Heart Transplantation and Exercise, in Adults

Indexing Metadata/Description

› Title/condition: Heart Transplantation and Exercise in Adults
› Synonyms: Transplantation, heart and exercise, in adults; exercise and heart transplantation, in adults; heart transplantation and cardiac rehabilitation, in adults; cardiac rehabilitation and heart transplantation, in adults
› Anatomical location/body part affected: Heart/cardiovascular system
› Area(s) of specialty: Acute care, cardiovascular rehabilitation
› Description: Heart transplantation (HTx) is the surgical option for end-stage heart disease/failure. Life expectancy increases in successful cases
• In adults, HTx is most often performed for advanced dilated cardiomyopathy, ischemic heart failure, valvular disease, or a failed primary transplant
• Candidates are commonly classified New York Heart Association (NYHA) class IV: symptoms of cardiac insufficiency at rest, unable to carry out any physical activity without discomfort, and very poor cardiorespiratory fitness as measured by peak oxygen uptake (VO\textsubscript{2peak}) on exercise testing\(^1\)
• Although HTx does reduce symptoms and improve functional capacity, recipients continue to have lower VO\textsubscript{2peak} than healthy people their age\(^2\)
• The continuing relatively poor physical capacity after HTx likely results in large part from muscular disuse and aerobic deconditioning associated with prolonged illness and physical inactivity\(^3\)
• In addition, autonomic denervation of the donor heart diminishes cardiac reserve because sympathetic neural stimulation is lost.\(^2,3,4,5,6,7,8\) The blunted sympathetic drive impairs chronotropic and ionotropic responses to exercise. In addition, underlying muscle weakness after HTx contributes to poor exercise capacity. Recipients typically have low VO\textsubscript{2peak} before physical training compared to age- and gender-matched healthy individuals\(^4,5,6,7,8,9,10\)
• Transplant recipients are thus commonly referred to exercise rehabilitation for improving VO\textsubscript{2peak}, as well as for reducing coronary risk factors, either preexisting or related to immunosuppressive drug therapy, which is known to promote hyperlipidemia, hypertension, diabetes, and obesity\(^9\)
• Supervised exercise training post HTx reliably increases VO\textsubscript{2peak}, lean tissue mass, and muscle strength, even though ventricular function of the grafted heart usually does not improve\(^4,5,6\)
• Home-based exercise under strict supervision after HTx might also improve functional capacity and quality of life in stable recipients\(^11\)
• This review discusses the altered cardiac responses to exercise after HTx and the role of exercise training in restoring physical work capacity

› ICD-9 codes
• V42.1 organ or tissue replaced by transplant, heart
• V58.44 aftercare following organ transplant

› ICD-10 codes
• Z94.1 heart transplant status
• Z48.21 encounter for aftercare following heart transplant
  (ICD codes are provided for the reader’s reference, not for billing purposes)

G-Codes

- Mobility G-code set
  - G8978, Mobility: walking & moving around functional limitation, current status, at therapy episode outset and at reporting intervals
  - G8979, Mobility: walking & moving around functional limitation; projected goal status, at therapy episode outset, at reporting intervals, and at discharge or to end reporting
  - G8980, Mobility: walking & moving around functional limitation, discharge status, at discharge from therapy or to end reporting

- Changing & Maintaining Body Position G-code set
  - G8981, Changing & maintaining body position functional limitation, current status, at therapy episode outset and at reporting intervals
  - G8982, Changing & maintaining body position functional limitation, projected goal status, at therapy episode outset, at reporting intervals, and at discharge or to end reporting
  - G8983, Changing & maintaining body position functional limitation, discharge status, at discharge from therapy or to end reporting

- Carrying, Moving & Handling Objects G-code set
  - G8984, Carrying, moving & handling objects functional limitation, current status, at therapy episode outset and at reporting intervals
  - G8985, Carrying, moving & handling objects functional limitation, projected goal status, at therapy episode outset, at reporting intervals, and at discharge or to end reporting
  - G8986, Carrying, moving & handling objects functional limitation, discharge status, at discharge from therapy or to end reporting

- Self Care G-code set
  - G8987, Self care functional limitation, current status, at therapy episode outset and at reporting intervals
  - G8988, Self care functional limitation, projected goal status, at therapy episode outset, at reporting intervals, and at discharge or to end reporting
  - G8989, Self care functional limitation, discharge status, at discharge from therapy or to end reporting

