

Supplementary File 1. REHAB-HF Intervention Manual of Procedures

1 Rehabilitation Intervention Overview

The multi-domain rehabilitation intervention for this study is a novel integration of rehabilitation therapies developed specifically for older heart failure patients who have been hospitalized for ADHF; a population characterized by heterogeneity in mobility status, multiple co-morbid conditions, and high rates of frailty. The intervention targets deficits in strength and endurance worsened by acute illness and hospital-associated immobility with an initial emphasis on regaining strength, balance and functional mobility allowing safe participation in rehabilitation more specifically targeting deficiencies related to the (central and peripheral) pathophysiologic effects of heart failure (i.e. walking-based endurance training and strength training). The goal of the intervention is to improve functional performance utilizing reproducible targeted exercises and progressions administered by a multi-disciplinary team.

This transitional intervention is designed to provide the appropriate rehabilitation and exercise training from the time of acute decompensation, through the transition to recovery, and finally to the return to chronic, stable disease state. Although the majority of the supervised intervention is intended to be administered in an outpatient rehabilitation facility, for future dissemination, it is designed to be easily adaptable to the hospital or home environment.

A key aspect of the REHAB-HF intervention is advancing performance through structured, gradual progression. Participants will be continually challenged to safely and effectively improve physical function by progressing through specified small increments for each exercise based on their individual performance. Once a participant has progressed as far as possible for a given exercise, the interventionist should introduce a new, more challenging exercise in place of the previous, lower level exercise.

The exercises in each domain (endurance, strength, balance, mobility) of the rehabilitation program and the relative emphasis of each of the domains will vary based on the needs of a particular participant at any given time. The broad range of exercises included in the study protocol are designed to be adaptable to the wide range of physical function, including frail older adults with multiple comorbidities, that is characteristic of this patient population. An exercise stratification grid (Table 1) has been developed to help guide the interventionist to the types of exercises that will be appropriate for a participant at a given performance level. Participant performance on the stratification grid is used to guide the initial exercise prescription and is reassessed periodically throughout the intervention to help ensure appropriate progression.

As functional mobility improves, priority should be given to increasing the duration of endurance based training as tolerated by the participant (see Figure 1). A participant with poor functional mobility may spend a greater proportion of time performing balance and mobility exercises in the early portions of the intervention whereas later in the study protocol, as functional mobility improves, this may constitute a very small portion of the exercise session. Alternatively, a participant with little baseline functional mobility impairment will spend the large majority of the exercise session performing endurance and strengthening exercises, even early in the study.

Achieving fidelity of the intervention across all participating sites and among all interventionists is critical to the success of the REHAB-HF. The intervention should only be administered by interventionists who have been fully trained in the study protocol. All rehabilitation exercises and progressions must be provided in accordance with the study protocol. The intervention team, including site and overall study (Dr. Duncan) intervention leaders, will monitor and review intervention adherence, progression and fidelity. Interventionists are invited to provide feedback

through their site study team and by participating in biweekly teleconferences used to discuss the progress of individual participants, the performance of interventionists and sites, and to troubleshoot any potential barriers to attendance or progression that may arise.

Further details of the study intervention, including mode, frequency, duration, intensity and progression of exercise training, are described below.

2 Exercise Prescription

The initial rehabilitation exercise prescription will be individualized for each participant based upon functional performance level (1-4, from lowest to highest) in each domain using the objective criteria shown below in **Table 1**:

**REHAB-HF Exercise Stratification Grid:
Performance Levels for Rehabilitation Exercise Prescription**

	Level 1 (low function)	Level 2 (low-moderate function)	Level 3 (moderate function)	Level 4 (high function)
Balance	Unable to stand with feet together for 10 seconds	Able to stand with feet together for 10 seconds	Able to stand unsupported and reach forward 10 inches	Able to stand on 1 leg for 10 seconds
Strength: Lower extremity Can sit on edge of chair and lean forward levels 1-2. Sit in back of chair for level 3-4.	Unable to rise from chair without use of hands.	Able to rise from chair without using hands at least once	Able to rise from chair without using hands 5 times in > 15 seconds but < 60 seconds	Able to rise from chair without using hands 5 times in ≤ 15 seconds
Endurance: Continuous Walking (at usual pace; can always use assistive device)	Walk at usual pace for less than 2 minutes	Walk at usual pace ≥ 2 but < 10 minutes	Walk at usual pace for ≥ 10 but < 20 minutes	Walk at usual pace for ≥ 20 minutes
Mobility: Walking Speed over 4 meters	≤ 0.4 m/sec	> 0.4 m/sec but ≤ 0.6 m/sec	> 0.6 m/sec but ≤ 0.8 m/sec	Walk greater than 0.8 m/sec

Performance level will be assessed in the first rehabilitation session in both the inpatient and outpatient setting. The performance level assessment will include having the participant: 1) stand with feet together; stand and reach, stand on 1 leg (perform until balance performance level is achieved); 2) attempt to rise from chair 5 times as quickly as possible; and 3) attempt to walk for > 2 minutes at usual speed (to determine mobility and endurance). Therefore, the initial endurance stratification level is limited to level 1 or 2. Using a standardized approach outlined in the sections below, exercises specifically targeted to the participant's functional level in each domain will be selected and progressed.

