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The Challenges Of Exercise Selection For A Post-Operative Patient With Severe Deconditioning And Longstanding Neurogenic Claudication: A Case Report

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The patient signed an informed consent allowing for the use of medical information and photographs for this report and received information on the institution's policies regarding the Health Insurance Portability and Accountability Act (HIPPA).

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Key Words: lumbar spinal stenosis, neurogenic claudication, lumbar laminectomy, exercise, deconditioning

Abstract

Background and Purpose: Lumbar spinal stenosis is an increasingly common diagnosis due to its association with degenerative changes of the lumbar vertebrae and the advancing age of our population. This condition may lead to neurogenic claudication which often results in significant pain and disability. Due to the negative impact on quality of life, surgical intervention is often utilized to reduce symptoms. However, post-surgical management is highly variable. The purpose of this case report was to examine a rehabilitation program used to address functional limitations and reverse impairments in a patient with severe deconditioning due to neurogenic claudication as a result of spinal stenosis. Case Description: The patient was an 86-year-old male who underwent a decompressive laminectomy to treat his neurogenic claudication. He presented with reduced cardiovascular endurance, ambulatory capacity, and lower extremity strength. His goal was to increase his walking capacity and improve his ability to complete activities of daily living. Interventions included resistance, aerobic, task specific, and balance training. Outcomes: After ten visits, the patient increased his lower extremity strength, reduced his Timed Up and Go score by 3.9 seconds, decreased his Five Times Sit to Stand time by 3.45 seconds, and walked 54.5m farther during the Six Minute Walk Test. This case report explored the use of strength, balance, and aerobic training to address the impairments and limitations of a patient who underwent a lumbar laminectomy to treat neurogenic claudication. Although the patient did not meet all goals, he demonstrated functional improvements in his daily life. Future research should focus on identifying interventions that are most advantageous for recovery to guide physical therapy decisions for the management of chronically deconditioned patients.

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Introduction/Background and Purpose

Lumbar spinal stenosis (LSS) is a condition associated with a narrowing of the spinal canal and surrounding anatomy which limits the space for the neural structures that pass within.[1] LSS is most often a consequence of acquired degeneration and can result from a variety of lumbar dysfunctions including loss of disc height, disc bulging, osteophyte formation, or hypertrophy of the ligamentum flavum etc.[1,2] LSS commonly leads to ischemia or mechanical compression placed on the neural tissue. This compression may result in neurogenic claudication (NC) that can cause poorly localized lower extremity (LE) pain and neurologic dysfunction frequently including poor balance, reduced walking capacity, sensory loss, and muscle weakness.[1,2] These symptoms are usually intermittent and provoked by walking and extended lumbar postures which further exacerbate the canal narrowing.[1,2]

LSS is an increasingly common diagnosis due to its association with advancing age and the increased use of magnetic resonance imaging (MRI) for detecting spinal narrowing.[2] In a cross-sectional observational study by Kalichman et al,[3] researchers evaluated the prevalence of acquired LSS in the general population. Researchers found that relative LSS (≤12 mm cross-sectional diameter of the canal) was found in 22.5% and absolute LSS (≤10 mm) in 7.3% of the population.[3] Acquired LSS also had increasing prevalence with age.[3] The relative and absolute prevalence in patients 60 years and older were found to be 47.2% and 19.4% respectively compared to 20% and 4% in patients younger than 40 years.[3]

LSS treatment includes both surgical and conservative interventions. Conservative management is intended to modify pain levels, improve function and mobility, and improve stability and control of the lumbar spine. Conservative treatments focus on education, cognitive behavioral therapy, medication, injections, and exercise.[1,2] Surgical procedures aim to increase the space surrounding the neural structures to reduce compression. Surgeries include

laminectomy, lumbar fusions, spinal instrumentation with posterior spacers, or spinal devices etc.[1,2,4] Due to the negative impact LSS has on quality of life, surgical intervention is often utilized in older patients to reduce symptoms.[5] Between 2002-2007, approximately 87,000 Medicare beneficiaries underwent a surgical procedure for LSS.[5]

