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Case Report

Development of a Therapeutic Exercise Program for Patients With Osteoarthritis of the Hip

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Background and Purpose. No detailed exercise programs specifically for patients with hip osteoarthritis (OA) have been described in the literature. This lack of data creates a gap between the recommendation that people with OA should exercise and the type and dose of exercises that they should perform. The purpose of this case report is to describe and demonstrate the use of a therapeutic exercise program for a patient with hip OA.

Case Description. A 58-year-old woman with hip OA completed a 12-week therapeutic exercise program (TEP) with a 6-month follow-up. The patient reported hip pain, joint stiffness, and limited physical function, and she had decreased hip range of motion (ROM) at baseline.

Outcomes. The patient performed 19 sessions during the TEP, with a mean of 19.5 exercises per session. She increased the resistance in 3 of 5 strength (force-generating capacity) training exercises and achieved the highest degree of difficulty in all functional exercises. During the TEP and follow-up, the patient reported improvements in pain, joint stiffness, and physical function. Performance improved on the following physical tests: isokinetic peak torque strength (60°/s) in hip extension (40%), hip flexion (27%), knee extension (17%), and knee flexion (42%); hip ROM extension (8°); and 6-minute walk distance (83 m).

Discussion. The patient experienced less pain and improved physical function and physical test outcomes after intervention and at the 6-month follow-up. The main challenges when prescribing an exercise program for a patient with hip OA are monitoring the exercises to provide improvements without provoking persistent pain and motivating the patient to achieve long-term adherence to exercising. Randomized clinical trials are needed to evaluate the efficacy of this TEP in patients with hip OA.

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Nonoperative management of osteoarthritis (OA) has been suggested to prevent or delay the impact of disability, and interventions such as patient education and exercise have been recommended as the first choice of treatment.[1,2] A review of the guidelines and recommendations for the management of hip and knee OA showed that aerobic and strengthening exercise were the most frequently reported interventions.[3] The evidence showing the effect of exercises, so far, has been based on studies of patients with knee OA. A recent meta-analysis, in which the authors were able to extract hip joint–specific data from 9 randomized clinical trials (RCTs) that evaluated the effect of exercise on both knee and hip OA, showed a significant effect size for exercise (0.43).[4] Strengthening exercise was the most common type of exercise in the 9 RCTs included in the meta-analysis, and the authors suggested that strengthening exercise might be the most effective type of exercise.[4]

However, to our knowledge, no specific exercise programs for patients with hip OA have been described in the literature. To be able to recommend exercise therapy for patients with hip OA, we need more knowledge and detailed descriptions of the exercises included in such therapy programs, why these specific exercises are included, and the dose for each exercise. All RCTs examining the effect of exercise therapy programs should include specific descriptions of the different exercises and the exercise dose. The purpose of this case report, therefore, is to describe the development of and demonstrate the use of a therapeutic exercise program (TEP) for patients with hip OA. More specific aims of the TEP are to reduce pain and to improve strength (force-generating capacity), flexibility, and physical function.

Table 1.
Patient Characteristics at Baseline

Variable	Data
Age (y)	58
Sex	Female
Body mass index (kg/m^2)	24.5
Minimum joint space (mm)	Target hip: 2.6 Contralateral hip: 2.3
Harris Hip Score (0–100 points)[a]	79
Medication	None
Comorbidities	None

[a] 0=extreme pain and limited function, 100=no pain or functional limits.

Patient History and Review of Systems

The patient was included in a large RCT evaluating the effect of exercise in addition to patient education for patients with hip OA. The patient had attended a group-based patient education program.[5] At inclusion, the patient was examined clinically by a physical therapist (L.F.) and an orthopedic surgeon (L.N.). The radiograph was examined by the orthopedic surgeon. Written informed consent was obtained from the patient.

