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ABSTRACT

Background and Purpose Post-COVID Condition (PCC) is defined as the presence of symptoms related to SARS-CoV-2 four weeks past the initial infection. The SARS-CoV-2 virus impacts many organs and body systems. The six-minute walk test (6MWT) is a standardized measure of cardiovascular endurance commonly used in physical therapy practice. Use of the 6MWT has been studied in specific patient populations (e.g., geriatrics, Parkinson's disease, stroke, and chronic obstructive pulmonary disorder). The purpose of this case report is to discuss the utility of the 6MWT as a measure of walking capacity in individuals with PCC.

Case Description The patient was a 46-year-old female diagnosed with PCC who presented to outpatient physical therapy with impaired cardiopulmonary endurance, including difficulty breathing, shortness of breath with exertion, and generalized muscle weakness. The patient had persistent pulmonary symptoms that impacted her ability to perform activities of daily living and recreational activities. The 6MWT was used to measure changes in cardiopulmonary endurance and walking capacity during her course of care. Interventions included whole body strengthening and aerobic exercise.

Outcomes The patient demonstrated significant improvements in her cardiopulmonary endurance as demonstrated by an increase in the 6MWT distance (from 450 meters to 588 meters) and patient-reported symptoms.

Discussion The 6MWT may be an appropriate outcome measure for monitoring change following physical therapy intervention for PCC. Further research is required to determine the psychometric properties of the 6MWT for this patient population.

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INTRODUCTION

Coronavirus Disease 2019 (COVID-19) is a respiratory disease caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), a novel virus discovered in 2019 that affected millions of individuals in the United States and around the world.[1] People with COVID-19 generally improve within a few days to weeks after infection.[2] Symptoms not resolved within four weeks are diagnosed as Post-COVID Condition (PCC) and can severely impact quality of life.[2] Patients with PCC often experience symptoms for months, with some never attaining full resolution.[3,4] An Italian study found 32-55% of patients experience lingering symptoms beyond 60 days,[5] and that number rises with those who required hospitalization, up to 85%.[6,7] Those with certain risk factors including but not limited to poor general health, obesity, poor mental health, type 2 diabetes, and asthma were found to be more susceptible in a recent UK study. Another revealed PCC in 94% of participants with a history of asthma compared to PPC in participants without.[8,9]

The prolonged inflammatory response that is associated with PCC affects multiple body systems. Symptoms include fatigue, dyspnea, chest pain, brain fog, depression or anxiety, and more.[3] It has been reported that up to 60% of people have chronic fatigue 12 months after recovery from SARS-CoV-2.[3] Dyspnea was found in 27% of individuals with PCC due to the structural and functional changes that can occur in the lungs and airways.[4]

The symptoms of PCC can be debilitating and require management by many healthcare providers, including pulmonologists, nurses, neurologists, cardiologists, occupational therapists and physical therapists.[3] Patients with PCC may benefit from physical rehabilitation to address cardiopulmonary symptoms and their ability to engage in activities of daily living (ADLs).[10] It is

recommended that the Two Minute Step Test[11] (2MST) and the Six-Minute Walk Test (6MWT) be utilized to measure fatigability, dyspnea, and endurance in patients diagnosed or recovering from SARS-CoV-2 infection.[12] The 2MST, a measure of exercise capacity, is a common rehabilitation measure used in multiple settings in physical therapy. However, the 6-Minute Walk Test (6MWT) is preferred over the 2MST in certain pathologies as a specific measure of walking capacity. [13,14,15]

The most common use of the 6MWT is measuring the response to medical interventions in patients with moderate to severe heart or lung disease.[16] The 6MWT is a performance-based outcome measure widely used by physical therapists for various patient populations as a measure of functional cardiovascular endurance. It measures the distance a patient can walk quickly on a flat, hard surface in six minutes under a specific script read by the provider.[15] Its validity, reliability, and responsiveness to change have been established for conditions including stroke, Parkinson's Disease, spinal injuries, Alzheimer's disease, and many more.[17,18,19,20] Additionally, it is utilized with cardiopulmonary and chronic respiratory diseases for monitoring medical management and determining prognosis.[16] The 6MWT is simple to implement, free, and safe to perform.[15] More importantly, it reflects a patient's exercise tolerance and cardiopulmonary functional status during daily physical activity such as walking.[15]