The incidence of spinal surgery is increasing but there is still a sizable proportion of patients who do not regain full function. Successful outcomes after surgical intervention occur in 58-69% of patients. [5,6] Those numbers unfortunately indicate that some patients continue to have leg and low back pain as well as lingering neurologic dysfunction and disability.[7] This may be due to the fact that there are no universally accepted guidelines for rehabilitation following surgery.[7,8] In a study by McGregor et al,[8] the post-operative management after spinal surgery was found to be highly variable. Only 35% of surgeons provided written instruction for post-operative management and only 55% of surgeons referred their patients to physical therapy (PT).[8] However, in a systematic review by McGregor et al,[7] three studies were found that examined the utilization of a supervised exercise program following spinal surgery. Those studies found that participation in an exercise program was more effective at reducing back pain and activity limitations compared to usual post-operative care of advice to stay active and a few general exercises with the intent to prevent deep vein thrombosis.[7] This data stressed the need to identify adequate post-surgical care for patients who have undergone surgery to address LSS. The purpose of this case report was to examine rehabilitation elements, including strength, balance, and aerobic training, that may be used to address functional limitations and reverse impairments in patients with severe deconditioning due to longstanding NC.

Patient History and Systems Review

The patient was an 86-year-old Caucasian male who presented to outpatient PT six weeks post multilevel laminectomy to address longstanding NC with LE weakness and deconditioning.

Prior to surgery, he reported symptoms of fatigue during walking going back several years but noted a recent progression in the severity of symptoms after walking a far distance while hunting. At that point he was only able to walk 15m before needing to rest. A neurosurgeon ordered radiographs and an MRI and diagnosed the patient with spondylolisthesis and LSS with NC. The patient received corticosteroid injections to the lumbar area with no improvements. A multilevel decompressive laminectomy was performed a few weeks later to address his continuing symptoms.

The patient was retired and living with his wife in rural Maine. He enjoyed walks throughout his neighborhood, shooting at the gun range, and hunting. Post-surgery, the patient's chief complaint was reduced walking and functional capacity. He reported his fatigue had improved compared to pre-surgery but was still limited in his ability to navigate his home and community. He reported severe fatigue in both LEs (more intense on the right) and shortness of breath with attempts to complete activities of daily living (ADLs) and recreational activities. His main goal for therapy was to tend his garden, walk to and from targets at the shooting range, and efficiently navigate his home.

Pertinent medical history included hypertension, atherosclerotic disease, myocardial infarction ten years prior, heart murmur, diabetes mellitus with foot neuropathy bilaterally, hearing loss, and mild visual impairment. His medications included; Metoprolol, Amlodipine, Losartan, Aspirin, Glipizide, Atorvastatin, Camotidine, and Tamsulosin. The patient had no known allergies. There was no known family, psychosocial, or genetic medical history relevant to this case report.

He reported no past experiences with PT but believed it would help him return to meaningful activities by improving his LE strength. The primary focus of PT was to address his deconditioning which resulted in generalized weakness of both LEs and reduced aerobic

endurance. The results of his systems review are described in Table 1. Based on the systems review, the initial examination would include range of motion, sensation, strength, endurance, and mobility testing. Continued neurologic involvement needed to be ruled out as a potential cause for muscle weakness and fatigue.

This patient was a good candidate for a case report due to his severe loss of function pre-decompressive laminectomy. Given its association with aging and the increased number of older individuals in our population, the number of patients who are seen for the condition has expanded.[1] This diagnosis is becoming more frequently seen by PTs who would benefit from additional evidence to support PT treatment decisions.[1,3] The patient provided informed consent to use his medical information and was made aware of the University's Health Insurance Portability and Accountability policies.

Examination – Tests and Measures

The initial examination included manual muscle testing (MMT), range of motion assessment, and dermatome and myotome integrity testing. The standardized outcome measures used to assess functional capacity included the Timed Up and Go (TUG), Six Minute Walk Test (6MWT), and the Five Times Sit to Stand (5xSTS).[9,10,111,12] Table 3 describes the results of the initial examination. The patient's LE dermatomes and myotomes were assessed for L2- S1 integrity by using the light touch key sensory points and key muscle strength tests, respectively, which are described by the International Standards for Classification of Spinal Cord Injury (ISCSCI).[13] Each dermatome was tested at the respective key point and rated from zero to two (absent to intact-normal).[13] Each myotome was tested by the associated muscle function and was rated from zero to five (complete paralysis to active movement through the full range against gravity and full resistance).[13] The face validity of the ISCSCI was shown to be good due to the experts involved in development and its international consensus.[14,15] The reported reliability and

