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Title: Home-based eccentric exercise program for fall prevention in an older adult - A
Case Report

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Abstract:

Background and Purpose: Falls in older adults are common. Fear of falling may affect activity levels in older adults and increase the risk for re-injury. Eccentric strengthening exercises are seldom incorporated into a home-based physical therapy program. Eccentric strengthening needs lower energy costs and may benefit the rehabilitation of older adults at home. The purpose of this case report is to outline a home-based eccentric exercise program and assess the feasibility of the program in home health to prevent falls.

Case Description: This case report outlines the initial evaluation, therapist-guided - home-based eccentric exercise program via video-conferencing, and monitor effectiveness of the program on balance outcome measures & fear of falling, over 6 week follow-up for a 66-year community-dwelling female with a history of fall in the past year.

Outcomes: The patient described in the case report progressed in balance outcome measures - Tinetti (24/28 to 27/28), Timed Up & Go Test (18 sec to 10.92 sec), Sharpened Romberg test with eye closed (from 7 sec to 34 sec) with low load eccentric exercise program. Fear of falling scores reduced from 39/64 to 28/64. Outcome scores had improved more than minimal detectable change for the measures demonstrating clinically significant improvement.

Discussion: This case report demonstrates the feasibility of a home-based eccentric exercise program in improving balance & reducing fear of falls. Longer duration

follow-up & including a larger sample to study the effectiveness of such program are recommendations for further research.

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Background & Purpose:

Falls in the older adult is one of the primary reason for seeking emergency services and/or hospitalization.¹ Center for Disease Control and Prevention reports >25% of older adults fall each year and the risk of falling again, increases after the initial fall.^{1,2} Older adults tend to self-limit physical mobility following fall and become afraid of falling. Fear of fall could lead to general de-conditioning, muscular weakness, newer dependency on assistive devices, increased dependency on caregivers, and reduce function below the baseline level. Home-based physical therapy is often referred to address modifiable risk factors - gait, strength deficits, balance deficits, and home safety evaluation. Multiple programs have been developed to address the fall risk, emphasize exercise interventions to improve strength and balance.^{3,4} Center for Disease Control and Prevention provides tools like STEADI, MyMobility Plan to facilitate healthcare providers and older adults to plan and prevent falling.^{3,5}

Functional movement tasks like gait, sit to stand, stair negotiation, carrying shopping bags involve both concentric and eccentric muscle activity.⁶ Functional tasks often require sub-maximal eccentric muscle activity to control movements and older adults with fall risk, have been documented with poor eccentric muscle control.⁶ Home-based exercise programs commonly focus on seated or standing strengthening exercises, progressive resisted exercises with cuff weights or elastic bands and balance exercises. Concentric strengthening exercises are mostly focused and eccentric component is often not emphasized in regular strengthening programs.⁷

A high level of motivation to participate, increased risk for muscle damage has been documented as potential limitations to eccentric exercises.^{6,8} However, eccentric

exercise has been studied for safe implementation in the rehabilitation of older adults.^{2,6,9,10} Low intensity or dose of exercise has been recommended to be a key component in avoiding adverse muscle damage associated with eccentric exercises.^{6,7,10} Gradual increase in intensity and duration of exercises, attention to posture, and precision of technique have been suggested to prevent muscle damage, avoid undue stress and promote optimal functional gains.^{6,10} Literature suggests a need for an initial familiarization phase with a perceived exertion of "very light" & then progressing intensity at "somewhat hard", with a frequency of 2-3 times/week for the eccentric training program.⁶ Eccentric exercises have also been hypothesized to improve proprioception, facilitate balance, and hence could be beneficial in preventing falls in older adults.⁷

This case report intends to document the feasibility of a low-load eccentric training program via video-conferencing that could be implemented in home-based physical therapy of older adults in improving balance, and reduce the fear of falling.

Patient History/Review of Systems:

A 66 year community-dwelling female patient with a history of 1 fall in the past year was selected for the study. The patient had a history of bilateral knee replacement surgeries (Left - 2017, Right - 2018) and at baseline had reported having pain in the knee with exertive tasks. The patient reported a history of losing her balance & falling when walking in the community (May 2020). The patient does not use a cane for ambulation at baseline, reported walking cautiously though at a slower speed to avoid falling. Post fall, she reported increased fear of falling, walking outdoors on uneven surfaces, and fear when using the bathroom. The patient was educated about the

purpose of the study and consented to participate in the study. The patient permitted her son to communicate with the researcher and coordinate visits. The study was prospectively conducted in February-April 2021 by video-conferencing via Skype (Version 8.68.0.96)®, the patient's son assisted in measuring objective outcomes and video recordings were used for data collection.

