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MUSCLE STRENGTH, WORKING CAPACITY AND EFFORT IN PATIENTS WITH FIBROMYALGIA

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ABSTRACT. The objective of the study was to evaluate the physical capacity and effort in patients with fibromyalgia. Muscle strength and the coefficient of variation of the strength measurements of 181 female fibromyalgia patients and 126 healthy females were compared. These measurements and ergometer exercise capacity, work status and psychometric scoring (SCL-90-R) were correlated. The fibromyalgia patients exhibited significant reduction in voluntary muscle strength of the knee and elbow, flexors and extensors in the order of 20–30%. However, the coefficient of variation was higher among patients, thus indicating lower effort. The physical performance during an ergometer test corresponded to a maximal oxygen consumption of 21 ml/kg^{-1} x min^{-1}. The maximal increase in heart rate was only 63% (44–90%) of the predicted increase. Degree of effort or physical capacity did not correlate to psychometric scores. Work status was related to psychometric scoring, but not to physical capacity or effort. In conclusion, we found a low degree of effort but near normal physical capacity in the fibromyalgia patients.

Key words: aerobic capacity, fibromyalgia, muscle strength, psychometric scales, variation.

INTRODUCTION

Physical capacity and functioning are key factors in patients with fibromyalgia (31) as well as in other pain conditions. For legislative purposes, impairment of physical function is a very important, though difficult, parameter to evaluate. In fibromyalgia discordance between self-reported physical function and observed function has been found (13). In the general population muscle strength and aerobic capacity have been found to be markers of physical activity and to be trainable even in elderly subjects (11, 18, 27). Low physical activity for long periods of time would be expected to result in reduced physical capacity. Previous studies have shown that patients with fibromyalgia display lower voluntary grip strength (23, 24), and lower voluntary strength of the knee extensors and flexors and ankle plantarflexors (2, 16, 26). Normal strength was, however, reported in studies of shoulder flexors, trapezius and dorsal flexors of the ankle (9, 28). It has been suggested that muscle strength can function as a measure of disease impact (15). The lower voluntary muscle strength has been found partly attributable to lower central activation (17, 21). A reduction of the estimated "true" muscle strength has also been found, however (26). The discrepancies between the different studies could partly be due to differences in the selection of patients and also to differences between the muscle groups investigated.

Other studies have shown lower aerobic capacity and lower maximal heart rates (partly indicating poor effort) in patients with fibromyalgia, although this has not been found in all studies (3, 23).

A higher degree of anxiety, depression and somatization in patients with fibromyalgia has also been reported (4, 20). No studies have examined whether low physical capacity or effort during physical capacity determination are related to specific psychometric parameters or work status.

The primary aim of the present study was to compare muscle strength measurements in the flexors and extensors of the knee and elbow in a group of newly referred fibromyalgia patients with measurements obtained in a healthy control group. Examination of the intra-individual variation of the muscle strength measurements is a tool which can help, though not completely, in determining subjects with low effort during muscle strength measurements (19, 29). Accordingly, we used the intra-individual variation as a marker of the central activation during the measurements.

The second aim of our study was to examine the interrelationship between physical performance (voluntary muscle strength and ergometer performance), markers of effort (coefficient of variation of the muscle strength, heart rate increase during ergometer test), work status, self-reported symptoms and functioning and psychometric scoring (SCL-90-R) (8).

MATERIALS AND METHODS

The study was conducted at the Department of Rheumatology, Frederiksberg Hospital, Copenhagen, Denmark.

Referral of patients

The patients had been referred from throughout Denmark and were recruited over a two-year period. The majority had been referred by their general practitioner. The examination of patients with the referral diagnosis fibromyalgia, or the like, included an interview and a clinical examination by a doctor, muscle strength measurements, an ergometer test and questionnaires. Owing to limited resources at the Department of Clinical Physiology, the ergometer test was stopped after about one year. In a certain period of time patients were not given the questionnaires because of an administrative failure.