The patient was a 58-year-old woman who worked full-time as an information consultant and who was seeking health care because of hip pain. She had radiographically verified hip OA bilaterally[6] (Tab. 1) and reported unilateral hip pain located over the right gluteal area, groin, and inner thigh (target hip). Thus, the painful hip was selected as the target hip. She reported no low back pain, knee pain, or any comorbidities, and she did not take any medications. The first hip pain episode was 9 years before inclusion in the RCT, and she reported having intermittent pain since then. The pain increased after walking on hard surfaces, but walking on paths or hiking in the woods did not provoke pain. The patient reported sensations of morning stiffness and stiffness after inactivity. At inclusion, the patient scored 79 points on the Harris Hip Score (HHS)[7] (Tab. 1). At our institution, an HHS of <60 points has been used as the cutoff criterion for surgery. The clinical impression of the patient was consistent with symptoms typical of patients with hip OA, although the symptoms were not severe enough that surgery was considered.

Examination

The questionnaires were completed and physical tests were performed at baseline, after intervention, and at follow-up 6 months after the intervention. Administrations and tests were carried out by a physical therapist (L.F.). The questionnaires that were administered were: (1) the disease-specific Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC)–VA3.1,[8] (2) the Physical Activity Scale for the Elderly (PASE),[9] and (3) the Medical Out-

Table 2.
Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) Scores (0–100 mm)[a] at Baseline, After Intervention, and at 6-Month Follow-up

Dimension	Item		Baseline	After Intervention	6-Month Follow-up
Pain	Mean score		22.8	3.6	10.8
	How much pain do you have?	Walking on flat surface	26	4	17
		Going up or down stairs	22	4	15
		At night while in bed	24	3	5
		Sitting or lying	15	3	9
		Standing upright	27	4	8
Stiffness	Mean score		42.5	9.0	7.5
	How severe is your stiffness?	After awakening in the morning	41	10	11
		After sitting, lying, or resting later in the day	44	8	4
Physical function	Mean score		17.5	5.6	8.1
	What degree of difficulty do you have?	Descending stairs	10	4	7
		Ascending stairs	28	5	6
		Rising from a sitting position	32	9	8
		Standing	3	5	4
		Bending over to floor	34	4	22
		Walking on flat surface	16	5	5
		Getting in and out of car	16	13	9
		Going shopping	15	3	6
		Putting on socks or stockings	31	4	12
		Rising from bed	23	6	9
		Taking off socks/stockings	27	6	18
		Lying in bed	10	2	3
		Getting in and out of bath	17	10	13
		Sitting	10	3	4
		Getting on and off toilet	6	3	4
		Heavy domestic duties	12	11	6
		Light domestic duties	7	3	2

[a] 0=no pain/stiffness/difficulty, 100=extreme pain/stiffness/difficulty.

comes Study's 36-Item Short-Form Health Survey (SF-36), version 2.[10] All questionnaires are considered reliable and valid measures.[8,11–13] The physical tests were: (1) a test of isokinetic concentric peak torque muscle strength measured with a dynamometer* at 60°/s for hip and knee extension and flexion[14]; (2) the Six-Minute Walk Test (6MWT)[15]; (3) a submaximal cycle ergometer† test[16]; and (4) range of motion (ROM) in hip flexion and extension, abduction and adduction, and medial (internal) and lateral (external) rotation[16–18] measured with a 1-degree–increment plastic goniometer.‡ After the 6MWT, the patient scored the maximum pain intensity experienced during the 6MWT on a 100-mm visual analog scale (VAS).

Clinical Impression

The patient scored 22.8 mm on the WOMAC pain scale and 57.5 points on the SF-36 bodily pain scale at baseline (Tabs. 2 and 3). Self-reported physical function on the WOMAC and SF-36 were 17.5 mm and 85 points, respectively. On the physical tests, the patient showed

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† Monark Exercise AB, 780 50 Vansbro, Sweden.

‡ Medema, Box 1169, 171 23 Solna, Sweden.