repeatability of the sensory and motor portions are variable.[13,14,15,16] Although the classification system was designed to assess the level of spinal cord injuries, the sensory and motor portions of the assessment can be useful for the examination of musculoskeletal patients.[1,13,15] The patient performed the TUG, described by Richardson et al,[9] which is designed to assess mobility, balance, fall risk, and walking capacity in older populations.[9] Completing the test in less than 20 seconds has been associated with functional independence, whereas requiring greater than 30 seconds has been associated with dependence in transfers.[9] Research has shown adequate test-retest reliability with the TUG.[9,17] The 6MWT was performed to assess the patient's aerobic capacity and endurance in a sub-maximal situation as discussed by Harada et al.[10] This test has excellent test-retest reliability and adequate concurrent validity with gait speed and standing balance.[10] The 6MWT has a minimally clinically important difference of 50m.[18] Steffen et al[19] found the mean distance during the 6MWT for community dwelling males aged 80-89 years old to be 417 meters. The patient completed the 5xSTS assessment, outlined by Whitney et al,[20] which was used to quantify functional LE capacity as well as observe transitional movement strategies.[11,12,19] The patient's active range of motion (AROM) for the trunk and LEs was examined and compared to normative values described by Norkin et al.[21] MMT was used as a standardized muscle strength assessment for the patient's LEs. [22,23] The standardized positions for testing hip flexion, abduction, extension, external rotation, knee flexion and extension, and ankle dorsiflexion and plantar flexion were used, as described by Kendall et al.[23] Each muscle group was tested and rated from zero to five (no movement to full movement against gravity and full resistance).[23]

Clinical Impression: Evaluation, Diagnosis, Prognosis

Based on the patient's signs, symptoms, and examination data, it was clear that this 86-year-old patient with longstanding LSS and resultant NC presented to therapy with extreme loss

of ambulatory capacity and decreased ability to perform ADLs. This was due to complications related to LE weakness, diminished LE sensation, and cardiovascular deconditioning. The patient's functional limitations included difficulty walking, ascending and descending stairs, standing for prolonged periods of time, and rising from sitting to standing. Those functional limitations impeded his ability to complete his ADLs, go on daily walks through his neighborhood, and participate in his hobbies. It was determined that he would be a good candidate for PT services. He continued to be a good subject for this case report in order to explore the most effective ways to improve muscular strength, cardiovascular endurance, gait pattern, and overall functional mobility in patients with a history of longstanding NC.

Based on the literature examining outcome prognosis following lumbar laminectomy and the patient's presentation, the patient was determined to have a fair prognosis due to his multiple comorbidities, advanced age, and symptom history.[23,24,25,26] In a retrospective cohort study, Li et al[24] analyzed the effects of age and comorbidities on lumbar laminectomy complications and outcomes. Increasing age and comorbidities were found to increase the complication and mortality rate for patients undergoing lumbar laminectomy.[24] Additionally, in a systematic review Shamji et al[25] examined the effectiveness of lumbar laminectomy to treat elderly patients (greater than 65 years) with symptomatic LSS. It was found that surgical intervention for elderly patients resulted in significant improvements with regards to pain and disability and that post-operative complications were rare.[25] However, greater complication rates and less favorable outcomes were found for patients with diabetes or obesity.[25] In a prospective study, Jonsson et al[26] found a significant correlation between good outcomes and pronounced constriction of the spinal canal, no pre-operative low back pain, and symptoms lasting less than four years.

At the initial examination, no referrals or additional tests were deemed necessary. The planned procedural interventions included therapeutic exercise to address muscle weakness and

gait mechanics, therapeutic activity to improve functional mobility, neuromuscular re-education to address balance abnormalities, and patient education to promote appropriate and safe continuation of a home exercise program (HEP). Short-term and long-term goals for therapy are listed in Table 2.

Intervention and Plan of Care

Coordination, Communication, and Documentation

The findings of the initial examination and prognosis were discussed with the patient as well as the planned interventions to address his impairments. The initial examination and all further treatment sessions were documented using an electronic medical record. A copy of the initial examination, progress, and the discharge notes were sent to the referring surgeon. At each visit the patient was asked about his response to the previous visit, his current status, and perceived level of function at the time of the visit. His responses were documented in his daily note.

Patient Related Instruction

As the patient progressed through therapy, additional interventions were included in his sessions, as described in Table 4. The patient was educated on the purpose of each intervention and how it related to his therapy goals. The patient performed each element with verbal feedback on proper form and demonstrations as needed. The patient received a copy of his HEP which included a verbal description and pictures of each exercise. The handout also highlighted the duration and frequency that each element should be performed. The patient verbalized his understanding of how to complete his HEP, the importance of compliance, and did not have any additional questions. Patient education was used to ensure the patient knew what was expected of him and to confirm that he would be able to complete his exercises independently and safely. HEP specific education was provided at the initial examination, session two, five, and ten.