Interview and clinical examination

A standardized interview scheme was filled in by the doctor. It included questions on localization and duration of symptoms, other rheumatic, endocrine or psychiatric diseases, previous operations, and employment status.

The patients were also interviewed and examined for other diseases that might account for the pain. Blood tests to exclude the symptoms of fibromyalgia being attributable to other diseases included: erythrocyte sedimentation rate, blood cell count, thyroid hormone levels, creatine kinase, calcium, rheumatoid factor, anti-nuclear antibodies, and hepatic enzymes. The patients were objectively examined for tender points by doctors who had been instructed in correct tender-point examination (32). Of 307 examined patients, 283 were females, of whom 210 fulfilled the fibromyalgia criteria (32). Included in this study were 181 of the 210 patients (86%) who completed the muscle strength measurements.

Questionnaires

The patients were asked to fill in a questionnaire which included the SCL-90-R (8) and the Fibromyalgia Impact Questionnaire (FIQ) (5, 12). The SCL-90-R was sufficiently completed by 138 subjects (77%), the FIQ by 147 subjects (82%).

From the SCL-90-R, nine primary psychological dimension scores were calculated including somatization, obsessive-compulsive, interpersonal sensitivity, depression, hostility, phobic anxiety, paranoid ideation and psychoticism, and a Global Severity Index (8).

The FIQ is a health status questionnaire developed to determine physical function and symptoms in a standardized way. Function is assessed using 10 questions on daily activities (5), and it also includes six visual analogue scales (VAS) for pain, fatigue, fatigue in the morning, stiffness, anxiety and depression. The questionnaire was individually translated into Danish by three different medical doctors. This was followed by a discussion of the wording and retranslation into English for comparisons, after which final formulations were agreed upon.

The function items pertaining to yard work and car driving were only filled in by approximately 70% and were therefore excluded from the scoring. The other eight items were filled in by more than 95% of the subjects. The test-retest reliability in 30 patients who filled in the FIQ function score twice was $Rs = 0.90$ (unpublished results). The internal consistency of the function score in this population expressed by Chronbach's α was 0.90 (using the eight items).

Other questions

The patients also filled in a question on habitual physical activity (scored from 1–4) and a question on social life (scored from 1–5).

Ergometer test

An exercise test was performed on an electronically braked bicycle ergometer (33). An initial load of 25–50 watts (W) was used with stepwise increments every third minute until exhaustion. The initial load and the step increments were in most subjects 25 W, but in some the steps were larger (30–50 W). The ergometer test was performed in 126 patients. The maximal working performance was calculated using standard formula, e.g. if a subject exercised for 1½ minutes at the last level, the mean value of the two last levels was chosen (7). Using the assumption of an equal efficiency of 23%, the corresponding oxygen consumption was calculated according to the formula (7):

$$VO_2\,max(ml\ O_2 x\ kg^{-1} x\ min^{-1})$$
$$= 3.5 + [\text{Maximal performance (watt)} \times 13/\text{Weight(kg)}].$$

The estimated working capacity was calculated (using linear extrapolation), on assumption of a maximal heart rate of 220 minus age (33). The corresponding oxygen consumption was calculated using the formula. The relative heart rate increase was calculated as the actual heart rate increase divided by the expected increase.

Muscle strength

Isokinetic muscle strength was determined using a LIDO isokinetic dynamometer. Voluntary muscle strength of the flexors and the extensors of the knee was determined using angular velocities of 30 and 60°/s. Muscle strengths of the elbow flexors and extensors were measured using angular velocities of 30, 60 and 90°/s. At each speed three measurements were performed. The maximal peak torque of three repetitions was used in the calculations. For each angular velocity a coefficient of variation (CV%) was calculated as a mean of the variation of the torque at all angle positions (LIDO manual). The patients were measured on both right and left sides. The side where the individual subjects exhibited greater strength is that used in the calculations. For practical reasons the muscle strength test, ergometer test and the clinical examination (including interview and questionnaire) were performed on different days with up to four weeks in between.