3 Allocation of Exercise Domains

The relative emphasis of each of the domains (endurance, strength, balance, mobility) will vary based on the functional performance level of a particular participant at a given time (see Figure 1). In general, a participant with low functional performance (level 1) may spend a greater proportion of time performing balance and mobility exercises in the early portions of the intervention whereas later in the study protocol, as functional performance improves, this may constitute a very small portion of the exercise session. Alternatively, a participant with moderate or high functional performance (level 3 or 4) will spend the large majority of the exercise session performing endurance and strengthening exercises, even early in the study. Also note that although exercises are categorized in one of four domains, more than one domain can be integrated into some exercises, e.g. mobility training while doing walking based endurance training or balance training while doing functional strengthening exercises.

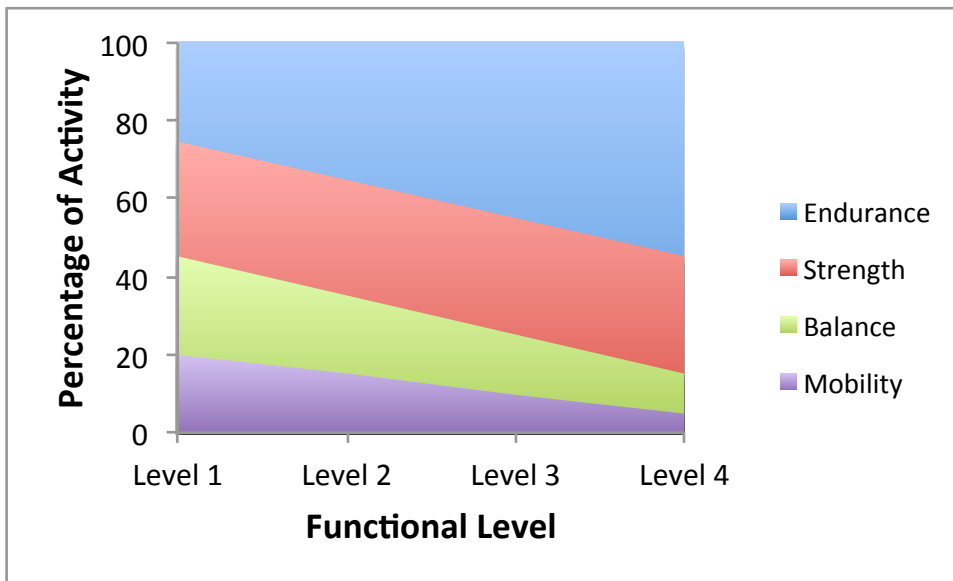


Figure 1. This graph represents an example of how time during exercise and rehabilitation sessions may be distributed at different levels of functional mobility and exercise tolerance, lowest (level 1) to highest (level 4). The exact proportions for any single participant will be adjusted based on individual needs based on performance in each domain on the exercise stratification grid. The general trend of increasing the relative portion of endurance training as functional mobility improves will be followed for all participants.

4 Exercise Progression

Performance level using the stratification grid will be assessed at the first inpatient and outpatient session. Based on the stratification grid as a standardized approach, initial exercises specifically targeted to the participant's functional level in each domain will be selected from the rehabilitation intervention protocols below. It is important to continually challenge participants to safely and effectively advance through the specified progression for each exercise. In addition, performance level in each domain will be reassessed bi-weekly in the outpatient setting to further guide progression and ensure no under-treatment. Exercise prescription within each domain will be adjusted accordingly. Importantly, as function improves, the duration of endurance-based exercise will be increased as tolerated by the participant. In each of the domain descriptions below, general guidelines will be given for progression.

5 Rehabilitation Intervention while Hospitalized for ADHF

Summary

Location: Hospital

Type of Exercise: Strength, endurance, mobility, and balance based on patient functional level in each category.

Intensity: RPE \leq 12

Duration: approximately 45 minutes as tolerated

Frequency: Participants will be seen once per day during hospitalization.

Functional Assessment: At first session

The REHAB-HF rehabilitation intervention will be performed once per day for up to 45 minutes each session while the participant is hospitalized and will include warm-up, cool-down, exercise intervention and rest periods as needed.

