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**OUTCOMES OF CONSERVATIVE PHYSICAL THERAPY TREATMENT FOR
OSTEOARTHRITIC KNEE PAIN IN A 58 YEAR-OLD FEMALE:
A CASE REPORT**

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ABSTRACT

Background/Purpose: Knee osteoarthritis (OA) is the most commonly diagnosed form of arthritis in older adults. The purpose of this case study is to describe a conservative physical approach towards alleviating symptomatic knee OA pain and achievement of functional outcomes.

Case Description: The patient was a 58-year-old Caucasian female with complaints of left shin and knee pain with a complex medical history. The patient's goal for physical therapy was to return to functional activities such as walking greater than 60 minutes and climbing stairs pain free.

Outcomes: Upon completion of physical therapy, the patient demonstrated slight increases in left knee flexion range of motion (ROM) that were within functional limits, improvements in left hip and knee muscle strength, improvements in the 6 Minute Walk Test (6MWT), and independence completing a Home Exercise Program (HEP).

Discussion: This case report has shown how conservative physical therapy treatment through the application of various interventions may be used to rehabilitate symptomatic arthritic knee pain in a 58-year-old female. This was demonstrated by improvement of active range of motion (AROM), muscle strength, and the 6MWT along with decreased reports of symptomatic knee pain.

INTRODUCTION

Knee osteoarthritis (OA) is the most commonly diagnosed form of arthritis in older adults in the USA.¹ In a study completed by Murphy *et al.* it was found that the probability of someone developing symptomatic knee OA in at least one knee by the age 85 is 1 of 2 in people with a knee injury, and 2 of 3 individuals with obesity.² Knee OA, and related pain symptoms, has been linked to diminished physical functioning and poor quality of life in patients seeking health care.³ Miller and Block found that with a multimodal conservative treatment program of low impact aerobic exercise, muscle flexibility exercises, joint mobilizations, physical therapy modalities, muscle strengthening, functional training, patient education, and hyaluronic injections for patients with advanced knee OA had a favorable prognosis without resorting to surgical intervention.⁴ Since life expectancy is increasing and the age that patients are diagnosed with knee OA is decreasing, alternative treatments for treating knee OA, continually needs to be explored. The purpose of this case study is to describe a conservative physical therapy treatment approach towards alleviating symptomatic knee OA pain and achieving functional outcomes.

CASE DESCRIPTION

Subject

The patient was a 58-year-old Caucasian female that presented to physical therapy in July of 2014 with complaints of left shin and knee pain. She had a history of bilateral knee OA and a right total knee replacement. She reported receiving three left knee lubrication injections that provided some left knee pain relief, but reported that she was unable to walk for greater than 40 minutes without pain.

Prior to onset of pain the patient had been participating in a daily walking regimen for 40-60 minutes a day, which had resulted in weight loss. The patient reported the onset of symptoms to be in May of 2014 with complaints of an intermittent throbbing and dull pain in and around the left knee, which she rated at its worst as a 5/10 on the Numerical Pain Rating Scale (NPRS). The patient had radiographs completed in May of 2014 indicating osteoarthritis of the left knee, which was reported stable since a previous radiograph in April of 2013. Past medical history included obesity, neoplasm of skin (nose), esophageal reflux, unspecified disorder of gallbladder, liver disease, kidney stones, hypertension, cholelithiasis, and detrusor instability of bladder. Past surgical history included right total knee arthroscopy and bone spur removal in right foot in May of 2014. Her current medications included: Furosemide, Vitamin D, Cholecalciferol (vitamin D3),

Biotin, Oxybutynin, Alprazolam, Pantoprazole, and a Multivitamin. The patient was employed as a teacher and married.

The patient reported receiving physical therapy treatment in the past but was not seeking additional care for her knee pain. Prior to this episode of care the patient was able to complete activities of daily living, climb stairs, and walk for prolonged periods of time (45-60 minutes) without complaints of pain. The patient reported that her goal for physical therapy was to be able to return to walking for 40-45 minutes, go up and down stairs, and to be able to teach for a full day without left knee pain.

Systems Review

Due to the patient's complaints of pain with increased walking, activities of daily living, and stairs, a systems review was completed upon initial examination. The patient presented with atypical findings for the musculoskeletal system. Active range of motion was found to be similar bilaterally, yet muscle strength deficits were found to be greater in the left hip and knee comparatively to the right hip and knee. The patient demonstrated typical findings for the neuromuscular, and integumentary system review. The cardiopulmonary system was not examined at the initial evaluation. Screening for bowel and bladder involvement was negative at the initial evaluation.

CLINICAL IMPRESSION #1

The patient presented with a main complaint of left knee pain and the goal of returning to a more active lifestyle. Since the patient presented with pain and atypical musculoskeletal findings, she was deemed appropriate for a physical therapy episode of care focusing on patient education, flexibility, muscular strengthening, and increased motor control. Tests and measures were completed to assess knee joint range of motion, hip and knee manual muscle strength, and endurance throughout the patient's episode of care. The following tests and measures were completed in order to examine whether the patient would benefit from a course of conservative therapy to alleviate symptoms of left knee pain. The patient was deemed a good candidate for physical therapy due to her atypical findings during the systems review and her high motivation to complete a course of physical therapy.