On initial evaluation, the patient's chief complaint was a pain in bilateral knees rated as 3-4/10 in NPRS, denied taking any medication specifically for pain, denied using any ice/heat, reported aggravation up to 4/10 when standing to perform chores for half-hour and alleviates to 2/10 with a rest of 5-10 minutes. The patient reported a feeling of tightness in the knees and performing stretching exercises. The patient reported walking regularly as tolerated, reported using Garmin Vivofit 1® for tracking steps. 1 fall was reported in the past year (May 2020) when she lost balance walking in the community. The patient denied using any assistive device when the fall occurred and denied having any significant injury from the fall. The patient self-referred for physical therapy due to fear that she might fall again walking outdoors, and felt a need for caregiver supervision for outdoor ambulation.

The patient reported a medical history of obesity, hypertension, type 2 diabetes mellitus, and currently on daily medications, follows a low sugar diet with good compliance. The patient denied any cardiac, neurological, integumentary, genitourinary, visuo-auditory, or vestibular symptoms, denied any recent hospitalization, and reported performing her self-care independently. The patient denied using any assistive device for ambulation, reported using a commode on the toilet and commode as a chair for showers. The patient reported no significant

limitation in the range of motion in the upper or lower extremity. Her goal for physical therapy was to be confident in walking on outdoor surfaces and reduce the fear of fall in the bathroom.

Clinical Impression 1:

The patient was identified as an ideal candidate for the study due to a history of fall in the past year, fear of falling limiting her outdoor/bathroom mobility, medical history not impacting current function, supportive family, and motivation to participate through the course of study. The evaluation was planned to be performed through video-conferencing, with the researcher instructing the family for measuring objective measurements, guarding the subject during balance testing/exercises, and coordinate in filling forms.

Clinical Examination:

Initial evaluation was performed with the patient's son measuring objective outcome measures with the researcher providing instructions during the video-conference session. The patient was inquired about current medications and reported no drug allergies. Vital signs measured included resting heart rate, blood pressure, oxygen saturation, height, weight, resting pain level. Height was measured in feet/inches with the patient standing against the wall, weight measured in kilograms with a digital weighing scale. Automated devices were used to measure blood pressure (Thermocare BP367A automated manometer, Manufacturer - Thermoplast, India)¹¹, pulse oximeter was used to measure heart rate & oxygen saturation (BPL Smart oxy, Manufacturer - BPL Medical Technologies, India)¹², strength testing was performed with patient's son giving resistance to bilateral upper & lower extremity with

instructions provided by the researcher during the video conference. Muscle strength was graded by ordinal grading (zero - normal) secondary to a video-conferencing visit.¹³ Caregiver was asked to describe patient's ability to resist manual forces and observation through video-conferencing for signs of giving way to resistance was used to objectify muscle strength. Measuring strength in televisit is technically difficult as there is no direct hands-on assessment. Recommendation to use antigravity movement or self-pressure has been suggested for use in televisit in a blog.¹⁴ In this study, giving way with break test was observed to record approximate strength. Thigh & calf circumference was measured in centimeters - 5 cm distal from tibial tuberosity and 10 cm proximal to lateral femoral condyle respectively, with the researcher providing instructions for palpation & measurement to the patient's son. Education was provided to the patient's son to identify bony prominence, education was provided through video-conference to facilitate the accuracy of reference points for circumference measurement.

Balance testing was measured with Timed Up & Go test (TUG),¹⁵ Tinetti Performance Oriented Mobility Assessment (T-POMA)¹⁶, and Sharpened Romberg Test¹⁷. Fear of falling was quantified with Falls Efficacy Scale - International (FES-I).¹⁸ TUG is a simple, functional test to assess balance and walking ability, which could be used in home settings. T-POMA was used to screen balance, gait performance as the test is feasible to perform in-home setting without special equipment.¹⁶ Sharpened Romberg test (SRT) has been performed with eyes open (EO) or eyes closed (EC) conditions in previous studies.¹⁷ FES-I is scored with a 4 point Likert scale about fear of fall in various activities.¹⁸ A study by Yardley et al,

reported no significant effect on FES-I scored with interview vs postal format.¹⁹
Psychometric properties of the outcome measures are described in Table 1.²⁰⁻²⁷

Clinical Impression 2:

The patient was identified as an ideal candidate for eccentric training exercises as the patient had good/normal strength in bilateral lower extremities at initial evaluation, low pain levels minimally affecting routine functions, low fall risk as measured by T-POMA, moderate fall risk as indicated by TUG, and high concern about falling as indicated by FES-I.

