Research Article

Exercise Training in Treatment and Rehabilitation of Hip Osteoarthritis: A 12-Week Pilot Trial

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Introduction. Osteoarthritis (OA) of the hip is one of the major causes of pain and disability in the older population. Although exercise is an effective treatment for knee OA, there is lack of evidence regarding hip OA. The aim of this trial was to test the safety and feasibility of a specifically designed exercise program in relieving hip pain and improving function in hip OA participants and to evaluate various methods to measure changes in their physical functioning. Materials and Methods. 13 women aged ≥ 65 years with hip OA were recruited in this 12-week pilot study. Results. Pain declined significantly over 30% from baseline, and joint function and health-related quality of life improved slightly. Objective assessment of physical functioning showed statistically significant improvement in the maximal isometric leg extensor strength by 20% and in the hip extension range of motion by 30%. Conclusions. The exercise program was found to be safe and feasible. The present evidence indicates that the exercise program is effective in the short term. However, adequate powered RCTs are needed to determine effects of long-term exercise therapy on pain and progression of hip OA.

1. Introduction

Osteoarthritis (OA) is a common disease presenting with joint pain, stiffness, swelling, and instability resulting in functional impairment in daily activities. Due to its high prevalence in the older population, OA has a major impact on healthcare costs globally. Pharmacological treatment is not recommended as the primary treatment for OA [1–3], and effects of various physical therapy techniques on relieving pain or improving joint function have remained rather small [4]. Consequently, symptomatic hip OA often leads to hip replacement surgery.

The main treatment goal in OA is to reduce joint pain and minimize physical disability [5]. Effectiveness of aerobic and strength training is recommended as the first-line conservative treatment approach in adults with mild-to-moderate knee OA [3]. Despite current national and international guidelines for the use of exercise in patients with hip OA, very few clinical exercise trials have been conducted in patients with hip OA. A Cochrane review by Fransen et al. included 10 exercise trials [6], and only 5 recruited solely patients with hip OA [7–10]; one of these was presented as an abstract only [11]. Five other included studies had mixed sample of hip and knee OA patients with the proportion of hip OA in these combined programs being always smaller than the proportion with knee OA [12–16]. However, the results are inconsistent.

Programs developed for OA of the lower limbs seem to benefit patients with knee OA more than those with hip OA. Juhl et al. found that exercise programs for knee OA should focus on improving aerobic capacity, quadriceps muscle strength, or lower extremity performance. For optimal results, the program should be supervised and carried out 3 times weekly and comprise at least 12 sessions [17].

Exercise therapy aims at reducing pain and disability by improving muscle strength, joint stability, range of motion (ROM), and aerobic fitness [10]. Whereas training focusing on improved muscle strength and aerobic capacity is known to alleviate OA symptoms, effects of exercise need further
elucidation [18]. Patients with hip OA are assumed to respond
to exercise in the same way as patients with other chronic
lower limb pain conditions do. Hip OA patients need specif-
ically developed and executed exercise training to ensure
adequate compliance [19].

Thus, more effective, feasible, and sustainable exercise
protocols for hip OA are needed for further developing ther-
apeutic exercise recommendations for the disease. The present
12-week pilot trial aimed to test the safety and feasibility of a
specifically designed exercise program in relieving hip pain
and improving function in hip OA subjects and to evaluate
methods to measure changes in physical functioning.

2. Participants and Methods

2.1. Participants. Participants were recruited from the wait-
ing list of the orthopedic outpatient clinic of Hatanpää
and COXA Hospital (specialized in joint replacements) in
Tampere, Finland. Thirteen women aged between 65 and
83 years, with moderate or severe restrictions in mobility,
debilitating pain, and difficulties in walking, stair climbing, or
putting on shoes, volunteered to participate in this pilot trial
and gave informed consent. A health history questionnaire
putting on shoes, volunteered to participate in this pilot trial
gave informed consent. A health history questionnaire
screened for self-reported health, comorbidities, medication,
and lifestyle (physical activity, use of alcohol, and smoking).

Participants were then invited to a baseline examination,
which included a physician’s examination, questionnaires,
and measurements of physical functioning (strength, balance,
and mobility).

Inclusion criteria were age ≥ 65 years, living at home
independently, and unilateral or bilateral hip OA with pain
in the hip region (groin and lateral hip) during the pre-
ceding month. Exclusion criteria were bilateral total hip
replacement, moderate-to-severe knee OA, fracture during
the preceding 12 months, and chronic conditions such as
rheumatoid arthritis or major surgical procedures in the
preceding 6 months (lower limb or lower back). Medication
used was not an inclusion or exclusion criterion.

