The Effects of a Physical Training Program on Patients With Osteoarthritis of the Knees

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ABSTRACT. Røgind H, Bibow-Nielsen B, Jensen B, Møller HC, Frimodt-Møller H, Bliddal H. The effects of a physical training program on patients with osteoarthritis of the knees. Arch Phys Med Rehabil 1998;79:1421-1427.

Objective: To investigate physical function in patients with severe osteoarthritis (OA) of the knees during and after a general physical training program.

Design: Randomized control trial, blinded observer, follow-up at 3 months and 1 year.

Setting: Outpatient clinic.

Patients: Consecutive sample of 25 patients (3 men, 22 women) with OA of the knees according to the criteria of the American College of Rheumatology (ACR). Two patients (8%) failed to complete the study. There were no withdrawals for adverse effects.

Intervention: Twelve patients received training in groups of 6, twice a week for 3 months. Training focused on general fitness, balance, coordination, stretching, and lower extremity muscle strength, and included a daily home exercise program.

Main Outcome Measures: Muscle strength across the knee (extension and flexion), Algofunctional Index (AFI), pain (0 to 10 point scale), walking speed, clinical findings.

Results: Patients participated in 96 of 96 assessments (100%) and in 218 of 280 training sessions (77.9%). From baseline to 3 months, isokinetic quadriceps strength (30°/sec) improved 20% (confidence interval [CI] $_{2\alpha = .05}$, 8% to 50%) in the least affected leg; isometric strength improved 21%. By 1 year, AFI had decreased 3.8 points ($CI_{2\alpha = .05}$, 1.0 to 7.0), pain had decreased 2.0 points ($CI_{2\alpha = .05}$, 0.0 to 4.0), and walking speed had increased 13% ($CI_{2\alpha = .05}$, 4% to 23%). There was an increase in the frequency of palpable joint effusions ($p < .01$) on the most affected side. Frequency of crepitus decreased on the least affected side ($p < .01$).

Conclusions: General physical training appears to be beneficial to patients with OA of the knee. As shown by the high compliance and low dropout frequency, such a program is feasible even in patients with severe OA of the knee.

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OSTEOARTHRITIS (OA) is a widespread, slowly developing disease, with a high prevalence increasing with age.[1,2] The most common large joints involved in the disease are the knees, where the disease is particularly disabling because of difficulty in rising from a chair, climbing stairs, kneeling, standing, and walking.[3] In a large study of a Dutch community, the maximum age-specific prevalence of severe radiological OA of the knee was 8.5% for men and 29.9% for women.[4]

The primary complaints of patients suffering from OA are pain, stiffness, instability, and loss of function. In addition to this, impaired muscle function is frequently observed in patients with OA of the hip or knee.[5,6] Ekdahl and colleagues[7] found that 80% of patients with knee or hip OA reported problems related to muscular function ie, muscle strength, endurance, and balance/coordination.

The success of joint replacement during recent years has to some extent changed the focus from the need for early effective medical treatment of OA.[8] Applied physical therapy mainly consists of the application of cold or heat, ultrasound, and shortwave therapy, instruction in joint use and maintenance of range of motion, supplying patients with canes or orthotic devices, and isometric exercises to prevent muscle atrophy.[3] In patients with light to moderate OA of the knees, regular strength exercise is possible and leads to improvement in muscle strength, endurance, and speed.[9] In patients with severe OA, strenuous strength exercise programs have not been applied, presumably on the assumption that they might be harmful to the knee. Another concern might be that pain could limit the outcome of such programs. The primary aim of the present study was to investigate whether patients with severe OA of the knee could undergo a physical training program despite their pain and disability. The secondary purpose was to evaluate the effect of the training program, based on general fitness, lower extremity muscle strength, agility, and balance and coordination.

MATERIALS AND METHODS

Patients

A total of 28 patients with bilateral complaints from knee OA were invited to participate in the study. Patients were recruited consecutively from the outpatient clinic on the basis of "first come, first served." Patients underwent an eligibility screening visit. To be eligible patients had to fulfill American College of Rheumatology (ACR) criteria for OA in the knee they appointed as the most affected knee, and the radiograph of this knee had to be rated at least 3 on the Kellgren scale.[10] All radiographic evaluations of knee changes were weight-bearing, performed with the patient standing. Twenty-four of the 28 patients were rated at least 2 on the Kellgren scale bilaterally. At the eligibility screening visit patients were evaluated by the physiotherapist to ensure that each patient was motivated for training. Following a thorough explanation of the training program the patient was asked directly if she or he was able and willing to participate in training sessions twice a week and also train at home. A test of physical function was performed to see

if the patient was able to get down on the floor and up again, which was necessary to participate in the exercise program. In addition the patient had to be capable of independent walking and transport and able to pass one flight of stairs unassisted to reach the training facilities. To obtain a starting point for the progressive strength training of the quadriceps, the number of straight leg liftings each patient could perform was measured.