Plan for Intervention:

Eccentric exercises were planned to be the primary mode of intervention as the patient's goal was to be more confident walking outdoor and reduce her fear of falls. Eccentric lower extremity and trunk muscle contractions are pivotal in balance strategies to prevent loss of balance. Patient scores of T-POMA, TUG at baseline assessment, indicating lower to moderate fall risk, permitted safe exercise intervention to be performed through video-conferencing, under caregiver/family supervision. The patient was educated about the effects of eccentric exercises, adverse outcomes (post-exercise muscle soreness, rhabdomyolysis), recommendations to hydrate at least 2-3 liters of water/day, follow a low sugar diet, and recommended to document any symptoms of fever, increased pain, urinary changes. The eccentric exercise intervention was planned to be performed through video-conferencing for 2 sessions/week, with the researcher instructing the patient for supervising during exercises, cueing body mechanics, and providing instructions for a rest-activity cycle. Eccentric exercise interventions planned included stand to sit, reverse abdomen curl in

sitting, forward and backward sway in standing, eccentric leg press with an elastic band. Eccentric exercises were instructed to be performed over a 3-second duration, followed by a rest interval of 5 seconds between repetitions. 1 set of 10 repetitions were planned to be performed during 1 session.

Hypotheses:

The case report hypothesized progressive improvement in eccentric control shown with increasing duration of control during exercises, with the expectation to improve balance outcomes (T-POMA, TUG, SRT-EC) and reduce fear of falling (FES-I).

Intervention Description:

Intervention sessions included a warm-up and cool-down phase of a seated pedal exerciser at patient-selected speed for 5 minutes. Eccentric exercise interventions were chosen to be simple tasks like standing to sit, forward and back sway facilitating ankle eccentric activity, reverse abdomen curl simulating sit to supine, and eccentric leg press with an elastic band. The eccentric phase was initiated to sustain for 3 seconds & progressed to 5 seconds as tolerated. The rest phase was initiated for 5 seconds & progressed to 10 seconds. Metronome app in a mobile phone was used at 60 beats/minute to facilitate coordinating activity-rest cycle. The caregiver was stand by guarding through the exercises to prevent the risk of fall during exercises and assisted the patient to return to starting position. The exercise was facilitated with 3-word instructions to aid the patient, caregiver and therapist coordinate the eccentric task. (Table 2) Cueing was provided to the patient to facilitate adherence to the duration of eccentric phase or rest phase, and adhere to appropriate body mechanics during forward/backward sway (to avoid hip strategy).

A rating of perceived exertion scale (RPE) from 6 to 20 was used to identify exertion level after every session.²⁸ Eccentric activity-rest phase was started at 3 sec:5 sec for 3 visits to familiarize patient, progressed to 5 sec:7 sec for 1 visit as the patient was able to demonstrate improved eccentric control and then sustained at 5 sec:10 sec for subsequent visits. The patient was questioned about pain levels (NPRS) after exercises and vitals (heart rate, blood pressure, oxygen saturation) were measured at end of every visit. The patient was subjectively assessed during every visit and inquired about post-exercise pain levels, general fatigue, ability to perform routine activities/walking, and urinary changes. The patient was educated & reinforced to hydrate 2 - 3 liters/day. The patient did not participate in 1 session citing increased fatigue and pain in bilateral shoulders/arm and ankles up to 7/10. The patient did not participate in any other exercises during the study period. The patient reported doing her regular walking and steps were tracked through her Garmin Vivofit® device.