EXAMINATION

Tests and Measures

Numerical Pain Rating Scale (NPRS)

Due to the patient's main symptomatic report of pain, the patient was asked to rate her knee pain over the past 24 hours on the NPRS scale at the start of each treatment session. The NPRS is a scale where 0 indicated no pain at all and 10 indicated being so painful the patient would seek care at

an emergency room. Table 1 depicts the patient's report of pain on the NPRS throughout her episode of care.

In a literature review by Hjerstad *et al.* numerical rating scales were found to have enough discrimination for patients to accurately depict their pain intensity for chronic conditions. The numerical rating scale was also found to be superior to the visual analog scale and the verbal rating scale secondary to its ease of use and patient compliance.⁵ It has also been found that a 3 point change in the NPRS is needed to demonstrate a true change in pain intensity.⁶

Table 1: Numerical Pain Rating Score Outcomes Throughout Physical Therapy Treatment

Session	NPRS
1	5/10
2	0/10
3	0/10
4	0/10
5	0/10
6	0/10
7	2/10

Active Range of Motion (AROM)

Upon initial evaluation, the patient demonstrated decreased terminal knee extension in the left knee during gait analysis. Due to the observed lack of knee extension, increasing this range could improve her gait, resulting in decreased pain with walking activities.

Bilateral knee flexion and extension were measured using a universal goniometer. Goniometer placement was as follows: stationary arm: lateral midline of femur towards greater trochanter; axis: lateral epicondyle of femur; and moving arm: lateral midline of fibula, in line with fibular head and lateral malleolus. AROM measurements are included in Table 2. Guidelines were adapted from *Reese, 2010*. Maintaining full knee AROM for patients with end stage knee OA has been found to delay the chance of requiring a total knee arthroscopy (TKA).⁷

Knee flexion intra-rater reliability has been shown to range from ICC = 0.86-0.97 and inter-rater reliability from 0.62-0.94. These numbers suggest good to excellent overall reliability for healthy adult patients who had knee OA.⁸

Table 2: AROM Outcomes following Conservative Physical Therapy Treatment Program

Session	AROM			
	Knee Flexion		Knee Extension	
1	Right:0°-110°	Left: 3°-116°	Right: 0°	Left: -3°
7	Right:0°-112°	Left: 2°-118°	Right: 0°	Left: -2°

Manual Muscle Testing (MMT)

During the initial evaluation the patient presented with decreased hip and knee strength with the left lower extremity musculature weaker than the right lower extremity. Bilateral hip and knee strength was measured in order to compare strength of muscle groups in the following positions: seated knee

flexion, seated knee extension, seated hip internal rotation, seated hip external rotation, side-lying hip abduction, and prone hip extension. Exact patient position and instruction was adapted from *Hislop*.⁹ Muscle strength outcomes are noted in Figures 1-6.

Since MMT is a subjective assessment, psychometric evidence is lacking. In an article by Bohannon, it was noted that the diagnostic accuracy of muscle strength between extremities ranged from 72%-77%, which suggested that differences in strength between extremities could be properly assessed by MMT. It was also noted that limitations exist for the specificity and sensitivity in MMT assessment and that dynamometer testing may be superior to MMT.¹⁰ Although these limitations are present, MMT has been found to be an appropriate test/measure for clinical use.⁹

Figure 1: Hip Extension Strength Outcomes Following Conservative Physical Therapy for 6 Weeks.

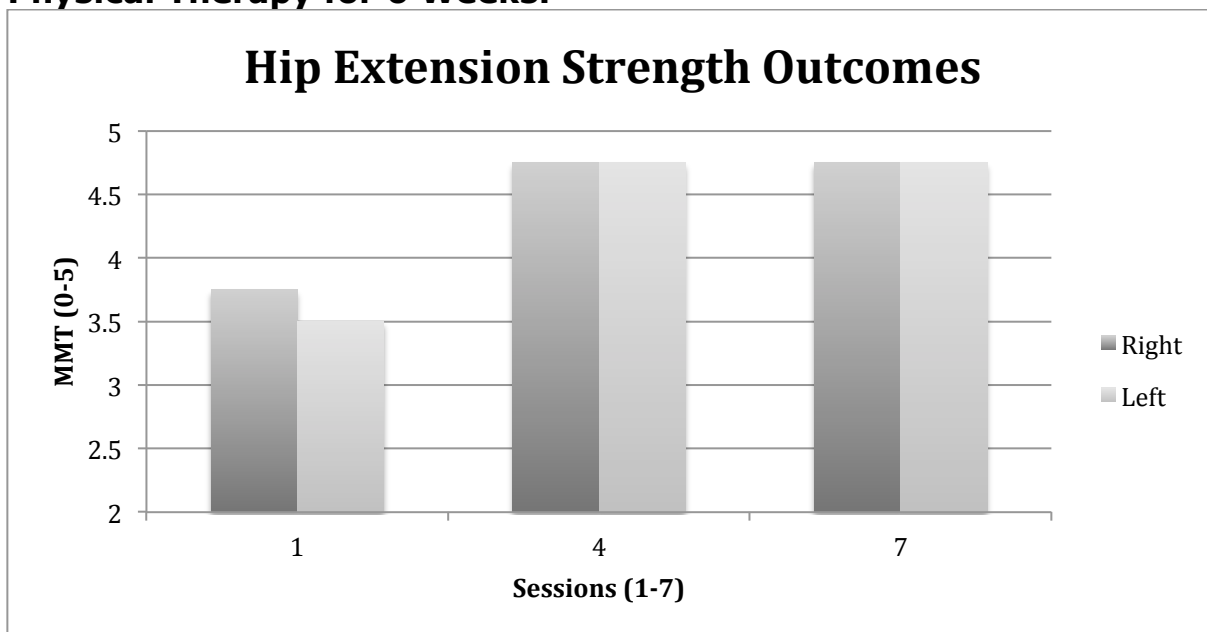


Figure 2: Hip Abduction Strength Outcomes Following Conservative Physical Therapy for 6 Weeks.