Previous research on the use of the 6MWT in patients with PCC has been limited to inpatient settings. A 2022 systematic review found that pulmonary rehabilitation could improve exercise capacity measured by the 6MWT among patients with mild-to-moderate lung impairment associated with COVID-19.[21] Another study utilized the 6MWT in a small number of patients with COVID-19 receiving rehabilitation but found poor results compared to studies that looked at patients affected by other interstitial pneumonias.[22] These findings

notwithstanding, the use of the 6MWT in patients with PCC treated in the outpatient rehabilitation setting has not been studied.

Recent literature has shown that the 6MWT may be a useful measure for assessing exercise tolerance and submaximal aerobic functional capacity in patients with PCC.[21] However, there is limited psychometric data for the use of this measure for patients with PCC in an outpatient setting. The purpose of this case report is to describe the use of the 6MWT as an outcome measure to monitor improvements in walking capacity in the physical therapy management of patients with PCC seen in an outpatient setting.

Case Description

The patient was a 46-year-old female who presented to outpatient physical therapy with a diagnosis of PCC. She had a past medical history of asthma that was well controlled with a metered dose inhaler and nebulizer. The patient experienced an asthma attack which prompted her to see her primary care physician. Soon thereafter, on December 16, 2021, she was tested for SARS-CoV-2 and received a positive result. Her symptoms were not severe enough for hospitalization. However, she returned to her primary care physician in January of 2022 with continued complaints of coughing, dyspnea or shortness of breath (SOB) at rest and during activity, weakness, and fatigue. She was given a provisional diagnosis of PCC and was referred for further testing.

A chest radiograph was performed and revealed structural changes to her lungs, but no official report was provided by the referring physician or the patient. Two months later she was seen by a pulmonologist and completed a pulmonary function test (PFT) which the patient described as “61% lung function.” The results of the patient’s PFT were indicative of obstructive lung disease, as a normal ratio between forced expiratory volume in one second (FEV_1) and

forced vital capacity (FVC) is greater to or equal to 75%. Having a 61% FEV_1/FVC indicates an impaired expiratory flow.[24]

Prior to having SARS-CoV-2, the patient participated in recreational physical activities such as running, long walks, bike rides, and strength training which were not impacted by her past medical history of asthma. The patient was a single mother to a son with developmental disabilities and worked full time in an office. She and her child lived in a third-floor apartment without an elevator in a walkable community.

Examination - Tests and Measures

The initial examination took place 137 days after the patient's initial diagnosis of SARS-CoV-2. The patient reported that she was having difficulties with ADLs including walking, performing household tasks, and taking care of her child. She could not perform her usual recreational activities, such as running and strength training, due to symptoms of severe fatigue, weakness, and SOB. During the initial examination and re-examination, the patient was asked to rate her best, worst, and current symptoms of fatigue, weakness, and SOB over a 24-hour period on a scale of 0-10, 0 meaning symptom-free and 10 meaning the worst symptoms. The average score was documented (Table 1).

Consistent with changes in pulmonary function, the patient's breathing pattern demonstrated noticeably shortened inhalation and exhalation phases which worsened with physical activity. Active range of motion was within normal limits. Manual muscle testing revealed gross muscle weakness (Tables 2 and 3). The neurological screening, including dermatomes and deep tendon reflexes, was unremarkable. The 6MWT and 30 Second Sit to Stand Test (30STS)[25] were not performed during the initial examination due to excessive fatigue. They were first administered 18 days later at the eighth follow-up visit (Table 4). During the

tests, heart rate (HR) and oxygen levels were measured using a pulse oximeter. Rate of perceived exertion (RPE) was documented using the 6-20 Borg Dyspnea Scale.[26]

