The Effectiveness of Exercise Therapy in Patients with Osteoarthritis of the Hip or Knee: A Randomized Clinical Trial

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ABSTRACT. ***Objective.*** To determine the effectiveness of exercise therapy in patients with osteoarthritis (OA) of the hip or knee.

Methods. A randomized single blind, clinical trial was conducted in a primary care setting. Patients with hip or knee OA by American College of Rheumatology criteria were selected. Two intervention groups were compared. Both groups received treatment from the patients' general practitioner, including patient education and medication if necessary. The experimental group also received exercise therapy from a physiotherapist in primary care. The treatment period was 12 weeks. The main outcome measures were pain, medication use (nonsteroidal antiinflammatory drugs, NSAID) and observed disability.

Results. A total of 201 patients were randomized. Exercise therapy was associated with a reduction of pain in the past week (difference in change −17.0; 95% CI −23.6, −10.4) and observed disability (−0.19; 95% CI −0.38, −0.01). Effect sizes were medium (0.58) and small (0.28), respectively. No effect of exercise therapy was found for the use of NSAID. Additional beneficial effects ($p = 0.05$) were found for the use of paracetamol (effect size 0.33), global effect as perceived by the patient (effect size 0.68), and muscle strength of the hip (effect size 0.34).

Conclusion. After 12 weeks, exercise therapy is effective in reducing pain and disability. The size of the effects is medium and small, respectively. (J Rheumatol 1998;25:2432–9)

Key Indexing Terms:
OSTEOARTHRITIS EXERCISE THERAPY RANDOMIZED CLINICAL TRIAL

Osteoarthritis (OA) is a relatively common musculoskeletal disorder. The incidence in general practice in The Netherlands is 2.1/1000 per year for OA of the hip and 3.6/1000 per year for OA of the knee. Prevalence increases with age[1].

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The main symptoms of OA include pain and disability. OA in the lower extremities is a highly disabling condition, resulting in problems with mobility. Important therapeutic approaches include patient education, drug therapy, and physiotherapy[2,3]. In The Netherlands, a patient is referred to a physiotherapist in 15.1 and 22.4% of the episodes of care for OA of hip and knee, respectively[4]. In the 4 years after consulting their general practitioner, 40% of the patients are referred to the physiotherapist[5]. Physiotherapists often apply exercise therapy in their treatment of patients with OA[6].

Exercise therapy aims at reduction of pain and disability. This is achieved through improvement of muscle strength, joint stability, range of joint motion, and aerobic capacity. These functions are frequently impaired in patients with OA, presumably contributing to pain and disability[7]. Improving these functions is hypothesized to result in a reduction of pain and disability. In addition, exercise therapy aims directly at reduction of disability, e.g., through corrections of the walking pattern[8].

There is some evidence in favor of exercise therapy for patients with OA. Controlled trials have shown its beneficial effects on pain[9,10], level of physical activity[10], walking distance[10], stride length[11], movement times[9,11], self-reported disability[9,12], muscle strength[9,12,13], and aerobic capacity[9,14]. However, clear statements about the effectiveness are premature due to methodological flaws in several studies.

These include inadequate randomization, no blinded outcome assessment, and insufficient power[8,15]. Two trials with adequate internal validity[9-11] have been published. These trials have studied exercise therapy in a research setting, using a restricted range of exercises for each patient. In regular health care, exercise therapy is tailored to the patient's individual needs, and therefore a broad range of exercises is applied. Furthermore, these trials studied group treatment, instead of individual treatment, which is common in regular health care. Thus, there is a need for a high quality trial examining the effectiveness of exercise therapy in individual patients.

In the present study we examined the effectiveness of exercise therapy in individual patients with OA of the hip or knee. The effects of exercise therapy given by a physiotherapist are studied when added to a treatment by the general practitioner, consisting of patient education and medication if necessary. The hypothesis was that exercise therapy results in less pain, medication use, and disability.