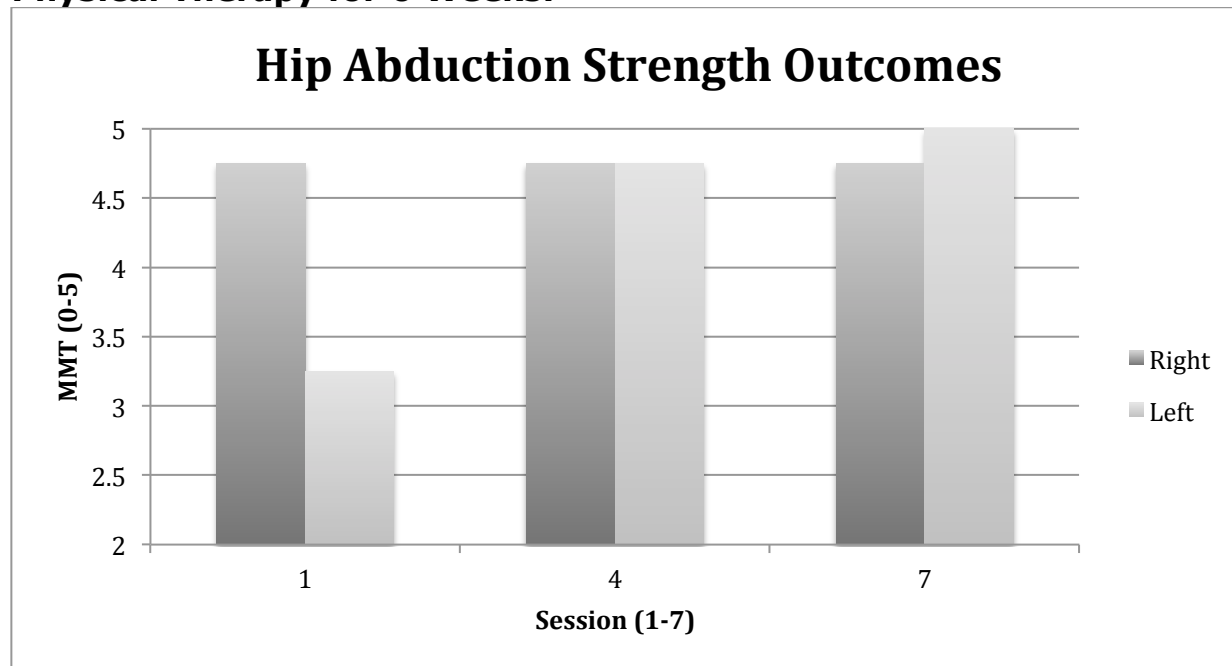


Figure 3: Hip Internal Rotation Strength Outcomes Following Conservative Physical Therapy for 6 Weeks.

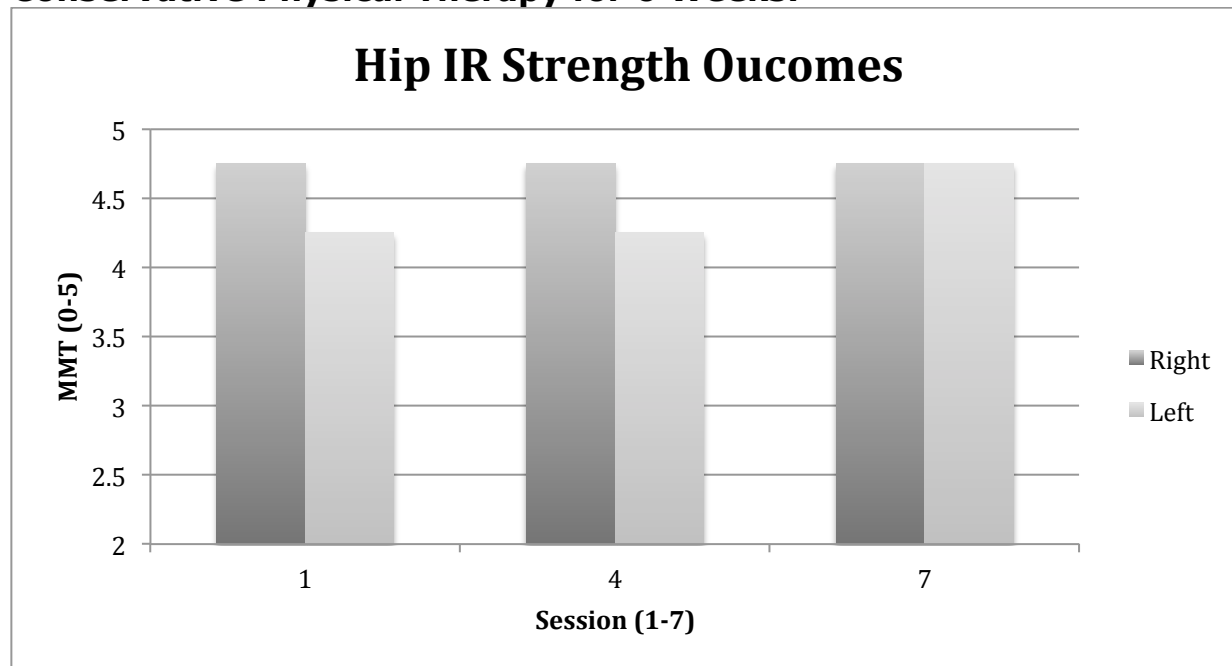


Figure 4: Hip External Rotation Strength Outcomes Following Conservative Physical Therapy for 6 Weeks.