Control group for muscle strength measurements

The control group for muscle strength measurements comprised 126 healthy female subjects. The subjects were randomly

Table I. *Voluntary muscle strength (VMS) in Nm (mean values and standard deviations in parentheses), and percentage coefficient of variations of the single persons (CV%) in patients and controls (median values)*

	Fibromyalgia			*Controls*		
	VMS	SD	CV%	VMS	SD	CV%
Knee 30°/s extension	94	(41)	14	115	(32)	6
flexion	48	(23)	14	64	(18)	7
Elbow 30°/s flexion	20	(8)	11	24	(6)	6
extension	16	(7)	12	21	(5)	6

All differences in VMS and CV% between fibromyalgia and controls were significant at $p < 0.001$ (Mann-Whitney).

selected from an epidemiological study (the Østerbro study) to establish a normative data material for voluntary muscle strength. The subjects were measured on the dominant side only.

Calculations and statistical analysis

Muscle strength has previously been found to be related to age, weight and height (1). We wanted to establish a model to predict muscle strength from these predictor variables in the control group of 126 females. A multiregression analysis was run on each of the different movements to examine this. Muscle strength was primarily related to age and weight and to a lesser, but still significant, extent to height and body mass index. The relationship to age could not be described simply as a linear relationship. As for the elbow movements, the muscle strength was almost constant up to the age of 50 years after which an almost linear decline could be observed. As regards the knee movements, the decline in strength with age was significant in the age group below 50 years, but the slope was approximately half of that observed in the age above 50 years.

To correct for this non-linearity, a transformed age parameter, was used in the model. For the arm movements, $age_{transformed}$ was defined as zero for ages below 50 years and for those above 50 years as age −50 (years). For the knee movements, the age minus 50 was transformed into two parameters in which value above and below 50 years was set at zero in each of the parameters, respectively.

The general model for the muscle strength for a $movement_{(m)}$ on a person (j) was: For the elbow:

$$\text{Muscle strength}_{m,j} = a_m + b_m{}^* \text{ weight}_j + c_m{}^* \text{ age}_{\text{transformed } j} + d_m{}^* \text{ height}_j$$

For the knee:

$$\text{Muscle strength}_{m,j} = a_m + b_m{}^* \text{ weight}_j + c_m{}^* \text{ age}_{<50j} + d_m{}^* \text{ age}_{>50j} + e_m{}^* \text{ height}_j.$$

This model was applied to the different movements. The adequacy of the different models was examined by analysis of the residuals. The residuals were found to be normally distributed, and were not systematically related to any of the background variables. The variation in the residuals was not related to the variables either. Inclusion of quadratic terms or the Body mass index did not increase the strength of the model. The parameters for the model (a–e_m) were determined for each movement. Hereafter a predicted muscle strength of both patients and controls was determined by the formula and a muscle strength index (MSI) was calculated as the actual muscle strength divided by the predicted muscle strength. For each movement (e.g. knee extension), a muscle strength index was calculated as the median of the MSIs at the different velocities and an overall muscle strength index ($MSI_{overall}$) was calculated as the median of the different movements. Similarly, an overall coefficient of variation ($CV\%_{overall}$) was calculated as the median of the CV%s.

Among patients, the muscle strength and the difference between the actual and predicted muscle strength were not normally distributed, primarily due to low effort in some subjects. The working capacity and the relative increase in heart rate was not normally distributed either. These distributions of the variables could not be normal by any simple transformation. Therefore, non-parametric analyses of the data (Mann Whitney and Wilcoxon tests) were performed, and these figures are presented as median values with the interquartile range in parentheses. Spearman's rank correlation coefficient r_s was used for correlation analysis. The software MINITAB release 10.5 for Windows was used for the calculations. A significance level of 2.5% was used. As the univariate analysis generally showed low or no significance, the multivariate non-parametric analysis was not applied.

RESULTS

Symptom duration of the 181 female patients included was 6 (3–14) years. The median age was slightly lower 47 (39–54) years in the fibromyalgia group vs 53 (36–68) years in the control group. The weights were similar 65 (57–73) kg in the patient group and 65 (59–73) kg in controls. The height was 164 (161–168) cm in the patients vs 163 (161–168) cm in controls.