Table 3.
Harris Hip Score (HHS), Physical Activity Scale for the Elderly (PASE), and 36-Item Short-Form Health Survey (SF-36) Scores at Baseline, After Intervention, and at 6-Month Follow-up

Measure		Baseline	After Intervention	6-Month Follow-up	Reference Values[a]
HHS (0–100 points)[b]		79	96	91	–
PASE (0–315 points)[c]		111.59	140.35	90.07	–
SF-36 (0–100 points)[b]	Physical functioning	85	95	100	85.6[63]
	Role limitations–physical	100	100	100	77.6
	Role limitations–emotional	100	100	100	84.3
	Bodily pain	57.5	100	80	73.8
	Social functioning	100	100	100	86.0
	Mental health	90	95	90	79.5
	Vitality	75	75	68.75	62.0
	General health perceptions	95	95	75	74.7

[a] Missing data (–).
[b] 0=extreme pain and limited function, 100=no pain or functional limits.
[c] 0=not active, 315=extremely active.

similar muscle strength in both the target joint and the contralateral joint but had less ROM in hip extension, abduction, and lateral rotation in the target joint than in the contralateral joint and less hip extension and abduction in the target joint compared with normative data.[19] She walked 665 m during the 6MWT and scored 22 mm on the VAS, and she was classified as having a "high" predicted aerobic capacity[20] based on the cycle test (Tab. 4). In summary, the baseline data showed that the patient had hip OA with mild pain[21] and an acceptable symptom state.[22] She had experienced intermittent hip pain, with the pain distribution commonly seen in patients with hip OA.[23] Pain increased while walking on flat surfaces, standing, and walking up or down stairs, and she experienced mild pain during the 6MWT. She had limited ROM during hip extension, abduction, and lateral rotation, and she reported having difficulty putting on socks, bending to the floor, and rising from a sitting position. She agreed to participate in a 12-week exercise program.

Therapeutic Exercise Program

Warm-up and Walking Instructions

The exercise program started with 5 to 10 minutes of warm-up walking on a treadmill or cycling on a stationary cycle (exercises 1A and 1B in the eAppendix, available at ptjournal.apta.org). As shown in biomechanical studies, patients with hip OA appear to alter their walking pattern, probably because of pain and altered joint loading.[24,25] The patient was instructed to walk symmetrically (ie, to maintain an equal cadence during walking and to extend the hip during the push-off phase of gait.) The intensity of the warm-up was set to 12 to 13 on the Borg Rating of Perceived Exertion Scale.[26]

Strength Training

Two case-control studies of patients with hip OA have shown less muscle mass and muscle strength in the pelvis and thigh muscles compared with control participants or the control limb.[27,28] Despite the existence of a few studies on the importance of muscle strength for patients with hip OA,[29] strength training has been considered a key factor in maintaining physical independence and is recommended to be performed twice weekly, both in rehabilitation and in public health studies.[30–32] Progression procedures for the strengthening exercises were aimed at increasing the resistance.

Strengthening exercises for both hip and core muscles were included based on previous studies of hip muscle activation during the performance of core exercises.[33] The patient performed hip extension of the gluteal muscle in a standing position, leaning halfway forward on stabilization pads (exercise 2C in the eAppendix). Crunches were performed lying supine on a mat with hip and knees partially flexed (exercise 2E in the eAppendix). Bridging also was performed on a mat, starting with 2-legged support (exercise 2Fa in the eAppendix) and advancing to 1-legged support, with the other leg extended and lifted about 20 cm above the floor (exercise 2Fb in the eAppendix). Side-lying hip abduction was performed on a mat on the floor (exercise 2Ga in the eAppen-

Table 4.
Muscle Strength Tests, Six-Minute Walk Test (6MWT), Submaximal Ergometer Cycle Test, and Hip Range of Motion (ROM) of the Target Hip and Contralateral Hip at Baseline, After Intervention, and at 6-Month Follow-up[a]