This study was conducted according to the guidelines of
good clinical practice, and the study protocol was approved
by the Pirkanmaa Hospital District Ethics Committee, Tam-
pere, Finland (RI5004).

2.2. Anthropometry. Height and weight were measured with
standard methods. Body composition (fat and lean soft
tissue mass) and femoral neck bone mineral density were
assessed with dual-energy X-ray absorptiometry (DXA,
Lunar Prodigy Advance, GE Lunar, Madison, WI, USA) [20].
DXA measurement was performed only at baseline. All other
measurements described below were done at baseline and at
12 weeks.

2.3. Pain and Self-Reported Physical Function. The primary
outcome of the study was hip joint pain assessed by the
Western Ontario and McMaster University Osteoarthritis
Index [21] (WOMAC, Finnish version [22]). WOMAC pro-
duces three subscale scores (pain, stiffness, and physical
function) and a total score (WOMAC Index) that reflects
overall disability. Each item is assessed on a Visual Analog
Scale, with a possible range of scores of 0–100 mm. Items
are summed for each subscale, pain (range = 0–500 mm, 5
items), stiffness (range = 0–200 mm, 2 items), and physical
function (range = 0–1700 mm, 17 items), and for the total
WOMAC Index (range: 0–2400 mm). Self-reported disease-
specific disability was assessed using the pain and functioning
subscales at baseline and at 12 weeks [23]. Quality of life was
assessed by the LEIPAD questionnaire [24].

2.4. Hip Joint Assessment and Physical Functioning. Physical
functioning (strength, balance, and mobility) was measured
objectively. The maximal isometric leg extensor muscle
strength was measured by a leg press dynamometer. Timed-
Up and Go (TUG) [25], the Short Physical Performance
Battery (SPPB) (static balance, 4-meter walking speed and
time chair stand) [26], 9-step stair climb 20 cm [27], and
hip ROM [28] were assessed. Postural balance was assessed
using the force platform (Good Balance, Meltitur, Jyväskylä,
Finland) [29]. The system uses vertical force signals from each
corner of the platform to calculate x (mediolateral, ML) and
y (anteroposterior, AP) coordinates of the platform center
of pressure (COP) when the test person stood on it. Mean ML
and AP velocity (mm/s) and moment of velocity (mm²/s²)
were calculated. Balance was tested in the normal standing
position in four test conditions: eyes open, eyes closed, eyes
open with cognitive task (mental arithmetic), and eyes open
while standing on a foam sheet. Pedometers (Omron WS
III; Omron Healthcare, Inc., Lake Forest, IL) were used
throughout the 12-week period for objective assessment of
daily steps taken.

2.5. Training Program. Training was led or implemented as
circuit training sessions by experienced exercise leaders
(physiotherapists) 3 times a week for 12 weeks. Five sessions
were offered weekly, from which participants could select
any three. Training was started with a 2-week familiarizing
period to accustom the participants to the exercise, followed
by 5 weeks in the exercise hall and 5 weeks in the gym. All
sessions lasted 60 minutes and included a 10-minute warm-
up as well as stretching for major muscle groups. Exercise
leaders kept a record of participants’ attendance and possible
adverse events.

Training was progressive and was implemented as group-
based sessions but was planned with individual goals and
limitations in mind. Sessions in the exercise hall focused
on range of motion, lower limb muscle strength, balance,
agility, mobility, and change of direction. Progression was
achieved with the use of different surfaces, multidirectional
movement patterns, and changing the base of support. In
addition to own body weight, ankle or vest weights and step-
boards of increasing height were used to increase the intensity
of training. Advanced programs were also aerobic in nature.

During the gym sessions, resistive equipment was used. All
sessions included 8-9 different exercises focusing on
strengthening lower limb muscles (leg extensors, hip exten-
sors, hip abductors, hip rotators, knee extensors, and calf
muscles) as well as other large muscle groups (abdominal,
back, shoulder, and arm muscles). The first gym period began
with 30–60% of one repetition maximum (IRM) progressing
### Table 1: Characteristics of the participants (mean (SD)).