MATERIALS AND METHODS

Study population. Patients were selected by general practitioners (GP) in the period from May 1994 to February 1996. The GP were situated in 4 cities and surrounding villages in the eastern part of The Netherlands. Inclusion criteria were OA of hip or knee according to the clinical criteria of the American College of Rheumatology[16,17]. Exclusion criteria were: other pathology explaining the complaints; complaints in less than 10 out of 30 days; treatment for these complaints with exercise therapy in the preceding 6 months; under 40 or over 85 years of age; indication for hip or knee replacement; contraindication for exercise therapy; contraindications for analgesics or nonsteroidal antiinflammatory drugs (NSAID); and inability to understand the Dutch language. After having orally consented, patients were registered and their names forwarded to the research team. Radiographs were obtained and evaluated by one of the authors (JAML) using grading scales (0–3) for individual radiographic features[18]. All patients were visited and their eligibility was checked by a GP research fellow (DB).

We aimed at 200 patients participating in the study (100 in each intervention group). This number of patients leads to a power of 0.80 to detect small to medium sized effects (effect size 0.4) with an alpha of 0.05 using a t test[19], with a magnitude similar to effects found in an earlier study[10].

Design. All eligible patients were asked to give written informed consent. Afterwards, patients were visited and randomly allocated equally to either exercise therapy or the control group, using sequentially numbered, opaque, sealed envelopes of the appropriate stratum containing the treatment assigned (see Figure 1). Randomization was performed by a research fellow. Patients were pre-stratified on their pain in the past week (visual analog scale, VAS, 0–30 vs 31–100 mm) and location of OA (hip or knee) to achieve comparability in these prognostic factors. Before patient enrolment started, a randomization list was prepared for each stratum on the principle of random permuted blocks of 4 patients, using a random number table[20]. Then, envelopes were filled, sealed, and numbered.

Interventions. Two interventions were compared. The patients in the exercise therapy group were given exercise therapy individually by a physiotherapist in primary care. In addition, their GP provided patient education (including a brochure), and medication if necessary. Treatment of the control group was restricted to treatment by their GP, as described above (patient education and medication if necessary). The treatment period was 12 weeks plus 24 weeks of followup.

Exercise therapy was given according to a written protocol[21], established by one of the authors (RABO) in cooperation with experts in the field. One protocol was developed for both hip and knee patients. It included exercises for muscle functions (strength and length), mobility and coordination, and exercises for elementary movement abilities and locomotion abilities. Also, instructions for the adaptation of activities of daily living and home exercises were given. Content and intensity of treatment were described in terms of treatment goals and corresponding exercises. For example, one possible treatment goal is improvement of muscle performance in terms of dimension and strength. Several starting positions and actions are described, such as stance on knees and steps with affected legs first, with full weight bearing. Content, intensity, and frequency of treatment were tailored to the patient's needs. Depending on the physiotherapist's diagnostic findings, specific treatment goals with corresponding exercises were chosen. The number of sessions per week was prescribed and this ranged from one to 3 times a week, depending on the pain level. As a main complaint in OA, pain was assumed to be an indication for the necessity to receive exercise therapy, and consequently for frequency of sessions.

Pain was assessed by VAS (0 mm no pain, 100 mm very severe pain). A physiotherapy session in primary care lasted about 30 min. Exercise therapy could be discontinued within the 12 week period if, according to the physiotherapists, treatment goals had been achieved. Physiotherapists were trained to use the protocol in 2 meetings by reviewing content and discussing and practising exercises.

A protocol was also used for the prescription of medication. The GP prescribed preferably paracetamol; NSAID prescribed were restricted to naproxen, diclophenac natrium, and ibuprofen (see Appendix for medication schedule). The patient was instructed to use as little medication as possible. The GP also provided patient education, using a brochure; the topics covered in the brochure include diagnosis, prognosis, advice concerning rest, daily activities and diet, the use of aids, and medical treatment. Patients consulted their GP at least twice, at Week 0 and Week 12, and further on the patient's initiative. Physiotherapists and GP recorded detailed information about the actual treatments on standardized forms, including any deviation from the protocol.