The following patient-reported outcome measures (PROM) were in standard use by the clinic and used in conjunction with impairment level testing: the Foot and Ankle Ability Measure - Sports (FAAM-S), Lower Extremity Functional Scale (LEFS), and Upper Extremity Quick Disability of the Shoulder, Arm and Hand (Quick DASH). The FAAM-S provides insight into overall physical functioning of individuals with musculoskeletal conditions of the lower extremity.[27] The measure has an ADL and sport subscale. The sport subscale has eight domains that are scored using an ordinal scale from zero to four, with four being no difficulty and zero being extremely difficult. The minimal detectable change (MDC) and minimal clinically important difference (MCID) values are eight and nine points, respectively.[27] The LEFS is a common assessment tool used by physical therapists to measure initial function, progress, and final outcome of therapeutic interventions applied to a patient with a musculoskeletal impairment.[28] It encompasses strength, quality of life, functional mobility, and many other domains. The MDC and MDIC for a range of conditions are both nine points.[29,30,31] The Quick DASH is a commonly used outcome measure that determines the function of the upper extremity as a result of musculoskeletal disorders.[32] This scale has 11 items pertaining to a patient's reported disability on a zero to five scale. The scale is scored from 0 to 100, 0 being no disability and 100 being the most severe disability. The MDC and MDIC an 11-point change.[32]

Clinical Impressions – Evaluation, Diagnosis, Prognosis

The patient's difficulties with ADLs, recreational activities, childcare, and stair climbing were likely a result from her diminished walking capacity, fatigue, SOB, and underlying pulmonary dysfunction associated with PCC and previous history of asthma. During the

examination, she demonstrated muscle weakness, poor endurance, and generalized deconditioning which were secondary to her impaired cardiopulmonary system. Her signs and symptoms were consistent with the criteria for PCC and her results from her pulmonologist suggested inefficient use of total lung capacity. The patient's past medical history of asthma was a risk factor for more severe PCC. Rehabilitation services were warranted to address her deconditioning, muscle atrophy, and exertional malaise with the hope of improving her quality of life and prevent further decline. By withholding rehabilitation services, the above impairments may worsen and further affect her role as a parent along with her ability to participate in work and perform self-care.[22] The patient agreed to the established physical therapy plan of care (POC). The program included a mixture of strength and functional endurance exercise to restore her functional exercise capacity, strength, and endurance. The 6MWT was chosen to measure functional capacity as it related to her goals of returning to ADLs without exacerbation of symptoms and walking community distances without SOB and fatigue. Her prognosis was good due to personal and environmental factors that are outlined using the International Classification of Functioning, Disability, and Health in Figure 1.

Intervention and Plan of Care

The patient's POC included physical therapy services two to three times per week for 10 weeks to address her impairments and to achieve her goal of returning to running (Figure 2). At the time of POC creation, there were limited recommendations and guidelines for patients with PCC. The POC was created with the patient's goals, current abilities, and impairments in mind.

The POC consisted of aerobic exercise, strengthening exercise, and neuromuscular re-education. The interventions were consistent with recommendations from the APTA Long COVID Clinical Summary published in September of 2022 and general principles of exercise

prescription from the American College of Sports Medicine's (ACSM) Guidelines for Exercise Testing and Exercise Prescription, 11th edition.[12,34] ACSM recommends at least three days a week of moderate and/or vigorous intensity aerobic exercise for at least 30-60 min/day plus 20-60 minutes per day of vigorous intensity aerobic exercise for healthy individuals.[34] For resistance training, the ACSM recommends single and multi-joint exercises with body weight or equipment at variable frequencies and intensities for healthy non-novice exercisers.[34] Neuromuscular re-education was utilized in the form of diaphragmatic breathing exercises to improve lung function and capacity[35] while resting and performing various activities, such as the agility ladder and traveling up/down stairs.

In conjunction with the exercise program, patient education was provided at every visit and included a home exercise program, energy conservation techniques, incorporation of exercise/activity throughout her day, and utilization of breathing techniques during times of breathlessness or lifting activities. Throughout the course of physical therapy, there were no indications to refer her out to another provider. Progress notes were sent to the patient's PCP to inform them of her progress in physical therapy.