- Other PT/OT Primary G-code set
  - G8990, Other physical or occupational primary functional limitation, current status, at therapy episode outset and at reporting intervals
  - G8991, Other physical or occupational primary functional limitation, projected goal status, at therapy episode outset, at reporting intervals, and at discharge or to end reporting
  - G8992, Other physical or occupational primary functional limitation, discharge status, at discharge from therapy or to end reporting

- Other PT/OT Subsequent G-code set
  - G8993, Other physical or occupational subsequent functional limitation, current status, at therapy episode outset and at reporting intervals
  - G8994, Other physical or occupational subsequent functional limitation, projected goal status, at therapy episode outset, at reporting intervals, and at discharge or to end reporting
  - G8995, Other physical or occupational subsequent functional limitation, discharge status, at discharge from therapy or to end reporting

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<thead>
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<th>G-code Modifier</th>
<th>Impairment Limitation Restriction</th>
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<td>CH</td>
<td>0 percent impaired, limited or restricted</td>
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<tr>
<td>CI</td>
<td>At least 1 percent but less than 20 percent impaired, limited or restricted</td>
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<td>CJ</td>
<td>At least 20 percent but less than 40 percent impaired, limited or restricted</td>
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Source: https://www.cms.gov/
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<td>At least 60 percent but less than 80 percent impaired, limited or restricted</td>
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<td>CN</td>
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Source: https://www.cms.gov/

Reimbursement
- Reimbursement for therapy will depend on insurance contract coverage; no specific special agencies are applicable for this condition
- Phase III and IV (long-term maintenance phase) of cardia rehabilitation might not be reimbursed by some insurance providers; clinicians/patients should clarify this information with insurance provider prior to beginning services
- For Medicare recipients, please see https://www.medicare.gov/coverage/cardiac-rehab-programs.html

Presentation/signs and symptoms
- Presentation specifically for cardia rehabilitation exercise training
- Reduced daily physical activity
- Poor age-related functional exercise capacity
- Sternotomy scar characteristic of open-heart surgery
- Resting heart rate (HR) and blood pressure (BP) might be somewhat elevated
- Electrocardiogram (ECG) might show two separate P-waves
- Possible adverse signs/symptoms of immunosuppressive therapy
  - Muscle weakness
  - Fatigue
  - Increased hair growth
  - Bruising
  - Hypertension

Causes, Pathophysiology, & Risk Factors

Causes
- Potential causes of reduced functional capacity after HTx:
  - Although cardiac function improves significantly, peak exercise capacity remains below predicted for gender and age. Contributing factors include:
    - Prolonged illness and extended physical inactivity leading to
    - Muscle weakness
    - Cardiovascular deconditioning
    - Orthotopic autonomic denervation
    - Complications of immunosuppressive therapy, such as corticosteroid-induced myopathy, might reduce muscle function and bone density
    - Chronic graft rejection
    - Transplant vasculopathy

Pathophysiology
- Impaired muscle function is associated with atrophy, reduced strength, and insufficient peripheral oxygen utilization during fatigue-limited exercise
- Cardiovascular deconditioning is associated with reduced cardiac output and low aerobic capacity compared to the age/gender norm. In one study, VO2peak averaged only 16.7 mL.kg⁻¹.min⁻¹ before hospital-based exercise training
• Sympathetic denervation of the donor heart blunts the recipient’s chronotropic response (i.e., the increase in HR at the onset of exercise, as well as the HR achieved during submaximal and maximal-effort exercise)
  – This “chronotropic incompetence” is a major factor limiting submaximal or peak HR and exercise performance after HTx\(^2\)
  – Maximal aerobic power was 19 \(\text{O}_2/\text{kg} \times \text{min}\), only about 60% of healthy age-matched sedentary controls. Peak HR was 140 beats/min\(^9\)
  – Achieving 80% or more of the age-predicted maximum HR might indicate a maximum effort for patients after HTx\(^{13}\)
• HR response to exercise is an important determinant of functional aerobic capacity after HTx.\(^{10,14}\) The percentage of predicted peak HR achieved on cardiopulmonary exercise testing is strongly correlated with the percentage of predicted \(\text{VO}_2\text{peak}\) achieved\(^{10}\)
• Compared to normal controls matched for age to the donor, patients recovering from HTx have lower cardiac preload reserve (i.e., end-diastolic volume), HR reserve, and vascular reserve during submaximal exercise\(^{2,8,9,10}\)
• Cardiac reactivity (i.e., the HR response) can increase as functional capacity improves with cardiac rehabilitation\(^6\)
• As in healthy individuals, circulating catecholamines released from the adrenal glands elevate and maintain HR and BP during and after vigorous exercise