Outcome assessment. Primary outcome measures were pain in the past week, use of NSAID, and observed disability. Patients rated their pain in the past week on a VAS. The use of NSAID was based on prescription data and counts of remaining medication during evaluation sessions. Observed disability was determined by studying videos of the patients' performance in a series of standardized tasks using an adaptation of the method described by Kecfe[22,23]. The tasks included walking, sitting down, bending, and reclining. Both movement times and quality of performance were assessed. The interobserver reliability of this method is good[23-25]. A total score was calculated based on 5 measures: 5 m walking time, stand-to-sit time, stand-to-recline time, and the levels of guarding and rigidity during performance of the tasks. Standardized scores (Z scores) of separate measurements were calculated and summed to obtain an overall score. To enhance comparability, the resulting overall score was standardized to render a score with a mean of zero and a standard deviation of one[26]. The internal consistency of the constructed overall score was good ($\alpha = 0.84$)[27].

Several secondary outcome measures were included to study the working mechanisms of exercise therapy in OA. These measures include pain at assessment as rated on VAS; pain in the past month with the IRGL questionnaire (Influence of Rheumatic Disease on General Health and Lifestyle)[28]; use of paracetamol assessed the same way as use of NSAID; global perceived effect as assessed by the patients themselves on an 8-point scale (1 vastly worsened; 8 completely recovered)[29]; self-reported disability with the IRGL questionnaire[28]; muscle strength of the hip and knee bilaterally measured with a hand-held dynamometer[30]; assisted active range of joint motion of the hip and knee bilaterally measured with a goniometer[31]; level of physical activity (excluding hobbies) measured using a questionnaire[32]; extent to which patients believe physical activity affects their pain, measured using an adaptation of the Fear-Avoidance Beliefs Questionnaire[33]; and functional limitations on rising and sitting down measured with a questionnaire on rising and sitting down[34]. Overall scores were deter-

mined for muscle strength of the hip and knee and range of joint motion of the hip and knee[26] (see Table 1 for separate measurements). The procedure was comparable to data reduction in observed disability (mean 0, SD 1). (For further details on outcome assessment, see Baar *et al*[26]).

Patients were evaluated by a blinded research assistant at baseline and at 12 weeks (post-treatment). Patients were also assessed in Week 24 and 36 (followup); followup results will be presented elsewhere. The research assistants had been trained to perform the measurements in a standardized manner. The evaluations took place in local health care centers.

Because of the kind of intervention, patients and physiotherapists could not be blinded for the assigned treatment. GP were blinded concerning whether the patient received exercise therapy. In addition, the researcher who performed data analyses was blinded until the main analyses and decisions concerning cutoff points for subgroups were made.

Statistical analysis. Analyses were performed according to the intention-to-treat principle[35]. Patient data were analyzed in the intervention groups to which they had initially been assigned. This included withdrawals and patients not treated by the assigned treatment. In addition, a per protocol analysis was performed excluding patients with deviations from the treatment protocol and late ineligibles.

To analyze the effects, change scores were calculated by subtracting the baseline scores from the post-treatment scores. With regard to medication use and global perceived effect, post-treatment scores were compared because no change scores could be calculated. The scores on global perceived effect were dichotomized to study the number of improved patients. In the analysis, the change (or post-treatment) scores were compared between interventions. Two multivariate analyses (MANCOVA) were performed to test for overall differences between the intervention groups: one on the primary outcome measures (see Table 2) and one on the secondary outcome measures (see Table 3). Subsequently, univariate tests were performed using analysis of covariance (ANCOVA). Adjusted analyses were performed. The baseline level of each outcome measure was included to improve the precision of the effect estimates. In addition, medication use and fear avoidance beliefs, the measures on which the groups differed at baseline ($p < 0.10$), were included as covariates in order to control for baseline differences. Group differences and 95% CI were calculated for all outcome measures. In addition, effect sizes were calculated by taking the difference between the change scores of the intervention groups and dividing it by the standard deviation of the change score of the total population. An effect size of 0.2 was regarded as small, 0.5 as medium, and 0.8 as large[19].

To study whether differences existed in the effects of exercise therapy between OA of the hip or knee, the interactions between location of OA (hip yes/no and knee yes/no) and treatment was tested by ANCOVA. This analysis was restricted to primary outcome measures. Analyses were carried out using SPSS/PC+ 5.0.

The study protocol was approved by the ethics committee of the Maastricht University Hospital (Maastricht, The Netherlands).

