Physical Therapist Management of Patients Following Total Hip Arthroplasty Using Traditional and Pilates-Based Mat Exercises: A Case Report

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Physical Therapist Management of Patients Following Total Hip Arthroplasty using Traditional and Pilates-based Mat Exercises: A Case Report

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Abstract

Background and Purpose. Traditional therapeutic mat exercises are often used by physical therapists when creating rehabilitation programs for patients following total hip arthroplasty (THA). Little is known, however, about the benefits of Pilates-based mat exercises. The purpose of this case report is to describe the use of traditional therapeutic mat exercises and Pilates-based mat exercises with patients treated in outpatient physical therapy following THA. **Case Description.** This case describes 2 female patients following right THA seen in outpatient physical therapy. One patient was instructed in Pilates-based mat exercises while the other received traditional mat exercises. Both received gait training, balance drills, and soft tissue and joint mobilizations. **Outcomes.** Both patients' hip manual muscle testing and hip joint range of motion values increased and pain (assessed on visual analog scale) decreased upon discharge, regardless of intervention. The Lower Extremity Functional Scale (LEFS) scores for both patients increased from 16/80 to 49/80 and 63/80 for the patients using traditional and Pilates-based mat exercises respectively. **Discussion.** Both the traditional and the Pilates-based mat exercises resulted in improvements in quality of life for these patients. The patient performing Pilates-based mat exercises had a greater improvement in the LEFS score and had an earlier discharge.

Key Words: Pilates, Total Hip Arthroplasty Exercises, Physical Therapy, Functional Outcomes

Introduction

Total hip arthroplasty (THA) is the most common surgical hip procedure in adults.[1] Individuals with THA contribute to a large patient population who benefit from physical therapy to improve musculoskeletal dysfunctions and ensure independent living.[2,3] A physical therapy examination and evaluation can determine the best course of action to improve a patient's quality of life and functional outcomes once the impairments have been identified following a THA. Traditional therapeutic lower extremity mat exercises are commonly included in rehabilitation protocols after THA to promote rapid recovery and return to optimal function.[4,5] Exercise programs that involve strengthening hip flexors, extensors, and abductors have been shown to increase hip muscle strength, walking speed, and function in patients following THA.[6,7]

Clinical research and clinical experiences assist physical therapists in selecting traditional lower extremity therapeutic mat exercises to limit functional deficits following THA.[5,8,9] The traditional mat exercises employed following a THA include but are not limited to gross hip musculature strengthening using isometrics, body weight open kinetic chain leg raises, closed kinetic chain bridging, and range of motion (ROM) activities all to increase strength, ROM, functional mobility, and increase quality of life.[5,10,11]

A primary goal of physical therapy following THA is regaining function. Frost et al[11] investigated functional movements and the necessary lower extremity strength of the hip to complete certain tasks. The authors found isometric hip extensor strength is essential for getting up from sitting, stair climbing, balance, and habitual gait. They concluded that impaired hip abductor strength was a contributing factor in falls as a result of loss of balance during gait. They also stated that multiple therapeutic exercises should be considered to

develop optimum strength. Gross hip musculature is essential to achieve optimal functional activities.

Mangione et al[5] surveyed American Physical Therapy Association physical therapist members to determine typical home care management for patients following THA. The following therapeutic exercises were found to be commonly used: hip flexion, hip extension, hip abduction, hip adduction, knee flexion, knee extension, ankle plantar flexion, ankle dorsiflexion, and exercises using multiple joints including: bridging, straight leg raises, squats, and step-ups. The physical therapists also provided patient and caregiver education and home exercise programs of active movement. The authors did not describe the effectiveness of the listed exercises and only created a composite list of therapeutic exercises as a result of the survey distributed.

In a study by Unlu et al[7] interventions were compared on groups of patients including (1) the effects of home exercise programs, (2) exercises supervised by physical therapists, and (3) patients with no specific intervention following THA. They found improvement with both the exercise groups in maximum isometric torque strength of the operated limb and gait speed and cadence improved in all 3 groups. Strength improved the most with supervision of physical therapists.

Freuburger[3] discussed cost efficient benefits of supervised strength training and functional improvements for patients following THA. In his study, he compared the effectiveness of physical therapy intervention in acute care and found that the outcomes were improved cost effectiveness, chiefly because of decreased length of stay for hospitalization. Therefore, he concluded that physical therapy intervention and education was a necessity after THA.

