity [μ Vs; mean (s.d.)] of the vastus lateralis (VL) and vastus medialis (VM) muscles in right knee extension in all study groups (HCt, healthy controls; FMT, fibromyalgia training patients; FMc, fibromyalgia control patients) during the 2-week control period and 21-week strength training period.

Explosive force and integrated EMG

The average force in KE during the initial 500 ms of action increased in groups HCt ($P < 0.05$) and FMT ($P < 0.01$) during the training period. The change in explosive force production was larger in group FMT than in groups HCt ($P < 0.1$) and FMc ($P < 0.01$). The 500 ms IEMGs of the VL ($P < 0.01$) and VM ($P < 0.01$) increased in group FMT throughout the training period, but only during the first 14 weeks of training in group HCt.

Physical functional capacity

During the training period, maximum walking speed improved in groups FMT ($P < 0.05$) and FMc ($P < 0.01$), but remained unchanged in group HCt (not significant). Stair-climbing time shortened significantly only in group FMT [from 3.61 (0.34) to 3.30 (0.33) s, $P < 0.01$] and the change differed significantly from that in group FMc ($P < 0.05$). The self-reported HAQ score in group FMT [from 0.5 (0.4) to 0.3 (0.2), $P < 0.01$], in contrast to that in group FMc [from 0.4 (0.5) to 0.5 (0.5), not significant], improved significantly during training.

Subjectively perceived symptoms and tender point counts

The number of tender points decreased ($P < 0.05$) during the experimental period in group FMT, while in FMc it remained

unaltered (not significant) (Table 1). The changes in perceived general health, sleep, fatigue, mood and pain showed a tendency towards improvement (not significant) in group FMT, while opposite changes were observed in group FMc.

Discussion

The present study showed that systematic strength training led to increases in isometric unilateral KE and KF forces and in the maximum EMG activity of the trained muscles in elderly patients with FM to the same extent as in elderly healthy subjects. Average explosive force production of the KE action also increased in both training groups and was accompanied by an increased average initial IEMG for the corresponding time period. Maximum walking speed, stair-climbing and self-reported function (HAQ) showed significant improvement after the training in group FMT. In group FMT the subjectively perceived symptoms of FM and the change in the number of tender points showed a tendency towards improvement.

The increases in maximum KE and KF forces, explosive force production [16, 22–24] and maximum IEMG of the VL and VM muscles [15–16, 22, 25] are in line with earlier studies using healthy elderly individuals and middle-aged FM patients as subjects and using a similar study design [25]. Antagonist coactivation was also similar between the groups and remained unchanged during training. Although the elderly FM patients had suffered from a variety of symptoms, such as pain and stiffness (causing inactivity), the present results support the view that the elderly FM patients had normal muscle function [3, 14] and a degree of trainability in the voluntary neuromuscular characteristics of muscles similar to that in younger FM patients and healthy subjects.

During the training period, a minor (non-significant) tendency towards improvement was seen in subjectively perceived symptoms of FM in the FMT group in comparison with untrained controls. It is noteworthy that, after the initial phase of training, the patients did not complain of any unusual exercise-induced pain or muscular soreness during the experimental period, and even intensive strength training did not worsen the symptoms. Endurance exercise has been shown to reduce the pain threshold of the patients [26–28]. In the present study, the tender point count in group FMT decreased significantly during the strength training. Although this change was minor, it is relevant clinically that FM patients can safely carry out strength training, which has been shown to have important health-related effects on body structure, function and metabolism [29].

The present FM groups improved their maximal walking speed, but only group FMT improved their stair-climbing time and functional disability, as assessed by the HAQ during the study period. The change in HAQ score was small, and it is possible that factors other than strength training, such as family and work, may have affected the improvement. This needs clarification. Nevertheless, strength training in the elderly population, even with pain syndromes, is probably very beneficial, e.g. with regard to protection from complications of falling.

The present study is one of the longest (21 weeks) and most carefully carried out exercise intervention studies in FM patients. However, this study has some limitations. First, subjects in the HCt group were significantly older than those in the FM groups. However, this should not be a major problem because the difference was only 4 yr and the two FM groups did not differ from each other. Secondly, the study groups were rather small and the results cannot be generalized to all age groups. Thirdly, the subjects used individually tailored medications designed by their physician, which might also have skewed the results relating to perceived symptoms. Fourthly, most of the subjects were able to work and participate in normal daily activities, which is quite usual in Finland among FM patients. Thus, these patients may

differ from patients in some other studies [30]. However, the subjects had the FM syndrome and the results showed clearly the normal trainability of the neuromuscular system in FM patients. Fifthly, the control subjects were measured only before and after the study period, which may have affected their motivation. However, the changes in neuromuscular function were so large that the possible lack of motivation in the FMc group does not explain these results, but it may have had some influence on perceived symptoms.

In conclusion, the present results indicate that the changes in neuromuscular function and the trainability of muscles were rather similar between the elderly FM patients and healthy women during the 21-week strength training period. The strength training had positive effects on symptoms and functional capacity. The clinically important conclusion is that FM patients can gain the same positive health-related long-term effects from strength training as healthy subjects [29]. Therefore, individually tailored, supervised strength training is a recommendable exercise for elderly patients with FM, and should be implemented in routine management programmes.

<i>Rheumatology</i>	Key Message
	Strength training is safe and improves neuromuscular function in FM.

Acknowledgements

This study was supported in part by grants from the Central Hospital of Central Finland; Kuopio University Hospital, Peurunka-Medical Rehabilitation Foundation and The Ministry of Education, Finland.

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