RESULTS

Participants. Figure 1 shows patient flow and followup to Week 12. For 13 patients treatment deviated from the study protocol. For 5 patients exercise therapy was terminated within 6 sessions. Reasons were comorbidity not related to OA (n=4) and the patient's decision to stop after additional medical information (n=1). Two patients receiving exercise therapy were given co-interventions, i.e., physical modalities for pain reduction. One patient underwent an intervention by a medical specialist (corticosteroid injection). Five patients receiving the control treatment were given physiotherapy, including exercise therapy. In two of these the decision was based on worsening of complaints. In addition to treatment deviations, one ineligible patient was withdrawn immediately after randomization.

Three patients (2 patients receiving exercise therapy and

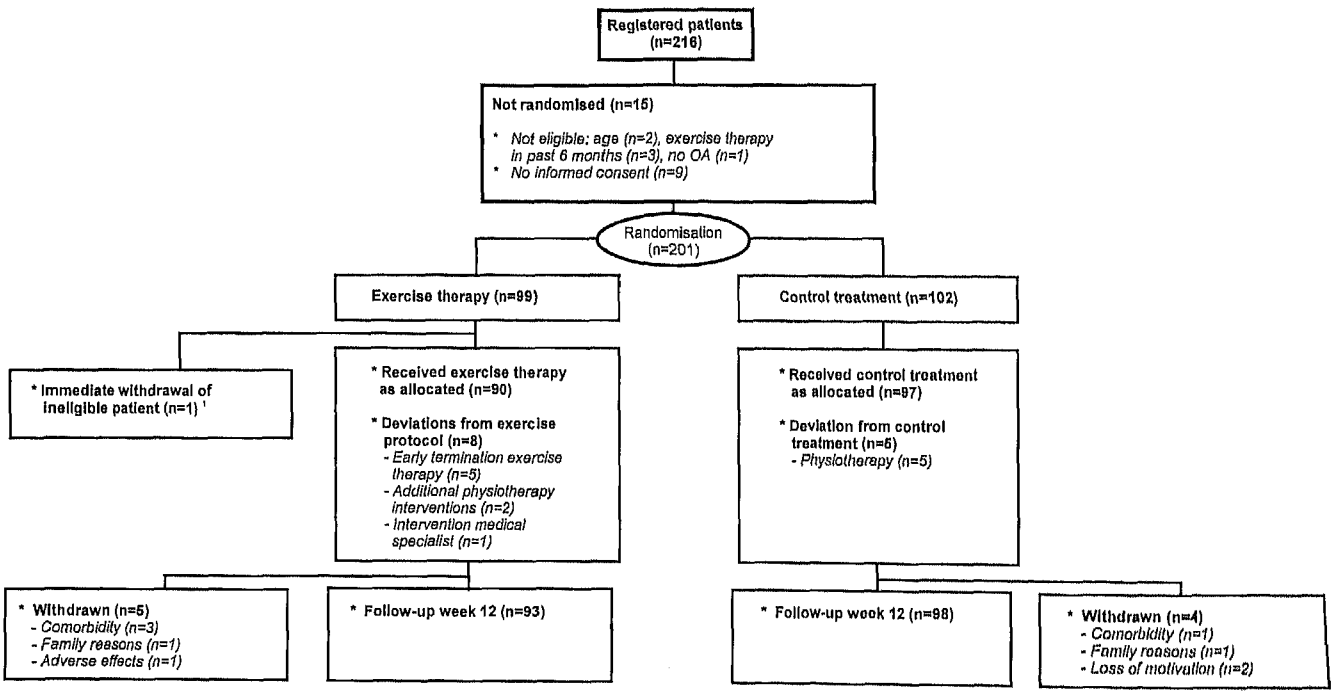

Figure 1. Study overview from registration to followup at Week 12. [1] One patient allocated to exercise therapy was withdrawn because of ineligibility due to additional medical information (ESR > 45 mm/h) immediately after randomization (within 3 days before starting therapy). This patient was excluded from the study.

l receiving the control treatment) were labelled as late ineligibles with the following diagnoses: spinal stenosis, polymyalgia rheumatica, and hernia nuclei pulposi. The number of withdrawals and reasons for withdrawal were similar in both treatment groups. One patient receiving exercise therapy reported adverse effects (deterioration of complaints) and withdrew after 6 weeks of therapy.