Criteria for exclusion were: rheumatoid arthritis or other inflammatory joint disease, knee arthroplasty or planned knee arthroplasty in the study period, intra-articular steroid injection within 2 weeks of the screening visit, medical or surgical condition contraindicating training during the intervention period, malalignment of the knees (varus/valgus) larger than 15°, OA of the hip, recent (3 months) fracture of upper or lower extremity, lack of understanding of the study (dementia, language problems), neurologic illness (stroke, polyneuropathy), and abuse of drugs or alcohol.

Study Design and Assessments

The investigation was designed as a prospective, randomized, single-blind study (fig 1). At the eligibility screening visit patients underwent a preliminary assessment to accustom them to the assessment procedures. The results from this assessment were not used during analysis. A baseline assessment was performed 2 to 4 weeks later, and patients were randomized using a table of random numbers to either an intervention group (IG, $n = 12$) or a control group (CG, $n = 13$). The IG received training twice a week for 3 months in groups of six.

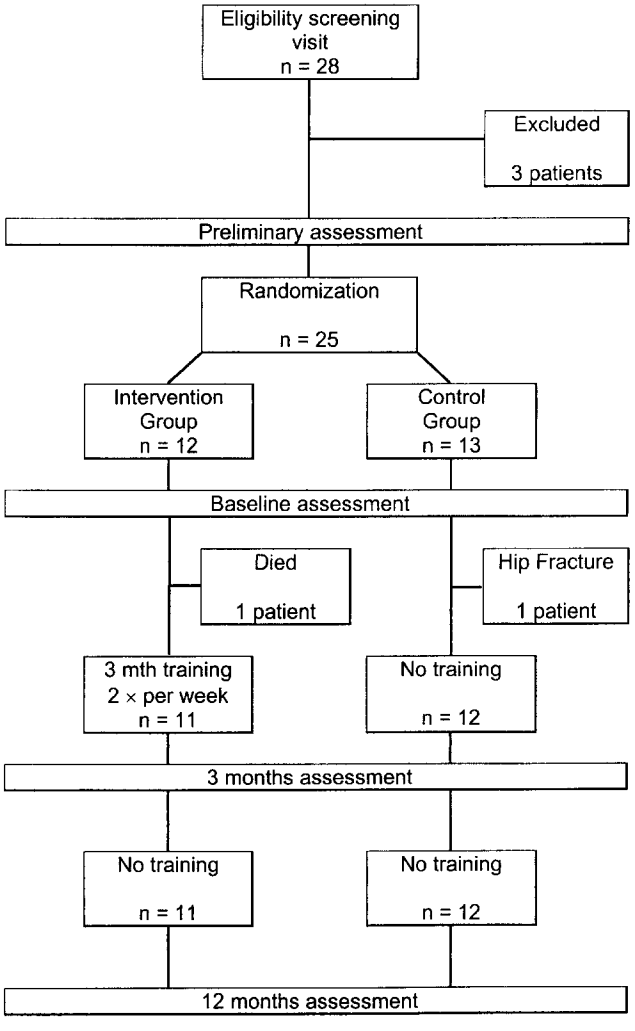

Fig 1. Patient flow chart.

The training was administered by a trained physiotherapist (BJ) and focused on mobility training, venous therapy, lower extremity and truncal muscle strength, flexibility of lower extremity soft tissue, and ability to balance and coordinate the body. Coordination exercises emphasized coordination between the ankle, the knee, and the hip on the most affected side. The mobility training and venous therapy were performed lying down. From the supine position the patients performed exercises moving the joints of the lumbar spine, hips, knees, ankles, shoulders, and elbows. All mobility exercises were performed against gravity at a constant pace to reduce venous pressure.