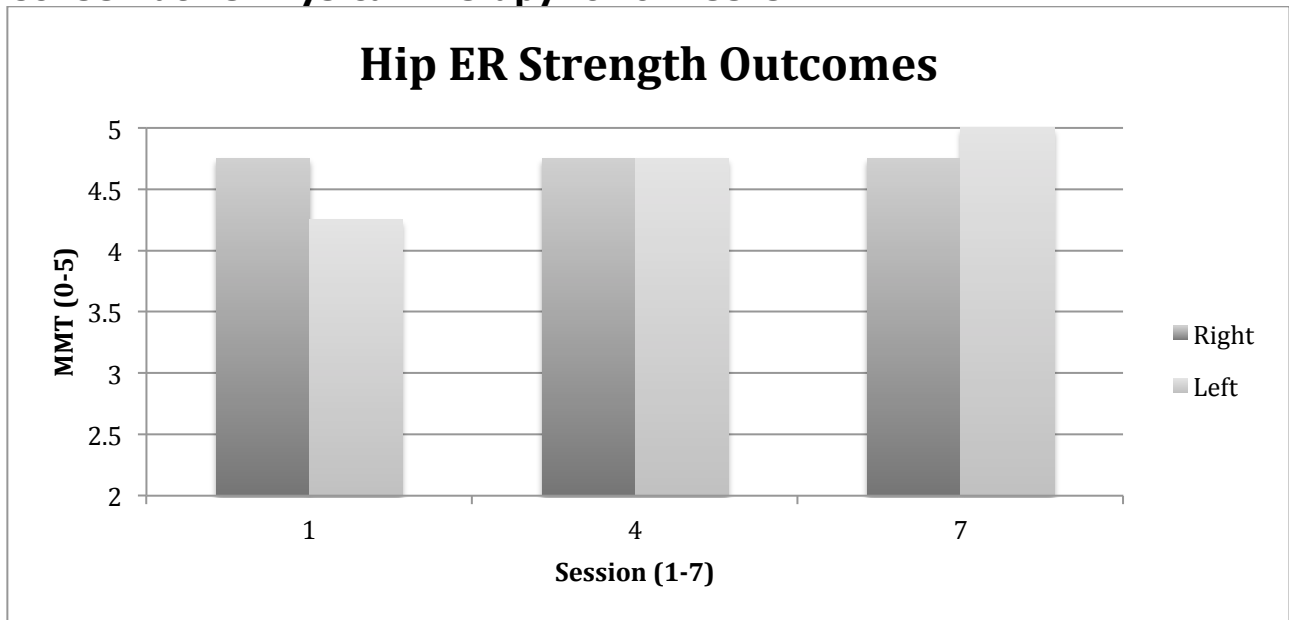


Figure 5: Knee Flexion Strength Outcomes Following Conservative Physical Therapy for 6 Weeks.

