Clinicians can use this job aid as a tool to guide them through mobilization and exercise prescription with patients who have cardiopulmonary conditions.

**Mobilization and Exercise Prescription**

Therapy interventions for the cardiopulmonary patient should be based on two main components: **mobilization** and **exercise prescription**. Let’s look at each of these components in detail.

- **Mobilization** – low-intensity exercise in the management of cardiovascular and pulmonary dysfunction, usually with patients who are acutely ill. The goal of mobilization is to use the early effects of exercise to maximize oxygen transport. The best position to perform mobilization is the upright position so that gravity effects can optimize hemodynamics (blood movement) peripherally and centrally.

- **Exercise prescription** – exercise prescribed in the subacute or chronic stages of cardiovascular or pulmonary dysfunction. The primary goal is to maximize the long-term effects of exercise, and therefore optimize the function of all steps of the oxygen transport pathway.

*Oxygen consumption refers to the amount of oxygen a person needs to meet the ever-changing metabolic demands of the body. Oxygen demand is least at rest, and increases to moderate levels during submaximal activity, and then peaks once a person performs maximal levels of activity that they can volitionally tolerate. Metabolic cost increases during times of injury or illness due to fever, healing and repairing, fighting infection, exercises, social contact, pain, anxiety and noise. Therapy interventions that address pain relief, and also focus on calming and relaxing the anxious or agitated patient is important to decrease the added metabolic demands these place on the body.*

Specific to physical therapy interventions, body positioning, exercise, mobilization, coughing, breathing control activities, range of motion, postural drainage all lead to increased oxygen demand and overall metabolic demand. Because of the above, it is imperative that a patient’s capacity of their oxygen transport system to meet the metabolic demands of the body be determined at initial assessment. And then decide if there is sufficient reserve capacity to meet the additional demands placed on the body from the interventions that will be performed.

Two stressors must be placed on the body to positively effect the oxygen transport system: **gravity** and **exercise stressors**. These two stressors are what is absent and what contributes to the deconditioning effects of bed rest, (recumbent position and inactive) The supine/recumbent position as a result of bed rest or inactivity alters the configuration of the chest wall, the anterior-posterior position of the diaphragm, the intrathoracic pressure and the mechanics of cardiac function.

**Physiologic Consequences of Bedrest**

- Fluid volume redistribution (plasma, blood and heart volumes decrease; venous stasis)
- Muscular inactivity leads to decreases in strength, mass and endurance
- Aerobic deconditioning: increases in HR at rest and at all levels of activity; decreased cardiac output, increased risk for thrombosis and decreased orthostatic tolerance.
- Others: anxiety, depression, constipation

*Cardiopulmonary and musculoskeletal changes can occur with 24-48 hours of bedrest.*
Primary Effects of Mobilization and Exercise

- Enhanced mucociliary transport, strength of cough and airway clearance
- Increased ventilation, perfusion and diffusion
- Increased tidal volume and minute ventilation
- Increased venous return, HR, stroke volume, myocardial contractility, cardiac output and coronary perfusion
- Decreased peripheral vascular resistance, increased peripheral blood flow, and tissue oxygen extraction
- Other: decreased constipation, increased arousal

Mobilization and Exercise Testing

- **Mobilization testing:** important to assess the patient’s response to a mobilization stimulus. This can be accomplished by monitoring a patient before, during and after mobilization. Examples of mobilization testing activities:
  - Bed exercises
  - Moving in bed
  - Changing body position
  - Sitting up/ side of bed sitting
  - Transferring to a chair
  - Chair exercises
  - Short walk with assistance

  Monitoring: BP, HR, RR, O2 sats, subjective responses related to dyspnea (Borg scale), pain, exertion (RPE), and fatigue.

- **Exercise testing:** important to assess to quantify maximal functional and aerobic capacities and endurance during low levels of activities of daily living. The functional capacity of the patient will help determine the test to use.

  Common exercise tests of submaximal functional capacity:
  
  - **12 minute walk test (12 MWT)** – original test developed in the 1960’s by Blake to test functional capacity; it was later determined that this test was appropriate to use with patient’s with cardiopulmonary dysfunction but not well tolerated.
  