The hospital based program will be low intensity based on the participant's RPE, with a target RPE of \leq 12. The ability of the participant to safely tolerate the exercise based on heart rate, blood pressure, oxygen saturation, respiration, and symptoms (e.g. chest pain) will also be monitored, as detailed in the safety section below. At the first rehabilitation session, the interventionist will evaluate the participant's functional performance (level 1-4) in each of the domains on the stratification grid (endurance, mobility, strength, and balance). The interventionist will use this performance to guide the initial exercise prescription with priority given to the areas of greatest deficiency. In the hospital setting, functional performance may be low, such that functional strengthening and balance exercises may comprise the majority of the session, with a smaller amount of time targeted to endurance and mobility.

The REHAB-HF intervention sessions will be in addition to rehabilitation and exercise prescribed by the treating physician. In the event of a conflict between usual care and the REHAB-HF intervention sessions, the REHAB-HF intervention will yield to usual care.

6 Outpatient Rehabilitation and Exercise Training

Summary

Location: Outpatient facility (preferred) or home-based

Type of Exercise: Increasing emphasis on endurance with continued strength, balance, and mobility training

Intensity: Endurance training target RPE 13 with range of 11-15; strength training RPE 15-16.

Duration: approximately 60 minutes

Frequency: 3 times per week

Functional Assessment: First session and bi-weekly thereafter

Similar to the inpatient setting, the initial exercise prescription will be guided by participant functional level (1-4) for endurance, mobility, strength, and balance on the stratification grid. The target RPE will be 13 (Somewhat Hard) with a range 11-15 for endurance training. Participants will be discouraged from exercising at RPE levels outside of the target range. In addition, intensity within the RPE range can be adjusted to achieve a heart rate response of at least 20 beats per minute (bpm) above the resting heart rate, as exercise that does not achieve this heart rate response is likely to be below 60% of VO₂ reserve. Further, observed exertion levels (perspiration, respiratory rate) should be assessed by the interventionist to refine RPE expectations. For strength training, target RPE will progress to 15-16 as this level of intensity may be necessary to obtain significant functional improvement in strength. Participants will exercise 3 times per week for approximately 1 hour of training.

The outpatient intervention is facility-based. However, if after enrollment it becomes apparent that a participant is unable to immediately begin the intervention in an outpatient facility, particularly in the first 2 weeks following hospital discharge, the REHAB-HF study intervention may be delivered in the participant's home by appropriately trained personnel for up to 6 sessions up to 2 weeks post hospital discharge. The focus of the home-based intervention is to improve functional performance to facilitate transition to facility-based rehabilitation and exercise training. Exercise prescription is the same as described above except that target intensity is low (RPE \leq 12). Safety monitoring as described below should also be followed.

7 Rehospitalization or Intercurrent Illness

Participants rehospitalized or with major intercurrent illness during the intervention will resume center-based rehabilitation when medically stable. Participants will have up to 4 additional weeks beyond the initially planned 12 weeks to complete the multi-domain intervention. In addition, if a participant is acutely ill or hospitalized within 2 weeks of the anticipated date of the final 3-month visit, the visit will be delayed for up to 2 weeks to allow for recovery and up to 6 additional rehabilitation and exercise sessions.

8 Rehabilitation as Part of Usual Care

All participants will have access to customary and usual care. The REHAB-HF intervention will be done in addition to any outpatient or home physical therapy that is ordered for a participant as part of usual home health care. In the event of a conflict, the REHAB-HF intervention will yield. Participants will be asked to keep a log of all usual care therapies (including physical therapy and occupational therapy).

9 Initiation of the Intervention

Though not required for enrollment, participants randomized to the rehabilitation intervention will begin the intervention in the hospital as soon as possible after randomization, typically that same day or the immediate following day. Plans for the initiation / continuation of the intervention in the outpatient setting will be made prior to hospital discharge. Study goals are to complete at least 1 inpatient session prior to hospital discharge, at least 1 outpatient session within the first week following discharge, and to begin 3 sessions per week by the second week.

10 Scheduling and Counting Visits

The in-hospital and outpatient intervention sessions will be counted separately. For example, the first in-hospital session will be counted as session #1 and the first outpatient session will be counted as session #1.

There is no limit to the number of in-hospital sessions. The goal while the participant is hospitalized is, as stated above, to complete 1 session per day until hospital discharge. An intervention session is not required, but is allowed, on the same day as enrollment, testing, and randomization. For each subsequent calendar day that a participant is in the hospital (defined as in the hospital at midnight) while randomized to the rehabilitation intervention, a therapy log should be completed either detailing the rehabilitation session or documenting why no session occurred (due to medical reason, refusal, discharge before session could occur, etc...). The intended outpatient intervention is 36 total intervention sessions. Once initialized, the goal is to complete 3 sessions per calendar week (Sunday-Saturday). No more than 3 sessions should be completed in a calendar week. At the beginning of the outpatient intervention, a schedule of 36 intervention sessions should be assembled for the participant. This planned schedule should incorporate known Holidays, planned vacation (or other planned days away) of the participant, or any other known day in which a session could not occur (e.g. facility closed due to inservicing). If the sessions are scheduled on fixed days of the week (e.g. MWF), and a

scheduled Holiday (or any other reason a session could not occur) falls on that day, it is ok to schedule less than 3 possible sessions for that week.