Comparability. The baseline characteristics of patients in the 2 intervention groups were generally similar, with 2 exceptions (Table 1). Patients allocated to exercise therapy reported a higher use of medication in the 7 days preceding participation in the study and scored higher on fear avoidance beliefs concerning activity.

Treatment. Forty-three GP from 40 practices and 39 physiotherapists from 29 primary care practices were involved in treatments. The mean number of GP consultations in control patients (1.8, SD 0.9) was higher than in exercise therapy patients (1.6, SD 0.7, $p = 0.03$). The mean number of physiotherapy sessions was 16.8 (SD 7.0) in exercise therapy patients and 0.6 (SD 2.8) in control patients. (In primary care a session lasts about 30 min.) Exercise therapy was mainly directed towards improvement of muscle strength, improvement of range of motion, and reduction of pain. These treatment goals were chosen by the physiotherapist in 93, 85, and 80% of all treatments. In 59% of treatments, treatment was focused directly on improvement of walking and other activities. Applied exercises were mainly active exercises and assisted active exercises: these exercises were applied in 98 and 84% of all treatments. Most patients reported they adhered to the home exercise program: 61 patients reported to exercise "frequently" or "very frequently." In addition, 18 patients reported to exercise regularly (not further defined).

Success of blinding. The success of blinding of the outcome assessors was checked. In 56 patients (36 patients receiving exercise therapy and 20 control patients) the assessors reported disclosure of treatment allocation. No relation between disclosure and outcome assessment was found. The effectiveness of exercise therapy in unmasked patients was comparable to the effects in patients with a successful blinding: the statistical interaction of disclosure (yes/no) and outcome assessment was not significant ($p = 0.66$ for pain past week, $p = 0.08$ for taking NSAID, and $p = 0.58$ for observed disability).

Outcome. MANCOVA indicated a significant overall difference ($p < 0.001$) between the intervention groups on the primary outcome measures at 12 weeks (post-treatment). The results of the separate primary outcome measures are shown in Table 2. Univariate analyses comparing exercise therapy with the control group showed beneficial effects of exercise therapy on pain in the past week and on observed disability. No effect of exercise therapy was found for the use of NSAID. The effect sizes indicate that exercise therapy was associated with a medium effect on pain and a small effect on observed disability.

Similarly, MANCOVA on the secondary outcome measures at 12 weeks indicated a significant overall difference ($p < 0.001$) between the intervention groups. The results of the univariate analyses regarding the secondary outcome measures are shown in Table 3. Beneficial effects of exercise therapy were found on 2 additional pain measures (pain at assessment and pain past month), use of paracetamol (i.e., a reduction), global perceived effect, and muscle strength of the hip. No effects were found for the other outcome measures (8 of 13). In a per protocol analysis, similar effects were found for both primary and secondary outcome measures.

The effectiveness of exercise therapy was similar in patients with OA of the knee and patients with OA of the hip. No significant interactions were found between location of OA (hip yes/no and knee yes/no) and effectiveness of the interventions: the statistical interactions with the primary outcome measures were not significant (hip: $p = 0.42$ for pain past week; $p = 0.99$ for taking NSAID, and $p = 0.12$ for observed disability; knee: $p = 0.31$ for pain past week, $p = 0.83$ for taking NSAID, and $p = 0.44$ for observed disability).

DISCUSSION

In this trial evidence was found for the effectiveness of exercise therapy in patients with OA of the hip or knee. Patients were treated individually; exercise therapy was tailored to the patient's individual needs. As expected, beneficial effects were found for pain and observed disability. In addition, beneficial effects were found on the use of paracetamol (reduction), global effect as perceived by the patient, and muscle strength of the hip. The magnitude of the effects was medium for pain and for global perceived effect, and small for the other effects. No effects were found for one primary outcome measure (use of NSAID) and 8 secondary outcome measures, including self-reported disability and joint range of motion. In conclusion, exercise therapy reduces pain and disability in patients with OA of the hip or knee. The size of the effects is medium to small, respectively.

The clinical relevance of our results can be determined using the calculated effect sizes. In one study, an effect size of 0.5 is considered as the threshold for minimal clinical importance (unpublished observation). Using this cutoff point, our beneficial effects on pain and global perceived effect can be considered clinically relevant. The effect on observed disability does not exceed this arbitrary cutoff point. In another study a difference in the success rate of 25% between groups is considered to be clinically relevant[36]. Using this criterion, the effect as perceived by the patient is clinically relevant.