  - **6 minute walk test (6 MWT)** – developed in the 1980’s as an attempt to accommodate patient’s with respiratory dysfunction for which walking 12 minutes was too exhausting; research has concluded that the 6 MWT was easier to administer, better tolerated and more reflective of activities of daily living than other tests. (Solway S, Brooks D, Lacasse Y, Thomas S. A qualitative systematic overview of the measurement properties of functional walk tests used in the cardiorespiratory domain. *Chest* 2001;119:256–270.)

  This test requires a 100 foot hallway; the test measures the distance the patient can walk in 6 minutes; it assess the submaximal functional capacity because this tests allows the patient to stop and rest as needed, unlike a maximal exercise capacity test.
3 minute walk test (3 MWT) – variant of above, less research demonstrated with the 3 minute test

Shuttle test – similar to the 6MWT except this test uses an audio signal from a tape cassette to direct the walking pace of the patient back and forth on a 10-m course; the walking speed is increased every minute, and the test ends when the patient cannot reach the turnaround point within the required time. The exercise performed is similar to a symptom-limited, maximal, incremental treadmill test. An advantage of the shuttle walking test is that it has a better correlation with peak oxygen uptake than the 6MWT.

Step tests – there are many varieties of step tests in the literature. 3 minutes, 5 minutes, differing number of steps up/down, those using a metronome to a predetermined stepping rate and some that do not. Using this as a baseline predictor or HR response and RPE can be useful in the home. Re-testing to determine progress utilizing the same test as baseline measurement is also commonly used in practice.

Common tests of maximal functional capacity: graded exercise testing (GXT) or exercise tolerance testing (ETT); exercise intensity is gradually increases in order to stress the patient to the point of limitation. Vital signs are monitored throughout; ECG is continuously recorded. ABG’s are measured during exercise to determine arterial oxygenation and the adequacy of the alveolar ventilation (can use SaO2 but this provides less information, but is noninvasive). These tests give us information to:

- Document a patient’s symptoms and physical impairment
- Prescribe safe exercise
- Document changes in oxygenation during exercise
- Identify any changes in pulmonary function during exercise

Treadmill walking – most common mode used; various protocols are utilized, with the most common one being the Bruce treadmill test or modified Bruce treadmill test. (Bruce RA, Kusumi F, Hosmer D. Maximal oxygen intake and homographic assessment of functional aerobic impairment in cardiovascular disease. Am Heart J. 1973;85:546-562.) Typically speed and % grade are increased in increments until the patient is no longer able to continue.

Cycle Ergometer

Monitoring: same as with mobilization activities; stronger emphasis placed on the subjective assessments because people who are physically challenged have more subjective reports related to exercise than healthy people do. In addition, the recovery response is very important. An increased systolic BP 2 minutes post exercise is directly related to risk for stroke. (refer to vital sign monitoring for normal responses to exercise guidelines)

Mobilization and Exercise Training Prescription

Prescription refers to the fact that the program must be patient specific based on that individuals needs and goals. Components include:

- Type of exercise (mode)

There is now an opportunity for a patient to experience a variety of exercise equipment, and the one that they enjoy and the one they will use the most is the best for that patient. Also important is to utilize the mode of exercise that allows the patient to exercise at their determined training heart rate for the advised duration.
Intensity

May be prescribed by either % VO2 max (as determined by a GXT/ETT), % of HRR, by subjective report, a rating of perceived exertion (Borg RPE Scale) or by METs (metabolic equivalents).

- **%VO2 max**: can only be determined by a GXT or ETT; then exercise can be prescribed at an intensity of 60-75% of the maximum VO2 achieved during the GXT/ETT
- **% HRR**: Based on HR, common aerobic exercise prescription is between 60-85% of maximal HR. More deconditioned patients may need to be trained at a lower level of 40-60% maximal HR.