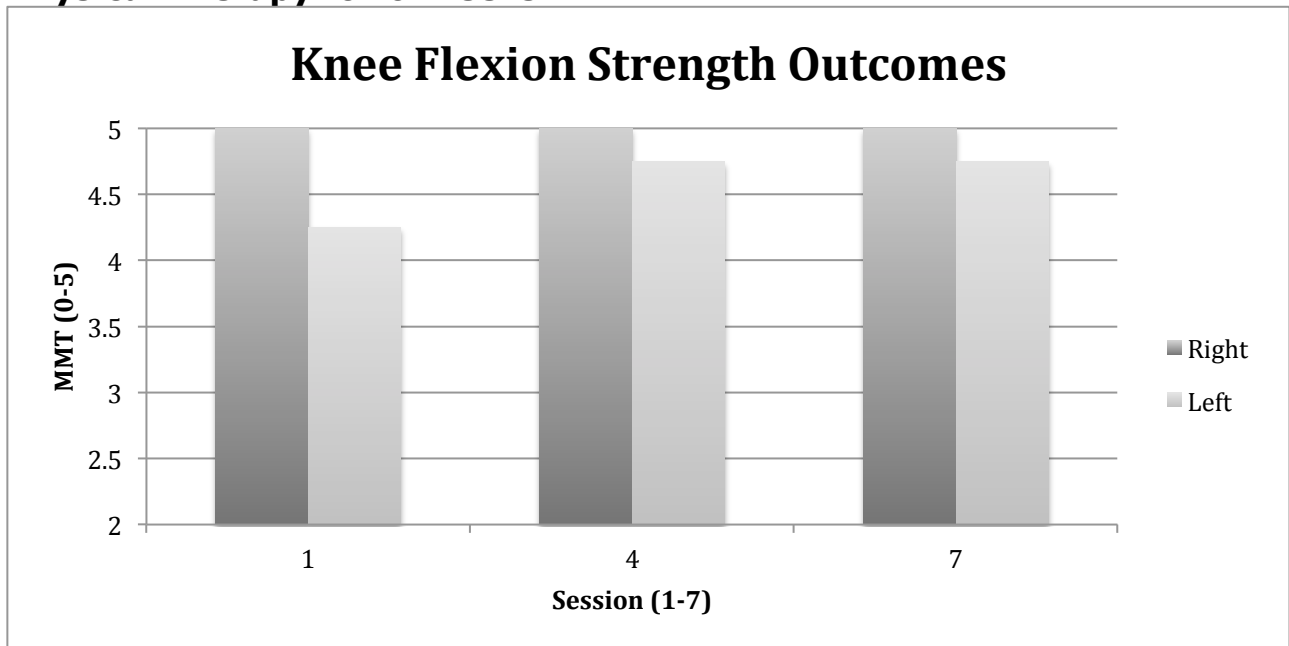
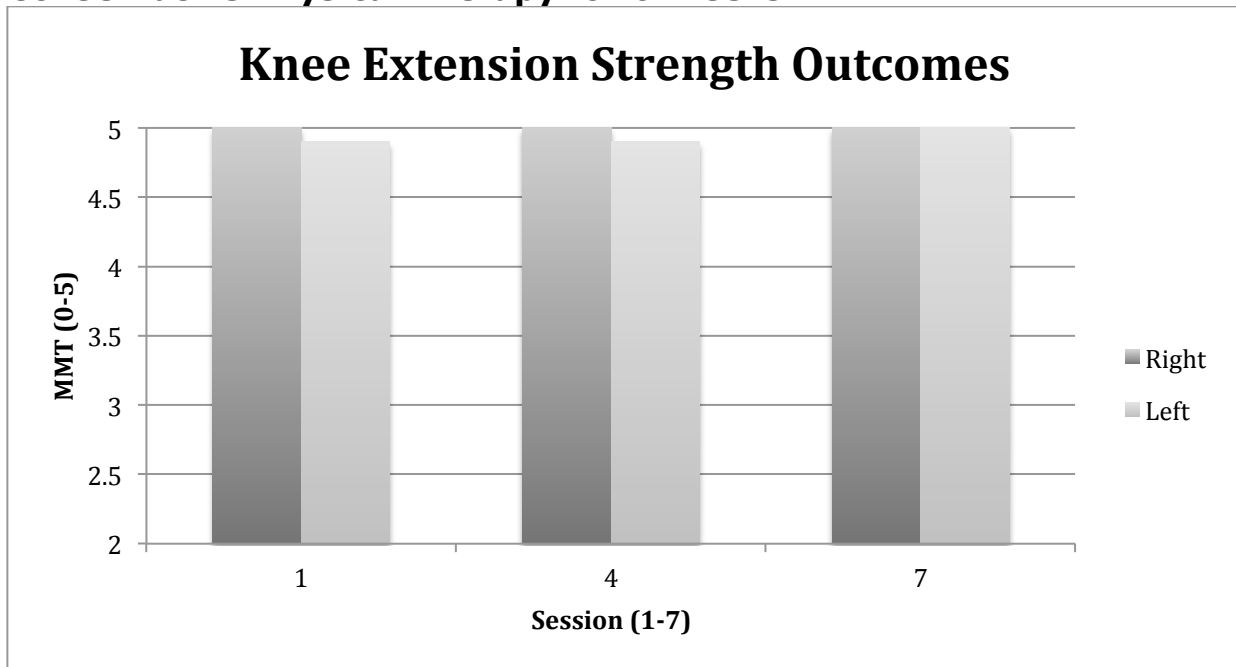


Figure 6: Knee Extension Strength Outcomes Following Conservative Physical Therapy for 6 Weeks.



*It should be noted that not all MMT strength measurements were retaken at session 4, some data points were duplicated conservatively from MMT strength measurements during session 1. At session 7, each MMT strength measurement was retested.

6-Minute Walk Test (6MWT)

The patient had been participating in a walking regimen for 40 minutes a day, but upon initial examination the patient expressed she could no longer ambulate the same distance secondary to the pain she was experiencing during endurance activities. The 6MWT was used at the middle and end of physical therapy to assess the patient's ability to complete endurance activities pain free. The initial evaluation of this patient was completed by a different physical therapist so the 6MWT was assessed during session 5 and session 7.

Instructions used for the 6MWT are as follows: Patient will walk in a clear path for 6 minutes. The patient may use an assistive device and may take standing or seated breaks at any time but the timer should continue running. Record the distance that the patient walks in 6 minutes. The distance walked by the patient in 6 minutes is recorded in feet in Table 3.

Psychometrics for the 6MWT assessing the distance walked in timed interval were evaluated and demonstrated a good re-test reliability of $r=0.85$.¹¹ The minimal detectable change (MDC) for patient's preoperatively and postoperatively for total hip/knee arthroscopy was found to be 61.34m (201.247ft) in a study completed by Kennedy *et al.*¹²

Table 3: 6 Minute Walk Test Distance Results

Session	Distance (feet)
5	1374
7	1432

Diagnosis

Upon initial physical examination, the patient presented with decreased knee range of motion, impaired hip and knee strength, and increased reports of pain. The physical therapy practice pattern for this case is Practice Pattern 4E: Impaired Joint Mobility, Motor Function, Muscle Performance, and Range of Motion Associated With Local Inflammation.¹³ These impairments limited the patient's functional ability to complete

endurance activities throughout the day and limited her ability to complete her duties as a teacher.

Prognosis

The patient had a good prognosis secondary to her motivation to participate in physical therapy and the objective results from her initial examination. The patient demonstrated deficits in range of motion and strength, which with improvement could result in decreased pain and ability to return to daily endurance activities. It should be noted that it may be necessary for the patient to receive a left total knee arthroscopy if the patient's subjective reports of pain continue since knee OA was noted during radiographic imaging.