Procedural Interventions

The patient was seen ten times over a six-week period, with appointments lasting 45-60 minutes. Table 4 describes the detailed timeline of each session. As stated previously, each appointment began by asking the patient about changes in function and compliance with HEP. The rest of the session time was spent on therapeutic interventions. The interventions were categorized into four groups; therapeutic exercise, therapeutic activity, neuromuscular re-education, and patient education. The equipment utilized for interventions is described in Appendix 2.

Therapeutic exercises were selected to improve LE strength and cardiovascular endurance through resistance and aerobic training. Descriptions of each exercise are listed in Appendix 1. In order to prioritize proximal hip stabilizers, three hip-strengthening exercises were prescribed as his introductory HEP to begin to address his lower extremity weakness. At the second session, toe and heel raises were added, and at the fourth visit, resisted knee flexion and extension movements were included. As the patient progressed and reported ease with the exercises, external weight was added as described in Table 4. Each exercise consisted of two sets of ten repetitions with a 60-120 second rest between sets, which has been shown to be an effective dosage for muscle strengthening.[31] Rest periods were based on patient tolerance. The purpose of the strengthening exercises was to address the weakness that was believed to be contributing to the patient's reduced walking speed.

In a systematic review, Hortobágyi et al[28] found that resistance training was associated with clinically meaningful changes in gait speed for older adults. Gait is described as a motor task used to transport the body and is comprised of five major components; generation and maintenance of forward progression, support of the upper body, balance, control of foot trajectory, and shock absorption.[29] Based on this model of gait, strength training exercises were

selected to address the necessary elements of successful gait. Generation and maintenance of forward velocity is primarily dependent on ankle plantarflexors, with additional contribution from the hip extensors.[29] The patient did not demonstrate difficulty with support of the upper body, so no specific exercises addressed this component of gait. Balance in the single leg stance phase is primarily maintained through co-contraction of much of the LE musculature.[29] The control of foot trajectory during the swing phase is achieved through eccentric activation of the hamstrings to control knee extension and ankle dorsiflexors to ensure foot clearance before the foot can be placed ahead of the body.[29] Shock absorption primarily occurs through the knee joint and is managed by eccentric activation of the quadriceps muscle.[29] At the third visit, the upper body ergometer (SciFit, Rosemont, IL) was added to the patient's intervention protocol. This aerobic training was selected in order to address the patient's cardiovascular impairments. A systematic review by Cadore et al[30] found endurance training in conjunction with strength training was able to improve the maximal oxygen uptake of elderly individuals to a greater degree than strength training alone.

Therapeutic activities were prescribed to improve functional mobility and skills associated with ADLs. Two major tasks the patient reported difficulty performing were rising from a seated position and ascending stairs. One intervention was completing repeated sit to stands from a standard chair height (45.72cm). Two 5.08cm foam pads (Prosource Fit, Chatsworth, CA) were placed in the chair during sessions three, four, and five to increase the seat height to reduce the task difficulty. For sessions six, seven, and eight, one pad was removed. At appointments nine and ten, both pads were removed. To practice ascending stairs, the patient performed step ups. At sessions four through six, the step height was 15.24cm. The step was progressed to 20.32cm on day seven due to the observed ease with which the patient was able to complete one set at 15.24cm. The 20.32cm step was continued through the rest of the

appointments. The patient completed two sets of ten repetitions for each activity with a 60-120 second rest between each set.[29] Rest periods were based on patient tolerance.

Neuromuscular re-education targeted balance and stability impairments. Based on the patient's LE weakness and sensory impairment, it was determined necessary to work on his static and dynamic balance. This was to ensure a safe return to increased ambulation after a period of reduced mobility. At the third appointment, front and lateral hurdles (Rogue, Columbus, OH) were added as a dynamic balance exercise that stressed stability in a single limb stance as the other limb is in motion. The patient completed two sets of ten repetitions with rests based on tolerance.[29] During the fourth visit, a foam pad balance exercise was added. This intervention was a static exercise used to practice maintaining stability in quiet stance on an unstable surface. The patient performed three sets of 30 second bouts with his feet positioned close together. At session seven, the foot position was changed to a semi-tandem stance in order to narrow his base of support and make the exercise more challenging. This decision was made due to the ease with which he was able to maintain stability in the feet together position. The patient completed the three sets for each foot placement.

