How to Set Exercise Prescription for Patients with Heart Failure

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Functional Impairments of Pts with HF

• Pathophysiology
  – Impaired cardiac output responses to exercise
  – Abnormal redistribution of blood flow
  – Reduced mitochondrial volume and density
  – Impaired vasodilatory capacity
  – Heightened systemic vascular resistance

• Characterized symptoms
  – Exercise intolerance
  – Early fatigue
  – Dyspnea at exertion

• Negative impact
  – Has a negative impact on daily activities
  – Reduced quality of life
  – Poor prognosis

The beneficial effects of physical training including:

- Neurohumoral
- Inflammatory
- Metabolic responses
- Central hemodynamic responses
- Endothelial
- Skeletal muscle
- Cardiovascular function

All of these are leading to improvement in functional capacity and quality of life.

Figure 1. Pathobiological pathways induced by exercise training in patients with heart failure

Endurance exercise training opposes many of the dysfunctional elements of CHF and facilitates improved skeletal muscle blood flow (Qm), pulmonary gas exchange (VO₂), and exercise tolerance.
Benefits of Exercise Training in Pts with HF

- In patients with stable HF, regular exercise training can
  - Improve muscle function
  - Increase patients’ ability to take in and use oxygen
  - Reduce fatigue
  - Enhance the work efficiency
  - Relieve symptoms
  - Improve exercise capacity
  - Enhance quality of life
  - Improve prognosis
  - Reduce disability
  - Decrease hospitalization and mortality
  - Improve psychosocial conditions

Figure a. Effect of exercise training on survival in HF patients

Risks of Exercise Training in Pts with HF

- Cardiac events during exercise are extremely low.
  - During outpatient cardiac exercise programs, it has been estimated to be 1 in 60,000 participant-hours.
  - There is a greater risk for sudden cardiac arrest during vigorous exercise (such as jogging).

- The most common events in HF pts include
  - Post-exercise hypotension
  - Atrial and ventricular arrhythmias
  - Worsening HF symptoms

- The type and intensity of exercise and the use of monitoring affect incidence of sudden cardiac arrest.

- The adjusted relative risk is greater in persons who do not regularly participate in physical activity.

Considerations before Exercise Training

- Before initiating an exercise program for patients with heart failure, a comprehensive clinical evaluation is necessary, which including
  - Treatment of underlying causes of CHF
  - Optimal pharmacologic therapy
  - Risk stratification
  - Exercise testing

Core Components of CR in Chronic Heart Failure

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Core components of cardiac rehabilitation in chronic heart failure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Baseline clinical assessment and risk stratification</td>
</tr>
<tr>
<td></td>
<td>Treatment of causative factors of heart failure (hypertension, coronary artery disease, atrial fibrillation, and valvular heart disease) and correction of precipitating causes (non-compliance with drugs, use of non-steroidal anti-inflammatory drugs and cyclooxygenases-2 inhibitors, nasal decongestants, infections, pulmonary emboli, dietary indiscretion, inactivity, hyperthyroidism)</td>
</tr>
<tr>
<td></td>
<td>Optimal pharmacological therapy directed by national and international guidelines</td>
</tr>
<tr>
<td></td>
<td>Management of HF-related diseases and competing comorbidities</td>
</tr>
<tr>
<td></td>
<td>Implementation of a continuing program on physical activity and exercise training</td>
</tr>
<tr>
<td></td>
<td>Counseling and education: lifestyle, dietary recommendations, coping strategies, medications, self-monitoring, prognosis</td>
</tr>
<tr>
<td></td>
<td>Psychological support</td>
</tr>
<tr>
<td></td>
<td>Planning of continuum of care thorough an efficient, organized linkage between hospital and community</td>
</tr>
</tbody>
</table>

## Table 2 Relative and absolute contraindications to exercise training among patients with stable chronic heart failure

### Relative contraindications
1. ≥1.8 kg increase in body mass over previous 1–3 days
2. Concurrent continuous or intermittent dobutamine therapy
3. Decrease in systolic blood pressure with exercise
4. New York Heart Association Functional Class IV
5. Complex ventricular arrhythmias at rest or appearing with exertion
6. Supine resting heart rate ≥100 beats·min⁻¹
7. Preexisting comorbidities