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Baseline</th>
<th>End point</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daily walking, mean steps in 12 wks</td>
<td>5195 (2133)</td>
<td>NA</td>
</tr>
<tr>
<td>Mini-Mental State Examination Score (0–30)(^1)</td>
<td>27.8 (2.3)</td>
<td>NA</td>
</tr>
<tr>
<td>Body fat, %(^1)</td>
<td>42.5 (6.4)</td>
<td>NA</td>
</tr>
<tr>
<td>Femoral neck t-score(^1)(^2)</td>
<td>0.01 (0.93)</td>
<td>NA</td>
</tr>
<tr>
<td>WOMAC</td>
<td></td>
<td></td>
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<tr>
<td>Total index (range: 0–2400)</td>
<td>796 (576)</td>
<td>583 (652)</td>
</tr>
<tr>
<td>Pain score (range: 0–500)</td>
<td>202.4 (123.4)</td>
<td>131.9 (143.6)</td>
</tr>
<tr>
<td>Stiffness score (range: 0–200)</td>
<td>99.1 (63.5)</td>
<td>76.8 (54.2)</td>
</tr>
<tr>
<td>Function score (range: 0–1700)</td>
<td>494.5 (413.9)</td>
<td>375.0 (474.1)</td>
</tr>
<tr>
<td>Physical functioning</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal walking speed, m/s</td>
<td>0.9 (0.2)</td>
<td>0.9 (0.2)</td>
</tr>
<tr>
<td>Fast walking speed, m/s</td>
<td>1.2 (0.2)</td>
<td>1.75 (1.8)</td>
</tr>
<tr>
<td>TUG, s</td>
<td>9.1 (1.5)</td>
<td>10.5 (2.2)</td>
</tr>
<tr>
<td>Chair stand time, s</td>
<td>14.8 (3.3)</td>
<td>14.2 (2.6)</td>
</tr>
<tr>
<td>Stair climb, s</td>
<td>11.5 (1.9)</td>
<td>12.2 (2.4)</td>
</tr>
<tr>
<td>Isometric leg extensor strength, N/kg</td>
<td>19.3 (8.0)</td>
<td>23.2 (10.2)</td>
</tr>
<tr>
<td>SPPB score (0–12)</td>
<td>9.9 (1.2)</td>
<td>9.9 (1.9)</td>
</tr>
<tr>
<td>Balance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ML velocity, eyes open, mm/s</td>
<td>3.7 (2.3)</td>
<td>4.7 (2.5)</td>
</tr>
<tr>
<td>AP velocity, eyes open, mm/s</td>
<td>6.7 (2.8)</td>
<td>8.7 (6.3)</td>
</tr>
<tr>
<td>Moment of velocity, eyes open, mm(^2)/s</td>
<td>8.8 (5.6)</td>
<td>15.1 (13.0)</td>
</tr>
<tr>
<td>ROM</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hip abduction, arthritic side</td>
<td>33.2 (11.5)</td>
<td>33.8 (11.2)</td>
</tr>
<tr>
<td>Hip abduction, healthy side</td>
<td>42.0 (7.2)</td>
<td>42.6 (6.8)</td>
</tr>
<tr>
<td>Hip flexion, arthritic side</td>
<td>96.2 (10.2)</td>
<td>98.8 (14.2)</td>
</tr>
<tr>
<td>Hip flexion, healthy side</td>
<td>104.0 (10.7)</td>
<td>103.5 (11.4)</td>
</tr>
<tr>
<td>Hip extension, arthritic side</td>
<td>12.1 (4.5)</td>
<td>15.8 (5.9)</td>
</tr>
<tr>
<td>Hip extension, healthy side</td>
<td>16.8 (5.5)</td>
<td>19.5 (7.0)</td>
</tr>
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</table>

\(^1\)Only baseline measurements.
\(^2\)Femoral neck bone density compared to reference population from Finland (age: 20–40 years).

3. Results

Baseline characteristics are given in Table 1. All participants were nonsmoking women with mean age (SD) of 71.6 (6.0) years. Mean height was 163.5 (7.0) cm, weight was 76.5 (12.3) kg, and body mass index (BMI) was 28.5 (3.3) kg/m\(^2\). Weight remained constant [mean change: 0.1 (1.9) kg, \(p = N.S\)] during the 12-week intervention. Three women had no diagnosed illness other than hip OA, and the most common medication was for high blood pressure (\(n = 8\)). No changes were made in OA medication during the intervention. The most often used medication was the NSAIDs (nonsteroid anti-inflammatory drugs).