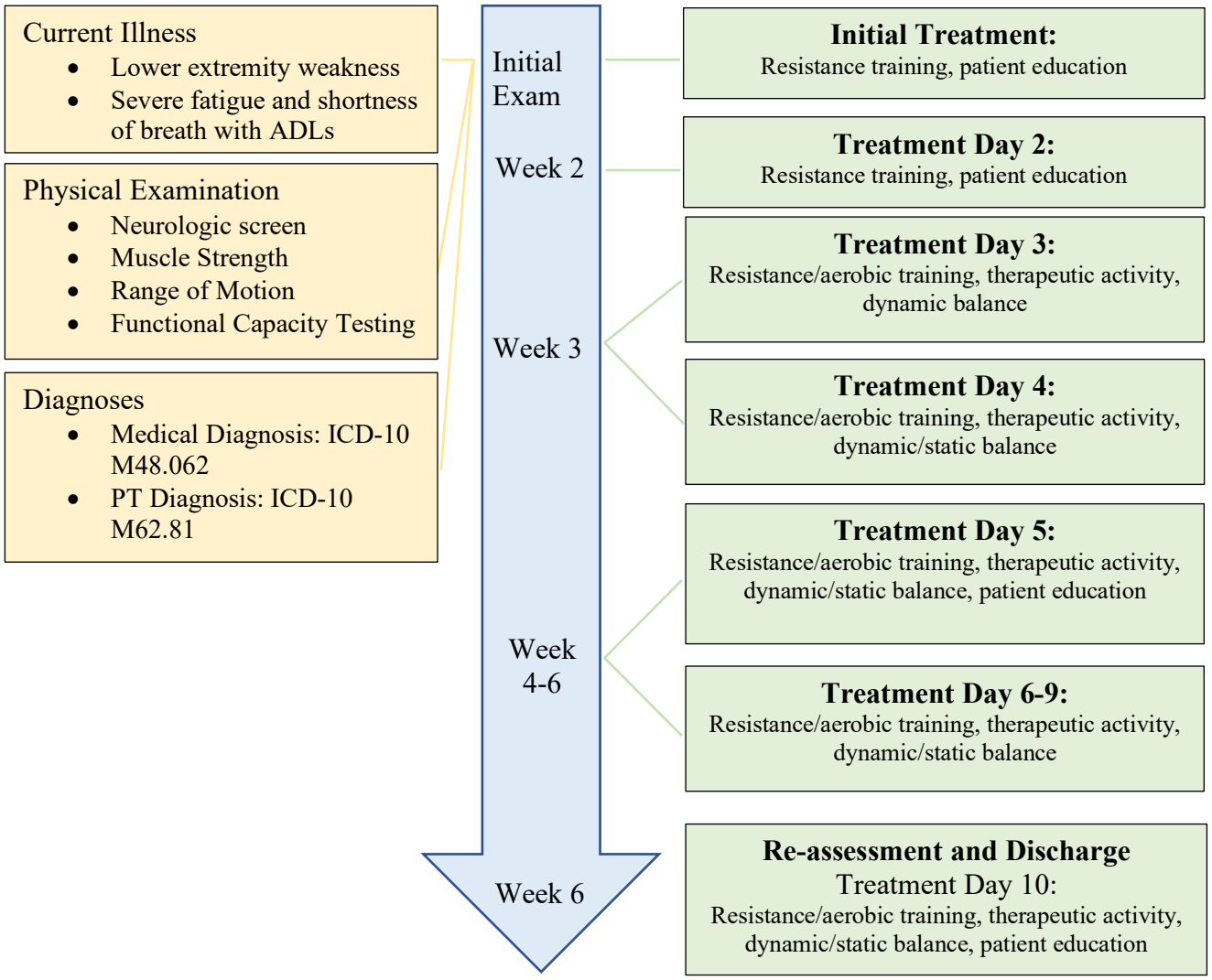
Timeline

Relevant Past Medical History

Symptoms:
- Lower extremity weakness
- Cardiovascular deconditioning
- Sever fatigue with walking greater than 50 feet

Diagnosis:
- MRI revealed lumbar spinal stenosis with neurogenic claudication
- X-ray revealed lumbar spondylolisthesis

Interventions:
- Corticosteroid injection to the lumbar area: patient reported no improvement in symptoms
- Multilevel decompressive lumbar laminectomy six weeks prior to initial examination