We tried to avoid methodological flaws described in several previous studies[8]. Appropriate randomization was per-

Table 1. Comparability of intervention groups concerning prognostic variables and outcome measures[a].

	Exercise Therapy, n = 98	Control, n = 102
Sex (female)	76 (78%)	81 (79%)
Age, yrs[b]	68.3 (8.4)	67.7 (9.2)
Comorbidity	63 (64%)	62 (62%)
Location of OA		
Knee	58 (59%)	61 (60%)
Hip	36 (37%)	35 (34%)
Both	4 (4%)	6 (6%)
Duration of complaints, yr		
≤ 0.5	34 (35%)	42 (41%)
0.5 ≤ 1	13 (13%)	12 (12%)
1 ≤ 5	29 (30%)	25 (25%)
> 5	22 (22%)	23 (23%)
Radiological OA (score ≥ 1)		
Joint space narrowing	62 (69%)	55 (60%)
Osteophytes	65 (72%)	65 (71%)
Previous medical treatment	59 (61%)	64 (64%)
Pain		
Past week[b]	46.9 (27.7)	43.1 (26.8)
At assessment[b]	34.0 (27.2)	28.7 (26.0)
Medication past week*		
Paracetamol	51 (52%)	39 (38%)
NSAID	34 (35%)	23 (23%)
Observed disability		
5 m walking time,[c]	4.9 (4.3, 6.0)	5.0 (4.3, 6.0)
Sit time, s[c]	3.4 (2.9, 4.1)	3.4 (2.9, 4.0)
Recline time, s[c]	6.9 (5.4, 9.0)	6.1 (5.1, 7.9)
Guarding (0–1)[b]	0.58 (0.48)	0.53 (0.50)
Rigidity (0–1)[b]	0.34 (0.38)	0.33 (0.37)
Self-reported disability (IRGL) (–28 – –7)[b]	–20.0 (5.8)	–20.6 (5.4)
Muscle strength, Newton[b]		
Flexion hip	162.4 (56.8)	164.8 (58.4)
Extension hip	109.3 (52.7)	108.7 (51.1)
Abduction hip	172.7 (57.5)	168.4 (60.3)
Adduction hip	138.7 (55.2)	137.3 (58.3)
Endorotation hip	126.4 (44.0)	117.8 (40.8)
Exorotation hip	102.6 (34.4)	97.1 (30.4)
Flexion knee	90.4 (32.9)	89.1 (31.7)
Extension knee	163.1 (50.2)	156.1 (52.2)
Joint range of motion, degrees[b]		
Flexion hip	115.4 (10.5)	115.4 (11.7)
Extension hip	1.5 (6.5)	2.9 (7.5)
Abduction hip	17.4 (6.0)	18.0 (6.4)
Adduction hip	12.1 (4.2)	11.9 (3.5)
Endorotation hip	28.9 (9.2)	29.0 (8.6)
Exorotation hip	34.7 (8.6)	34.6 (8.7)
Flexion knee	136.0 (9.8)	136.6 (9.4)
Extension knee	–0.1 (4.6)	–0.0 (4.7)
Physical activity in min/week[b]	1699 (897)	1829 (1119)
Fear avoidance beliefs towards physical activity (0–24)[b]	14.6 (5.9)	13.1 (6.7)
Questionnaire rising and sitting[b]		
High chair, on toilet, and bed (0–10)	3.0 (2.6)	2.7 (2.6)
Low chair and car (0–10)	5.5 (3.3)	5.0 (3.2)

*Difference between intervention groups, p ≤ 0.10.

[a]Missing values: Comorbidity (in exercise therapy, 2 in controls); Duration of complaints (2 in exercise therapy, 6 in controls); Radiological OA (7 in exercise therapy, 12 in controls). Previous medical treatment (1 in exercise therapy, 2 in controls); Self-reported disability (1 in exercise therapy); Muscle strength, hip (2 in controls). Physical activity (3 in exercise therapy, 1 in controls). Questionnaire rising and sitting (1 in exercise therapy). [b]Mean (sd). [c]Median (interquartile range: 25th, 75th percentile).