Test		Baseline		After Intervention		6-Month Follow-up		Reference Values
		Target Hip	Contralateral Hip	Target Hip	Contralateral Hip	Target Hip	Contralateral Hip	
Isokinetic strength at 60°/s (N·m)	Hip extension	102	83	143	122	139	132	
	Hip flexion	70	68	76	67	89	87	
	Knee extension	100 1.43[b]	97 1.39[b]	106 1.51[b]	109 1.56[b]	117 1.67[b]	114 1.63[b]	1.94[19,b]
	Knee flexion	48	49	65	60	68	71	
6MWT (m)		665.4		720.0		748.2		528.0[64]
Visual analog scale (0–100 mm)[c]		22		0		11		
Cycle test (mL/kg×min)		38		40		36		37–41[65,d]
Hip ROM (°)	Flexion	143	138	139	136	–	–	127–155[66]
	Extension	1	9	9	9	–	–	16–35
	Abduction	28	34	31	29	–	–	35–50
	Adduction	25	25	26	25	–	–	24–37
	Medial rotation	50	48	59	48	–	–	34–71
	Lateral rotation	26	42	32	48	–	–	25–56

[a] Missing data (–).
[b] Newton-meters per kilogram.
[c] 0=no pain, 100=extreme pain.
[d] High oxygen uptake capacity.

dix). Progression in the hip abduction exercise was included in the side-lying plank exercise (exercises 2Gb and 2Gc in the eAppendix). Leg extension and leg curl exercises were performed to strengthen the quadriceps and hamstring muscles, respectively (exercises 2A and 2B in the eAppendix). Heel-raise exercise to strengthen the gastrocnemius muscles was performed in a standing position with weight on the shoulders (exercise 2D in the eAppendix).

Functional Exercises

The rationale for including functional exercises in this TEP was based on hip OA studies in which patients experienced difficulties in performing activities of daily living, such as rising from a sitting position, standing, and ascending and descending stairs.[29,34] The functional exercises for this TEP were chosen to imitate those movements required in daily activities. The procedures to ensure progression in the functional exercises were aimed at increasing the degree of difficulty by reducing the base of support, adding dynamic movements, or increasing the range though which a movement was performed.[35]

The functional exercises for this TEP included squats performed initially from a standing position and progressing to standing on a balance pad and further to squats with weight on the shoulders (exercises 3Aa–c in the eAppendix). The other functional exercises were: single-leg stance on a balance pad, with progression to single-leg squat (exercises 3Ba and 3Bb in the eAppendix); forward and sideways lunges (exercise 3C and 3D in the eAppendix); and step-up and step-down onto a stool at 2 different heights and advancing to a balance pad on the stool (exercise 3E in the eAppendix). All exercises emphasized the need to perform the exercise accurately by controlling the movement. An *accurate performance* of the exercises was defined as the patient's performing the exercises through the full available ROM. Control of movement for dynamic double-limb–support exercises was defined as keeping the knees over the balls of the feet, referred to as the "athletic position."[36] For single-limb–support exercises, *control of movement* was defined as keeping the knees over balls of the feet and maintaining hip alignment (ie, not dropping or rotating the pelvis) while performing the exercises.

Flexibility Exercises and Stretching

Decreased ROM in the hip joint is common in patients with hip OA.[37–39] The ROM exercises for this TEP involved both relaxed, repetitive movements and static stretching. The relaxed, repetitive movements were performed lying on a mat on the floor with one leg suspended in a sling fixed to the ceiling. The patient repeatedly moved the leg in

hip flexion and extension and in hip abduction and adduction for 2 minutes in each direction (exercises 4A and 4B in the eAppendix). The static stretching followed the stretching exercises that were included in the patient education program reported by Klassbo et al,[5] which emphasized maintenance of ROM needed for activities of daily living, rather than stretching of specific muscles (exercises 5A–D in the eAppendix). The patient was asked to hold the static stretch for 30 seconds in each direction.