### Absolute contraindications
1. Progressive worsening of exercise tolerance or dyspnea at rest or on exertion over previous 3–5 days
2. Significant ischemia at low work rates (≤2 METS, or ≈50 W)
3. Uncontrolled diabetes
4. Acute systemic illness or fever
5. Recent embolism
6. Thrombophlebitis
7. Active pericarditis or myocarditis
8. Moderate to severe aortic stenosis
9. Regurgitant valvular heart disease requiring surgery
10. Myocardial infarction within previous 3 weeks
11. New onset atrial fibrillation

From Recommendations for exercise training in chronic heart failure patients

*Working Group on Cardiac Rehabilitation & Exercise Physiology and Working Group on Heart Failure of the European Society of Cardiology. Eur Heart J 2001;22:125–135*
Upper Limit of Exercise Intensity

Table 3  Signs and symptoms below which an upper limit for exercise intensity should be set

- Onset of angina or other symptoms of cardiovascular insufficiency
- Plateau or decrease in systolic blood pressure, systolic blood pressure of >250 mmHg or diastolic blood pressure of >115 mmHg
- ≥1.0 mm ST-segment depression, horizontal or downsloping
- Radionuclide evidence of left ventricular dysfunction or onset of moderate to severe wall motion abnormalities during exertion
- Increased frequency of ventricular dysrhythmias
- Other significant ECG disturbances (e.g., 2 or 3 degree atrioventricular block, atrial fibrillation, supraventricular tachycardia, complex ventricular ectopy, etc.)
- Other signs/symptoms of intolerance to exercise

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* The exercise heart rate generally should be at least 10 beats-min⁻¹ below the heart rate associated with any of the referenced criteria. Other variables (e.g., the corresponding systolic blood pressure response and perceived exertion), however, also should be considered when establishing exercise intensity.

Principle of Exercise Prescription for HF Pts

- Three basic principles
  - Individualized
  - Effective
  - Progressively changed

- Four basic elements
  - Frequency
  - Intensity
  - Time
  - Type

- Aerobic exercise, resistance exercise, and respiratory muscle training are the most commonly used exercise mode among HF patients.

![Table 4 Components of the exercise prescription for patients with heart failure](image-url)

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aerobic, dynamic exercise</td>
<td>Light resistance training (high repetition, low resistance)</td>
</tr>
<tr>
<td>Avoid isometric, body-building type activities</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Intensity</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Below ventilatory threshold</td>
<td>Target work rate corresponding to 50–70% of peak VO₂</td>
</tr>
<tr>
<td>Rating of perceived exertion (Borg 6–20 scale) approximately 12–14</td>
<td></td>
</tr>
<tr>
<td>Heart rate reserve 60–80% of maximum</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Duration</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>May need to start at only 10–20 min/sessions</td>
<td>Work up to 30–40 min/sessions</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>3–5 times/week</td>
<td></td>
</tr>
</tbody>
</table>
Recommendation of Aerobic Exercise for HF Pts

- **Frequency**
  - 3 to 5 times per week

- **Intensity**
  - 50–70% of peak VO$_2$, or VO$_2$@AT
  - RPE (Borg scale 6-20) approximately 12-14
  - Heart rate reserve 60-80% of maximum
  - Heart rate @ AT

- **Time**
  - Warm-up (10-15min) + targeted exercise + cool down (10-15min)
  - 20 to 60 min exercise at targeted intensity

- **Type**
  - Walking is the most popular exercise

Notes: Supplemental walking should be encouraged on the nontraining days.

Warming up Exercise Demonstration
Tools Used in Monitoring Exercise Intensity

Rating of Perceived Exertion
Borg RPE Scale

<table>
<thead>
<tr>
<th>Rating</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>Very, very light</td>
</tr>
<tr>
<td>7</td>
<td>Very light</td>
</tr>
<tr>
<td>8</td>
<td>Fairly light</td>
</tr>
<tr>
<td>12</td>
<td>Somewhat hard</td>
</tr>
<tr>
<td>13</td>
<td>Hard</td>
</tr>
<tr>
<td>17</td>
<td>Very hard</td>
</tr>
<tr>
<td>18</td>
<td>Very, very hard</td>
</tr>
<tr>
<td>20</td>
<td>Maximum exertion</td>
</tr>
</tbody>
</table>
EXERCISE

Cool down and stretching exercise
Recommendation of Resistance Exercise for HF Pts