The following are guidelines for counting the outpatient intervention sessions and documenting missed sessions: 1) For each scheduled session, it should be documented whether the session occurred or not, either through completing the exercise log or filling out a missed visit form; 2) If a participant successfully completes a session or arrives at a scheduled session but could not start (or complete) the session due to a medical reason, that session counts as having occurred and an exercise log should be completed; 3) If a scheduled session is missed for any reason, a missed visit form should be completed; and 4) Sessions are counted separately for completed (occurred) and missed visits (for example: completed session 1, completed session 2; missed session 1, missed session 2...). Missed sessions can be made up during the same calendar week in which it occurred or can be added to the end of the initially planned schedule (up to 4 weeks as described above).

11 Exercise Safety

During each exercise session, participants will sign an attendance sheet and log any health-related problems or symptoms they are experiencing. These sheets will be reviewed by intervention staff before initiating physical activity. Should a participant report a significant change in health status (see safety parameters below) before or during exercise, a study physician onsite or the participant's primary doctor should be consulted prior to exercise participation. Vital signs, including heart rate, blood pressure and pulse oximetry will be recorded at the beginning and conclusion of each session. Routine assessment of heart rate during the exercise session will also be used to enhance exercise safety. Exercising blood pressure and pulse oximetry will be monitored on a symptom-driven basis as needed during the trial to ensure participant safety.

For participants who meet any of the safety parameters listed below, the following steps and additional monitoring procedures will be conducted:

- Exercise training sessions will be stopped
- The participant will subsequently be re-evaluated for medical contraindications to exercise
- Exercise intensity levels will be re-assessed and modified as needed

Safety Parameters

- Resting blood pressure systolic > 200 mm Hg or diastolic > 100 mm Hg
- Resting blood pressure systolic < 80 mm Hg
- Resting blood pressure systolic between 80 and 89 mm Hg with associated or uncertain symptoms of lightheadedness or dizziness
- Resting heart rate >120 beats/min or < 40 beats/min
- Increase in heart rate \geq 90% of age predicted maximum during exercise
- Oxygen saturation < 90% on room air or supplemental oxygen
- Unusual or severe shortness of breath
- Chest pain including chest discomfort or pressure, left arm pain, report of indigestion or stomach discomfort
- Palpitations
- Severe light headedness, dizziness or feeling about to faint
- A physical activity session had to be discontinued because of other symptoms excluding musculoskeletal symptoms (e.g. knees, ankles, hips) reported by the participant

- Decrease in diastolic blood pressure ≥ 20 mmHg during exercise
- Increase in systolic blood pressure to ≥ 250 mmHg or in diastolic blood pressure to ≥ 115 mmHg during exercise
- Decrease in oxygen saturation to $< 88\%$ on room air or supplemental oxygen during exercise

An automated external defibrillator (AED) will be available at the facility. On-site staff, including a study interventionist, trained in basic life support, will be available to deal with medical emergencies. Also, institutional and community emergency medical services will be activated if needed.

12 Therapy Log

The study interventionists will record activities completed in the intervention log during or after each session. The therapy log will include a list of exercises accomplished, stage of functional performance for strength, balance, mobility and endurance. Key information should be entered into the REDCap database at least weekly so that the intervention subcommittee can review progress.

13 Home Visit and Home Exercise Prescription

All participants randomized to the study intervention will receive a home evaluation within 1 week following hospital discharge (preferred within 3 days). The home visit will be utilized to:

- Establish patient identified goals
- Prescribe a customized the home exercise program based on patient goals and identified deficits
- Identify areas for safe performance of walking and functional strengthening exercises
- Engage the participant's caregiver/partner to support home exercise
- Identify resources in the home and community (i.e. technology, exercise facilities) to promote adherence to home exercise and goal achievement
- Review use of physical activity monitor to track progress towards goals and promote adherence

A study interventionist will instruct participants in a home exercise program to be done (2 days per week) on days they do not undergo a supervised training session. This unsupervised home training will consist of low-intensity walking at their usual pace, gradually increasing toward a goal of 30 minutes daily. The functional strengthening exercises (sit-to-stand from chair, step-ups, if feasible, and calf raises) will be incorporated as well. Participants will be encouraged to wear a physical activity monitor to both motivate and track adherence to the home exercise.