Muscle strengthening was performed by doing progressive repetetive exercises for quadriceps, hip adductors, hip abductors, hamstrings, gluteus maximus muscles, erector spinae muscles, and abdominal muscles. Hip adductor and abductor muscle groups were strengthened by having the patient lie down on one side doing straight leg lifting for the adductors and then for the abductors. Then they changed sides, doing exactly the same lifting. Abdominal muscles were strengthened lying supine doing sit-ups. Hamstrings, gluteus maximus, and erector spinae muscles were all strengthened lying prone on a hard training pillow: hamstrings by lifting both legs straight holding on to the top of the pillow, gluteus maximus by lifting one leg at a time with the knee in flexion, and erector spinae by having the physiotherapist hold the legs while the patient lifted the upper body. Progression was achieved by increasing the number of repetitions (starting number was 10), and for the hip adductors and abductors by applying weight to the patient's ankles. The quadriceps muscle was trained in three different ways. First supine with a straight leg lifting; then supine with a pillow under the knee placing it in approximately 15° flexion, from which the patient fully extended the knee; and finally standing on one leg while performing 20° flexion exercises of the weight-bearing knee. All patients were tested at baseline to establish how many repetitions of a straight leg lifting they could perform. Initial muscle strengthening was performed by having the patient do 70% of their individual ability three times during a training session. When this was possible after weeks of training a 2-kg weight was applied to the patient's ankle. A maximum of one progression was possible during this short period of time.

Flexibility was trained by doing stretching exercises for calf muscles, quadriceps, hip adductors, hamstrings, gluteus maximus, lower back muscles, and pectoralis major, with an emphasis on hip adductors because most patients were sore at pes anserinus of one or both knees. Balance and coordination was trained standing up, focusing on the anatomically right way of using the hip, knee, and ankle joints.

Once the patients were familiar with the exercise program, a written home exercise program was issued. This home exercise program consisted of exercises well known to the patient from the training sessions, with an emphasis on strengthening quadriceps, and stretching hamstrings, lower back, and hip adductors. The patients were asked to do the home exercise program once a day except for the 2 days per week when they attended a training session in the project. They were also asked to take a 1-day break per week. This was performed for the duration of the 3-month intervention. For the remainder of the follow-up period no training was performed, but it is unknown whether any of the patients continued with their home exercise program.

During the entire study patients were followed on a regular basis in the outpatient clinic of the department to monitor medication and therapy. As far as possible the medication was kept constant, apart from small changes in mild analgesics (acetaminophen). No intra-articular or periarticular injections were given during the entire study period. None of the patients reported participating in other exercise programs on a regular basis before or during the study, and while participating in the study none of the patients reported medical treatments elsewhere.

Follow-up was performed immediately after intervention (3 months) and after 1 year. All assessments were performed by blinded observers (HR, BBN). Each assessment included the following evaluations.

Overall evaluation. The Algofunctional Index (AFI) consisted of 10 questions regarding pain/discomfort, stiffness, maximum distance walked, and activities of daily living. The scores are summed into a single score (0 to 4, mild; 5 to 7, moderate; 8 to 10, severe; 11 to 13, very severe; and 14 or higher, extremely severe).[11]

Pain scores. Patients were asked to score night pain, weight-bearing pain, and pain at rest on an 11-point scale (0 = no pain, 10 = worst pain imaginable).

Clinical evaluation. Flexion deformities and range of movement of the knees bilaterally were assessed using a goniometer with the patient supine. Presence of crepitus, intra-articular effusions, heat, and rubor were noted.

Basic functional tests. A 20-meter walking time was assessed. The time to walk up and down one flight of stairs was noted; patients were permitted to use the handrail or walk backwards if necessary. Timed balance tests were given: bilateral one-legged stance, best of three attempts, maximum 60sec. The ability to rise from chair and sit down again without the support of the upper extremity was also assessed.

Postural sway. Posturography was carried out on a computerized force platform[a] in four 10-second test sequences of increasing difficulty: eyes open/stable platform; eyes closed/stable platform; eyes open/moving platform; eyes closed/moving platform. All measurements were performed under standardized conditions in a quiet room reserved for this purpose. The root mean square parameter sway index (SI) was chosen as the effect variable.