Plan of Care

The plan of care was implemented with one-on-one physical therapy sessions in an outpatient clinic and included interventions focused on improving muscle strength and decreasing pain. Physical therapy sessions were scheduled for 30 minutes, 2 times per week for 6 weeks at a moderate intensity level.

Goals

Within two weeks: Increase left knee extension ROM to full to improve gait and to progress muscle strength by 1/2 a grade in weak muscles to improve ability to ascend/descend stairs pain-free with proper mechanics.

Within four weeks: progress muscle strength by 1 grade in weak muscles to improve ability to ascend/descend stairs with proper mechanics and to be able to be independent in the HEP to ambulate for greater than 60 minutes in a grocery store.

CLINICAL IMPRESSION #2

The data gathered from the patient's history and examination indicated that the patient would benefit from continued physical therapy. Goals of physical therapy would be to improve left knee range of motion and left hip and knee strength, and to decrease subjective reports of left knee pain. The patient was scheduled for physical therapy for 6 weeks to address these deficits. The interventions introduced during each physical therapy session were progressed in difficulty from isometric exercises, to concentric exercises, to eccentric exercises in order to improve the patient's motor control and endurance.

The patient was to be provided with a HEP that incorporated therapeutic exercises and activities that were to be completed as interventions during therapy sessions. For the HEP the patient was to be

given written and pictorial instructions including the frequency for which to complete each exercise. The patient was also to be reassessed for range of motion at the first and last session and for muscle strength during the first, fourth, and seventh session. The 6MWT was to be administered during session five and seven. The interventions prescribed are described in more detail below.

INTERVENTIONS

The American Academy of Orthopedic Surgeons strongly recommended that patients with symptomatic knee OA participate in strengthening exercises, low-impact aerobic exercises, neuromuscular re-education, and physical activity.¹⁴ Rationale for interventions performed is described below and interventions are summarized in Table 4.

Table 4: Intervention Schedule During 6 Weeks of Conservative Physical Therapy Treatment

Week #	Interventions				
1	1	3	3	3	1
2	2	5	5	5	1
3	2	5	5	7	8
4					
5	2	5	5	7	7
6	5	5	5	1	8

1=patient education

2=ROM exercise

3=isometric strength exercise

4=stretching exercise

5=therapeutic exercise

6=progressive resistive exercise

7=neuromuscular re-education

8=reassessment

Patient Education

During the initial evaluation and subsequent therapy sessions, the patient was educated in knee OA and why various therapeutic exercises were being completed during therapy and as part of a HEP. Hurley *et al.* found that few patients were educated in knee OA and were more often given medication or a surgical option to manage pain.¹⁵ The goal of therapy was to make the patient independent in her pain management rather than have her dependent on medication or surgery for pain relief.

Range of Motion

The patient displayed some restrictions in knee range of motion and terminal extension during gait. Stretching exercises to increase left hamstring, quadriceps, and gastrocnemius muscles were included to improve knee range of motion in pain free range.

The International Osteoarthritis Research Society guideline from 2008 advocated for regular aerobic, strengthening, and ROM exercises for all patients with knee OA.¹⁴ Improving knee ROM will allow for muscular forces to be appropriately attenuated around the knee joint, which can contribute to decreased reports of subjective knee pain.³

Isometric Strength Exercises

The patient initially presented with pain and decreased muscle strength; so isometric strengthening exercises were utilized at the beginning of episode of care to increase muscular strength in the lower extremities in a pain free manner. Examples of isometric strength exercises completed were: quadriceps sets, gluteal sets, and hip abduction against a firm surface.

In a study completed by Tanaka *et al.* it was found that if non weight bearing exercises are completed, such as the isometric exercises included in this case study, they should be followed by weight bearing activities to allow for cartilage repair and improved joint position sense.¹⁶ This theory is congruent with Wolff's law, which states that for healing to occur, stresses must be placed upon the tissue.¹⁷

Therapeutic Exercise

Once the patient was able to complete isometric strength exercises pain-free with proper mechanics, various exercises were progressed concentrically to eccentrically to increase bilateral lower extremity muscular strength and endurance. Exercises such as clamshells, mini squats, lunges, single leg step-downs/step-ups, and lateral resistance band walking were included. The patient completed 1 set of 10 repetitions of each exercise during physical therapy sessions and the exercise would be added to the HEP

once the patient verbally and physically demonstrated completing the exercise pain free with proper body mechanics.

With improved muscle strength, muscles are less fatigable and exhibit greater motor control, thus avoiding damaging increases in shear forces and peak joint forces, which have been reported during activity for those with weak muscles.¹⁴ The goal with the improvement in muscle strength is that the patient will perceive less pain in the left knee joint and leg with increased activity.

Progressive Resistive Exercise

Supine progressive resistive exercises were used to increase hamstring muscle length including the contract-relax technique to increase passive joint mobility along with the hold-relax technique to increase passive joint mobility and to decrease movement related pain adapted from Adler.¹⁸ Each position was held for 10 seconds repeated 3 times.

Neuromuscular Re-education

Interventions that focused on increasing motor control of muscles when walking and ascending/descending stairs were also incorporated. Balance activities were integrated using a wobble board forward and backward and side-to-side for 1 minute each way. Single leg stance ball

tosses to the rebounder and to the physical therapist were also used to incorporate hip, knee, and ankle balance reactions.