14 Maintenance Phase

Following the completion of the outpatient intervention, participants in the intervention arm will be encouraged to continue with exercise training as part of a maintenance phase. Preparations for the maintenance phase will begin after randomization and continue throughout the supervised exercise portion of the intervention. These preparations may include

- Evaluation of home environment for safe and feasible participation in home exercises as described below
- Ongoing encouragement to participate in the home walking exercise as described above
- Identifying and addressing potential barriers to participation in exercise training after the supervised portion of the protocol is complete

- Discussing the importance of continued regular exercise after the supervised intervention is complete
- Identifying community resources available to the participant for ongoing physical activity and exercise training
- Engagement of spouse or caregiver, when applicable, for ongoing support of continued exercise training

Towards the conclusion of the outpatient intervention, an individualized exercise prescription will be developed by the interventionist and approved by a study physician. This exercise prescription will be given to the participant at the 3-month visit.

15 REHAB-HF Rehabilitation Exercises

A. Warm-up

The warm up is to be performed at the beginning of every session.

1. Baseline vital signs

Measure resting heart rate (HR), blood pressure (BP), and O₂ saturation before the commencement of each exercise session and review the symptom log. Refer to the safety section for full details concerning guidelines for beginning exercise, continuing exercise, and terminating exercise based on vital signs and participant response.

2. Warm-up exercises:

a. Walking: Participants with level 2 or higher endurance, strength and balance.

- i. 2-3 minutes of light walking at usual pace.

b. Stretching Exercises:

General stretching exercises for

- i. Upper extremity (UE)
- ii. Lower Extremity (LE)
- iii. Trunk.
- iv. If specific joints have soft tissue limitations, perform assisted stretching

B. Strength Training

1. Introduction

Strength training will include functional strengthening exercises focusing on the lower extremities and resistance exercises for major muscle groups of the upper and lower extremities. It is important to note that participants are not expected to perform all of the exercises listed below at each visit. Rather, the exercises best suited to the exercise environment (hospital, home, or outpatient clinic) and that address the participant's needs should be selected.

Functional strength training generally involves closed-chain exercises that use the participant's body weight for resistance. The participant performs repetitions of movements commonly performed during daily activities (sit-to-stand, step-ups, etc...). **Priority is to progress each participant through the range of functional strength training activities.** High functioning participants may still perform the functional strength exercises, but should also be challenged with general open chain resistance training. For each exercise, the participant should begin within the progression that he/she is able to perform without substitutions.

Open chain resistance training can be used to supplement to functional strength training activities because of limited ability to progress through functional strength exercises (e.g. due to specific strength deficiencies, general deconditioning or orthopedic issues) or in those

participants who have progressed to the highest level of a functional strengthening progression. The open chain resistance training can be accomplished through manual resistance (low function), resistance bands, free weights, pulley systems, or other exercise equipment. Unless otherwise specified, resistance will be adjusted such that participants can perform 1 set of 10 repetitions for each exercise in the hospital and 1 to 2 sets of 10 repetitions in the outpatient setting. Once the participant can perform these repetitions without exceeding the target RPE in 2 consecutive sessions, the resistance must be increased. Thus, regardless of the mechanism used to apply resistance, it is crucial that the participant be continually challenged and the amount of resistance gradually **progressed**. Clear documentation of the type and amount of resistance for each session will be important to track a participants strength gains. Again, priority should be given to functional strength training and open chain resistance training used as a supplement.

3. Functional Strengthening

a) Hospital only - Sit to Stand from Bed

Bed height should be approximately 16 to 17 inches.

Level 1: the participant leans forward, places arms across chest, and with assistance as needed and guarding by interventionist, stands up. The participant should progress to 5 repetitions.

b) Sit to Stand from Chair

Chair height should be 16 to 17 inches.

The participant should stand up from a seated position and return to a seated position with weight evenly distributed on both lower extremities. At each session, the progression should begin at the level and progression completed at the previous session. The participant will complete 1 set of 5 repetitions before attempting to complete a 2nd set of 5 repetitions at the next, higher progression and / or level.

Progression:

Level 1: Move to edge of chair, lean forward, push up with arms, stand up.

Level 2:

a: Sit back in chair, push with arms, stand up.

b: Move to edge of chair, lean forward, put arms out in front, stand up.

c: Move to edge of chair, lean forward, fold arms across chest, stand up.

Level 3:

a. Sit back in chair, put arms out, stand up.

b: Sit back in chair, fold arms across chest, stand up.

Level 4

a: Perform 5 repetitions as above as quickly as possible while remaining safe.

b: Place a 6 inch platform in front of chair and repeat progression of exercises. May lower the seat surface up to 6 inches to increase difficulty as an alternative to the 6 inch platform.

c) Step Ups

The participant will step up on a raised surface and lower body weight back down slowly and in a controlled fashion. There are 3 levels of progression that increase difficulty by decreasing support. Initial step height is based on participant level. At each session, the progression should begin at the level and progression completed at the previous session. The participant will complete 1 set of 10 repetitions before attempting to complete a 2nd set of 10 repetitions at the next, higher progression and / or level. Participants are progressed to the next step height once 1 set of 10 repetitions without holding on is completed with both legs. If orthopedic issues

limit progression to higher step, then resistance can be added at a lower step height.