**Risk factors**

- Risk factors for poor functional capacity after HTx
  – Poor adherence to therapeutic regimen
  – Smoking
  – Physical inactivity
  – Dietary habits that might promote obesity, diabetes, or hyperlipidemia
  – Abuse of alcohol, drugs, or illegal substances
  – Complications of immunosuppressive therapy (e.g., obesity and corticosteroid-induced myopathy)

**Overall Contraindications/Precautions**

- Immunosuppressive medications help block rejection of the transplanted heart; however, they increase susceptibility to infection and various types of cancer. Clinicians should remain alert for new infections and postpone exercise during active infection
- Metabolic complications of immunosuppressive therapy include arterial hypertension, chronic renal insufficiency, hyperlipidemia, diabetes, and osteoporosis
- Notify physician immediately if a patient presents with recent onset of signs and symptoms of acute illness, including
  - unusual fatigue
  - fever
  - malaise
  - flu-like symptoms (e.g., chills, headache, dizziness, muscle aches)
  - pulmonary crackles/rales
  - nausea
  - diarrhea
- Postpone physical activity/exercise therapy and notify physician in case of\(^3\)
  - resting systolic BP over 200 mmHg
  - resting diastolic BP over 110 mmHg
  - symptoms such as severe headache, dizziness, or lightheadedness during exercise
  - fatigue resolves very slowly after exercise
- After HTx, recipients are also at risk for neurologic complications that include diseases of the peripheral nerves and muscles\(^{15}\)
- Lower-extremity weakness and cramps might restrict exercise capacity before cardiac responses become limiting
- See specific **Contraindications/precautions to examination** and **Contraindications/precautions** under **Assessment/Plan of Care**
Examination

Contraindications/precautions to examination
- Stop the exam and notify physician if patient reports unexpected symptoms such as chest pain, shortness of breath, dizziness, etc.
- Chronotropic incompetence is common after HTx. The actual peak HR achieved during standard exercise testing should be documented rather than estimated from age.
- In the absence of exertion-related symptom limitations, exercise testing on a treadmill or cycle ergometer should be terminated at voluntary fatigue or at other predetermined endpoints specific for the patient.