In a study on chronic knee pain by Hurley *et al.* the rehabilitation focus was on the incorporation of improved balance, muscular strength, coordination, and the patient's confidence in their ability to complete the rehabilitation program.¹⁴ The incorporation of muscle strength, motor control, and balance allowed the patient to become more confident in her ability to complete endurance activities without the limiting factor of left knee pain.

OUTCOMES

The patient attended all scheduled therapy sessions except 2 sessions during the 4th week because of a family emergency. Goals attained following 6 weeks of conservative physical therapy are depicted in Table 5. The patient was compliant and independent in completing the assigned HEP.

Upon completion of physical therapy, the patient demonstrated decreased reports of subjective knee pain from a 5/10 to a 2/10, slight increases in left knee flexion ROM from 116° to 118° which was within functional limits and pain free. She also demonstrated slight improvements in knee extension from terminal knee extension being limited by 3° to 2°, improvements in left hip and knee muscle strength where lower extremity strength improved from a MMT assessment from 3+/5 to at least 4+/5 bilaterally in all muscle groups, and independence completing the HEP. At

the end of the episode of care, the patient reported that she met her goal of being able to walk without pain for 45-60 minutes and to go down stairs pain-free. She also stated that she would be able to independently continue her HEP. Since pain was the patient's main complaint with activities and the pain was mostly resolved, she was appropriate for discharge from outpatient physical therapy.

Table 5: Goal Attainment Following 6 Weeks of Conservative Physical Therapy

	Goal	Goal Attained?
Short Term Goal 1	Increase left knee extension ROM to full to improve gait	Yes
Short term Goal 2	Progress muscle strength by 1/2 a grade in weak muscles to improve ability to ascend/descend stairs pain-free with proper mechanics	Yes
Long Term Goal 1	Progress muscle strength by 1 grade in weak muscles to improve ability to ascend/descend stairs with proper mechanics	Yes
Long Term Goal 2	To be independent in the HEP to ambulate for greater than 60 minutes in a grocery store.	Yes

DISCUSSION

This case report has shown how conservative physical therapy treatment may be used to rehabilitate symptomatic arthritic knee pain in a 58-year-old female. Although progression of knee OA varies patient-to-patient, the exploration of the progression of interventions that decreases symptomatic pain should continued to be explored.³ The incorporation and progression of patient education, range of motion exercises, isometric exercises, therapeutic exercises, and neuromuscular reeducation in this case study allowed the patient to return to a more active lifestyle. She was able to complete her desired daily activities due to decreased pain, improved muscle strength, and improved motor control. These results were congruent with studies that explored the use of conservative treatment options to alleviate symptoms of knee OA.^{4, 14,15}

A study completed by Snijders *et al.* found that baseline conservative treatment options of education, lifestyle advice, physical therapy focusing on aerobic and strengthening exercises, and acetaminophen usage are often not used adequately and patients should be offered conservative treatment prior to referral for joint replacement.¹⁹ In 2009, it was calculated that hospital expenditures associated with knee and hip replacements were \$42.3 billion, where OA was the main diagnosis resulting in a total joint replacement.²⁰ By exploring conservative treatment options as stated above,

a course of conservative physical therapy can potentially aid in the reduction of an individual's costs to manage OA and should be studied further.

The patient had decreased reports of pain from a 5/10 at initial evaluation to a 2/10 during the final session where she often did not have reports of pain during PT plan of care. The initial decrease from pain at a 5/10 in session 1 to 0/10 in session 2 could be attributed to isometric strengthening exercises included in the HEP given to the patient following the initial evaluation. The change in patient's reported pain of at least 3 points has been found to be clinically significant on the NPRS.⁶ Kittleson *et al.* noted that it is important to consider the psychological and neurophysiological factors of pain in knee OA, which can also contribute to the reports of pain.³

Slight increases in left knee flexion ROM were noted from 116° to 118° which was within functional limits and pain free. She also demonstrated slight improvements in knee extension from terminal knee extension being limited by 3° to being limited by 2°. A study by Zeni *et al.* found that individuals under 60 years old, who have full knee extension, are much less likely to undergo a TKA. It was also reported that each degree of knee flexion contracture could increase the chance of TKA in 2 years by 23%.⁷ The patient in this case demonstrated a decrease in knee flexion contracture by 1° which can be hypothesized to contribute to the patients reduced

symptoms, delaying the need for a TKA. The continued application of the HEP by the patient could continue to improve full knee extension limitations.

The patient in this case study was able improve in her left lower extremity muscular strength from a 3+/5 to a 4+/5 in hip extensors and hip abductors. These results were consistent with the timeline of 4-6 weeks for muscle strength improvements of one muscle grade in individual muscle groups following resistance exercise. Any additional strength gains could be contributed to improved neuromuscular control and joint proprioception. It should be noted that the patient had greater strength measurements demonstrated in left hip external rotation than right hip external rotation which can be attributed to the patient's main focus of improving left lower extremity strength in her HEP.

The patient's 6MWT distance increased from 1374 feet to 1432 feet in 2 weeks. Although the patient did not reach the minimal detectable change of 200ft for the 6MWT, the patient did increase her distance ambulated by just less than 10% over 2 sessions without any reports of pain. Since the patient demonstrated such improvements over 2 sessions, continued improvement in the future could be expected.