Table 2. Primary outcome measures: improvements and differences between intervention groups[a].

Outcome Measure	Exercise Therapy n = 93	Control n = 98	Difference (95% CI) Exercise Therapy vs Controls	p	Effect Size
Pain past week	−22.8	−5.7	−17.0 (−23.6, −10.4)	< 0.01	0.58
Medication use:					
taking NSAID	39 (42%)	35 (36%)	6% (−8%, 20%)	0.38	0.12
Observed disability[b]	−0.21	−0.02	−0.19 (−0.38, −0.01)	0.04	0.28

[a]Analyses are adjusted for baseline differences (fear avoidance beliefs towards physical activity, use of paracetamol, use of NSAID) and baseline score on the specific outcome measure.
[b]Missing values: 2 in exercise therapy.

Table 3. Secondary outcome measures: improvements and differences between intervention groups[a].

Outcome Measure	Exercise Therapy, n = 93	Control, n = 98	Difference (95% CI), Exercise Therapy vs Controls	p	Effect Size
Pain at assessment	−10.5	0.7	−11.2 (−17.7, −4.7)	< 0.01	0.40
Pain past month[b]	−4.3	−1.9	−2.5 (−3.4, −1.5)	< 0.01	0.61
Medication use:					
Taking paracetamol	33 (35%)	50 (51%)	−16% (−29%, −3%)	0.02	0.33
Global perceived effect					
improved[c]	44 (47%)	18 (18%)	28% (15%, 42%)	< 0.01	0.64
Self reported disability	−1.1	−0.0	−1.1 (−2.3, 0.1)	0.07	0.26
Muscle strength[b]					
Hip	0.22	0.04	0.17 (0.02, 0.33)	0.03	0.32
Knee	0.19	0.06	0.13 (−0.04, 0.29)	0.14	0.22
Joint range of motion[b]					
Hip	0.21	0.06	0.15 (−0.03, 0.32)	0.10	0.23
Knee	0.17	0.09	0.08 (−0.09, 0.25)	0.37	0.13
Physical activity[b]					
improved[d]	43 (46%)	47 (48%)	−2% (−17%, 13%)	0.80	0.04
Fear avoidance beliefs towards					
physical activity	−1.2	−0.2	−1.1 (−2.9, −0.8)	0.25	0.15
Questionnaire rising and sitting[b]					
High chair, toilet, and bed	−0.1	−0.0	−0.1 (−0.7, 0.4)	0.61	0.08
Low chair and car	−0.2	0.2	−0.4 (−1.1, 0.3)	0.28	0.16

[a]Analyses are adjusted for baseline differences (fear avoidance beliefs towards physical activity, use of paracetamol, use of NSAID), and baseline score on the specific outcome measure.
[b]Missing values: Pain last month (2 in exercise therapy); Muscle strength hip (2 in exercise therapy; 4 in control); Knee (1 in exercise therapy); Joint range of motion (1 in exercise therapy); Physical activity (6 in exercise therapy; 1 in control). Questionnaire rising and sitting (5 in exercise therapy; 1 in controls).
[c]Results on 8 point scale are dichotomized as: improved (completely recovered, very much improved and much improved) and not improved (slightly improved, not changed slightly worsened, much worsened and vastly worsened).
[d]Results are dichotomized as: improved (increase in physical activity level, change ≥ 1 min/week() versus not-improved (stabilization or decrease in physical activity level, change ≤ 0 min/week).

formed using random number tables and concealed assignment of patients. The criteria for the selection of patients and patient characteristics have been clearly described. Treatment was documented in both the experimental (exercise) group and the control group. Patient compliance was checked. Patients were evaluated by blinded outcome assessors and the timing of outcome assessment was similar in the 2 groups. The statistical power was adequate to detect the expected small to medium effects. Nevertheless, some comments can be made. First, although treatment groups were quite comparable with regard to almost all variables (n = 35) assessed, baseline differences existed for medication and fear avoidance beliefs concerning physical activity. In our adjusted analyses we controlled for these differences. Second, no data were available on patients who withdrew from the study. However, the number of study withdrawals post-treatment was small (5%) and number and reasons were comparable across intervention groups. No indication