History
- History of present injury or etiology of illness
  - Document date and stage of heart disease at surgery. How long was patient on waiting list? Any recent changes in weight, physical activity, diet, smoking, or use of caffeine or alcohol?
  - Course of treatment
    - Medical management: Is the patient being treated for complications of HTx (e.g., arterial hypertension, chronic renal insufficiency, hyperlipidemia, neurological disease, diabetes, or osteoporosis)?
    - Medications for current illness/injury: Determine what medications have been prescribed. Confirm that they are being taken. Daily and lifelong immunosuppressive medication is required to prevent organ rejection. Most patients are treated with a triple-drug immunosuppressive regimen: i.e., a combination of calcineurin inhibitor (cyclosporine A or tacrolimus), antimetabolite agent (azathioprine [Imuran] or mycophenolate mofetil), and corticosteroid. Other immunosuppression treatments include radiation and plasmapheresis. Patients might also receive treatment for coexisting morbidities such as hypertension or diabetes
    - Diagnostic tests completed
      - The workup might include:
        - ECG
        - urinalysis
        - blood glucose
        - serum potassium, creatinine, and calcium
        - hematocrit
        - lipid profile – HDL cholesterol, LDL cholesterol, triglycerides
        - optional – urinary albumin/creatinine ratio or urinary albumin excretion
        - cardiopulmonary exercise stress test before and/or after treatment
    - Home remedies/alternative therapies: Document use of herbal, behavioral, or other alternative therapies for health, and whether or not they help
    - Previous therapy: Document whether patient has received post-HTx physical therapy and what specific treatments were helpful or not helpful
  - Aggravating/easing factors (and length of time each item is performed before the symptoms come on or are eased)
  - Body chart: Use body chart to document location and nature of symptoms
  - Nature of symptoms: Document reported symptoms
  - Rating of symptoms: Use a visual analog scale (VAS) or 0-10 scale to assess symptoms at their best, at their worst, and at the moment. The Borg Rating of Perceived Exertion (RPE) Scale can be used
  - Pattern of symptoms: Document changes in symptoms throughout the day and night, if any (A.M., mid-day, P.M., night); also document changes in symptoms due to weather or other external variables
  - Sleep disturbance: If present, document number of wakings/night
  - Other symptoms: Document other symptoms patient might be experiencing that could worsen ability to exercise and/or symptoms that might indicate referral to physician (e.g., dizziness, bowel/bladder/sexual dysfunction, saddle anesthesia)
  - Respiratory status: Note any history of use or need for supplemental oxygen, mechanical ventilator, asthma inhaler, etc.
  - Barriers to learning
    - Are there any barriers to learning? Yes ___ No ___
    - If Yes, describe _________________________
  - Medical history
    - Past medical history
    - Previous history of same/similar diagnosis: Any prior exercise therapy for chronic conditions?
- **Comorbid diagnoses:** Any history of stroke, kidney disease, diabetes, or renovascular disease?
- **Medications previously prescribed:** Obtain a comprehensive list of all prescribed and over-the-counter medications, herbal remedies, and use of illegal street drugs
- **Other symptoms:** Ask patient about other symptoms he or she might be experiencing
- **Social/occupational history**
  - **Patient’s goals:** Document what the patient hopes to accomplish with therapy (patient-oriented outcomes)
  - **Vocation/avocation and associated repetitive behaviors, if any:** Does the patient want to participate in recreational sports? Did the patient work previously? If so, does he or she plan to return to work? What duties does the job entail?
  - **Functional limitations/assistance with ADLs/adaptive equipment:** Inquire about ADL status and functional limitations. Is the patient using any adaptive equipment?
  - **Living environment:** Ask about family situation and with whom patient lives, caregivers, etc. Identify if there are barriers to independence in the home; any modifications necessary; how many stairs, numbers of floors in home

**Relevant tests and measures:** (While tests and measures are listed in alphabetical order, sequencing should be appropriate to patient medical condition, functional status, and setting)
- **Anthropometric characteristics:** Determine body mass index (BMI)
- **Assistive and adaptive devices:** Assess fit and use of prescribed assistive devices, if applicable
- **Balance**
  - Assure that static and dynamic balance reactions are adequate for use of exercise equipment such as treadmill or elliptical trainer
  - Berg Balance Scale (BBS)\(^{(16)}\)
    - An outcome measure designed to measure static balance and fall risk in an adult population during 14 different activities
    - Grading is based on a 0 to 4 scale in which all of the points are tallied together for a final score
- **Cardiorespiratory function and endurance**
  - Assess HR, BP, and respiratory rate during quiet rest and with activity
  - The 6-minute walk test for distance, administered in a hospital setting, was found to be a safe and practical submaximal measure of functional exercise capacity in heart transplantation.\(^{(12)}\) This is a submaximal aerobic/endurance test, in which clinicians measure the distance walked by patients over the span of 6 minutes. The average distance walked by chronic heart failure patients is between 310 and 427 meters, depending upon the severity of the condition\(^{(18)}\)
- **Circulation:** Assure that peripheral pulses are present in all limbs
- **Functional mobility:** Assure normalcy in gross movement during transfers and functional tasks using the upper extremities (e.g., reaching, pulling, pushing, holding, etc.) and lower extremities (e.g., steps, squatting, kneeling, kicking). The FIM or Timed Up and Go (TUG) test can be used for objective measurement
- **Gait/locomotion:** Prior to prescribing a walking exercise program, assure that ambulatory function is normal, including synchrony of limb movements and gait speed, as well as posture in walking
- **Joint integrity and mobility:** Assess passive accessory movement if there is a history of joint pain
- **Muscle strength:** Manually scan strength in functional tasks (e.g., handgrip, pushing, pulling, sit-up, squatting). Assess strength using manual muscle testing (MMT), dynamometry, or weights in muscle groups targeted for exercise training to calculate 1-repetition maximum (1-RM)
- **Observation/inspection/palpation:** Assure that no physical deformities are present that might prevent patient from participating in the prescribed exercise program. Assess for general pain and fatigue during exercise testing. The Borg RPE Scale can be used
- **Range of motion:** Assure that normal functional ROM and flexibility are present in all extremities
- **Reflex testing:** Assure that deep tendon reflexes are normal
- **Sensory testing:** Scan dermatomes for normal sensation
- **Special test specific to diagnosis**
  - In compliance with medical guidelines, assess HR, BP, adverse signs/symptoms, and perceived exertion responses during graded exercise testing on a cycle ergometer or treadmill\(^{(3)}\)
  - Medical Outcomes Study 36-item Short Form (SF-36): a general health outcome measure that can be completed in 10 minutes. The questionnaire involves 35 questions in 8 different domains and 1 general health question, with scores between 0 (worst possible health, most disabled) and 100 (best possible health, no disability)\(^{(19)}\)
Assessment/Plan of Care