**Determining the heart rate reserve (difference between resting heart rate and maximal heart rate):**

**Karvonen's Formula**

\[ \text{THR range (THRR)} = (\text{Max. HR} - \text{Rest HR}) \times (0.60 \text{ to } 0.85) + \text{Rest HR} \]

- **Predicted maximum heart rate is 220 minus your age.**
- **Heart rate reserve (HRR)** – difference between resting and maximal heart rates
- **Target heart rate range (THRR)** – defines safety guidelines for intensity during an exercise session
- **Target heart rate (THR)** – defines the most appropriate heart rate within a prescribed target heart rate range for a specific pt; determining this requires careful consideration of a pts functional limitation and individual abilities. Usually a minimum of 60% of the HRR and a maximum of 85% (with deconditioned patients, use a range of 50-70%).
- **Max. HR** – maximum heart rate (determined from GXT/ETT or from 220-age formula)
- **Rest HR** – resting heart rate (taken for a full minute prior to getting gout of bed in the morning)

**Example #1**: on a GXT a 75 year old male achieved a max HR of 165 beats/min. His resting HR is 85 beats/min.

His HRR would be 165-85=80 beats/min

60% of 80 beats/min + rest HR = 48 beats/min + 85 = 133

85% of 80 beats/min + rest HR = 64 beats/min +85= 149

So this patients THRR is \(133 – 149 \text{ beats/min}\)

**Example #2**: same patient as above, but no GXT/ETT was performed, so we must use 220-age to determine max HR. 220-75= 145 beats/min

His HRR would be 145-85= 60 beats/min

60% of 60 beats/min + rest HR = 36 beats/min + 85 = 121 beats/min

85% of 60 beats/min + rest HR = 51 beats/min + 85 = 136 beats/min

So this same patient’s THRR in the absence of a maximal exercise test is \(121 – 136 \text{ beats/min}\)
Cardiopulmonary Physical Therapy Interventions Job Aid

- **RPE**: Provides important information of how the patient feels or perceives the intensity of the exercise. The Borg scale ranges from 6-20 and correlates very highly with HR in normals and those with cardiac disease. (ie. A rating of 10 on the RPE scale correlates with a HR of 100 bpm) Borg guidelines typically are to stay between a fairly light (11) – somewhat hard rating (13). A modified Borg scale is also available for those who can relate to a 0-10 scale more easily, however this scale is not as universally used as the 6-20 scale. (refer to RPE scale materials for more information)

- **Rating of perceived dyspnea** (0-10 scale) has also been shown to correlate with VO2. Ratings between 3 (moderate shortness of breath or 50% Vo2 max) and 6 (between severe and very severe shortness of breath or 85% Vo2 max) define the range in which patients with pulmonary disease generally exercise.

- **METs**: The metabolic equivalent, or MET, is a way of measuring physical activity intensity level. Although the intensity of certain activities is commonly characterized as light, moderate, or vigorous, many activities can be classified in any one or all three categories simply on the basis of the level of personal effort involved in carrying out the activity (i.e., how hard one is working to do the activity). For example, one can bicycle at intensities ranging from very light to very vigorous.

The table, *General Physical Activities Defined By Level of Intensity*, provides one method of characterizing physical activities at different levels of effort based on the standard of a metabolic equivalent (MET). This unit is used to estimate the amount of oxygen used by the body during physical activity (Ainsworth et al., 1993).

1 MET = the energy (oxygen) used by the body as you sit quietly, perhaps while talking on the phone or reading a book.

The harder your body works during the activity, the higher the MET.

- Any activity that burns 3 to 6 METs is considered moderate-intensity physical activity.
- Any activity that burns > 6 METs is considered vigorous-intensity physical activity.

**The prescription for exercise intensity should incorporate symptoms of shortness of breath and rating of perceived exertion and not be based solely on THR, fixed work levels or VO2.**

**If there is no exercise tolerance testing data available, cautious exercise prescription is the rule. Best to use the RPE and not HR as a guide to intensity. Use of the talk test (refer to handout on the talk test) is beneficial to make sure a patient is exercising below maximal oxygen capacity.**

- **Duration**

The goal of 30-40 minutes of aerobic exercise with an additional 5-10 minute warm up and adequate cool down is appropriate. Patients who are deconditioned may need to perform interval work, bouts of 5-10 minutes at a time. If either of these are uncomfortable for the patient, any amount they can do without adverse symptoms is appropriate. An adequate warm up is important for patients with CAD. Gradually increasing the myocardial oxygen demand and allowing for dilation of the coronary arteries leads to a better chance for balance oxygen supply and demand. Generally, conditioning exercises are conducted over a course of 6-8 weeks.
Frequency
Exercise is commonly prescribed 3-5 times per week. The patient should not experience increased fatigue as a result of exercise. If fatigue is experienced, the intensity and/or frequency should be decreased.