OUTCOMES

Of the 29 scheduled visits, 21 were completed and eight were missed due to personal reasons regarding her child and father undergoing surgical procedures**.** Re-evaluation revealed increased scores across many outcome measures during care since initial examination. Two out of three PROMs, the LEFS and FAAM, each displayed 6-point increases, which did not meet the tests' respective MDC and MCID values. The patient's QDASH score dropped by 2.27 points, also not reaching MDC and MCID value. In addition to PROMs, strength testing was readministered and revealed minor increases of 1 grade (Kendall Manual Muscle Test scale[36]) in

global strength for both upper and lower extremities. Retesting the 30-second STS and 6MWT also revealed increased scores. At initial testing, the patient scored 18 repetitions in the 30-second STS and upon retesting the patient completed 19 repetitions. Performance on the 6MWT improved 83 feet (Table 4).

Out of all measures retested, the 6MWT was identified as the greatest change from baseline performance. The 83-meter increase in distance equated to an 18.4% increase from the 450-meter baseline score. Vitals and RPE scores recorded immediately post-test did not align with the 6MWT outcomes as expected, however. Baseline testing in week 3 displayed a heart rate (HR) of 114 beats per minute (BPM) and oxygen saturation (SpO2) of 99%, while RPE was stated by the patient to be 7/20 (Borg Dyspnea Scale). Upon re-testing in week 6, HR was measured at 88 BPM, spO2 of 97%, and an RPE of 14/20. The discrepancy between the decreased HR and elevated RPE score during re-testing are discussed in the final section of this case report.

Finally, it is noteworthy to mention that the patient's subjective report and therapist assessment noted improvements between testing periods and continued to do so through her final visit. At initial examination, the patient scored a 9/10 at worst, 3/10 at best, and 6/10 current report for averages among shortness of breath, fatigue, and weakness, where 10 equates to her worst symptoms experienced and 0/10 is absence of symptoms. Retesting at re-evaluation showed a decrease in all scores: 6/10 at worst, 2/10 at best, and current 4/10. In addition, the patient subjectively reported an improved ability to complete all ADL's and a decreased intensity of coughing spells experienced. Furthermore, the patient's tolerance to exercise steadily increased throughout the course of care as demonstrated by increased exercise intensity and

evolution of exercise complexity (Figure 3). Unfortunately, the patient reported that she had not yet achieved a return to her prior level of function for running.

DISCUSSION

This case study describes the use of the 6MWT as an outcome measure for assessing progress in walking capacity for patients diagnosed with PCC. The 6MWT was utilized to measure walking capacity and symptomatology while walking longer distances. Compared to her baseline performance, the patient increased her distance completed at re-assessment. The improvement meets the established MCID of 54 meters for patients diagnosed with cardiopulmonary conditions.[37] While this has not been validated for patients diagnosed with PCC, the patient's 6MWT improvement mirrored both her subjective reports of being less fatigued throughout the day and the subsequent assessments of improved endurance during the treatment sessions, as determined by her improved tolerance to progressive FITT (Frequency, Intensity, Time, Type), documented in Figure 3.

Physical therapy management for patients with PCC remains unclear due to the recency of the infection and limited research. The patient's POC was formulated using an individualized approach to address contextual factors (Figure 1) and identified impairments including chronic fatigue, SOB with exercise, and decreased functional endurance that impact ADLs and recreational activities, such as running and exercising. The 6MWT was able to measure meaningful change that corresponded to the patient's subjective improvements such as performing ADLs and walking longer distances. Despite this, the patient was unable to return to running at increments greater than one minute. Possible hypotheses regarding the patient's difficulty with running are likely due to non-compliance with physical therapy and continued difficulty with prescribed therapeutic activity and exercise, however, there is still much to

explore in regard to prognosis and recovery time of patients with PCC.