Contraindications/precautions
- Only those contraindications/precautions applicable to this diagnosis are mentioned below, including with regard to modalities. Rehabilitation professionals should always use their professional judgment in their assessment and treatment decisions.
- Patients with this diagnosis might be at risk for falls; follow facility protocols for fall prevention and post fall prevention instructions at bedside, if inpatient. Ensure that patient and family/caregivers are aware of the potential for falls and educated about fall prevention strategies. Discharge criteria should include independence with fall prevention strategies.
- Clinicians should follow the guidelines of their clinic/hospital and what is ordered by the patient’s physician. The summary below is meant to serve as a guide, not to replace orders from a physician or a clinic’s specific protocols.
- Tailor the exercise prescription to fit each patient’s measured functional ability, symptoms, and cardiorespiratory responses to exercise testing.
- Monitor BP on a regular basis during exercise. According to standard exercise guidelines, exercise testing or exercise training should be terminated if:
  - systolic BP exceeds 260 mmHg or diastolic BP exceeds 115 mmHg
  - systolic BP fails to rise more than 20 mmHg
  - systolic BP falls more than 10 mmHg
  - exertional symptoms, such as chest discomfort (uncommon because of denervation), arrhythmia, lightheadedness, or dyspnea, suggest insufficiency.
- BP higher than 180/110 mmHg is an absolute contraindication and BP higher than 160/100 mmHg is a relative contraindication to resistance exercise.
- To prevent an exaggerated BP response to exercise, provide the patient with a thorough orientation to using the prescribed exercise equipment and adequate warm-up time.
- Research on the safety and appropriateness of resistance exercise (weight lifting) after HTx is limited, and thus general guidelines for including weight lifting in the training program are not available.
- In addition to monitoring HR and BP, use the patient’s perceived exertion and any other symptoms to manage exercise intensity for either aerobic or resistance training.
- Extend the cooling-down period and avoid having the patient stop suddenly after exercise because this might cause a precipitous drop in systolic BP (orthostatic hypotension and possibly syncope) due to venous pooling.
- Electrotherapy contraindications/precautions:
  - Do not place electrodes near:
    - Carotid bodies, cardiac pacemakers or implantable cardioverter defibrillators, phrenic nerve or urinary bladder stimulators, phrenic nerve, eyes, gonads
    - Osteomyelitis
    - Hemorrhage
    - Impaired sensation, mental status, communication
    - Cardiovascular disease
    - Malignancy
    - Dermatological conditions
    - Proximity of electromagnetic radiation
  - In pregnant women, near the pelvis, lumbar spine, hips, abdomen
  - In patients with stroke or seizures, near the neck
  - History of spontaneous abortion in pregnant women

Diagnosis/need for treatment: Status post HTx/physical inactivity contributes to reduced functional capacity and increases risk for comorbidities. For example, poor adherence to prescribed exercise is associated with obesity, dyslipidemia, and hypertension.

Rule out: N/A

Prognosis: Lack of improvement in exercise capacity (assessed as percentage of predicted VO_2_ peak achieved on exercise testing) after supervised exercise training is a strong predictor of adverse cardiac events, independent of classical prognostic
factors (e.g., left ventricular ejection fraction or NYHA class) in chronic heart failure. This exercise prognostic factor has not been tested in patients with HTx, but it should be considered a red flag.