The literature indicates improvements in objective measurements from physical therapy interventions of traditional therapeutic mat exercises following THA.[6,7,10,11] Therapeutic mat exercises with physical therapist supervision for patients following THA also resulted in earlier discharge from physical therapy, along with improved strength and ROM, improved gait speeds, and increased functional activities.[3,6,7,10,11] However, there is little research on alternative physical therapist intervention techniques and outcomes for patients following THA.

Pilates exercise emphasizes core strength and is often practiced by dancers and athletes. Pilates has seen growth as an exercise program with 9.5 million practitioners in the United States.[12] The Pilates method is designed to stretch and strengthen muscles and improve coordination.[13,14] It emphasizes postural symmetry, breath control, abdominal strength, spine, pelvis and shoulder stabilization, muscular flexibility, joint mobility and strengthening through the complete range of motion of all joints.[13,15] Pilates exercises are also designed to lengthen and strengthen core stabilizers including transverse abdominis, multifidus, and pelvic floor stabilizers along with the superficial abdominal and back extensor muscles while incorporating diaphragmatic breathing.[12] The difference between Pilates and Pilates-based exercise is the use of specialized equipment, Pilates-based is a mat program without the use of equipment. However, there is little information that exists on Pilates-based mat exercises as a viable method to meet functional goals established by physical therapists.

In a systematic review of Pilates research Bernardo[16] found 277 articles with only 39 refereed. Three of those articles were clinical trials which showed Pilates to be an effective

exercise program for healthy adults. The author stated the majority of articles lacked true experimental design and noted a need for further research.

In a clinical trial by Keayes et al[17] the effects of Pilates on shoulder range of motion was investigated in women with breast cancer. The authors found improvements in shoulder abduction and external rotation ROM but limited effects on pain, mood, and upper-extremity function, although no adverse effects were reported. While this study found Pilates increased shoulder ROM for patients following surgery for breast cancer, there is little research with other diagnoses including injuries to the hip.

Levine et al[19] described the use of Pilates for rehabilitation following hip and knee arthroplasty. Like Bernardo,[16] the authors indicated that the current literature was lacking and more controlled studies are necessary. The authors discussed rehabilitation using the whole body approach for maximizing function and flexibility. They stated that the Pilates method provides a quicker return to independent exercise. They listed and described beginner, intermediate, and advanced mat exercises that are safe for patients after either total hip or knee arthroplasty and stated the benefits may be seen in gait and balance. While this article was not a controlled study, it provided Pilates protocols following THA for up to 6 months after surgery.

In another study with healthy adults, Herrington and Davies[18] compared isolating the activation of transverses abdominis in a Pilates trained group, abdominal crunch group, and no training group. Thirty-six asymptomatic females were assessed using a pressure biofeedback unit. Eighty-three percent of the Pilates group was able to isolate the transversus abdominis compared to 33% of the abdominal crunch group and 25% of the control group,

indicating that Pilates training provided the best transversus abdominal activation for non-injured females.

At present, there is limited research to determine the effectiveness of the Pilates method compared to traditional intervention techniques as an option for patients receiving physical therapy for any surgical rehabilitation. Supervised strength training has been shown to improve functional outcomes measures efficiently and cost effectively in patients following THA.[3,7,11] Pilates exercises have been shown to improve shoulder ROM[17] and isolate the transverses abdominis[18] but their effectiveness following THA has not been studied. This case report describes the use of traditional and Pilates-based mat exercises for two patients seen in outpatient physical therapy following THA.

Case Description

Two moderately conditioned females sought outpatient physical therapy 5 weeks following right posterior approach THA. Both received 1 week of subacute care and, upon discharge, received 4 weeks of home care prior to their first outpatient visit. Patient 1 was a retired 72-year-old female with complaints of right hip and thigh pain with prolonged walking greater than 30 minutes on hard surfaces, worst at the end of the day, and was unable to participate in road cycling due to right hip weakness. Her past medical history included: hypertension, breast cancer, and gall bladder removal. Patient 2 was a retired 77-year-old female with complaints of right hip and thigh pain with descending stairs, rising from prolonged sitting greater than 30 minutes, and prolonged walking of greater than 15 minutes. She was unable to participate in horseback riding due to decreased right hip ROM and weakness. Patient 2 presented with a straight cane for ambulation. Her past medical history included right knee osteoarthritis, bronchitis, ovarian cyst removal, and fractured ribs. Both