3.1. Safety and Feasibility of the Program. Exercise compliance measured as attendance at all offered sessions was 90% (range: 42% to 100%), and all participants attended the end point measurements. In general, the training program was...
<table>
<thead>
<tr>
<th>Period</th>
<th>Description</th>
<th>Movements and Execution</th>
</tr>
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<tbody>
<tr>
<td>Introduction</td>
<td>Group training, weeks 1 and 2</td>
<td>Warm-up and balance training in standing position</td>
</tr>
<tr>
<td>to exercise hall, 2 weeks</td>
<td>(i) 10 min warm-up</td>
<td>Strength and mobility while training partly while sitting on a chair</td>
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<td></td>
<td>(ii) 20 min balance and agility exercises</td>
<td>Stretching while sitting on a chair</td>
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<td></td>
<td>(iii) 20 min muscle strength, flexibility, and mobility exercises</td>
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<td></td>
<td>(iv) 10 min stretching</td>
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<tr>
<td>I period: exercise hall, 5 weeks</td>
<td>Group training, weeks 3, 5, and 7</td>
<td>Balance and mobility:</td>
</tr>
<tr>
<td></td>
<td>(i) 10 min warm-up</td>
<td>(i) Reducing base of support using different foot positions in standing</td>
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<td></td>
<td>(ii) 20 min balance and agility exercises</td>
<td>(ii) Swaying, reaching out in different directions</td>
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<tr>
<td></td>
<td>(iii) 20 min muscle strength, flexibility, and mobility exercises</td>
<td>(iii) Changing directions and speed during walking, multidirectional stepping patterns</td>
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<tr>
<td></td>
<td>(iv) 10 min stretching</td>
<td>(iv) Stepping over obstacles and using different surfaces for walking and stepping</td>
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<tr>
<td></td>
<td>Circuit training, weeks 4 and 6: 8 movements, 1 min work, 1 min rest, 2 rounds</td>
<td>Flexibility and joint mobility:</td>
</tr>
<tr>
<td></td>
<td>(i) 10 min warm-up</td>
<td>(i) Hip area, spine, upper limbs, and shoulder-neck region</td>
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<tr>
<td></td>
<td>(ii) 40 min balance, agility, mobility, and muscle strengthening</td>
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<td></td>
<td>(iii) 10 min stretching</td>
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<td>Introduction to gym II period: in the gym, 4 weeks</td>
<td>Introduction, week 8</td>
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<td></td>
<td></td>
<td>(i) Leg press</td>
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<td></td>
<td></td>
<td>(ii) Hip abduction</td>
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<td>(iii) Standing up from the chair (using a weight vest)</td>
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<td>(iv) Hip extension</td>
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<td></td>
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<td>(v) Hip flexion</td>
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<td>(vi) Hip rotation</td>
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<td>(vii) Heel rise with a weight vest</td>
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<td>(viii) Back extension</td>
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<td>(ix) One limb chest press with body rotation</td>
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<td>(x) Rowing, sawing</td>
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<td></td>
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<td>(xi) Squatting with pulley weights</td>
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<td></td>
<td>Circuit training in pairs, weeks 9–12</td>
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<tr>
<td></td>
<td>(i) 10–15 min warm-up emphasizing balance and mobility exercises</td>
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<td></td>
<td>(ii) 40 min training especially for the lower limbs</td>
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<td></td>
<td>(iii) 5–10 min stretching</td>
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<tr>
<td></td>
<td>(iv) 6–8 exercises, 10–12 repetitions, 2 sets with 2 min rest</td>
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<td></td>
<td>(v) First 4 weeks, progression from the level 30% 1RM to 60% 1RM: target 60–65% 1RM</td>
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<td>(vi) Weekly 5–10% increase in resistance, accompanied by reduction in the number of repetitions</td>
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</table>

**Table 2: Detailed description of the training program.**
3.2. Effects on Pain, Stiffness, and Function. Mean changes (95% CI) in the outcomes of interest are shown in Table 1 and Figure 1. Mean reduction in the WOMAC pain score was 35% (8% to 62%), with large individual variations; decline was seen in 9 of 13 participants (Figure 2). Reduction in the stiffness or function scores was also seen but did not reach statistical significance. The total WOMAC Index reduced by 27% (−4% to 57%, p = 0.079).

3.3. Effects on Physical Functioning. Mean SPPB score was 9.9 (1.2) at baseline, with no change at 12 weeks. Also, there were no significant changes in walking speed, chair stand, or step climbing times. Mean (95% CI) isometric leg extensor strength increased by 3.8 (1.1 to 6.6) N/body weight. Unexpectedly, mean TUG time was 1.4 s (0.6 to 2.2 s) slower at 12 weeks compared to baseline (Figure 1). Postural sway with eyes open showed a trend for small 6.3 (−0.3 to 12.9, p = 0.06) mm²/s increase in moment of velocity. Closing eyes, adding a cognitive task, and standing on foam increased sway and velocity compared with the eyes open test, with no statistically significant changes (results not shown). Hip extension ROM increased significantly, with the mean change being 30% (7% to 54%), but no significant changes were found in hip abduction or flexion. There was a trend for improvement in quality of life, with mean change of 13.8% (−2.4 to 29.9%, p = 0.09).