Muscle strength. Maximal isometric extension and flexion was measured at 90° knee angle and maximal isokinetic knee extension and flexion at angular velocities of 30, 60, 120, and 180°/sec across both knees using an isokinetic dynamometer.[b] Three repetitions were performed with the subjects sitting with a 90° hip angle maintained by the backrest of the dynamometer, with the lower leg attached to the lever of the dynamometer. Both thighs were immobilized by a strap, and subjects were not allowed to use their upper extremities. The maximal peak torque was chosen as the effect variable.[12]

Statistical Analysis

The data were analyzed as a two-way classification across time of treatment (baseline, 3 months, 12 months) and treatment group (IG, CG). This is a three-step process:

1. The effect of treatment regardless of time was analyzed by representing each subject by the mean value of the parameter at the three times of measurement. The treatment groups were then compared by a Mann-Whitney test, corrected for ties (or in the case of one-legged stance time by the median test because this parameter was measured on a scale with a maximum of 60sec).
2. The effect of time regardless of treatment group was analyzed on the basis of mean values of couples of subjects (one from the IG and one from the CG) at each time of measurement. These means were then compared across times of measurement by a Friedman test, corrected for ties. In case of a significant effect of time of measurement, each time of measurement was compared to the others with a correction for multiple comparisons.[13]
3. The interaction between time of treatment and treatment group was analyzed on the basis of the arithmetic difference between the IG and CG subject of each couple at each time of measurement. These differences were then compared across time of measurement by a Friedman test corrected for ties.

In addition each group was compared separately across time of treatment by a Friedman test, corrected for ties.

Differences between visits are given as the median of the relative change:

$$\frac{(\text{visit } 2 - \text{visit } 1)}{\text{visit } 1} \times 100\%$$

with confidence intervals calculated by the 1-sample Wilcoxon confidence interval procedure of Minitab 10Xtra.[c] Two-sided significance limits of $2\alpha = .05$ were used.

One patient randomized to the IG did not wish to participate in training after all, but participated in all assessments. This patient was included in the IG during analysis on an intention to treat basis.

Analysis was carried out on a personal computer[d] using a spreadsheet (Excel 7.0)[e] and statistics software (Minitab 10Xtra).[c]

Ethical Considerations

The investigation was approved by the local Ethical Comittee, and was in accordance with the Helsinki Declaration of 1975, as revised in 1983.[14]

RESULTS

Three patients were excluded before randomization. One withdrew consent after the initial evaluation by the physiotherapist, one was immobilized by severe acute back pain, and one was hospitalized because of severe burns. Twenty-five patients (3 men, 22 women) were randomized to the IG or CG. The gender skew was a matter of chance because the patients were enrolled consecutively. There were no reported treatment complications, and no patients dropped out because of adverse effects. After randomization one patient from each group dropped out prematurely for causes unrelated to the study. One fractured a hip, and one died of cancer, diagnosed after the inclusion in the study (fig 1). These two patients were excluded from analysis, constituting a dropout frequency of 8%. At baseline, the two groups were comparable with respect to age, gender, weight, height, body mass index, and severity of OA bilaterally (table 1). The median AFI corresponds to very severe/extremely severe OA.[11]

Patient compliance to the investigation was high: the IG and CG participated in 96 of 96 assessments (100%). The IG participated in 218 of 280 training sessions (77.9%). Of the 62 missed sessions the patient who did not wish to participate in training but was analyzed as intention to treat accounted for 24, the remainder participating in 85.2% of sessions (range 71% to 100%). Information on compliance with the home exercise program was insufficient for statistical evaluation.

Overall evaluation. There was an effect of time of measurement regardless of treatment group ($p < .01$), which was due to a decrease in median AFI from 13.5 at baseline to 10.5 at 1-year

Table 1: Baseline Comparison of the IG and CG

	IG	CG	Total
Patients	11	12	23
Right knee most affected*	7	5	12
Left knee most affected*	4	7	11
Bilateral OA on X-ray†	9	10	19
Gender			
Men	1 (9.1%)	1 (8.3%)	2 (8.7%)
Women	10 (90.9%)	11 (91.7%)	21 (91.3%)
Age, yrs			
Mean ± SD	69.3 ± 8.2	73.0 ± 6.5	71.2 ± 7.4
Range	50-77	63-83	50-83
Weight, kg			
Mean ± SD	73.7 ± 9.4	68.6 ± 9.5	71.0 ± 9.6
Range	63-90	50-83	50-90
Height, cm			
Mean ± SD	164.4 ± 7.0	159.7 ± 5.4	162.0 ± 6.5
Range	154-173	150-167	150-173
Body mass index, kg/m^2			
Mean ± SD	27.4 ± 4.0	26.8 ± 3.2	27.1 ± 3.5
Range	23-37	21-32	21-37
AFI			
Median (interquartile range)	13.5 (11.5-15.3)	13.5 (10.5-15.0)	13.5 (11.3-15.0)
Range	9.5-18	6.5-18.5	6.5-18.5

* Rated at least 3 on the Kellgren Scale.
† Rated at least 2 on the Kellgren Scale.

follow-up ($p < .01$) (table 2). This corresponded to an improvement in the IG from 13.5 at baseline to 10 at 1-year follow-up ($p < .05$), whereas no change was seen in the CG.