› Referral to other disciplines
• Physician for management of symptoms related to immunosuppression
• Clinical exercise testing laboratory for measurement of VO\(_2\)peak
• Nutritionist for dietary management and advice on weight control
• Occupational therapist for limitations in ADLs
• Psychiatrist/psychologist for stress/anxiety disorder
• Smoking cessation programs

› Other considerations
• VO\(_2\)peak is widely used to assess aerobic work capacity in patients who have undergone HTx because it reflects the integrated function of the heart, lungs, and blood vessels to deliver oxygen and the working muscles to utilize it.
• Deficits in both central factors and peripheral factors contribute to the observed lower VO\(_2\)peak in heart transplant recipients\(^{2,3,4,5,6,7,8,10,11,13}\)
• VO\(_2\)peak can be measured directly in a cardiopulmonary exercise testing laboratory or estimated from standard testing protocols\(^{3}\)
  – Based on a study in Switzerland, incremental stepwise (30-60 W per 3 min) or continuous ramping (10-20 W/min) workloads on a bicycle ergometer were found equally effective for achieving VO\(_2\)peak, provided the total exercise time to peak exertion was 8 to 12 minutes\(^{24}\)
• Based on a systematic review of 3 studies, there is insufficient evidence to support exercise as an intervention to decrease psychological distress in patients who have undergone a heart transplantation\(^{31}\)
• Patients who have undergone a heart transplantation are at greater risk for increases in body mass index (BMI), body fat percentage, and waist circumference when admission to a cardiac rehabilitation program is delayed\(^{32}\)
  – Based on retrospective Canadian research study of 43 heart transplant patients

› Treatment summary
• General considerations
  – Following HTx, patients might begin to participate in an aerobic exercise program as early as 1 month postoperatively\(^{25}\) pending physician approval
  – Resistance training might be initiated 6 to 8 weeks after HTx\(^{25}\) pending physician approval
  – High-intensity interval training might be safe for patients who have undergone a heart transplantation more than 1 year prior to the initiation of the program\(^{30}\)
  – Based on a randomized controlled crossover trial in Denmark; 16 subjects completed the study and were included in data analysis
• Aerobic exercise training after HTx
  – Type of activity: Rhythmic movement with the legs (e.g., walking, jogging, or cycling), arms (e.g., upper-body cycle ergometer), or both legs and arms (e.g., elliptical trainer with arm levers)
  – Intensity: “Moderate” exertion, equaling 11 to 13 on the Borg RPE Scale\(^{3}\) or HR equal to 60-80% of VO\(_2\)peak
  – Duration: Continuous or discontinuous exercise totaling 30-45 min of physical activity per day. Five hours or more per week for promoting weight loss, as advised
  – Frequency: 3 alternating days per week, to as many as 5 times per week\(^{26}\)
• Resistance exercise training after HTx
  – Although exercise therapy should target muscle weakness, the intensity of strengthening exercise that is generally safe and effective post HTx is unclear
  – The cardiac responses of 23 recipients to single leg-press exercise (28 repetitions over 2 min 20 sec) at “moderate” intensity (50% of 1-RM) were considered within safe and acceptable physiological limits, according to a study in Canada.\(^{27}\) At peak exercise, systolic BP averaged 179 mmHg, pulmonary artery BP did not exceed 30 mmHg, and pulmonary wedge pressure did not exceed 15 mmHg
  – The cardiovascular responses of 18 recipients to a 3-minute set of whole-body isometric exercise at 50% of maximal voluntary contraction were blunted compared to healthy controls. Static exercise was reported to be well-tolerated, according to a study in Israel\(^{28}\)
Resistance training at 40-60% of 1-RM is considered safe and effective in persons with cardiovascular diseases. Type of activity: weight-lifting exercises on machines or using free-weights (e.g., leg press, chest press, leg extension, lat pull-down, leg curls, shoulder press, biceps curl, triceps press). Intensity: 40-60% of 1-RM for each exercise. Duration: 1-3 sets of 10 repetitions per exercise, taking about 30 min to complete the exercise session. Frequency: 2-3 nonconsecutive days per week.