Ergometer test

The maximal heart rate of the patients performing the ergometer test was 146 (123–160) min^{-1}. This corresponded to a heart rate increase of 63% (44%–90%) of the predicted maximal heart rate increase, given the assumption of a maximal heart rate of 220 minus age. The maximal performance corresponded to an estimated VO_2max of 21 ml $O_2 x\, kg^{-1} x\, min^{-1}$ (16–25). The estimated maximal aerobic capacity corresponded to an estimated oxygen consumption of 30 ml $O_2 x\, kg^{-1} x\, min^{-1}$ (24–39).

Table II. *Percentage muscle strength index of predicted in patients and controls. Median values and IQ range*

	Fibromyalgia		Controls	
Knee extension	78	(52–93)	101	(88–110)
flexion	70	(43–87)	100	(88–112)
Elbow flexion	79	(55–96)	99	(88–109)
extension	71	(51–87)	97	(88–110)
Overall	75	(49–89)	99	(91–109)

All differences between fibromyalgia and controls were significant at $p < 0.001$.

Voluntary muscle strength

In all four movements and at all angular velocities the muscle strength was significantly lower in the patients than in the control group (Table I). The CV% was also higher in patients—indicating lower effort. When corrected for age, weight and height (see methods), the muscle strength index (MSI) was still 20–30% lower in the patients than in the controls (Table II). In the patients the MSI of all movements was lower at the highest velocities (all $p < 0.001$).

Performance and other parameters

The ergometer performance did not correlate significantly to any variable or psychometric score.

In patients, $MSI_{overall}$ showed a significant, negative correlation to the $CV\%_{overall}$ ($r_s = -0.69$, $p < 0.001$) (Fig. 1). In controls there was no significant correlation. If the series in which the $CV\%_{overall}$ was more than 10% were excluded, the fibromyalgia patients ($n = 70$) would have had a lower ($p < 0.001$) $MSI_{overall}$ of 88% (82–100), compared with 99% (91–109) in the controls ($n = 124$). The $MSI_{overall}$ showed a significant correlation to self-reported physical function (FIQ) ($r_s = -0.35$, $p < 0.001$) and tender point count ($r_s = -0.24$, $p = 0.002$) but not to the psychometric scores.

Effort and other parameters

The effort during ergometer testing (the relative heart rate increase) only correlated significantly with age ($r_s = 0.38$, $p < 0.001$).

The CV% showed a significant correlation to FIQ function score ($r_s = 0.28$, $p = 0.001$) and tender points count ($r_s = 0.21$, $p = 0.006$) but not to any of the psychometric scales.

Work status

The work status was related to clinical characteristics in subjects below the age of 60 ($n = 160$). The group on early retirement pensions, subjects on sick leave and the unemployed were pooled in the group ''Not working'' ($n = 115$), and subjects with jobs or undergoing education were pooled in the group ''Working'' ($n = 45$). There was no difference in muscle strength index, CV%, ergometer performance, relative heart rate increase and estimated maximal capacity between those who were working and those who were not. Obsessive-compulsive score of the SCL–90-R was markedly lower in those working (indicating lower distress) when compared with those not working, 0.8 vs 1.5

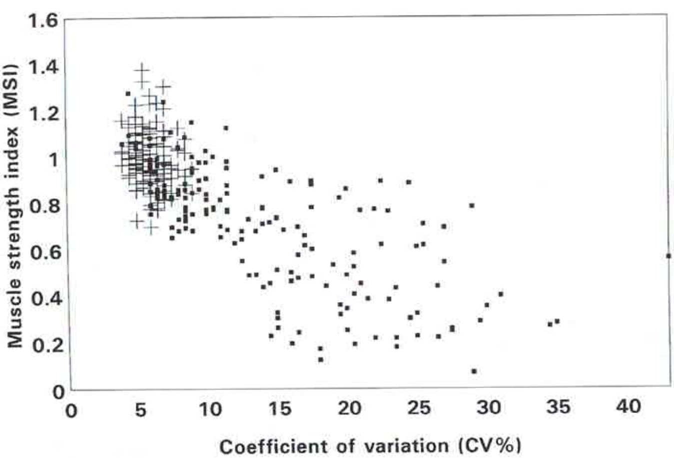

Fig. 1. Relationship between voluntary muscle strength index $MSI_{overall}$ and the $CV\%_{overall}$ in fibromyalgia patients and controls. ■ = Fibromyalgia, + controls.