Dose

No study has described the optimal dose of exercise in patients with hip OA. The total amount of physical activity can be described in terms of intensity, volume, frequency, and duration.[32,40] A systematic review on progressive resistance training in elderly people showed that the intensity of the training was the strongest factor affecting strength and functional outcome.[41] Similarly, a study comparing high- versus low-resistance strength training in patients with knee OA showed consistently larger effect sizes for the high-resistance training group.[42] The latest update of physical activity recommendations are to perform 8 to 10 strengthening exercises of the major muscle groups twice or more per week.[32,35] For untrained and recreationally trained individuals, an intensity of 60% to 80% of 1 repetition maximum (1RM), a volume of 4 sets, and a frequency of 2 to 3 times per week have been recommended,[43,44] with at least 6 weeks of progressive training to achieve muscular hypertrophy.[45]

Therefore, the TEP was set as 3 sets of 8 repetitions for strengthening exercises, corresponding to 70% to 80% of 1RM,[46] and 3 sets of 10 repetitions for functional exercises, 2 to 3 sessions per week for 12 weeks. Single-leg exercises were performed with both the target leg and the contralateral leg. In total, the TEP comprised 26 different exercises of the lower limbs and trunk (eAppendix). The patient was supervised by a physical therapist who modified the TEP during the sessions according to the patient's capacity by choosing exercises from the 26 suggested exercises (eAppendix). Performance of 10 strengthening and functional exercises per session and exercising twice a week for 12 weeks was considered acceptable adherence.[44]

Exercise Regulation to Pain Level

The physical therapist introduced a pain scale as a tool to help the patient modify the TEP to her pain.[47] The therapist informed the patient that the exercise could provoke some pain, especially during the initial exercise period, but this pain should not concern the patient. The therapist also emphasized that the exercises should not exceed the limit for "acceptable pain"[22] and that the pain level should decrease to the same level as prior to the exercise session within 24 hours after exercising. Pain after exercise in patients with knee OA has been reported as transient pain (ie, even if the pain increased immediately after an exercise session, the pain decreased to an even lower level later in the day following exercise).[48]

The therapist determined when to adjust the exercise intensity upward or downward. The intensity was increased in the strengthening exercises by increasing the resistance when the patient could tolerate more than 8 repetitions.[46,49] The intensity was increased in the functional exercises by increasing the degree of difficulty of the exercise when the patient was able to perform 10 repetitions with a controlled movement. If the patient reported that an exercise was more painful than "acceptable pain," the intensity was decreased in the strengthening exercises by reducing the resistance and in the functional exercises by decreasing the degree of difficulty or excluding the exercise. If pain persisted, the exercise intensity was decreased further until the pain level became acceptable. Because the side-lying plank (exercises 2B and 2C in the eAppendix) and squat with weights (exercise 3Ac in the eAppendix) exercises may stress the neck, shoulders, and back, these exercises were adjusted if the patient experienced any neck, shoulder, or back pain.

Outcomes

The patient attended the TEP for 19 sessions during the 12-week period. She performed between 13 and 20 different exercises, with a mean of 19.5 exercises per session. The patient chose to warm up on a stationary cycle for all 19 sessions. She increased the resistance during the hip extension strength exercise, the heel-raise, and the squat exercises with weights, and she progressed on the bridging and hip abduction exercises during the training period (Tab. 5). She tried to increase resistance of the leg extension (exercise 2A in the eAppendix) at session 17 but was unsuccessful because of hip pain (Tab. 5). The patient improved her scores on the WOMAC (Tab. 2), HHS, and SF-36 physical functioning scales (Tab. 3) during the follow-up period. After intervention, the patient reported no pain (100 points) on the SF-36 body pain scale, and she reported mild pain (80 points) at the 6-month follow-up.

Compared with the baseline score, the PASE showed a higher activity level score after the intervention and a lower activity level score at the 6-month follow-up (Tab. 3). Isokinetic peak torque strength increased in hip extension (36%), hip flexion (27%), knee extension (17%), and knee flexion (42%) at the 6-month follow-up (Tab. 4). The 6MWT

Table 5.
Training Diary of the 19 Sessions Performed by the Patient During the Exercise Intervention[a]