Progression
Modifications in the exercise intensity and duration should be made to an individual's exercise prescription based on the physiologic adaptations to exercise the individual demonstrates. Once a patient perceives the intensity of the exercise to be easier or when the same exercise intensity results in a lesser degree of shortness of breath or HR, progression is appropriate. Exercise prescription specific to diagnosis or condition is covered in a separate module. Refer to exercise prescription seniors.diagnosis specific.

An exercise session for a patient is similar to one for an athlete, it must contain a warm up period with musculoskeletal stretching included to avoid injuries, then the majority of the exercise session will be spent in steady-state exercise, followed by a cool down and recovery period.

Prior to beginning the session, a patient must be asked and assessed for several items that might preclude them from exercising that particular time.

1. fever, infection, (feeling well over the past 48 hrs)
2. chest tightness or pain
3. no “abnormal” muscle or joint pain; breathlessness
4. no heavy meal 2-3 hours prior to the session
5. taken prescribed medications
6. Has appropriate medications nearby if the need arises (nitroglycerine, inhalers, sugar for diabetics)

Long-term Effects of Exercise and Mobilization
- Increased respiratory muscle strength and endurance
- Decreased submaximal minute ventilation
- Increased myocardial muscle mass and efficiency
- Decreased resting HR, BP, stroke volume
- Decreased submaximal dyspnea, perceived exertion and othostatic intolerance
- Increased circulating blood volume and red blood cells
- Increased muscle strength, endurance and movement economy
- Increased resistance to infection and increased healing
Patient Response to Exercise

Normal Response to Exercise:

Heart rate increases: there is a direct, almost linear relationship between heart rate (HR) and external workload. If any clinical intervention requires an increase in systemic oxygen consumption (i.e. increase in MET level, kcal) then heart rate should also increase. (refer to the physical activity intensity and energy level requirements handout)

* Beta-blocker medications suppress the sympathetic nervous system’s effect on the heart and will limit this HR increase, the HR should however rise nonetheless.

Blood Pressure: a linear increase in systolic blood pressure is expected with increasing workloads. Diastolic blood pressure demonstrates limited changes with exercise. It may show no change, or increase or decrease slightly (10 mm Hg); should be taken before and immediately after exercise. If the BP can be taken during the activity, that is ideal, although it can be quite difficult.

If HR and BP are to be taken immediately after exercise, HR should be taken first.

Respirations: as systemic oxygen requirements increase, the depth and rate of respirations will normally increase from resting tidal volume.

Abnormal Response to Exercise

(American College of Sports Medicine Guidelines for Exercise Testing and Training)

If a patient experiences any of the below listed symptoms, the activity should be stopped and the patient stabilized.

- Persistent dyspnea
- Dizziness or confusion
- Pain
- Severe leg claudication
- Excessive fatigue
- Pallor, cold sweat
- Ataxia
- Pulmonary rales

* Along with the above symptoms, it is very important the clinician pay close attend to any subtle signs of inadequate activity tolerance such as changes in: facial expression, skin color, tone of voice, or thought processing.

It is also important to explain to the patient that some of these responses to exercise may be delayed up to several hours after exercise (listed below).

- Prolonged fatigue
- Insomnia
- Sudden weight gain indicating fluid retention
In addition to the subjective complaints listed above, there are more objective responses that if occur, exercise should be terminated immediately.

- Failure of the systolic blood pressure to rise as exercise continues
- Hypertensive BP response, including a systolic pressure higher than 200 mm Hg and/or a diastolic pressure greater than 110 mm Hg
- Progressive fall in systolic pressure of 10-15 mm Hg
- Significant change in cardiac rhythm detected by palpation

**Appropriateness for Exercise Prescription and Training**

*(American Association of Cardiovascular and Pulmonary Rehabilitation - AACVPR)*

The American Association of Cardiovascular and Pulmonary Rehabilitation has issued guidelines for evaluating a patient's appropriateness for exercise participation. Patients with the following conditions should be excluded from exercise training unless otherwise stated by their physician.

- Unstable angina
- Symptomatic heart failure
- Uncontrolled arrhythmias
- Moderate to severe aortic stenosis
- Uncontrolled diabetes
- Acute systemic illness or fever
- Uncontrolled tachycardia (HR > 100 bpm)
- Resting systolic BP ≥ 200 mm Hg
- Resting diastolic ≥ 110 mm Hg
- Thrombophlebitis