Limitations of this case report include the retrospective nature of the case report and the lack of standardized outcome measures for knee OA. This case study could have incorporated additional standardized outcome measures to evaluate the patient's progress throughout therapy such as the

Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) and the Knee Injury and Osteoarthritis Outcome Score (KOOS). These measures have been found to have good to excellent internal consistency and test re-test reliability for subjects with knee OA.²¹

In conclusion, this case report demonstrated that it is possible to improve functional performance and decrease subjective reports of pain with conservative physical therapy for a patient with knee OA. The results of this case report cannot be generalized to a larger population due to the small sample size of this case and large number of variables. Future research incorporating greater sample sizes and specific osteoarthritic outcome measures would be appropriate to better focus on the patient population.

References

1. Osteoarthritis. Centers for Disease Control and Prevention; <http://www.cdc.gov/arthritis/basics/osteoarthritis.htm>. Updated May 2014; accessed October 23, 2014.
2. Murphy L, Schwartz TA, Helmick CG, et al. Lifetime risk of symptomatic knee osteoarthritis. Vol 59: *Arthritis Rheum*;2008:1207-1213.
3. Kittelson AJ, George SZ, Maluf KS, Stevens-Lapsley JE. Future directions in painful knee osteoarthritis: Harnessing complexity in a heterogeneous population. *Phys Ther*. 2014; 94(3):422-432.
4. Miller LE, Block JE. An 8-week multimodal treatment program improves symptoms of knee osteoarthritis: a real-world multicenter experience. *Pragmatic Obs Res*. 2013;4:39-44.
5. Hjermstad MJ, Fayers PM, Haugen DF, et al. Studies comparing numerical rating scales, verbal rating scales, and visual analogue scales for assessment of pain intensity in adults: A systematic literature review. *J Pain Symptom Manage*. 2011; 41(6): 1073-1093.
6. Finch E, Brooks D, Stratford PW, Mayo N. Physical rehabilitation outcome measures – A guide to enhanced clinical decision making, 2nd ed. Baltimore, MD: Lippincott, Williams & Wilkins; 2002
7. Zeni Jr J, Axe M, Snyder-Mackler L. Clinical predictors of elective total joint replacement in persons with end-stage knee osteoarthritis. *BMC Musculoskeletal Disorders* [serial online]. January 2010;11:86-93. Available from: Academic Search Complete, Ipswich, MA. Accessed November 18, 2014.
8. Reese N, Bandy W. *Joint Range of Motion and Muscle Length Testing*. 2nd ed. St. Louis: Elsevier Health Sciences;2009.
9. Hislop H, Montgomery J. *Daniels and Worthingham's Muscle Testing, Techniques of Manual Examination*. 8th ed. St. Louis: Saunders Elsevier;2007.
10. Bohannon RW. Manual muscle testing: does it meet the standards of an adequate screening test? *Clin Rehabil*. 2005;19(6):662-667.
11. Wang T-J, Lee S-C, Liang S-Y, Tung H-H, Wu S-FV, Lin Y-P. Comparing the efficacy of aquatic exercises and land-based exercises for patients with knee osteoarthritis. *J Clin Nurs*. 2011;20(17/18):2609-2622.
12. Kennedy D, Stratford P, Wessel J, Gollish J, Penney D. Assessing stability and change of four performance measures: A longitudinal study evaluating outcome following total hip and knee arthroplasty. *BMC Musculoskeletal Disord*. 2005;6(3).
13. American Physical Therapy Association. *Guide to Physical Therapy Practice*. Second Edition. 2003.
14. Susko AM, Fitzgerald GK. The pain-relieving qualities of exercise in knee osteoarthritis. *Open Access Rheumatol: Res Rev*. 2013;5:81-91.

15. Hurley MV, Walsh N, Bhavnani V, Britten N, Stevenson F. Health beliefs before and after participation on an exercised-based rehabilitation programme for chronic knee pain: Doing is believing. *BMC Musculoskeletal Disorders*. 2010;11:1-12.
16. Tanaka R, Ozawa J, Kito N, Moriyama H. Efficacy of strengthening or aerobic exercise on pain relief in people with knee osteoarthritis: A systematic review and meta-analysis of randomized controlled trials. *Clin Rehabil*. 2013;27(12):1059-1071.
17. Magee DJ, Zachazewski JE, Quillen WS. *Pathology and Intervention in Musculoskeletal Rehabilitation*. Elsevier Health Sciences;2008.
18. Adler S, Beckers D, Buck M. *PNF in Practice: an Illustrated Guide*. Springer, Berlin:2003.
19. Snijders GF, den Broeder AA, van Riel P, et al. Evidence-based tailored conservative treatment of knee and hip osteoarthritis: Between knowing and doing. *Scand J of Rheumatol*. 2011;40(3):225-231.
20. Barbour KE, Helmick CG, Theis KA, et al. Prevalence of doctor-diagnosed arthritis and arthritis-attributable activity limitation - United States, 2010-2012. 2013;62(44):869-873.
21. Collins N, Misra D, Felson D. Measures of knee function: international knee documentation committee (IKDC) subjective knee evaluation form, knee injury and osteoarthritis outcome score (KOOS), knee injury and osteoarthritis outcome score physical function short form (KOOS-PS), knee outcome survey activities of daily living scale (KOS-ADL), lysholm knee scoring scale, oxford knee score (OKS), western ontario and mcmaster universities osteoarthritis index (WOMAC), activate rating scale (ARS), and tegner activity score (TAS). *Arthritis Care Res*. 2011;63(suppl 11):S208-S228.