patients reported their mechanism of injury was from repetitive wear-and-tear resulting in right THA. Patient 1 quantified pain intensity on a 10 mm visual analog scale (VAS) 3/10 at worst in the evening and with walking greater than 10 minutes on hard surfaces and 0/10 at best with rest. Patient 2 reported a 6/10 at worst on the VAS with ascending/descending 1 flight of stairs, initial getting up from prolonged sitting greater than 20 minutes, and prolonged walking greater than 10 minutes on hard surfaces and 0/10 at best with rest.

Gait was analyzed while the patient ambulated at a self-selected pace. Patient 1 used one auxiliary crutch on the left with right toeing-out and right hip drop during mid-stance phase and right hip circumduction during mid-swing. Patient 2 used a straight cane on the left with decreased stride length on the right during initial contact, right toeing-out during mid-stance, poor right hip extension with push-off in terminal stance and right hip circumduction during mid-swing.

The patients completed the Lower Extremity Functional Scale (LEFS). The LEFS was used to measure functional capacity. The LEFS was found to have a .94 test-retest reliability.[20] This scale uses a grading system from 1-4 with 1 being most difficult to perform activity of daily living (ADL) and 4 being the least difficult with a score of 80/80 indicating the highest functioning level.[20] Both patients scored 16/80. The LEFS is found in Appendix A.

Range of motion was measured on the right surgical hip by use of a large goniometer while the patient actively moved the joints as described in Norkin and White.[21] See Table 1 for right hip active ROM measurements. Hamstring length flexibility was recorded in supine with a straight leg raise of 45° and 58° for Patient 1 and 2 respectively.

Lower extremity strength was measured by manual muscle testing (MMT) using the break test as described by Daniels and Worthingham.[22] The MMT for both patients indicated moderate (2+/5 to 4+/5) deficits in muscle force production in the right lower extremity (Tab. 2).

Additional objective measurements were obtained including lumbar screens and reviews of the cardiovascular and pulmonary systems and were found to be unremarkable in both patients. The integumentary system was assessed by observation and well-healing 32.5 cm (Patient 1) and 33.75 cm (Patient 2) incisions with minimal exudate or edema were observed. Palpation was notable for moderate to marked tenderness along the length of incision, proximal gluteus medius insertion, all of the piriformis, and distal iliopsoas insertion.

Following examination, I determined that both patients were functionally limited because of muscle imbalance and weakness of the hip abductors and external rotators due to incision, trauma of surgery, and subsequent deconditioning. The following impairments were present in both patients: decreased strength, flexibility, and ROM. The patients also presented with gait abnormalities and pain that led to the following functional limitations for both patients: decreased community ambulation (unable to participate in walking distances greater than 20 minutes from patient report), performance of ADL's including dressing and household activities (vacuuming, laundry), yard work (gardening), and recreational activities including sports and hobbies. Patient 1 was unable to return to road cycling and Patient 2 was unable to participate in horseback riding. These impairments and functional limitations are typical following THA.

For treatment, I chose exercises to improve control and strength of the hip, spine, and pelvic musculature and stabilizers to return both patients to their previous activity level, as they both fell into Pattern 4I: Impaired Joint Mobility, Motor Function, Muscle Performance, and Range of Motion Associated With Bony of Soft Tissue Surgery from the American Physical Therapy Association Guide to Physical Therapist Practice.[23]

Intervention

Exercises for each patient were chosen to address the identified impairments of decreased strength, flexibility, and ROM. Patient 1 received Pilates-based mat exercises and Patient 2 received traditional mat exercises. There were no contraindications for either patient in performing either strength training intervention. In addition, both patients received gait training, cardiovascular conditioning, balance and proprioception drills, and manual physical therapy of soft tissue and joint mobilizations to aid in decreasing pain.

Both patients received gait training on a treadmill at 0% incline at 1.7 miles per hour for 5 minutes with verbal, tactile, and visual feedback for proper gait mechanics to minimize right toeing-out during mid-stance and normalize right hip extension at terminal stance. They both received cardiovascular conditioning on a stationary upright bike for up to 10 minutes with level 1 resistance. Both patients also were instructed on balance activities starting with bilateral static balance on the floor to dynamic unilateral balance on a foam pad for 3 sets of 30 seconds on the surgical right limb. Manual therapy was provided to both patients including transverse friction over the scar and soft tissue mobilization to the gluteus medius, piriformis, and iliopsoas to minimize edema along with grade 1 joint distractions to the surgical right hip for pain relief.