4. Discussion

The significant 30% reduction found in pain is large enough to be considered clinically relevant [9, 12]. Thus, the results of this pilot trial support and further develop the specific exercise program for rehabilitation of hip OA.

Besides pain, the purpose of the training was to improve joint function which was also largely achieved. Importantly, isometric leg extensor muscle strength improved statistically significantly by 20% and hip extension ROM by 30%. However, no improvements in ROM of the hip flexion or abduction were seen, possibly because both strengthening and ROM exercises were mainly targeted towards improving hip extension. Other outcomes of physical functioning remained unchanged or only showed a trend for improvement. Surprisingly, the TUG test even showed 15% worsening in spite of reduced pain and improved leg strength and hip ROM.

Hip OA may reduce postural stability, increasing the risk of falling. In our study, postural sway with eyes open...
increased slightly, as did hip extension ROM. This may indicate that the participants have better confidence in maintaining stability as a result of training, not necessarily declined balance [30]. Similarly, Nagy et al. showed greater sway in older adults after 8-week balance, strength, flexibility, and aerobic training in spite of improved functional performance. This might have been due to improved balance confidence related to trainees’ better ability to control the motion of their hip and lower limbs [31]. It has also been shown that time of day effect in postural sway measurements is high especially in older adults [32]. In this study, the baseline and end point measurements were done at the same time of the day.

Wide individual variation in training responses and the small study sample possibly confounded some of the findings. OA is a disease with intermittent symptoms aggravated by various factors such as activity levels, lifestyle, and even time of day [33]. These may affect performance in mobility tests, such as the TUG and stair climbing. Therefore, in addition to a larger study group, a longer follow-up period with a control group with more than two measurement points is needed to evaluate the effects of exercise.

The recent Cochrane review by Fransen et al. demonstrated a significant improvement with exercise in self-reported pain and physical function among the small subset of participants with hip OA only, but the pain reduction was rather small [6]. Physical functioning was assessed objectively in only two studies [8, 9], and no between-group differences were observed. Results from more recent meta-analysis of land-based exercise for hip OA remain consistent with the Cochrane review. Similarly, water-based exercise therapy showed slight pain relief in patients with hip OA in the short term [34]. However, water-based exercise therapy is not always feasible. Also, no benefits of physical therapy either combined with exercise or alone have been found, both in terms of self-reported pain or function and in objectively measured changes in physical functioning [4, 34].

Whereas pain relief is the most important outcome, physical functioning ought to be evaluated objectively as well, because it is difficult to attain long-term benefits without clinically meaningful improvements in function. Twelve weeks is a short time for effective progression in training. Progressing too rapidly could worsen pain, likely discouraging patients to continue training. On the other hand, too light exercise may remain ineffective. In spite of the short duration, our results were encouraging. Most other exercise trials in hip OA patients have also been of short duration, mainly between 6 and 12 weeks, with some benefits reported immediately at the end of the intervention. Only two studies evaluated sustained benefits for physical function [7, 9], with neither demonstrating a significant reduction in pain. One reason for this may be the fact that the participants had relatively low WOMAC pain scores, with less room for improvement. This suggests that the frequency or intensity of exercise was too low or duration was too short to improve physical functioning.

Effective exercise in hip OA also requires motivated participants. Our training was started at low intensity and level of difficulty. Since group sizes were small, the leaders were able to pay individual attention to optimal joint loading and performance techniques to avoid aggravation of joint symptoms. This resulted in excellent training compliance over 12 weeks. Compliance may be more difficult to maintain over a longer duration.

5. Conclusions

Exercise programs focusing on improving aerobic capacity, quadriceps muscle strength, or lower extremity performance carried out 3 times weekly comprising at least 12 sessions have been considered optimal treatment for knee OA. These principles were followed in planning the exercise program for hip OA. The training program was found to be feasible and safe, though it was of a short duration. This study supports the use of exercise training in reducing hip OA pain. Further controlled studies with larger group sizes are needed to determine the long-term benefits of exercise and its effects on the progression of the disease.

Competing Interests

The authors declare that they have no competing interests.

References