Pain scores. For pain at night there was an interaction between time of measurement and treatment group ($p < .01$) (table 2). This seemed to be caused by reduced pain in the IG and unchanged or increased pain in the CG although statistically significant changes within the groups could not be demonstrated. In the IG the median decrease in pain score was 1.0 ($CI_{2\alpha = .05}$, 0.0 to 2.0) at 3 months and 2.0 ($CI_{2\alpha = .05}$, 0.0 to 4.0) at 12 months. Similar, although not statistically significant, results were seen for weight-bearing pain and pain at rest.

Table 2: Overall Evaluation, Pain Assessment, Clinical Evaluation, Basic Functional Tests, and Computerized Posturography

	IG			CG		
	Baseline	3Mo	12Mo	Baseline	3Mo	12Mo
Overall evaluation						
AFI†	13.5 (11.5-15.3)‡	10.5 (9.5-13.8)‡	10.0 (7.8-11.3)‡	13.5 (10.5-15.0)	11.5 (8.8-14.0)	11.5 (6.0-14.1)
Pain (11-point scale)						
At night‖	4.0 (3.0-6.5)	3.0 (2.0-6.0)	2.0 (0.0-4.5)	5.0 (1.0-7.3)	4.5 (0.0-6.0)	6.0 (3.0-8.0)
At rest	5.0 (3.0-5.0)	2.0 (1.5-4.0)	3.0 (2.0-4.0)	4.5 (3.0-5.3)	3.5 (1.5-5.3)	4.0 (1.5-6.0)
Weight bearing	7.0 (4.5-7.5)	4.0 (3.0-5.5)	4.0 (3.0-6.0)	5.0 (5.0-6.5)	6.0 (4.8-7.3)	7.0 (4.0-7.5)
Clinical evaluation						
Range of motion, most affected knee (°)*	130 (125-135)	135 (130-140)	130 (125-138)	123 (114-130)	125 (120-130)	125 (119-136)
Range of motion, least affected knee (°)*	132 (130-135)	135 (133-138)	133 (128-138)	126 (124-130)	125 (125-131)	121 (114-128)
Basic functional tests						
Walking speed (m/sec)	1.18 (1.08-1.48)‡	1.18 (1.18-1.54)‡	1.33 (1.25-1.54)‡	1.25 (.98-1.45)	1.21 (1.11-1.57)	1.29 (1.05-1.67)
Stair climbing (sec)	24.0 (17.5-25.5)	24.0 (16.0-25.5)	25.0 (17.5-27.0)	21.5 (17.3-32.5)	23.5 (18.0-32.5)	24.0 (18.0-29.0)
Stance, most affected leg (sec)†	6.0 (3.5-19.5)	10.0 (4.5-40.5)	12.0 (8.0-37.5)	9.0 (2.0-12.3)§	20.0 (4.0-35.3)§	8.0 (4.0-21.0)§
Stance, least affected leg (sec)	7.0 (3.5-25.5)	10.0 (5.0-37.5)	9.5 (4.0-37.0)	13.0 (4.3-23.0)	12.5 (8.3-33.8)	12.0 (4.8-18.8)
Posturography (sway index, cm^2)						
Eyes open, stable platform	.34 (.33-.41)	.40 (.31-.50)	.42 (.34-.47)	.37 (.31-.44)	.34 (.31-.51)	.43 (.36-.49)
Eyes closed, stable platform	.59 (.44-.80)	.48 (.43-.63)	.64 (.59-.92)	.48 (.38-.55)	.43 (.34-.67)	.48 (.33-.71)
Eyes open, moving platform	1.44 (1.15-1.66)	1.20 (1.10-1.57)	1.71 (1.23-1.91)	1.34 (1.12-2.17)	1.49 (1.33-2.00)	1.54 (1.27-1.73)
Eyes closed, moving platform†	2.37 (1.98-2.93)	2.33 (2.11-2.56)	2.08 (1.75-2.21)	2.80 (1.88-3.14)	2.29 (1.74-2.87)	2.45 (2.09-2.59)

Values are presented as median (interquartile range).
* Difference between treatment groups regardless of time of measurement ($p < .05$, Mann-Whitney).
† Difference between times of measurement regardless of treatment group ($p < .05$, Friedman).
‡ Change over time within the intervention group ($p < .05$, Friedman).
§ Change over time within the control group ($p < .05$, Friedman).
‖ Interaction between time of treatment and treatment group ($p < .01$, Friedman).