Stage of Program	Exercise	Exercise No.[b]	Session																		
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Warm-up	Walk	1A	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Cycle	1B	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Strength training, 3 sets × 8 repetitions	Leg extension	2A	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	35	30	30
	Leg curl	2B	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40
	Hip extension	2C	40	40	40	40	45	50	50	50	50	–	55	55	55	55	55	55	60	60	60
	Heel-raise	2D	30	30	30	30	30	30	30	30	30	30	35	35	35	35	35	40	35	35	35
	Crunches	2E	x	x	x	x	x	x	x	x	x	–	x	–	x	x	x	x	x	x	x
	Bridging	2Fa	x	x	x	x	x	–	–	–	–	–	–	–	–	–	–	–	–	–	–
		2Fb	–	–	–	–	–	x	x	x	x	–	x	–	x	x	x	x	x	x	x
	Hip abduction	2Ga	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
		2Gb	x	x	x	x	x	–	–	–	–	–	–	–	–	–	–	–	–	–	–
		2Gc	–	–	–	–	–	x	x	x	x	x	x	–	x	x	x	x	x	x	x
Functional exercises, 3 sets × 10 repetitions	Squats	3Aa	x	x	x	x	x	x	x	–	–	–	–	–	–	–	–	–	–	–	–
		3Ab	–	–	–	–	–	–	–	x	x	x	x	x	x	x	x	x	x	x	x
		3Ac	20	20	20	20	25	25	25	25	25	25	27.5	27.5	27.5	27.5	27.5	27.5	30	30	30
	Single-leg stance/ squat	3Ba	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
		3Bb	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	Lunge	3C	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	Sideways lunge	3D	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	Step-up/step-down	3E	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Flexibility	Flexion/extension	4A	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	Abduction/ adduction	4B	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	Extension	5A	x	x	x	x	x	x	x	x	x	x	x	–	x	x	x	x	x	x	x
	Abduction	5B	x	x	x	x	x	x	x	x	x	x	x	–	x	x	x	x	x	x	x
	Lateral (external) rotation	5C	x	x	x	x	x	x	x	x	x	x	x	–	x	x	x	x	x	x	x
	Medial (internal) rotation	5D	x	x	x	x	x	x	x	x	x	x	x	–	x	x	x	x	x	x	x

[a] Exercise performed (x). Exercise not performed (–). Exercise performed and values represent the resistance (in kilograms) used in the exercise.
[b] See eAppendix (available at ptjournal.apta.org) for descriptions of exercises in the therapeutic exercise program.

distance walked increased from baseline (665 m) to the 6-month follow-up (748 m), along with a decrease in pain on the VAS from 22 to 11 mm. The predicted maximal aerobic capacity varied from 38 to 40 to 36 mL/kg×min from baseline to after the intervention to the follow-up test (Tab. 4). From baseline to after the intervention, ROM increased by 8 degrees in hip extension, by 9 degrees in medial rotation, and by 6 degrees in lateral rotation in the target hip (Tab. 4).

Discussion

The purpose of this case report is to describe and demonstrate the use of a TEP designed specifically for patients with hip OA. The patient completed the TEP with no complications. We thought it important to set the dose individually with a gradual progression of the resistance and degree of difficulty while keeping the pain level within an acceptable range. The TEP included different types of exercises aimed at reducing pain, strengthening the muscles, increasing flexibility, and improving the patient's physical function.

Strength Training and Functional Exercises

Strength training was included in the TEP for several reasons. First, case-control studies have shown low muscle strength and muscle hypotrophy in patients with hip OA.[27,28] Second, strength training has been recommended as one treatment modality for patients with hip or knee OA.[3,4] Third, RCTs have shown benefits from strength training on physical function and physical independence in young adults and older adults.[50] It is impossible to separate strengthening and functional exercises completely because of the overlap between exercises, as functional exercises also include strengthening components (eg, the squat exercise). Similarly, in a patient with low initial functional status, functional exercises such as squats or stepping up and down can be exhausting and thus could be classified as strength training. Therefore, some of the functional exercises could be classified as strengthening exercises.