Level 1: Use 4 inch step

Level 2: Use 6 inch step

Level 3: Use 8 inch step

Level 4: Add resistance (e.g. hand held weights) or increase step to 10 inches.

Progression

a: Hold on with both hands, raise right foot up on step, follow with left. Lower left foot down first, and follow with right. Repeat with feet reversed.

b: Hold on with one hand, raise right foot up on step, follow with left. Lower left foot down first, and follow with right. Repeat with feet reversed.

c: Without holding on, raise right foot up on step, follow with left. Lower left foot down first, and follow with right. Repeat with feet reversed.

d) Side Step-ups

The participant will step up sideways on a raised surface and lower body weight back down slowly and in a controlled fashion. There are 3 levels of progression that increase difficulty by decreasing support. Initial step height is based on participant level. At each session, the progression should begin at the level and progression completed at the previous session. The participant will complete 1 set of 10 repetitions before attempting to complete a 2nd set of 10 repetitions at the next, higher progression and / or level. Participants are progressed to the next step height once 1 set of 10 repetitions without holding on is completed with both legs. If orthopedic issues limit progression to higher step, then resistance can be added at a lower step height.

Level 1: Use 4 inch step

Level 2: Use 6 inch step

Level 3: Use 8 inch step

Level 4: Add resistance (e.g. hand held weights) or increase step to 10 inches

Progression

a: Hold on with both hands, raise right foot up on step, follow with left. Lower left foot down first, and follow with right. Repeat with feet reversed.

b: Hold on with one hand, raise right foot up on step, follow with left. Lower left foot down first, and follow with right. Repeat with feet reversed.

c: Without holding on, raise right foot up on step, follow with left. Lower left foot down first, and follow with right. Repeat with feet reversed.

e) Ankle Plantarflexors: Calf Raises

The participant will stand up tall, look straight ahead, and (depending on level) hold on to support. With feet shoulder-width apart (unless otherwise specified), the participant will come up onto toes, hold for a brief moment (2-3 seconds), then lower heels to ground and repeat to complete 1 set of 10 repetitions.

At each session, the progression should begin at the level and progression completed at the previous session. The participant will complete 1 set of 10 repetitions before attempting to complete a 2nd set of 10 repetitions at the next, higher progression and / or level.

Progression:

Level 1:

- a) Sitting, plantarflexion, active
- b) Standing: Hold on with both UE's, raise up on toes of both feet

Level 2: Standing:

- a) Hold on with one UE, rise up on toes of both feet
- b) Without holding on, rise up on toes of both feet

Level 3: Standing:

- a) Without holding on and with feet together, rise up on toes of both feet
- b) Hold on with both UE, rise up on toes of one LE. Repeat with other LE
- c) Hold on with one UE, rise up on toes of one LE. Repeat with other LE

Level 4: Standing: Without holding on, raise up on toes of one LE.

f. Stand to Squat

The participant should stand up tall, look straight ahead, and (depending on progression) hold on to support. With feet shoulder-width apart, the participant will flex knees and hips (squat) to the target level, hold for a brief moment (2-3 seconds), and return to starting position, completing 1 set of 10 repetitions.

At each session, the progression should begin at the level and progression completed at the previous session. The participant will complete 1 set of 10 repetitions before attempting to complete a 2nd set of 10 repetitions at the next, higher progression and / or level.

The target flexion level ranges below are guidelines for classification. In practice, the participant should be continually challenged within the range to increase flexion while following the progression below.

Level 1: Flex knees and hips minimally (0-15 degrees)

Level 2: Flex knees and hips 15-30 degrees

Level 3: Flex knees and hips 30-45 degrees

Level 4: Flex knees and hips to 45-90 degrees

Progression

- a: Hold on to a chair with both hands
- b: Hold on to a chair with one hand
- c: Without holding on

2. Resistive Strengthening

For the lowest functional performance (level 1), movements in PNF patterns will be assisted or resisted by the study therapist to match the participant's ability. These participants will be progressed to level 2 strengthening exercises once able to do components of PNF patterns with resistance.

In locations where gym equipment is not readily available (i.e. hospital room and home), resistance strengthening exercises can be provided by Theraband® with the following progression:

- a) Yellow Theraband®
- b) Red Theraband®
- c) Green Theraband®
- d) Blue Theraband®
- e) Black Theraband®
- f) Silver Theraband®

If the participant cannot grasp the TheraBand® secondary to hand weakness, the therapist can assist the participant in doing so.