Clinical evaluation. In the IG the number of knees with effusions in the most affected leg increased from baseline to 1-year follow-up, whereas this number decreased in the CG ($p < .01$). In the least affected leg of IG the number of knees with crepitus decreased from baseline to 1-year follow-up, whereas it increased in the CG ($p < .01$) (table 3). Range of motion was slightly larger in the IG than in CG in both the most affected ($p < .05$) and the least affected leg ($p < .01$). However, there was no interaction between time of measurement and treatment group and no change within either group across time. This greater mobility might therefore be a result of a small, systematic effect of randomization (table 2).

Basic functional tests. Walking speed improved within the IG from 1.18m/sec at baseline to 1.33m/sec at 1-year follow-up ($p < .05$) corresponding to a 13% improvement ($CI_{2\alpha = .05}$, 4% to 23%) (table 2). However, this finding is uncertain because it was not supported by the two-way analysis.

Postural stability. Postural sway in the most difficult test (closed eyes, moving platform) was reduced from baseline to 3-month follow-up regardless of treatment group. No differences between the IG and the CG could be established in any of the four test sequences.

Muscle strength. The most pronounced effects were seen for extension of the least affected knee. At an angular velocity of 30°/sec there was interaction between time of measurement and treatment group ($p < .05$) because of increased performance in the IG ($p < .05$) most pronounced at 3 months ($p < .05$) with a median improvement of 20% ($CI_{2\alpha = .05}$, 8% to 50%) (fig 2). Isometric extension of the least affected knee showed an improvement from baseline to 3 months ($p < .05$), but here the 21% median improvement in the IG at 3 months was not large enough to reach statistical significance ($p \approx .06$). On the other hand peak torque decreased by a median of 15% ($CI_{2\alpha = .05}$, 0% to 32%) from 3-month to 12-month follow-up in the CG ($p < .05$) (fig 3).

Table 3: Clinical Evaluation and Basic Functional Tests

	Affected Knee	IG (n = 11)			CG (n = 12)		
		Baseline	3Mo	12Mo	Baseline	3Mo	12Mo
Clinical evaluation							
Knee effusion	Most*	1	2	5	5	1	1
Knee effusion	Least	0	1	1	3	0	2
Crepitus	Most	11	10	9	10	11	12
Crepitus	Least*	10†	7†	4†	8	11	12
Heat	Most	0	0	2	1	1	0
Heat	Least	0	0	1	0	0	0
Flushing	Most	0	0	0	0	0	1
Flushing	Least	0	0	0	0	0	1
Flexion deformity	Most	6	6	6	10	6	5
Flexion deformity	Least	3	5	3	6	5	3
Basic functional tests							
Able to rise from chair without the assistance of the arms		11	11	11	10	9	9

Values listed are number of patients.
* Interaction between time of measurement and treatment group ($p < .01$, Friedman).
† Change over time within the intervention group ($p < .05$, Friedman).

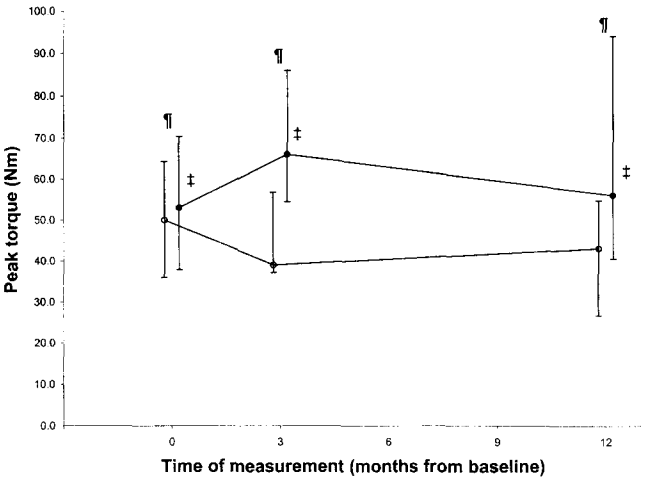

Fig 2. Maximum isokinetic peak torque (30°/sec), extension for the least affected knee in the IG (●) and the CG (○): medians and upper and lower quartiles at baseline, 3 months, and 12 months. ¶Interaction between time of measurement and treatment and group ($p < .05$, Friedman); ‡change over time within the intervention group ($p < .05$, Friedman), median improvement 20% ($CI_{2\alpha = .05}$, 8% to 50%) at 3 months.