Outcomes

Over the course of a six-week PT episode of care, the patient was able to partially resolve impairments, reduce activity limitations, and increase his participation in meaningful tasks. At the tenth visit, a re-examination was completed which included myotome, dermatome, and MMT testing as well as the TUG, 5xSTS, and the 6MWT as indicators for household ambulation capacity, functional LE capacity, and aerobic endurance respectively.[9,10,11,26] The results of the re-examination are presented in Table 3. The patient showed improvements in LE strength, TUG, 5xSTS, and the 6MWT, while no changes were noted for myotome, dermatome, or range of motion testing. At the tenth visit the patient had met some of his goals which are identified in Table 2. Although he did not meet every objective goal, the patient reported subjective improvement in many aspects of his daily life including reduced difficulty with ascending stairs, rising from a seated position, standing at the sink, and walking through his neighborhood. He also reported being able to resume several hobbies like gardening and shooting at the gun range. At the tenth visit, it was determined that the patient had improved his functional ability and would be able to continue to make improvements on his own through his HEP. The therapist was confident in the patient's ability to be discharged to a home program because he had shown independence with exercises and no longer required cuing to complete them safely and correctly.

Discussion

This case report provides insight into the use of varying rehabilitation elements to reduce disability in a patient post-lumbar laminectomy with longstanding NC. Past research has shown that active rehabilitation is superior than the usual care of advice from the surgeon to stay active and several simple exercises for reducing pain and improving disability, but it did not highlight the specific elements that are favored.[7] For this case report the physical therapist chose to utilize resistance, aerobic, and balance training as well as some task-specific interventions to optimize

the patient's function. Those decisions were based on the research of Borde et al,[27] Hortobágyi et al,[28] Kepple et al,[29] and Cadore et al,[30] which demonstrated the effectiveness of resistance and aerobic training in elderly individuals especially for the purpose of improving gait mechanics, speed, and endurance. The results of therapy supported the use of those interventions in the PT plan of care for patients who underwent a lumbar laminectomy. After six weeks of PT, the patient demonstrated improvements in several outcome measures as well as in his ability to complete ADLs. He was also able to resume hobbies he was unable to partake in for several years leading up to surgery. This patient case demonstrated the successful utilization of PT for addressing disability for this patient, however, a large variety of interventions were employed; therefore, it is difficult to assess which specific elements were most useful. Future research should focus on identifying which particular interventions are most advantageous for recovery of function. Through this research, physical therapists would be better able to make decisions about the inclusion of strengthening, cardiovascular endurance training, task-specific skill practice, or possibly a combination of these elements.

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Tables and Figures

Table 1: Results of Systems Review

System	Status
Cardiovascular/Pulmonary	Impaired: Reduced cardiovascular and pulmonary function and endurance. Patient reported sensations of shortness of breath while walking from the waiting room to the examination room.
Musculoskeletal	Impaired Gross Strength: Bilateral hip flexion, extension, abduction, and external rotation. Bilateral knee flexion and extension. Bilateral ankle plantar flexion and dorsiflexion.
Neuromuscular	Impaired Sensation: Reduced sensation in both feet. Patient reported feelings of numbness in both feet.
Integumentary	Unimpaired
Communication	Unimpaired
Affect, Cognition, Language, Learning Style	Unimpaired. Patient appeared calm, interested, and focused. Patient used English as his primary language. Utilized verbal and visual cuing for learning.

Table 2: Patient Goals

Goals	Outcomes
Short Term: Patient will be able to complete the TUG in eight seconds without the use of a cane in four weeks in order to walk to and from the target at the shooting range without difficulty.	Goal was met. The patient completed the timed up and go in 7.87 seconds without the use of an assistive device. Patient reported returning to the gun range and was able to complete a shooting session with minimal discomfort or increase in symptoms.
Short Term: Patient will be able to complete heel raises with correct form in four weeks in order to effectively propel during push off phase of gait while walking through the grocery store.	Goal not met. Patient was still unable to perform a proper heel raise. He was unable to maintain extended knees during the motion or raise his heels farther than five centimeters.
Long Term: Patient will increase strength of bilateral lower extremities to 4/5 in six weeks in order to ascend and descend one flight of stairs with minimal to no difficulty.	Goal partially met. The patient increased lower extremity strength to at least 4/5 in all tested muscles except the left hip extensors, bilateral hip external rotators, and bilateral ankle plantarflexors. Patient reported much greater ability to ascend and descend stairs and was able to complete the task without the use of an arm railing for assistance.
Long Term: Patient will be able to walk 245 meters during the 6MWT without requiring rest breaks in six weeks in order to efficiently walk community distances (grocery store, neighborhood walks for exercise) with minimal to no difficulty.	Goal not met. Patient walked 210 meters during the 6MWT and still required several rests but did so without the use of an assistive device. Patient reported being able to walk farther on his daily neighborhood walks before needing to stop and rest.