Patient 1 was seen in physical therapy for 12 sessions over 6 weeks and was given Pilates-based mat exercises to specifically target the impairments found upon examination (Tab. 3). The patient was given verbal and tactile cueing along with pictures and written instructions during her physical therapy sessions. She was also given imprinting, bridging, table top marching, and clams (sidelying hip external rotation with bent knee) to continue in a home exercise program for 1 set of 8 repetitions 1 time a day throughout the course of her physical therapy sessions. Refer to Appendix B for a description of Pilates-based mat exercises. Imprinting, the term used to describe flattening the lumbar spine in supine with bent knees, was given to patient 1 for a warm-up to help her segmentally mobilize the lumbar spine to become centered. Centering is a Pilates principle meaning stabilizing the core prior to initializing movement of the arms or legs. Imprinting helped to lengthen and relax the patient's spine prior to performing bridging. Bridging focused on maintaining pelvic stability through movement. After warm-up, Patient 1 was asked to perform table top exercises that included laying supine with hips and knees at 90 degrees. Table top exercises are an effective transition from warm-ups because they involve abdominal stabilization with lower extremity movement. Single leg circles were prescribed to engage the stabilizing and rotary hip muscles as well as providing flexibility to the hamstrings. The sidelying kick series are a set of 6 different leg lifts prescribed to Patient 1 to incorporate abdominal stabilization while involving all hip gross movers to benefit hip range of motion and strength and, in turn, improve ambulatory capacity, reduce postoperative limping, and increase hip stability.[19]

Patient 2 was seen in physical therapy for 24 sessions over 11 weeks and was instructed in the following traditional mat exercises: short arc quadriceps, straight leg raises, bridging in supine, long arc quadriceps, hip adduction in sitting, hip abduction in side lying,

and hip extension in prone and was instructed to perform 3 sets of 10 repetitions. The patient was instructed verbally and shown by demonstration-return demonstration and given tactile cues on correct positioning and action throughout each exercise, and visual pictures with written instructions for a home exercise program including straight leg raises, bridging, hip abduction and hip extension. The patient was to perform exercises bilaterally and instructed to perform 3 sets of 10 repetitions daily. Exercise was progressed by adding resistance during her physical therapy sessions and at discharge she was able to perform short and long arc quadriceps with 10 pound ankle weights, straight leg raises with 8 pounds, and hip abduction and extension with 5 pounds. Resistance was added to bridging by using a 4 pound medicine ball between her thighs just superior to the knees. No additional resistance was added to hip adductor squeezes.

Short arc quadriceps was performed in supine with a 12 inch foam roll placed under the knee. The patient was instructed to lift the heel while maintaining contact on the roll to terminally extend the knee. For straight leg raises, the patient remained in supine and was instructed to keep the leg extended by dorsiflexing the foot while raising the leg 12 inches. Bridging was also performed in supine with the knees bent. The patient was instructed to lift the hips without arching the low back and to maintain parallel hips. Long arc quadriceps was performed in sitting and she was instructed to extend the leg to tighten the quadriceps. The patient performed hip adduction by placing a towel roll between the thighs and providing isometric contraction by squeezing into the roll for 5 seconds with each repetition. Hip abduction was performed in side lying where the patient was instructed to bend the bottom knee while straightening the top limb to maintain a straight line from the shoulder to the hip and ankle. The patient was then instructed to lift the straight limb 12 inches without letting

the foot externally rotate. The patient performed prone hip extensions by squeezing the gluteus maximus while lifting the straight limb without rotating the lumbar spine.

Outcomes

At discharge, both patients noted improved right hip function but Patient1 had complaints of continued difficulty with putting shoes on and kneeling. Both patients were able to ambulate without an assistive device with observed increased stride length and decreased circumduction on the surgical leg. Quality of life and functional gains improved regardless of exercise intervention with patient 1 returning to 30 minutes of outdoor cycling and patient 2 to 2 hours of leisure horseback riding. Both patients' objective measurements increased following the course of physical therapy sessions. ROM and MMT improved with both patients. Refer to Table 1 and 2, respectively, for ROM and MMT measurements at initial examination and discharge. For both patients, pain decreased along with improved functional scores (Tab. 4). The major difference between the outcomes of the patients was the time of discharge and the LEFS scores at discharge. Patient 1, who received Pilates-based mat exercises, was discharged at her 12th visit after 6 weeks with a functional score of 63/80. Patient 2 was seen for 24 visits over 11 weeks with a lower functional score of 49/80 at discharge.