Outcomes:

The patient had improved in balance measures - T-POMA, TUG, tandem standing, and reduced fear of falling as measured by FES-I. (Table 3) The patient had attended a total of 10 sessions of eccentric exercise training from February 20 - April 1, 2021. The patient preferred not to participate in 1 session secondary to fatigue and pain from the previous session. The average duration of sessions is 46.64 ± 13.46 minutes (Mean, SD). (Figure 1)

The patient had demonstrated a minimal increase in thigh and calf circumferences bilaterally. Strength in bilateral lower extremities improved and the patient was able

to sustain a break test for lower extremity muscle testing. The patient had reported minimal pain during the start of sessions and varying pain from minimum to moderate after exercises as measured by NPRS. (Figure 2) The patient had reported exertion ranging 10-15 after exercises as measured by RPE. (Figure 2) Pedal exerciser warm-up & cool-down were performed during 3rd-11th treatment sessions. Pedal exerciser cycles were observed to progressively increase through the sessions during the 5-minute duration. (Figure 3) A trend of reduced cycles was observed during the cool-down phase after exercises, in comparison to the initial warm-up phase in almost every session. The cool-down phase was unable to be monitored completely on the 10th session due to an internet connectivity issue, but the patient reported completed 5 minutes of pedal cycling. The patient had used a yellow elastic thera band for eccentric leg press during the initial 2 sessions of familiarization, followed by a red elastic thera band for 8 consecutive sessions. The patient was apprehensive about progressing to the green thera band due to fear of pain exacerbation.

The patient had improved T-POMA from 24/28 to 27/28. MDC for T-POMA in older adults has been reported to be 4 points.¹⁶ In this study, the patient had staggered during perturbing forces reducing the score by 1 point at the final assessment. T-POMA has been shown to have a poor ceiling effect in older adults.¹⁶ The patient had improved TUG from 18 seconds to 10.92 seconds. MDC for TUG has been shown to be ranging from 1.10 - 3.01 seconds in multiple studies.²²⁻²⁴ The patient reported improved confidence in FES-I, with scores improving from 39/64 to 28/64. Scores between 28-64 have been documented with high concern of fall.¹⁸ Smallest detectable difference for FES-I was reported as 9.6 in patients with Parkinson's Disease.²⁷ Subjective feedback provided by patient included - "feel more confident,

doesn't think exercises were strenuous, thinks the exercises help her daily activities with improved duration for standing during chores." The patient was able to tolerate 30 seconds of SRT-EO, reported improved confidence during the final assessment session. The patient had significant unsteadiness and was unable to sustain 7 seconds of SRT-EC during baseline assessment but progressed to being able to sustain 34 seconds (right foot forward) and 22 seconds (left foot forward) for tandem standing with eye closed. MDC for SRT-EC has been documented to be 19 sec in Parkinson's Disease.²⁶ The patient had clinically significant improvements in all balance outcome measures except T-POMA.

The patient had reported fatigue following exercises on the same day and the next day after most sessions. The patient reported no fatigue or pain on the 2nd consecutive day and was able to tolerate all sessions well, except on 1 occurrence when sessions were separated by 1 rest day due to unavailability of family member to coordinate.

Discussion:

The case report intended to demonstrate the feasibility of a low-load eccentric training program via video-conferencing, implemented in home-based physical therapy of older adults. Eccentric training program has been documented in direct visits, however, this study has been conducted exclusively with video-conferencing. American Physical Therapy Association has been advocating the use of electronic & telecommunication devices to provide health care services.²⁹ Eccentric training has been documented to enhance ankle balance strategies, improve proprioception and facilitate balance recovery.^{2,7} Katsura et al reported a reduction in time taken for TUG, improved 2-minute stepping repetitions, and reduced movement of the center of

pressure with eye closed static balance in the eccentric exercise training group as compared to the concentric training group.⁷ The patient in this case report, was able to improve in balance outcome scores & reduced fear of falling, in 10 sessions with clinically significant improvement.

The intensity of exercises, in this report, were lower as compared to previously documented studies.^{2,7,10} Previous studies have recommended exercises at varying intensity with RPE ranging from 6-11 at initial session progressing to RPE >18 towards the final session, progress from 1 to 5 sets and repetitions progressed from 10-15.^{6,7,9} In this case report, the patient had reported RPE from 10/20 - 15/20 (range), and RPE 13/20 in 5 out of 10 sessions (mode) during the study duration. Eccentric loads at patient comfortable speeds have been documented to lead to functional improvements in frail older adults.¹⁰ Eccentric exercises were fixed at 10 repetitions for the 6 exercises for 9 consecutive visits to allow adequate time for warm-up, activity-rest cycles, and cool down. The total time duration of the individual sessions through the video conferencing was relatively similar to session times for direct patient care and could be implemented in routine practice.