In outpatient rehabilitation facilities, resistance may be applied using standard equipment such as free weights or pulley-based systems for these exercises. Resistance is to be adjusted such that participants can perform 1 set of 10 repetitions for each exercise in the hospital and 1 to 2 sets of 10 repetitions in the outpatient setting. Once the participant can perform these repetitions without exceeding the target RPE in 2 consecutive sessions, the resistance is to be increased. It is important for the therapist to clearly document the type and amount of resistance used and continue to progress gradually throughout the intervention.

a. Proprioceptive Neuromuscular Facilitation (PNF)

Level 1: Unilateral D1, D2 flexion and extension patterns used for UE and / or LE

Progression: Active assist to gentle resistance working until the participant can complete 1 set of 10.

b. Lower Extremity

These exercises will most often be performed in an outpatient rehabilitation facility with free weights or other standard equipment. In areas where these items are not easily accessible (e.g. hospital or home) resistance bands may be used. For hip extension, hip abduction, knee flexion and knee extension, TheraBand® can be stabilized in a closed door. For hip flexion, TheraBand® can be stabilized underneath the leg of bed or couch or can be stabilized by the therapist. For the outpatient phase, exercises will generally be performed in the sitting or standing positions. In addition to these positions, supine positioning may also be used in the hospital or in the event the participant cannot perform the exercise in standing or sitting.

1) Hip abductors

Stand up tall holding on to bench; keep the exercising leg straight and the foot straight forward. Lift leg out to the side and return. Repeat with both legs.

Progression: sitting, pushing out

a) Level 1: Standing against gravity, no resistance

Options for hospital, or if unable to stand:

Supine, gravity eliminated

Side lying against gravity, no resistance

b) Level 2 – 4: Standing against gravity with resistance

2) Hip flexors

Progression:

a) Level 1

Sitting: Knee to chest

Standing: hip flexion to 90 degrees

Options for hospital, or if unable to stand:

Supine: knee to chest, active

Supine: straight leg raise, no TheraBand

b) Level 2-4:

Standing: straight leg raise with resistance

3) Hip extensors

Progression:

Level 1:

a) Supine: bilateral bridge

- b) Supine, unilateral bridge, active
 - c) Standing, no Theraband
- Level 2-4: Standing, with resistance
- i) Home: Theraband
 - ii) Center: Ankle weights or pulleys

4) Knee Flexors

Progression

Level 1:

- a) Supine, heel slide, active
 - b) Sitting, no resistance
- Level 2-4: Sitting, with resistance

- i) Home: Theraband
- ii) Center: Ankle weights or pulleys

5) Knee Extensors

Progression:

Level 1

- a) Supine, knee over bolster, active
- b) Sitting, no resistance
- c) Level 2-4: Sitting, with resistance

- i) Home: Theraband
- ii) Center: Ankle weights or pulleys

c. Upper Extremity

These exercises will most often be performed in an outpatient rehabilitation facility with free weights or other standard equipment. In areas where these items are not easily accessible (e.g. hospital or home) resistance bands may be used. For shoulder flexion, elbow flexion and wrist extension, the Theraband® is stabilized by the participant's foot; for elbow extension, the Theraband® is stabilized by a closed door.

- i. Shoulder press
- ii. Shoulder abductors
- iii. Elbow flexors
- iv. Elbow extensors

C. Endurance Training

As functional mobility and aerobic capacity improve, the goal is to gradually progress all participants to 30-35 minutes of endurance aerobic activity at the prescribed intensity level at each session. This progression will be based upon each participant's stratification level and exercise performance.

The goal durations of endurance training will be as follows (start at lower end of range and progress to higher end):

- level one participants- 5-9 minutes
- level two participants- 10-19 minutes
- level three participants- 20-29 minutes
- level four participants- 30-35 minutes

Participants will be instructed to walk for as long as they can at the desired intensity until they experience signs or symptoms or exceed the target RPE, which require them to rest. If rest is required, intervals will be repeated until the goal duration is met. The length of each interval

should gradually increase until the goal duration is met with continuous activity. While maintaining RPE, it is important for the participant to be challenged to progress in duration of endurance training, both in total duration and within intervals. The participant should be encouraged to exceed the goal duration if able and then progressed to the next level at the subsequent session. For example, if a level 2 participant can walk for 25 minutes, this should be encouraged, and he/she will be classified a level 3 endurance stratification at the next session.

The primary mode of exercise will be walking, either on a treadmill or indoor track. However, other modes of aerobic activity (e.g. exercise bike, NuStep) may be used to supplement walking in participants who are unable to attain the goal duration by walking alone (because of gait, pain, or fatigue).

During the initial hospitalization, the duration and intensity of the endurance training will be low. Participants will walk at their own pace while maintaining a Borg RPE ≤ 12 until 1) they meet the goal duration, or 2) they experience signs or symptoms (see exercise safety section) or exceed the target RPE, which requires them to rest. If rest is required, the walking will be continued in intervals until the goal duration is met. The goal duration of walking will be a total of 5 to 10 minutes per session while in the hospital.