Discussion

Physical therapist examination findings for both patients determined loss of strength and ROM with decreased ability to perform functional tasks following right THA. Therefore, interventions included supervised strength training to target functional limitations. Traditional therapeutic mat exercises have been used to treat patients following THA.[3,7,11] Supervised traditional mat exercises are designed to strengthen leading to improved

functional tasks[7,11] while providing cost efficient care and earlier discharge.[3] Both patients demonstrated improved strength, ROM, and function and return to premorbid activities (bicycling and horseback riding) along with decreased pain. However, the patient receiving Pilates-based exercises was discharged 5 weeks earlier from physical therapy with a higher score on the LEFS compared to the patient receiving traditional mat exercises.

Pilates-based exercise was believed to be an appropriate intervention option because the exercises mimicked traditional exercises and also focused on core stabilization.[12] Despite the lack of randomized controlled trials determining the effectiveness of Pilates-based exercise on meeting functional goals for patients following THA, some benefits are thought to include: improved coordination, pelvis strength and stabilization, muscular flexibility, joint mobility and strengthening through the complete range of motion of all joints.[12-15] Another benefit of Pilates-based exercises is that they can be practiced independently as a home exercise program. While adverse effects have not been investigated related to Pilates-based exercise following THA, general precautions include patients with osteoporosis[24] or who are pregnant.[25] Since neither patient presented with osteoporosis or were pregnant, exercises were progressed without limitations.

The differences in outcomes between these 2 patients were length of care and function as measured by the LEFS. Perhaps the more rapid return of premorbid function in Patient 1 can be explained by the use of the whole body rehabilitation approach[13, 15] instead of just focusing on strengthening the weak musculature found during examination. The patients' outcomes cannot be credited to only the exercises provided. Cardiovascular conditioning, gait training, balance training and manual therapy were used to assist in improved ROM, strength, and return both patients to independent ADL and function.

One limitation with this case report is the same physical therapist delivered the intervention and took the objective measurements that could have led to unintentional bias on re-assessment. An additional limitation was the lack of supervision or follow-up on home exercise program compliance for either patient. If either patient was inconsistent with following her home exercise program, this could have influenced the length of time needed in supervised physical therapy.

The patients' outcomes could be due to additional contributing factors including age and the natural course of recovery. Patient 1 was younger which could address her faster improvement and functional outcome score. Wagenmakers et al[26] suggest normal activity for patients' following THA under the age of 65 is significantly higher than those older than 65.

Pilates-based exercises may lead to continued exercise beyond the course of physical therapy and could contribute to further improvement. Patient 2 was motivated to continue to get stronger and because of the popularity of Pilates exercise, decided to take a Pilates-based weekly mat class after discharge from physical therapy. After an 8 week session, she reported feeling more flexible and stronger in her abdominals. Perhaps this continued exercise could contribute to maintaining and prolonging functional use of her hip.

An experimental research design is necessary to validate and justify the Pilates-based exercise effects as a physical therapy intervention for patients following THA. Future considerations should include randomized controlled trials evaluating multiple individuals following THA to determine cause-effect relationship. Studies should determine what specific Pilates-based exercises would be most appropriate for patients following THA. Future studies could also include the use of Pilates-based interventions that would address other joint replacements such as total knee replacements.

Physical therapist management of 2 patients following THA using traditional and Pilates-based mat exercises appeared to help in the return to prior level of function. However, the patient who received Pilates-based mat exercises was discharged 5 weeks earlier from physical therapy with a higher score on the LEFS. Pilates-based exercise should be considered as a potential intervention for patients following THA based on further research to determine effectiveness.

References

1. Munin MC, Rudy TE, Glynn NW, et al. Early inpatient rehabilitation after elective hip and knee arthroplasty. *JAMA.* 1998;279(11):847-852.