The study had a few limitations including lack of direct contact for palpation, strength measurements, tactile cue for body mechanics which were due to the video conferencing. The caregiver had to be educated through video with simple instructions for palpation and strength testing which reduces the reliability of circumference & strength measurements. Balance testing was performed through instructions and visual assessment was made to score T-POMA, TUG, SRT-EC tests. Visual assessment for break test was used to differentiate good vs normal strength.

Technical difficulties due to internet connectivity, unavailability of caregiver for coordinating visit were also limitations for the study.

Patient motivation, caregiver support for supervision and coordination, presence of resources (devices to measure vitals, thera band, laptop for video conferencing, internet), and willingness to participate have been facilitating factors in this case study. This case report was conducted over 6-week duration and further research is recommended to follow up for a longer duration to study carry-over effects, measure fear of falling prospectively, and monitor the risk of fall. The study could be expanded to a larger population served by home health agencies to validate the feasibility in home-based physical therapy, given the need for technological devices and supportive caregivers.

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Table 1. Psychometric Properties of Outcome Measures

Outcome Measure	Psychometric Properties
Timed Up & Go test (TUG)	<ul style="list-style-type: none"> ▪ Fall risk, specificity & sensitivity - Cut off score > 13.5 sec indicates fall risk in community-dwelling older adults, Sensitivity 87%, Specificity 87%.^{15,20} Cut-off score - 10 sec, Sensitivity 71%, Specificity 89%.²¹ ▪ Test retest reliability - ICC >0.97¹⁵ ▪ Standard error of measurement (SEM) in knee arthroplasty patients - 0.82²² ▪ Minimal Detectable Change (MDC) in knee arthroplasty patients - 2.27 sec²² ▪ MDC in patients with osteoarthritis - 1.10-1.14 sec²³ ▪ MDC in patients with COPD - 3.01 sec²⁴
Tinetti Performance Oriented Mobility Assessment (T-POMA)	<ul style="list-style-type: none"> ▪ Fall risk cut off score < 19/28 indicate fall risk¹⁶ ▪ Normative data for females aged 65 - 79 years - 25.16 (4.30)¹⁶ ▪ Test retest reliability - ICC = 0.72-0.96¹⁶ ▪ Sensitivity - 64-85%¹⁶ ▪ Specificity - 56-78%¹⁶ ▪ MDC for T-POMA in older adults - 4 points¹⁶
Sharpened Rhomberg Test (SRT)	<ul style="list-style-type: none"> ▪ Test-retest reliability 0.90-0.91 with EO, 0.76-0.77 with EC.¹⁷ Average duration for SRT for females aged 60-69 years - 55.93 sec for EO-shoes on, 54.13 sec with EO-shoes off, 31.58 sec with EC-shoes on, 29.86 sec EC-shoes off.²⁵ ▪ MDC documented only on patients with Parkinson's disease - 39 sec for SRT - EO, 19 sec SRT-EC.²⁵
Falls Efficacy Scale - International (FES-I)	<ul style="list-style-type: none"> ▪ Moderate concern for fear of fall - cut-off score of 20-27¹⁸ ▪ High concern for fear of fall - cut off score 28-64¹⁸ ▪ Test-retest reliability (ICC = 0.96).¹⁸ ▪ SEM documented in patients with Parkinsons disease as 3.4 and the smallest detectable difference was reported as 9.6.²⁷