TUG= Timed Up and Go, 6MWT= Six Minute Walk Test

Table 3: Results of Initial Examination Tests and Measures

Tests and Measures	**Initial Examination**		**Visit 10**	
Gross LE AROM	Left	Right	Left	Right
Trunk Flexion	50%		50%	
Trunk Extension	25%		25%	
Trunk Side bend	50%	60%	50%	60%
Trunk Rotation	40%	40%	40%	40%
Hip Flexion	105 degrees	105 degrees	105 degrees	105 degrees
Knee Flexion	110 degrees	110 degrees	110 degrees	110 degrees
Knee Extension	0 degrees	0 degrees	0 degrees	0 degrees
Gross LE Strength	Left	Right	Left	Right
Hip Flexion	-4/5	-4/5	4/5	4/5
Hip Extension	+3/5	+3/5	-4/5	4/5
Hip Abduction	+3/5	-4/5	4/5	4/5
Hip External Rotation	-4/5	-4/5	-4/5	-4/5
Knee Flexion	4/5	4/5	+4/5	+4/5
Knee Extension	4/5	4/5	+4/5	+4/5
Ankle Plantarflexion	+3/5	+3/5	-4/5	-4/5
Ankle Dorsiflexion	-4/5	-4/5	4/5	4/5
LE Light Touch Sensation	Left	Right	Left	Right
L2	2	2	2	2
L3	2	2	2	2
L4	2	1	2	1
L5	1	1	1	1
S1	1	1	1	1
LE Myotomes	Left	Right	Left	Right
L2	4	4	4	4
L3	4	4	4	4
L4	4	4	4	4
L5	4	4	4	4
S1	4	4	4	4
Timed Up and Go	11.73 seconds using a single point cane		7.87 seconds without use of an assistive device	
Five Time Sit to Stand	14.81 seconds using bilateral arms to push up		11.36 seconds without the use of arms to push up	
Six Minute Walk Test	155.5 meters with the use of a single point cane. Required ten sitting rest breaks.		210 meters without the use of an assistive device. Required four standing breaks and two sitting breaks.	

LE= lower extremity, AROM= active range of motion

Table 4: Interventions

Interventions		**Treatment Day**									
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Therapeutic Exercise	Toe Raise		**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**
	Heel Raise		**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**
	Standing Hip Flexion	**x***	**x** 1.4kg	**x** 1.4kg	**x** 1.4kg	**x** 1.8kg	**x** 1.8kg	**x** 1.8kg	**x** 2.3kg	**x** 2.3kg	**x** 2.3kg
	Standing Hip Extension	**x***	**x** 1.4kg	**x** 1.4kg	**x** 1.4kg	**x** 1.8kg	**x** 1.8kg	**x** 1.8kg	**x** 2.3kg	**x** 2.3kg	**x** 2.3kg
	Standing Hip Abduction	**x***	**x** 1.4kg	**x** 1.4kg	**x** 1.4kg	**x** 1.8kg	**x** 1.8kg	**x** 1.8kg	**x** 2.3kg	**x** 2.3kg	**x** 2.3kg
	Long Arc Quad				**x** 1.4kg	**x** 1.4kg	**x** 1.4kg	**x** 1.4kg	**x** 1.8kg	**x** 1.8kg	**x** 1.8kg
	Hamstring Curl				**x**	**x**	**x**	**x**	**x**	**x**	**x**
	UBE			**x** 5min	**x** 5min	**x** 5min	**x** 5min	**x** 5min	**x** 5min	**x** 5min	**x** 5min
Therapeutic Activity	Sit to Stand			**x** 2pads	**x** 2pads	**x** 2pads	**x** 1pad	**x** 1pad	**x** 1pad	**x**	**x**
	Step Ups				**x** 15.24cm	**x** 15.24cm	**x** 15.24cm	**x** 20.32cm	**x** 20.32cm	**x** 20.32cm	**x** 20.32cm
Neuromuscular Re-Education	Forward Hurdles			**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**
	Lateral Hurdles			**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**
	Foam Pad Balance				**x** FT	**x** FT	**x** FT	**x** ST	**x** ST	**x** ST	**x** ST
Patient Education	HEP Description	**x**	**x**			**x**					**x**