Very similar torque-velocity relationships existed for flexion of the least affected leg (data not shown) with a 40% ($CI_{2\alpha = .05}$, 18% to 83%) improvement in peak torque at 30°/sec in the IG from baseline to 3-month follow-up.

For the most affected leg no obvious effects of the intervention were demonstrated (data not shown). There was a change over time in flexion at 30°/sec within the IG ($p < .05$), which is probably caused by a 25% improvement from baseline to 3-month follow-up, although this did not reach statistical significance when corrected for multiple comparisons.

DISCUSSION

Reduced balance, muscle strength, and flexibility in the elderly predispose them to falls and impaired quality of life.[15,16] This is accentuated in patients with OA of the lower extremities,

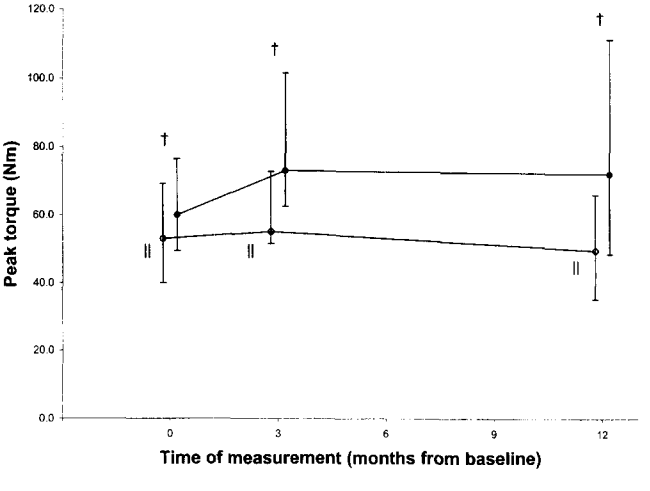

Fig 3. Maximum isometric peak torque, extension for the least affected knee in the IG (●) and the CG (○): medians and upper and lower quartiles at baseline, 3 months, and 12 months. †Change over time regardless of treatment group ($p < .05$, Friedman), median improvement 21% ($CI_{2\alpha = .05}$, 7% to 35%) at 3 months. ‖Change over time within the control group ($p < .05$, Friedman), median decrease 15% ($CI_{2\alpha = .05}$, 0% to 32%) at 12 months.

in whom joint instability and pain further limit functional capacity. Previous studies have shown patients with OA of the knees to have reduced muscle strength compared with normal subjects.[5,6] Jones and colleagues[17] found reduced quadriceps strength and increased postural sway in patients with self-reported OA compared with controls, and Ekdahl and colleagues[7] demonstrated considerably impaired functional capacity with a high frequency of self-reported muscle problems in patients with OA of the knee or hip. The clinical presumption underlying the study of exercise programs in patients with OA of the knees is that improving muscle strength in particular, and also coordination and flexibility, will improve functional capacity and reduce pain without causing deterioration of the disease despite the increased mechanical loading of joint tissues. The present study shows that it is possible to undertake such an exercise program in a group of patients with OA so severe that under normal circumstances they would be referred to an orthopedic unit for arthroplasty. The exercise program has some clinical benefit, although the finding of an increased number of knees with effusions after intervention might indicate that the intervention leads to increased disease activity.