Table 2. Eccentric Task & Instructions

1. Stand to sit - Instruction GO - WAIT - UP		
	Eccentric	Starting position: Standing with upper extremities crossed. Patient slowly lowers to sitting without hand support for 3-5 sec
	Rest	Instructed to wait for 5-10 seconds in sitting
	Assist	Caregiver assists patient to starting position
2. Reverse Abdomen Curl - Instruction GO - WAIT - UP		
	Eccentric	Starting position: Sitting on edge of chair with upper extremities crossed. Patient slowly reclines back on backrest without hand support for 3-5 sec
	Rest	Instructed to wait for 5-10 seconds in reclined position
	Assist	Caregiver assists patient to starting position
3. Forward Sway - Instruction GO - PUSH - WAIT		
	Eccentric	Starting position: Standing with upper extremities crossed. Patient slowly sways forward without hand support for 3-5 sec
	Assist	Caregiver assists patient back to starting position
	Rest	Instructed to wait for 5-10 seconds in standing
4. Backward Sway - Instruction GO - PUSH - WAIT		
	Eccentric	Starting position: Standing with upper extremities crossed. Patient slowly sways backward without hand support for 3-5 sec
	Assist	Caregiver assists patient back to starting position
	Rest	Instructed to wait for 5-10 seconds in standing
5. Eccentric leg press with elastic band (Right) - Instruction - GO - STRAIGHT - WAIT		
	Eccentric	Starting position: Supine. Thera band was attached to both ends of wand to create a loop. The loop was positioned around patient's foot and the wand was held by both upper extremities at sternal level with elbows flexed. Patient starts from neutral position (leg extended), upon instruction slowly flexes hip/knee through available range for 3-5 sec.
	Assist	Caregiver assists patient's leg back to neutral starting position
	Rest	Instructed to wait for 5-10 seconds in supine
6. Eccentric leg press with elastic band (Left) - Instruction - GO - STRAIGHT - WAIT		
	Eccentric	Starting position: Supine. Thera band was attached to both ends of wand to create a loop. The loop was positioned around patient's foot and the wand was held by both upper extremities at sternal level with elbows flexed. Patient starts from neutral position (leg extended), upon instruction slowly flexes hip/knee through available range for 3-5 sec.
	Assist	Caregiver assists patient's leg back to neutral starting position
	Rest	Instructed to wait for 5-10 seconds in supine

Table 3. Objective and Clinical Outcome Measures

Measures	Baseline Assessment	Final Assessment
Vitals		
Height (ft in)	5' 1"	-
Weight (kgs)	88.6	90
Pain (NPRS)	3-4/10	0
Heart Rate (bpm)	73	77
Blood pressure (mmHg)	168/80	145/87
Oxygen Saturation (%)	94	97
Circumference		
Right Calf (cm)	37.5	38
Left Calf (cm)	37	38
Right Thigh (cm)	51	54
Left Thigh (cm)	52.5	54
Manual Muscle Grading		
Bilateral Upper Extremity	Normal	Good
Bilateral Hip flexor	Good	Good
Bilateral Hip abductor	Normal	Normal
Bilateral Hip extensor	Good	Normal
Left Knee extensor	Normal	Normal
Right Knee extensor	Good	Normal
Left Knee flexor	Good	Normal
Right Knee flexor	Normal (pain 3/10 with resistance)	Normal
Left Ankle Dorsi/plantarflexor	Good	Normal
Right Ankle Dorsi/plantarflexor	Good	Normal
Balance Outcome Measures		
Tinetti POMA	24/28	27/28
Timed Up and Go (sec)	18	10.92
Fall Efficacy Scale - Int	39/64	28/64
Sharpened Romberg - EO (sec)	30	30
Sharpened Romberg - EC (sec)	7	34 sec (R foot forward) 22 sec (L foot forward)