respectively ($p<0.001$). FIQ function score was lower (better function) in those working—1.56 vs 1.75 in those not working ($p=0.004$).

DISCUSSION

In all joint movements measured, the voluntary muscle strength was found to be lower in fibromyalgia patients than in the controls. However, the difference between the patients and the controls only amounted to 20–30%. This difference is lower than the reduction of knee extension/flexion strength observed in previous studies (17, 26). The CV% was larger in the patient group than in the control group, indicating lower effort. Among patients a strong negative correlation was observed between muscle strength index and CV%. If subjects with a CV% of more than 10% were excluded, the muscle strength index would only be about 10% lower in the patients than in the healthy controls. The higher muscle strength in this study is probably due to changes in the referral of patients and shorter symptom duration. There was no correlation between the CV% and the psychometric parameters. This suggests that the lower central activation in some fibromyalgia patients (17, 21) cannot simply be attributed to psychopathology. The CV% correlated to the number of tender points but not to self-reports of pain.

Exercise performance and capacity were determined by ergometer testing. We found that the median maximal heart rate was only 63% of that expected. A relatively higher degree of effort could be observed in the eldest subjects. The maximal exercise performance was rather low, corresponding to an oxygen uptake of 21 ml $O_2 \times kg^{-1} \times min^{-1}$. If the patients had reached the expected heart rate, a median maximal oxygen consumption of 30 ml $O_2 \times kg^{-1} \times min^{-1}$ would have been the result. The estimated maximal aerobic capacities correspond to those found in normal sedentary subjects of the same age (25, 33). This estimation is based upon an assumption of equal maximal heart rates in the two groups. The maximal heart rate in fibromyalgia during exercise might, however, be smaller due to altered sympathetic reactivity (25, 30).

The absence of any significant correlation between self-reports of pain and the CV% of the muscle strength measurement or the maximal heart rate can be due to the fact that only the overall pain intensity was registered. Pain and exhaustion were not registered during the tests. Nor was pain registered in the specific muscle group tested.

Patients' reasons for early termination of the physical capacity tests are usually pain and general exhaustion (25). This exercise-induced pain and fatigue could partly be explained by an altered neuro-humeral reactivity during exercise (10, 30). Patients also often complain of deterioration in symptoms after light or moderate exercise, which has also been reported in experimental studies (25, 30). This exercise-induced, delayed soreness is, however, not followed by an increase in creatine kinase or myoglobin, as observed in the case of ''delayed onset muscle soreness'' after eccentric exercise (25). Long-term exercise studies have, however, suggested a beneficial effect of exercise training in fibromyalgia (14, 22). This effect could be due to an altered cerebral neurotransmission in response to long–term exercise training (6).

These findings on muscle strength and exercise capacity indicate that this group of fibromyalgia patients does not have a long history of low physical activity level.

Work status was not related to any of the objective measures of physical capacity (muscle strength or aerobic exercise capacity) or to markers of degree of effort. Only the obsessive-compulsive scale of the SCL-90-R showed markedly higher scores in non-working subjects (mostly receiving pensions). This scale consists of items pertaining to concentration difficulties, poor memory and other cognitive functions. Even though the temporal relationship has not yet been clarified, it might be that cognitive and psychological function is equally or more important for working ability as physical function and capacity (31).

In conclusion, we found low effort but near-normal physical capacity in our group of newly referred fibromyalgia patients. The low effort in some subjects could not be attributed to psychopathology as measured by psychometric scoring.

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