During the follow-up period, the patient's isokinetic peak torque strength values in hip extension and flexion and knee extension and flexion increased by 17% to 42%, indicating improvements in strength.[51,52] The patient's scores on the WOMAC pain, stiffness, and physical function scales, the HHS, and the SF-36 physical functioning and bodily pain scales improved from baseline to after the intervention. Improvements after the intervention exceeded the minimal perceptible clinical improvements,[7,53,54] indicating a potential difference from baseline. The aims of the TEP to reduce pain and to improve strength, flexibility, and physical function appear to have been achieved by this patient. The distance walked in the 6MWT increased, and the patient reported reduced pain during the follow-up period, indicating a trend toward better walking capacity.[55] Compared with the value at baseline, the predicted aerobic capacity calculated from the cycle test was higher after the intervention but was lower after the 6-month follow-up. This finding may be explained by the reduced activity reported in the PASE during the same period.

Flexibility Exercises

The rationale for including flexibility exercises in the TEP was that some studies have shown reduced hip ROM and the sensation of stiffness in patients with hip OA.[8,37,38] In addition, hip extension and lateral rotation have been reported to be associated with high levels of disability.[39] It is important to maintain sufficient hip ROM to manage activities of daily living, which was one purpose of the static stretching exercises in the TEP. The patient increased right hip extension by 8 degrees from baseline to after the intervention, indicating a real increase. The other ROM differences from baseline to after the intervention did not exceed the measurement errors and might not be regarded as real changes.[56] The small changes in ROM might indicate that, although the TEP was unable to change ROM, the program helped maintain hip ROM. In contrast, the WOMAC stiffness score decreased from 42.5 mm at baseline to 7.5 mm during the follow-up period, a change that exceeds the minimum clinically important difference[57] and thereby indicates a real change.

Individually Adjusted Exercise Program

There are no reviews comparing a standard regimen with an individually adjusted exercise programs for patients with OA. However, individually designed and supervised exercise programs for patients with low back pain were found to be superior to an unsupervised exercise program.[58] Benefits of individualized and supervised exercise programs may be attributed to individually designed exercises and individually set doses. It was considered important that the physical therapist considered the resistance and degree of difficulty of the exercises and the patient's pain level when setting the dose of the TEP. Pain provoked by exercise has been shown to reduce adherence to the exercise program,[59] and we believed it was important to obtain thorough information to keep the pain level within an acceptable range. The patient had one episode of hip pain when trying to increase the load in the leg extension exercise in the 17th session (Tab. 5), so the physical therapist reduced the resistance in the next session. Otherwise, progression in the resistance was seen in hip extension, heel-raise, and squats with weights, and progression in the degree of difficulty was seen in bridging, hip abduction, and squats.

Motivation for Exercising

The patient attended an education program[5] before starting the TEP. The purpose of the education program is to empower patients to manage pain relief themselves and to improve or maintain physical function. This program, in itself, might have motivated the patient to adopt a more active lifestyle. Motivation is a key factor for long-term adherence to exercise and has been considered crucial to maintaining the benefits of exercise.[60] It has been shown to be important for the patient to understand *why* exercise would be beneficial to ensure adherence to an exercise program.[61,62] *Adherence* was defined as performing 10 strengthening and functional exercises per session and exercising twice weekly during the study period. The patient performed a mean of 19.5 exercises per session and a total of 19 sessions during the exercise period. She fulfilled the criterion for adherence for the number of exercises per session, but she did not adhere fully to the number of sessions per week. We

believed an individually adjusted exercise program with supervision for 12 weeks should give the patient sufficient confidence in to monitor and adjust the exercises to her pain level, thus encouraging the her to continue to exercise over the long term.

Conclusion

The main challenge associated with a TEP for patients with hip OA is balancing the progression in such a manner that it does not provoke persistent pain while improving muscular strength and physical function. We recommend that the physical therapist should provide thorough information about the benefits of exercise and how to adjust exercise intensity according to pain level. The patient described in this case report achieved fairly good exercise adherence and had no complications. Her pain level decreased and her muscular strength, walking distance, and physical function increased after the intervention and were maintained at the 6-month follow-up. In summary, the patient showed reduced pain and improved physical function over the follow-up period. Randomized clinical trials are needed to evaluate the efficacy of this TEP for patients with hip OA.

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