The primary purpose of this study was to investigate whether it is possible for patients with severe OA of the knees to undertake a physical training program to improve muscle function. Previous work in this area has been reported by Chamberlain and colleagues,[18] who evaluated the effects of an exercise regimen in a study without a nontraining CG and demonstrated diminished pain, increasing function, maximum weight lift, and endurance after 4 weeks of intervention. These findings correspond well with the results of another study that did not use a nontraining CG, in which a 16-week rehabilitation program improved muscle strength and endurance by 35% and muscle speed by 50% in men with OA of the knees.[9,19] Apart from this work this aspect of physical therapy has not received much scientific attention in the treatment of OA, although probably most patients with OA, during some period, have participated in various exercise programs performed by physiotherapists or in a more general community setting. The subjects participating in our study were primarily female and a little older than the patients studied by Fisher and colleagues.[9,19] Most importantly they seemed to have more severe disease scoring a median 13.5 on AFI corresponding to very severe to extremely severe OA.[11] Despite their severe disability these patients showed a remarkable compliance both with the training program and with the evaluation protocol, participating in 77.9% of training sessions and 100% of the assessment sessions. The training sessions were not designed to improve compliance by attempting sozialization or otherwise, and no economic compensation was paid. The low drop-out frequency is very similar to earlier studies of the effect of training on patients with OA.[18-20] This might be because this group of patients normally is not seen on a regular basis, and the increased attention given during the study period in itself could improve compliance. This could also explain why the control group had such a high compliance to the assessment sessions. Indeed it should be emphasized that the control group in our study is by no means a non-IG, but rather a nontraining group, subjected to intervention in the form of increased attention, which might explain the fact that even the CG to some extent seemed to benefit from participation in the study.

The secondary purpose of this study was to evaluate the effect of the training program, being designed as a randomized trial with a blinded observer. The most pronounced effects were a 20% increase in muscle strength for extension and a 40% increase for flexion of the least affected knee at low angular velocities. In the most affected knee there was no clear effect. This is in contrast to the findings of Fisher and coworkers,[9,19] who found no differences between the two legs in the response to intervention. This could be because of the severity of OA in our subjects. However, it may be speculated that a true measurement of quadriceps strength is hampered by knee pain in patients with severe affections of the knees, thus making the interpretation of the data for the most affected knee particularly difficult.[21,22] Changes in muscle strength was most pronounced under isometric circumstances and at low angular velocities.

The effects of the intervention were not limited to increased muscle strength. Increased walking speed, decreased pain, and decreased AFI score were demonstrated. Interestingly, these effects were most pronounced at 12-month follow-up, whereas the changes in muscle strength were seen immediately after the intervention. This lag of some of the more functionally related parameters suggests that the effect of the intervention on these parameters might be indirect: the training program leads to greater muscle strength and perhaps to improved agility, which in turn permits a greater level of general physical activity in the months following the intervention. This increased activity might then lead to increased functional capacity and less reported pain up to 1 year after the training program. It cannot be ruled out that the benefits of the program may be from changes in general health status. Indeed, the beneficial effect of exercise need not be limited to the specific effects on the musculoskeletal system, but could also enhance the sense of general well-being or give opportunity for recreation.[23] It is, however, unlikely that altered medication or participation in additional physical treatment programs during the follow-up period could explain the effect seen at 1-year follow-up because this was discouraged and no such altered therapy was reported at the regular visits in the outpatient clinic.

The notion of a greater physical activity in the months following the intervention is supported by the finding of an increasing number of knees with clinical knee effusions in the most affected leg in the IG during the study period. Although the number of studied patients is low, we find that the data could indicate an increased disease activity in the IG during and after the training program, which might be a result of an increased general physical activity. Data from an experimental animal model of osteoarthritis have shown that regular exercise exacerbates the underlying arthritic lesions.[24] On the other hand, previous trials of exercise in groups of OA patients have given no indication of increased disease activity,[25] and moderate exercise has been deemed relatively safe in patients with knee OA.[26] The safety of exercise programs in patients with OA as severe as in our study remains to be clarified, and the possibility for adverse effects underlines the need that caution be observed. Further studies of the safety of exercise in OA are called for, with careful monitoring of disease activity during the trials.

CONCLUSION

It is possible to carry out a physical training program in patients with severe OA of the knees. The patients had a high compliance to the program. During training muscle strength increased, but this effect was not sustained at the end of the observation period. However, the IG was characterized by a lasting increase in functional level and decrease in pain at night. The training program may be accompanied by adverse effects such as knee effusions.

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Suppliers

a. Chattecx Balance System®, version 4.01; Chattanooga Group, Inc., 4717 Adams Road, Hixson, TN 37343.
b. Cybex 6000®; Lumex Inc., 81 Spence Street, Bay Shore, NY 11706.
c. Minitab Inc., 3081 Enterprise Drive, State College, PA 16801-3008.
d. 133mHz Pentium IBM, 1 Old Orchard Road, Armonk, NY 10504.
e. Microsoft Corporation, 1 Microsoft Way, Redmond, WA 98052.