X= intervention completed, *= intervention included in home exercise plan, UBE= upper body ergometer, FT= feet together, ST= semi-tandem, HEP= home exercise program

Appendices

Appendix 1: Exercise Descriptions

Intervention	Description
Toe Raises	Patient standing. One foot at a time, bring the foot into dorsiflexion hold for one second then return to starting position
Heel Raises	Patient standing. Both feet together, push feet into plantarflexion hold for one second then return to starting position
Standing Hip Flexion	Patient standing. One leg at a time, bring the hip into flexion while simultaneously flexing at the knee
Standing Hip Extension	Patient standing. One leg at a time, bring one leg into hip extension while maintaining the knee extended
Standing Hip Abduction	Patient standing. One leg at a time, bring the leg into hip abduction while maintaining the knee extended
Long Arc Quad	Patient seated with feet hanging. One leg at a time, move into knee extension
Hamstring Curl	Patient seated with feet hanging. One leg at a time, move through full knee extension into full flexion
Sit to Stand	Patient seated. Without use of hands, move into a standing position
Step Ups	Patient standing. One foot at a time, step up with one foot and lower with the opposite foot
Forward Hurdles	Patient standing in front of a hurdle. One foot at a time, lift the foot over the hurdle to lightly touch the ground then return to the starting position
Lateral Hurdles	Patient standing parallel to the hurdle. One foot at a time, lift the foot over the hurdle to lightly touch the ground then return to the starting position
Foam Pad Balance	Patient standing on foam pad with feet either together or in semi-tandem stance. With hands hovering over a support surface for safety, maintain balance for 30 seconds. Only touch support surface when necessary to prevent a fall

Appendix 2: Equipment Descriptions

Intervention	Equipment Manufacturer	Equipment Description
UBE	SciFit. Rosemont, IL	SciFit Pro 1 upper body: premium seat.
Step Ups	The Step. Marietta, GA	The original step with universal risers
Hurdles	Rogue. Columbus, OH	6” step hurdle
Standing hip flexion, abduction, extension, and long arc quad	Elgin. Burr Ridge, IL	Easy-clean long strap cuff weight
Sit to stand and foam balance	Prosource Fit Chatsworth, CA	2” exercise balance pad
Hamstring Curls	TheraBand. Akron, OH	TheraBand professional latex resistant tubing with hard handles, 48”. TheraBand Red: 3.7lbs resistance at full elongation.

UBE= upper body ergometer

445 **CARE Checklist**

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CARE Content Area	Page
1. **Title** – The area of focus and "case report" should appear in the title	1
2. **Key Words** – Two to five key words that identify topics in this case report	1
3. **Abstract** – (structure or unstructured) a. Introduction – What is unique and why is it important? b. The patient's main concerns and important clinical findings. c. The main diagnoses, interventions, and outcomes. d. Conclusion—What are one or more "take-away" lessons?	2
4. **Introduction** – Briefly summarize why this case is unique with medical literature references.	3
5. **Patient Information** a. De-identified demographic and other patient information. b. Main concerns and symptoms of the patient. c. Medical, family, and psychosocial history including genetic information. d. Relevant past interventions and their outcomes.	4
6. **Clinical Findings** – Relevant physical examination (PE) and other clinical findings	6
7. **Timeline** – Relevant data from this episode of care organized as a timeline (figure or table).	13
8. **Diagnostic Assessment** a. Diagnostic methods (PE, laboratory testing, imaging, surveys). b. Diagnostic challenges. c. Diagnostic reasoning including differential diagnosis. d. Prognostic characteristics when applicable.	8
9. **Therapeutic Intervention** a. Types of intervention (pharmacologic, surgical, preventive). b. Administration of intervention (dosage, strength, duration). c. Changes in the interventions with explanations.	9
10. **Follow-up and Outcomes** a. Clinician and patient-assessed outcomes when appropriate. b. Important follow-up diagnostic and other test results. c. Intervention adherence and tolerability (how was this assessed)? d. Adverse and unanticipated events.	14
11. **Discussion** a. Strengths and limitations in your approach to this case. b. Discussion of the relevant medical literature. c. The rationale for your conclusions. d. The primary "take-away" lessons from this case report.	14
12. **Patient Perspective** – The patient can share their perspective on their case.	5
13. **Informed Consent** – The patient should give informed consent.	1

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