There are several weaknesses to consider when reviewing the results of this case report. The 6MWT was not performed at the initial examination due to the exacerbation of symptoms during other tests and measures. Not having performed the 6MWT at the initial examination does not allow for capturing the patient's true baseline prior to physical therapy management, however, it could be suggested a "floor effect" may have been observed with this and other measures during this acute stage of PCC. Another limitation was the patient's poor compliance towards the end of physical therapy treatment due to personal reasons. This may have impacted her rehabilitation potential and therefore ability to make measured progress as assessed by the outcome measures utilized. Appropriate selection of an outcome measure by the clinician may have also played a role in test results. The patient's prior level of function may have warranted a test of higher intensity, such as a sub-maximal treadmill test. However, this test could not have been performed due to resources of the clinical setting and safety concerns with administration. Finally, the discrepancies in HR, RPE, and 6MWT performance may be explained by both the patient's lack of understanding and application of the 6-20 RPE scale, along with the fact that the patient had completed their strength and endurance interventions prior to 6MWT administration during the week 6 re-evaluation which may have exacerbated her fatigue. Despite these weaknesses, a strength of this case report is the comprehensive treatment of the patient. The interventions encompassed many aspects of physical activity to improve muscular strength as well as cardiorespiratory endurance to accomplish the patient's goals.

We presented this case study to highlight the lack of guidance regarding the physical therapy evaluation and treatment of individuals with PCC in an outpatient setting. Due to the novelty of SARS-CoV-2 and PCC, there are minimal and conflicting evidenced-based

recommendations for which performance-based outcome measures should be used. Since the completion of the treatment for this patient, recommendations on the examination and treatment of individuals with PCC have been published from the APTA and the CDC.[12,33] These recommendations included the use of the 6MWT as well as other performance-based outcome measures such as the 2MST, 10 Meter Walk Test (10MWT), or One Minute Step Test (1MST).[12,33] The 6MWT was used in this case due to its simplicity and its high construct validity to measure walking capacity.[14,15] Further research is needed to accurately determine the utility and psychometric properties of the test in patients with PCC to allow for clinicians to choose adequate tests and measures as well as measure the effectiveness of physical therapy intervention.

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Appendix

Table 1. Description of patient-reported outcome measures.

	Week #0	Week #3	Week #6
Subjective Report of Fatigue, Weakness, SOB – worst	9/10	9/10	6/10
Subjective Report of Fatigue, Weakness, SOB – best	3/10	3/10	2/10
Subjective Report of Fatigue, Weakness, SOB- current	6/10	6/10	4/10
LEFS	40/80	NT	46/80
Foot and Ankle Ability Measure – Sports Subscale	9.38	NT	15.63
Quick DASH	31.82/100	NT	29.55/100

SOB = shortness of breath, LEFS = lower extremity functional scale, DASH = disability of the arm, shoulder and hand, NT = not tested

Table 2. Strength testing of the bilateral upper extremities at time of initial examination.

	Right	Left
Shoulder Flexion	4-/5	3+/5
Shoulder Extension	4+/5	4/5
Shoulder Abduction	4-/5	3+/5
Shoulder Internal Rotation	4/5	4/5
Shoulder External Rotation	3+/5	3+/5

Table 3. Strength testing of the bilateral lower extremities at time of initial examination.

	Right	**Left**
Hip Flexion	3+/5	3+/5
Hip Extension	4-/5	3+/5
Hip Abduction	3/5	3+/5
Hip Internal Rotation	3+/5	3+/5
Hip External Rotation	3+/5	3+/5
Knee Flexion	4+/5	4+/5
Knee Extension	5/5	5-/5
Ankle Dorsiflexion	5/5	4+/5
Ankle Plantarflexion	5/5	4+/5

Table 4. 6MWT results.

	Week 0	**Week 3**	**Week 6**
6MWT	NT	450 meters	533 meters
HR	NT	118 BPM	88 BPM
SpO_2	NT	99%	97%
RPE	NT	7/20	14/20

Figure 1. ICF Model.