Authors of a U.S. study concluded resistance training for 6 months was effective in reversing skeletal muscle myopathy in HTx recipients. The program involved:

- 8 exercises (chest press, knee extension, latissimus dorsi pull-down, seated leg curl, overhead shoulder press, seated triceps dip, biceps curl, and lumbar extension)
- 1 set of 10-15 repetitions per exercise
- intensity at 50% of 1-RM
- 2 days per week

Combined aerobic and resistance exercise training after HTx

Findings of a Canadian randomized controlled trial involving 43 participants (mean age 57 years, mean 5 years post HTx) who underwent 12 weeks of supervised aerobic and strength training:

- Aerobic program
  - For the first 8 weeks, treadmill and cycle exercise 5 days/week at HR equal to 60-80% of VO\textsubscript{2peak}, for 30-45 min
  - For the final 4 weeks, continuous aerobic training was performed 3 days/week at HR equal to 80% of VO\textsubscript{2peak}, for 45 min
  - In addition, during the final 4 weeks interval cycle training was performed 2 days/week at 90-100% of peak power for 30 sec followed by 30 sec rest, for 10 to 25 repetitions, as tolerated
- Strength program
  - 1-2 sets of 10-15 reps, at 50% of 1-RM, 2 days/week
  - 3 upper extremity exercises (chest press, latissimus dorsi pulldown, biceps curl)
  - 1 lower extremity exercise (leg press)
- No adverse events were associated with the 12-week training program
- Compared to no exercise training group (n = 21), the supervised aerobic and strength training group had significant increases in:
  - VO\textsubscript{2peak}
  - Leg and total lean tissue mass
  - Muscle strength (chest press and leg press)
- Training did not change left ventricular function

Patients with existing osteoporosis

Avoid high-intensity exercise training and trunk flexion because of the increased risk of fractures.

<table>
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<th>Problem</th>
<th>Goal</th>
<th>Intervention</th>
<th>Expected Progression</th>
<th>Home Program</th>
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<tbody>
<tr>
<td>Reduced strength, aerobic endurance, and functional exercise capacity</td>
<td>Improvement of strength, aerobic endurance, and functional exercise capacity to age-norm or better</td>
<td><strong>Exercise therapy</strong></td>
<td>Gradually progress the intensity and duration of exercises to the maintenance phase</td>
<td>Provide the patient with an independent home program at discharge from supervised exercise. Physical fitness can continue to improve with an ongoing progressive exercise program after HTx.</td>
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<td>See review in Treatment summary</td>
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<td>Monitor vitals</td>
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**Desired Outcomes/Outcome Measures**

- Desired outcomes and outcome measures
  - Improved strength
  - Improved aerobic endurance
  - Improved functional exercise capacity

**Outcome measures**

- Strength assessed by MMT, with machines, or using free weights to calculate 1-RM
- VO2peak
- Aerobic endurance assessed by graded exercise testing
  - Functional aerobic capacity assessed by 6-minute walk distance or graded exercise test

**Maintenance or Prevention**

- Continue prescribed exercise training through independent home program
- Weight reduction and control, as indicated
- Dietary program, as prescribed

**Patient Education**

- See “Patient’s Guide to Heart Transplant Surgery” from the University of Southern California Keck School of Medicine at [http://www.cts.usc.edu/ht-patientguide.html](http://www.cts.usc.edu/ht-patientguide.html)

**Note**

- Recent review of the literature has found no updated research evidence on this topic since previous publication on November 14, 2014

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**Coding Matrix**

References are rated using the following codes, listed in order of strength:

- **M** Published meta-analysis
- **SR** Published systematic or integrative literature review
- **RCT** Published research (randomized controlled trial)
- **R** Published research (not randomized controlled trial)
- **C** Case histories, case studies
- **G** Published guidelines
- **RV** Published review of the literature
- **RU** Published research utilization report
- **QI** Published quality improvement report
- **L** Legislation
- **PGR** Published government report
- **PFR** Published funded report
- **PP** Policies, procedures, protocols
- **X** Practice exemplars, stories, opinions
- **GI** General or background information/texts/reports
- **U** Unpublished research, reviews, poster presentations or other such materials
- **CP** Conference proceedings, abstracts, presentation

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**References**