During the outpatient rehabilitation phase, the duration and intensity of the endurance training program will be gradually increased. The intensity will initially begin at a Borg RPE of 11-12 for the first two weeks, progressing to a target Borg RPE of 13 (range 12-14) for the remainder of the intervention. The goal duration of the endurance training will be guided by the participant's stratification level, based primarily on exercise performance during the sessions.

If the exercise is performed in the home, the endurance goals should still be attempted through walking in the home or outside as appropriate.

The intensity of the endurance training should be maintained at the target RPE. This may require walking speed and / or treadmill incline to increase as functional performance increases. In addition, heart rate and / or observed exertion levels (perspiration, respiratory rate) should be assessed by the interventionist to refine RPE expectations. Once the goal duration for level four participants is met, the duration will not be increased, but the walking speed / treadmill incline will continue to increase within the target RPE.

D. Mobility Training

The following activities are designed for those participants with limiting walking mobility, particularly in those participants with slower gait speeds (< 0.8 meter/sec or levels 1-3) or with mobility limitations otherwise identified during participant evaluation. These activities will challenge the participant's endurance, dynamic balance, and in some instances muscle strength with the goal of safely improving walking mobility.

Because these activities require participants to change their speed and direction of walking, this type of walking training cannot be performed on a treadmill. Also, close (1 on 1) supervision and guarding of the participant (potentially including the use of a gait belt) will be required to ensure participant safety.

These integrative mobility activities that involve stopping and changing direction can be incorporated into a walking session before or after more focused (e.g. treadmill based) endurance training, particularly for moderate to high functioning participants (level 3 or 4). The

brief accelerations in the participants walking speed could also be included in a separate walking session, particularly in participants whose endurance is more limited (e.g. endurance level 1-2). Although gait speed is specifically targeted on the stratification grid, these activities can be incorporated for any participant with observed difficulty with ambulation related to balance or strength limitations.

1. Increasing walking speed

If the participant walks less than 0.8 m/sec, attempt to increase pace as comfortable with supervision for a short distance (initially as little as 3 meters). Vary pace of walking from self-selected to as fast as individual can safely walk over a 3 to 10 meter distance or greater. Greater distances and variability in pace of walking can be practiced. Aim to maintain safety, independence, and balance.

2. Dynamic start and stop

With close guarding, the participant is asked to walk as quickly as they can and abruptly stop on command. After coming to a complete stop and demonstrating stable balance, the participant is instructed to begin walking again. This can be repeated at unpredictable intervals until the participant demonstrates mastery of the task.

3. Dynamic Turning

Practice turning around at self-selected speed: 90 degrees, 180 degrees, turning right and left. Walk in a figure 8 pattern, begin in middle and make a left turn, then right turn (and vice versa). Suggested width of the figure 8 is approximately 10 feet wide x 15 feet long.

While walking and turning, respond to simple questions such as: "Where are you headed after training today? What time will I see you next training day?"

E. Balance

1. Standing Balance

At each session, the progression should begin at the highest level achieved at the previous visit. The participant will complete that level one time and then attempt to complete the next level and progression.

Progression:

Level 1: Shoulder-width stance for 30 seconds, weight evenly distributed with eyes open progressing to eyes closed.

Level 2:

a) Feet together for 30 seconds, weight evenly distributed with eyes open progressing to eyes closed.

b) Feet in semi-tandem or staggered stance, eyes open progressing to eyes closed.

Level 3:

a) Heel to toe (tandem) stance for 30 seconds, one leg in front, weight evenly distributed with eyes open progressing to eyes closed.

b) Stand and hold on to support (table or bench), look straight ahead and stand on one leg. Try to hold for 10 seconds, progressing to 30 seconds. Repeat position with other leg.

Level 4: Stand on one leg with no support, look straight ahead and try to hold for 10 seconds, progressing to 30 seconds. Repeat position with other leg.

Maintenance: Stand on one leg with no support for 30 seconds with each leg.

2. Stand and Reach Balance

At each session, the progression should begin at the highest level achieved at the previous visit. The participant will complete that level one time and then attempt to complete the next level and progression.

Progression: For all, hold for at least 10 seconds, progressing for up to 30 seconds.

Level 1: (Attempt 1b; start at 1a if reaching 6 inches is not attainable)

a) Stand and reach forward as far as possible, reach backwards as far as possible (assuming less than 6 inches)

b) Stand and reach forward 6 inches, reach backwards 6 inches

Level 2: Stand and reach forward 10 inches, reach backwards 10 inches.

Level 3: Stand with feet together and reach forward 6 inches (progressing to 10 inches).

Level 4: Stand with staggered or semi-tandem stance and reach forward 6 inches (progressing to 10 inches).

F. Cool Down

1. Stretching Exercises

General stretching exercises for

a. Upper extremity (UE)

b. Lower Extremity (LE)

c. Trunk.

d. If specific joints have soft tissue limitations, perform assisted stretching

Vital signs (HR, BP, and O2 saturation) should be recorded on the standardized documentation sheet.