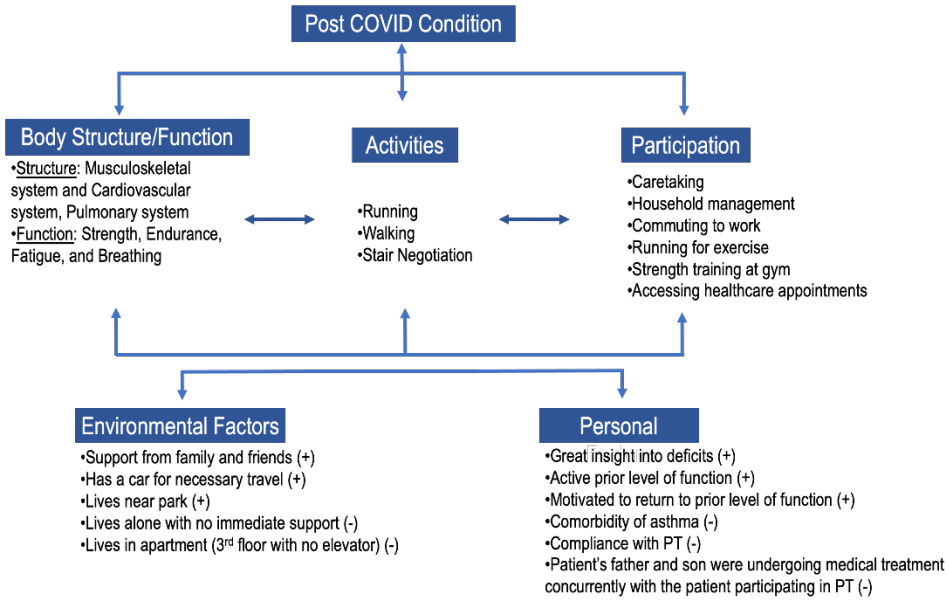

Figure 2. Clinical timeline from the patient's initial diagnosis of COVID infection in December 2021 to their self-discharge from physical therapy services in August of 2022.

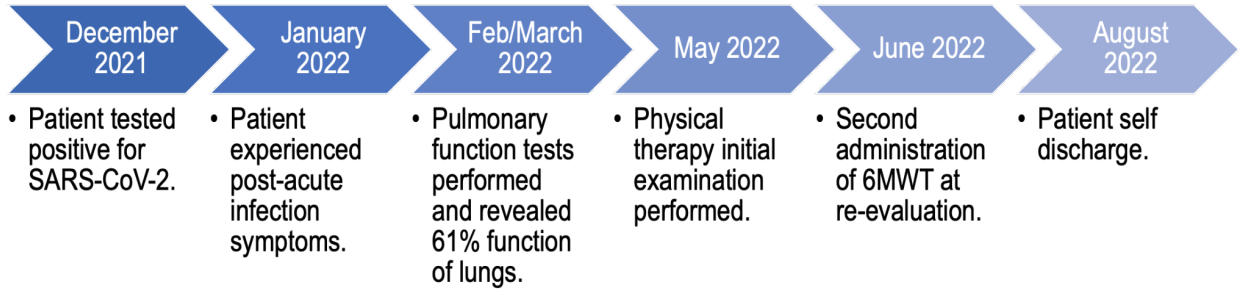

Figure 3. Outline of therapeutic exercise performed each visit.

Visit number		1	2	3	4	5	X	6	7	8
Aerobic exercise	UBE Level 1→3.5-6 min (warm up)	L1	L2	L3	L3	L3		L3	L3	L3
	TM 3.0 m/h-5 min (cool down)	L3	L3	L3	L3	L3		L3	L3.5	
Upper body	Rows with cable machine Level 3 3x10 repetitions									
	Bicep curls with DB 8lb→10lb 3x10 repetitions									
	Davinci[a] with GTB[c]→BTB 3x10 repetitions									
Lower body	SLR, ABD with DB 2lb→3lb→4lb ankle weight 3x10 repetitions	2lb	2lb	2lb	3lb	3lb		3lb	3lb	3lb
	Bridges with marches 3x10 repetitions									
	Side lying clamshells 4ways with GTB→BTB 3x10 repetitions									
	Knee EX with machine 25lb→40lb 3x10 repetitions	25lb	25lb	25lb	25lb	25lb		25lb	25lb	
	Sit to stand 3x10 repetitions									
	Leg press/calf press with machine 3x10 repetitions	55lb	55lb	55lb	55lb	55lb		60lb	60lb	
	Lateral walk/monster walk w/BTB x3									
	Bear kick back[b] 3x10 repetitions									
Trunk	Dead bugs ISO 10x10"									
	Diaphragmic breathing 10 repetitions									
Dynamic balance	Step up on 6" step with ankle weight 5lb 3x10 repetitions									
	Agility ladder 10 →15 repetitions									
	Stairs x2→3→4 sets									