2. Wagenmakers R, Stevens M, van den Akker-Scheek I, Zijlstra W, Groothoff JW. Predictive value of the Western Ontario and McMaster Universities Osteoarthritis Index for the amount of physical activity after total hip arthroplasty. *Phys Ther.* 2008;88(2):211-217.

3. Freburger JK. An analysis of the relationship between the utilization of physical therapy services and outcomes of care for patients after total hip arthroplasty. *Phys Ther.* 2000;80(5):448-458.

4. Berger RA, Jacobs JJ, Meneghini RM, Della Valle C, Paprosky W, Rosenberg AG. Rapid rehabilitation and recovery with minimally invasive total hip arthroplasty. *Clin Orthop Relat Res.* 2004;429(12):239-247.

5. Mangione KK, Lopopolo RB, Neff NP, Craik RL, Palombaro KM. Interventions used by physical therapists in home care for people after hip fracture. *Phys Ther.* 2008;88(2):199-210.

6. Jan MH, Hung JY, Lin JC, Wang SF, Liu TK, Tang PF. Effects of home program on strength, walking speed, and function after total hip replacement. *Arch Phys Med Rehabil.* 2004;85(12):1943-1951.

7. Unlu E, Eksioglu E, Aydog E, Aydoo ST, Atay G. The effect of exercise on hip muscle strength, gait speed and cadence in patients with total hip arthroplasty: a randomized controlled study. *Clin Rehab.* 2007;21(8):706-711.

8. Bhave A, Marker DR, Seyler TM, Ulrich SD, Plate JF, Mont MA. Functional problems and treatment solutions after total hip arthroplasty. *J Arthroplasty.* 2007;22(6):116-124.

9. Botney R, Stacey BR. Rehabilitation after hip and knee athroplasty. *JAMA.* 1998;280(16):1402-1403.

10. Allen RA, Brander VA, Stulberg SD. Rehabilitation: the importance of physical conditioning. In: *Arthritis of the Hip and Knee: The Active Persons Guide to Taking Charge.* Atlanta, GA: Peachtree; 1998:171-195.

11. Frost KL, Bertocci GE, Wassinger CA, et al. Isometric performance following total hip arthroplasty and rehabilitation. *Rehabil Res Dev.* 2006;43(4):435-444.

12. Isacowitz R. Enhancing the mind and body. In: *Pilates: The Ultimate Pilates Reference*. Champaign, IL: Human Kinetics; 2006:6-9.

13. Pilates Method Alliance®. Position paper: on pilates. Available at: http://www.pilatesmethodalliance.orgpmapositionpaper_on_pilates.pdf. Accessed September 16, 2008.

14. Pilates JH, Miller WR. *Return to Life Through Contrology.* Miami, FL: Pilates Method Alliance, Inc; 2003.

15. Lugo-Larcheveque N, Pescatello LS, Dugdale TW, Veltri DM, Roberts WO. Management of lower extremity malalignment during running with neuromuscular retraining of the proximal stabilizers. *Curr Sports Med Rep.* 2006;5(3):137-140.

16. Bernardo LM. The effectiveness of Pilates training in healthy adults: an appraisal of the research literature. *J Bodyw Mov Ther.* 2007;11(2):106-110.

17. Keayes KS, Harris SR, Luchyshyn JM, MacIntyre DL. Effects of Pilates exercises on shoulder range of motion, pain, mood, and upper-extremity function in women living with breast cancer: a pilot study. *Phys Ther*. 2008;88(4):494-509.

18. Herrington L, Davies R. The influence of Pilates training on the ability to contract the transversus abdominis muscle in asymptomatic individuals. *J Bodyw Mov Ther.* 2005;9(1):52-57.

19. Levine B, Kaplanek B, Scafura D, Jaffe WL. Rehabilitation after total hip and knee arthroplasty: a new regimen using Pilates training. *Bull NYU Hosp Jt Dis.* 2007;65(2):120-125.

20. Binkley JM, Stratford PW, Lott SA, Riddle DL. The lower extremity functional scale (LEFS): scale development, measurement properties, and clinical application. *Phys Ther.* 1999;79(4):371-383.

21. Norkin CC, White DJ. *Measurement of Joint Motion: A Guide to Goniometry*, 3rd ed, Philadelphia, PA: FA Davis; 2003:183-220.

22. Hislop HJ, Montgomery J. *Daniels and Worthingham's Muscle Testing: Techniques of Manual Examination*, 7th ed, Philadelphia, PA: WB Saunders; 2002.