for selective withdrawal was found and therefore, no additional analyses including study withdrawals were needed. Third, deviations from allocated treatments were registered in 7% of the patients, resulting in a smaller treatment contrast than initially intended. However, this contamination bias does not affect the internal validity of our study, since no indications for selection bias exist. These treatment deviations reflect daily practice and should therefore be investigated in a study into the effectiveness of an intervention. Fourth, although in a limited number of cases treatment allocation was unmasked, no indication for biased outcome assessment was found. The treatment effects in unmasked patients were similar to the effects in patients with successful blinding. The unmasking of exercise therapy in particular can be explained in terms of the additional time and energy required for this type of treatment. Finally, both hip and knee patients were included in our study. Prior to the study there were no indications suggesting differences in the effectiveness of exercise therapy between these patient categories. This was confirmed by a subgroup analysis revealing no differences between hip and knee patients.

In analysing the effects of exercise therapy we used change scores between baseline values and post-treatment values. A disadvantage of this method is the relatively high measurement error of the change scores. However, a main advantage of change scores is that they directly reflect the response to treatment in intervention groups. In addition, this approach allows comparison with most other trials in this field, which mainly apply change scores.

Previous clinical trials already had shown beneficial effects of exercise therapy in patients with OA[9-14]. However, the internal validity of previous trials was often inadequate. Methodological flaws include inadequate randomization, no blinding of outcome assessment, and insufficient power[8]. Positive exceptions are the study of Kovar, *et al*[10,11] and the recently published study of Ettinger, *et al*[9]. They both reported beneficial effects on pain and disability. However, these studies were exploratory trials, studying exercise therapy in optimal research settings. Patients were treated in groups, using more or less standardized treatment for all patients. This restricts the external validity of these studies. The surplus value of our study is in the nature of our intervention. Our trial was a randomized single blind trial assessing the effect of exercise therapy in patients treated individually. Within the limits of the protocol, exercise therapy could be tailored to the patient's needs, as is usual in clinical practice. The use of a written protocol resulted in a clearly described intervention. Our study has shown the effectiveness of this modality of exercise therapy in reducing pain and disability.

The results of this study elucidate the mechanisms underlying exercise therapy only to a small extent. Beforehand, it was expected that exercise therapy would lead to improvement of muscle strength and range of motion, and thereby to a reduction of pain and disability in OA[7]. Muscle strength of the hip was indeed found to be improved. However, no effects were found for muscle strength of the knee or for range of motion. Other explanations are therefore needed to clarify the effectiveness of exercise therapy. Exercise therapy possibly has a beneficial effect on aerobic capacity or muscle spasm, which are known to be related to pain and disability[37,38]. This could explain the positive effect of exercise therapy on pain and disability. Because aerobic capacity and muscle spasm were not assessed in our study it is not possible to assess the validity of this explanation. Also, psychological mechanisms such as attention or pain coping could play a role in the effectiveness of exercise therapy. We did not control for attention, so attention could explain our results. However, trials controlling for the effect of attention indicate a beneficial effect of exercise therapy itself[9,11]. Pain coping is thought to be related to pain and disability in OA and possibly has an influence on the effects of exercise therapy[7,26]. However, no effect was found on a specific pain coping assessment, i.e., the extent patients believe physical activity to affect their pain.

The mechanisms underlying the beneficial effect of exercise therapy remain to be elucidated. Our trial was designed as a randomized single blind trial, not as an exploratory or feasibility trial assessing the efficacy of specific components of exercise therapy. Therefore, further research is necessary to understand the mechanisms underlying the effects of exercise therapy on pain and disability.

In conclusion, our randomized clinical trial in primary health care showed beneficial post-treatment effects of exercise therapy on pain and disability in OA in the hip or knee. Effect sizes are medium and small, respectively. These results support the current referral pattern to physiotherapy in primary care.

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APPENDIX 1, Medication schedule.

Step	Medication, mg	Maximum Daily Dosage (No. of tablets)
1	Paracetamol	6*
2	Naproxen, 250	2
or	Diclofenac Na, 25	3
or	Ibuprofen, 400	3
3	Another choice from Step 2	Idem
4	Naproxen, 500	2
or	Diclofenac, 50	3
or	Ibuprofen, 400	6

*1 or 2 tablets at a time.

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