Visit number		9	10	11	X	12	13	14	15
Aerobic exercise	UBE Level 1→3.5-6 min (warm up)	L3		L3		L3	L3	L3.5	
	TM 3.0 m/h-5 min (cool down)	L3.5	L3.5	L3.5					L3.5
Upper body	Rows with cable machine Level 3 3x10 repetitions								
	Bicep curls with DB 8lb→10lb 3x10 repetitions	8lb					9lb		9lb
	Davincis[a] with GTB[c]→BTB 3x10 repetitions								
Lower body	SLR, ABD with DB 2lb→3lb→4lb ankle weight 3x10 repetitions	3lb	3lb	3lb			3lb	3lb	4lb
	Bridges with marches 3x10 repetitions								
	Side lying clamshells 4ways with GTB→BTB 3x10 repetitions								
	Knee EX with machine 25lb→40lb 3x10 repetitions	25lb	25lb	25lb			40lb	40lb	40lb
	Sit to stand 3x10 repetitions								
	Leg press/calf press with machine 3x10 repetitions	60lb	65lb	65lb			70lb	70lb	70lb
	Lateral walk/monster walk With BTB x3								
	Bear kick back[b] 3x10 repetitions							3x5 reps	
Trunk	Dead bugs ISO 10x10"						DC	DC	DC
	Dead bugs 3x10 repetitions								
	Diaphragmic breathing 10 repetitions								
Dynamic balance	Step up on 6" step with ankle weight 5lb 3x10 repetitions	DC	DC	DC		DC	DC	DC	DC
	Agility ladder 10 →15 repetitions		x10	x10			x15		
	Stairs x2→3→4 sets	x2	x4	x4			x4	x3	

Visit number		16	X	17	18	19	20	X	21
	TM 3.0 m/h-5 min (cool down)	L3.5		L3.5	L6	L6	L6		L6
Upper body	Rows with cable machine Level 3 3x10 repetitions								
	Bicep curls with DB 8lb→10lb 3x10 repetitions	DC		DC	DC	DC	DC		DC
	Davincis[a] with GTB[c]→BTB 3x10 repetitions					DC	DC		DC
Lower body	SLR, ABD with DB 2lb→3lb→4lb ankle weight 3x10 repetitions	3lb		4lb	4lb	4lb			4lb
	Bridges with marches 3x10 repetitions								
	Side lying clamshells 4ways with GTB→BTB 3x10 repetitions								
	Knee EX with machine 25lb→40lb 3x10 repetitions	40lb		40lb	40lb	40lb			40lb
	Sit to stand 3x10 repetitions								
	Leg press/calf press with machine 3x10 repetitions	75lb		75lb	75lb	75lb	75lb		75lb
	Lateral walk/monster walk With BTB x3								
	Bear kick back[b] 3x10 repetitions								
Trunk	Dead bugs ISO 10x10”	DC		DC	DC	DC	DC		DC
	Dead bugs 3x10 repetitions								
	Diaphragmic breathing 10 repetitions								
Dynamic balance	Step up on 6” step with ankle weight 5lb 3x10 repetitions	DC		DC	DC	DC	DC		DC
	Agility ladder 10 →15 repetitions			x10	x10	x10			x10
	Stairs x2→3→4 sets	X4		x4	x4	x4			x6

[a]Bilateral shoulder extension. [b]Quadruped hip and knee extension. [c]Green icon stands for green therapeutic band.
UBE=upper body ergometer, TB=treadmill, DB=dumb bell, Lb= pound, GTB=green therapeutic band, BTB=blue therapeutic band, SLR=straight leg raise, ABD=abduction, EX=extension, ISO=isometric, DC=discharge, X=cancellation