Figure 1. Treatment Session Duration

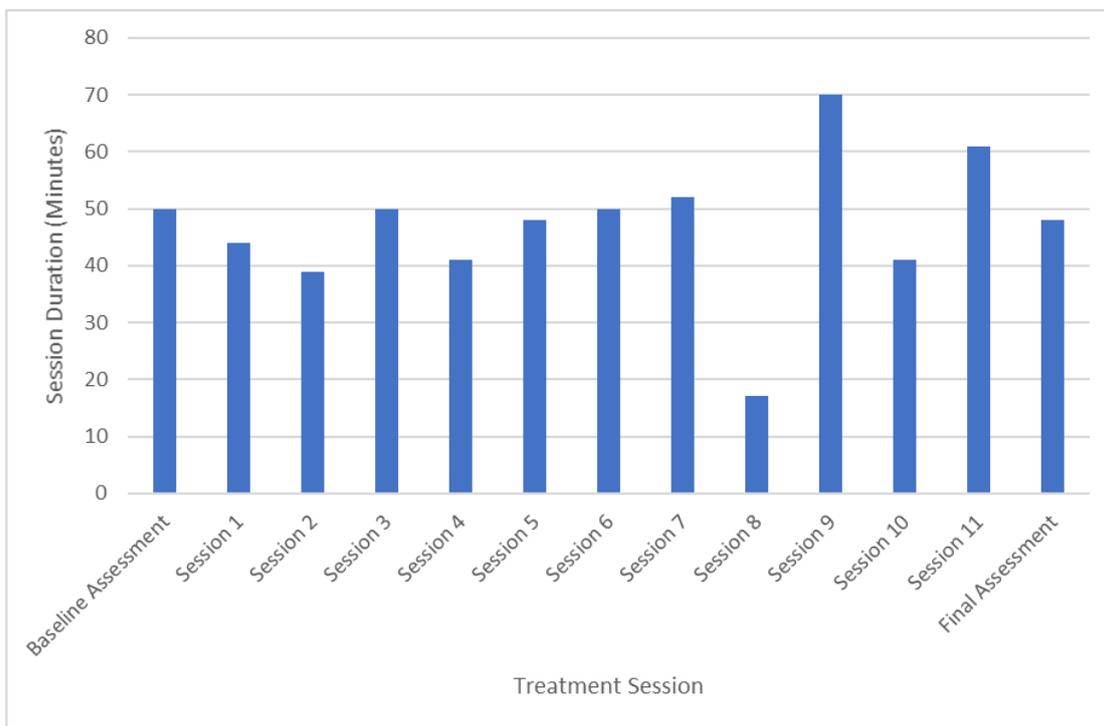


Figure 2. Pain Level and Perceived exertion after exercise.

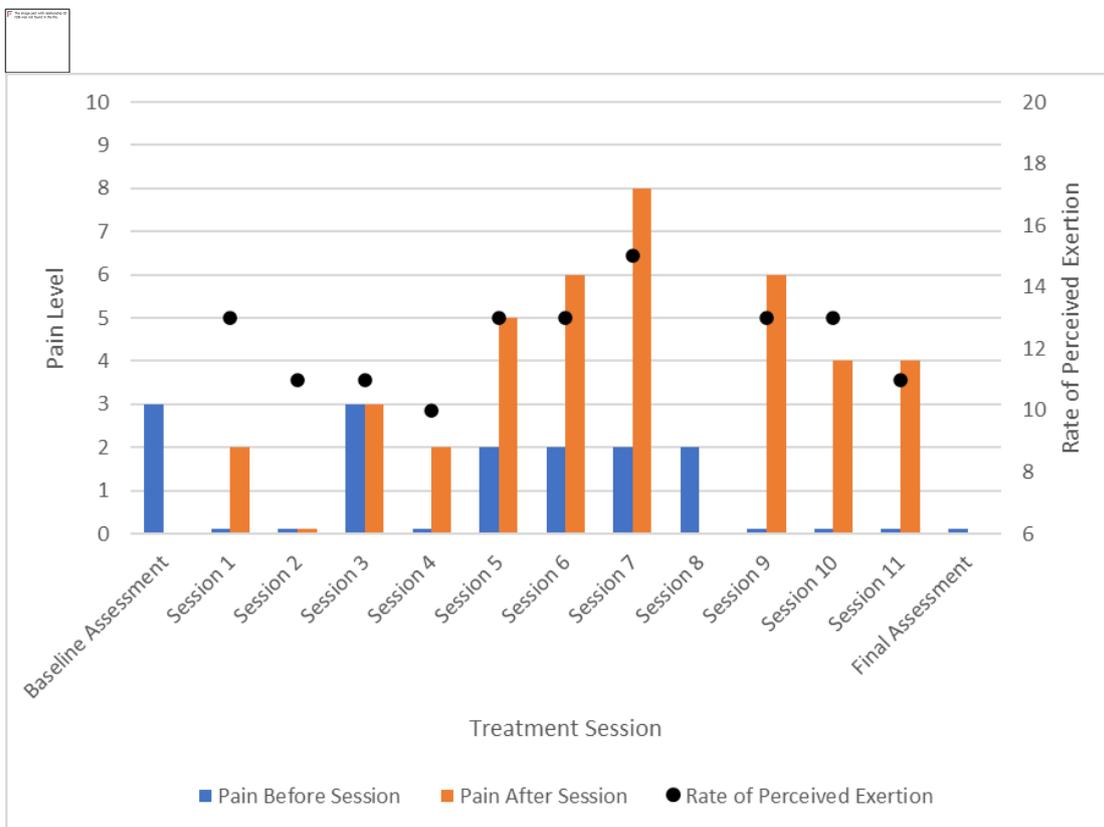


Figure 3. Pedal exerciser cycles in 5 minute duration