23. Guide to Physical Therapist Practice. *Phys Ther,* 2001;81(1):277-294.

24. Sinaki M, Mikkelsen B. Postmenopausal spinal osteoporosis: flexion versus extension exercises. *Arch Phys Med Rehabil.* 1984;65(10):593-596.

25. ACOG Committee. Opinion no. 267: exercise during pregnancy and the postpartum period. *Obstet Gynecol.* 2002;99:171-173.

26. Wagenmakers R, Stevens M, Zijlstra W, et al. Habitual physical activity behavior of patients after primary total hip arthroplasty. *Phys Ther.* 2008;88(9):1039-1048.

Table 1: Active range of motion using goniometric measurements[a] for right hip at initial examination (IE) and at discharge (DC).

	Patient 1		Patient 2	
	IE	DC	IE	DC
Hip Flexion	82°	115°	85°	100°
Hip Extension	5°	-4°	5°	-12°
Hip Abduction	15°	24°	20°	28°
Internal Rotation	22°	32°	20°	35°
External Rotation	10°	20°	5°	20°

[a]Range of motion measured according to procedure of CC Norkin and DJ White, *Measurement of Joint Motion: A Guide to Goniometry,* 3rd ed, FA Davis, 2003

Table 2: Manual muscle testing[b] for the right hip and knee at initial examination (IE) and at discharge (DC) (* denotes pain).

	Patient 1		Patient 2	
	IE	DC	IE	DC
Hip Flexion	3+/5*	5/5	3/5*	5/5
Hip Extension	3-/5*	5/5	3/5*	4+/5
Hip Abduction	3-/5*	5/5	3/5*	5/5
Hip Adduction	2+/5	4+/5	2+/5*	4/5
Internal Rotation	3/5	5/5	3/5	5/5
External Rotation	3/5*	5/5	3/5*	4+/5
Knee Flexion	5/5	5/5	4+/5	5/5
Knee Extension	5/5	5/5	5/5	5/5

[b]Manual muscle testing measured according to procedure of HJ Hislop and J Montgomery, *Daniels and Worthingham's Muscle Testing,* 7th ed, Philadelphia, PA, WB Saunders, 2002

Table 3: Pilates-Based Mat Exercises

Phases	**Exercises**
Warm-Up	- Imprinting - Bridging
Mat Exercises	- Table Top (marching/circles) - Single leg circles - Sidelying kick series (flexion/extension, abduction/adduction, circles, double leg lifts, bicycles, clams)

Table 4: Pain and Lower Extremity Functional Scale (LEFS) scores at initial examination (IE) and discharge (DC)

	Patient 1		Patient 2	
	IE	DC	IE	DC
Pain (VAS*)	3/10	1/10	6/10	1/10
LEFS	16/80	63/80	16/80	49/80

*visual analog scale

Appendix A: Lower Extremity Functional Scale Survey[c]

We are interested in knowing whether you are having any difficulty at all with the activities listed below because of your lower limb problem for which you are currently seeking attention. Please provide an answer for **each** activity.

Today, do you or would you have any difficulty at all with:

(Circle one number on each line)

Activities	Extreme Difficulty or Unable to Perform Activity	Quite a Bit of Difficulty	Moderate Difficulty	A Little Bit of Difficulty	No Difficulty
a. Any of your usual work, housework, or school activities.	0	1	2	3	4
b. Your usual hobbies, recreational or sporting activities.	0	1	2	3	4
c. Getting into or out of the bath.	0	1	2	3	4
d. Walking between rooms.	0	1	2	3	4
e. Putting on your shoes or socks.	0	1	2	3	4
f. Squatting.	0	1	2	3	4
g. Lifting an object, like a bag of groceries from the floor.	0	1	2	3	4
h. Performing light activities around your home.	0	1	2	3	4
i. Performing heavy activities around your home.	0	1	2	3	4
j. Getting into or out of a car.	0	1	2	3	4
k. Walking 2 blocks.	0	1	2	3	4
l. Walking a mile.	0	1	2	3	4
m. Going up or down 10 stairs (about 1 flight of stairs).	0	1	2	3	4
n. Standing for 1 hour.	0	1	2	3	4
o. Sitting for 1 hour.	0	1	2	3	4
p. Running on even ground.	0	1	2	3	4
q. Running on uneven ground.	0	1	2	3	4
r. Making sharp turns while running fast.	0	1	2	3	4
s. Hopping.	0	1	2	3	4
t. Rolling over in bed.	0	1	2	3	4
Column Totals:					

SCORE: _____/80

Error (single measure): ±5 scale points
MDC: 9 scale points
MCID: 9 scale points

[c]Reprinted with permission of the American Physical Therapy Association from: J Binkley, P Stratford, S Lott, D Riddle & The North American Orthopaedic Rehabilitation Research Network. The lower extremity functional scale (LEFS): scale development, measurement properties, and clinical application, *Phys Ther*. 1999;79(4) 371-383.

Appendix B: Pilates-based mat exercises

Imprinting

1. Start in supine hooklying with feet shoulder width apart.
2. Relax shoulders into floor while relaxing spine and lightly imprinting lumbar spine into mat.
3. Maintain imprint for 3 to 5 breaths.

Bridging

1. Start in supine hooklying with feet shoulder width apart.
2. Inhale to prep to relax the spine then exhale and tilt the pelvis and pull abdominal muscles toward spine.
3. Inhale and press through heels as the tailbone raises off mat.
4. Exhale and roll spine back down and lower hips using abdominal control.

Table Top Marching

1. Start in supine with leg hips and knees bent to 90°.
2. Inhale to relax spine and exhale to lower toe of one leg while maintaining other leg in table top.
3. Inhale and raise lowered leg back to table top and exhale and lower opposite toe down.

Table Top Circles

1. Start in supine with hips and knees bent to 90°.
2. Lightly press knees and heels together and inhale to relax spine then exhale and rotate knees in a circle maintaining table top.
3. Repeat 4 times then reverse direction.

Single Leg Circles

1. Start supine.
2. Engage abdominals to anchor pelvis and extend one leg toward the ceiling.
3. Inhale and cross extended leg toward the opposite hip then exhale and drop leg a few inches and sweep into circular motion to return back to center while maintaining stable hips.
4. Repeat 4 times then reverse direction and repeat on other leg.

Side-Lying Kick Series: Flexion/Extension

1. Start laying on side propping head with same side hand and rest the opposite hand in front of chest. Keep hips stacked and slightly bend same side knee.
2. Inhale and engage abdominals to keep pelvis stable then exhale and swing top leg forward and flexing foot.
3. Inhale and point foot while extending straight leg back.
4. Repeat 4 times then do 4 more reversing the angle at the ankle (Ex. Point toes while flexing hip, flex foot and extend hip).

Abduction/Adduction

1. Start in same starting position as flexion/extension.
2. Inhale and engage abdominals then exhale and abduct top leg while flexing foot.
3. Inhale and point foot while adducting top leg.
4. Repeat 4 times then do 4 more reversing the angles at the ankle (Ex. Point toes while abducting, flex foot and adduct).

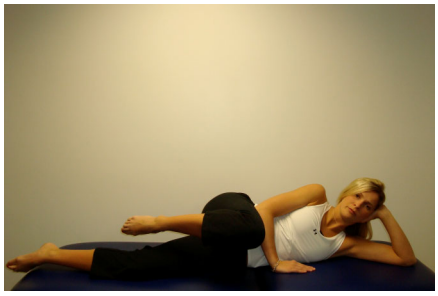
Circles

1. Start in same starting position as flexion/extension.
2. Inhale and engage abdominals then exhale and point foot while flexing hip then circumducting toward ceiling and return to start.

3. Repeat 4 times then repeat 4 more times in reverse direction.

Double Leg Lift

1. Start in same starting position as flexion/extension except extend bottom leg straight and lightly press feet together.
2. Inhale and engage abdominals then exhale and lift both legs together toward ceiling.
3. Inhale and drop legs down together keeping abdominals engaged.



Bicycles

1. Start in same starting position as flexion/extension.
2. Inhale and engage abdominals then exhale and flex top hip and knee to 90°.
3. Inhale and extend top knee then exhale and swing hip into extension.
4. Inhale return to start.
5. Repeat 4 times then repeat 4 more times in reverse direction.

Clams

1. Start in sidelying with both knees bent to 90°.
2. Lightly press toes together, inhale and engage abdominals then exhale and raise top knee toward ceiling keeping hips stacked.
3. Inhale and return to start.
4. Repeat 8 times.