- **Frequency**
  - 2 or 3 days per week

- **Intensity**
  - 50% to 70% 1RM for lifts involving the hips and lower body;
  - 40% to 70% 1RM for lifts involving the upper body

- **Time**
  - 20 to 30 minutes per session, 10 to 15 repetitions of every movement, doing in a rhythmical manner at a moderate to slow controlled speed

- **Type**
  - Small free weights (1, 2, or 5 lb)
  - Elastic bands
  - Weight machines

Resistance Exercise Demonstration

Examples of Exercises

- Chest Press
- Shoulder Press
- Front Raise
- Bent Row
- Bicep Curl
- Step Up
More about the Resistance Training in HF Pts

- RT prevents the decline in skeletal muscle mass and function.
- Regular and vigorous RT results in a shift from fatigue-prone type II fibers to fatigue-resistant type I fibers.
- Study demonstrated a 10–18%↑ in peak VO₂ in HF pts during RT, compared with a 20%↑ observed during AT.
- RT as a complement of AT, pts can benefit from it.
- Short duration exercise with a sufficient rest interval is recommended.
- Isometric exercise and valsalva maneuver are forbidden.

Notes: RT means resistance training and AT means aerobic training.

Circuit Training in HF Pts

• Circuit training (i.e. training that involves both resistance and aerobic exercise) is a well tolerated form of exercise training for patients with HF, which is associated with similar oxygen and hemodynamic demand to aerobic exercise alone.

Recommendation of Respiratory muscle training for HF Pts

- Studies have demonstrated the benefit of respiratory muscle training among heart failure patients, especially the inspiratory muscle training.
  - **Frequency**
    - Daily
  - **Intensity**
    - 15% to 60% of maximal inspiratory mouth pressure
  - **Time**
    - 15 to 30 minutes
  - **Type**
    - Inspiratory muscle training

Effects of Inspiratory Muscle Training

- IMT improves cardio-respiratory fitness and quality of life to a similar magnitude to conventional exercise training and may provide an initial alternative to the more severely de-conditioned CHF patients who may then transition to conventional ExT.

Endurance and strength training, and moderate continuous training, are less effective than high intensity interval training, but training involving resistance and aerobic exercise might be the most beneficial regimen.

Some research has looked at HIIT using treadmill for 4 minutes at 90-95% VO$_2$ with 3 minutes of active recovery plus warm up and cool down.

However, HIIT is not recommended routinely and more research in this area is needed.
Other Recommended Exercise Modality

- Tai Chi, which is benefit for HF patients, is also recommended.
- It helps to
  - Improve balance
  - Increase strength
  - Increase functional mobility
  - Increase flexibility
  - Increase cardiovascular function
  - Enhance sleep quality
  - Reduce fear of falling
  - Improve quality of life
  - Increase psychological well being
- Swimming training
- Home-based exercise training with remote monitoring device
Other Considerations for Exercise

- Previous studies have shown that the type and intensity of exercise training might determine the level of benefit.
- The ‘dose’ of the intervention explains much of the variation seen in the relative benefits of the different forms of exercise regimens.
  - Dose = exercise duration × number of sessions × duration of training period
  - With improvements in peak VO₂ seen for increasing doses of exercise training
- Most of the evidence of the benefits of exercise training in patients with HF is from patients with stable HF in NYHA functional classes II or III.

Case Report

- Male, 68y
- Admitted to hospital due to exertional dyspnea
- Medical history: HTN, T2DM
- Ultrasonic cardiogram: dilated cardiomyopathy, LVEF 38%
- Diagnosis: dilated cardiomyopathy, hypertension, type II diabetes mellitus
- Medications:
  - Aspirin 100mg qd, Bisoprolol 5mg qd, Valsartan 80mg qd, Lasix 20mg qd, Antisterone 20mg qd
CPET report and Exercise prescription

住院号：P  心内科 区 床
姓名： 性别：男 年龄：68 岁 身高：173 cm 体重：115 Kg BMI：38.4 kg/m²

临床诊断： 扩张性心肌病 目前用药：Concor 5mg qd

心肺运动测试评价：

运动试验方案采用 坡度试验（Ramp 方案，预热3min，递增12watt/min）
运动负荷测试时间 10 min 8 sec，最大负荷 122 Watt，负荷 @AT 96 Watt
VO₂max：16.32 ml/Kg/min（max/pred 86 %，Mets 4.8），
VO₂@AT：13.33 ml/Kg/min（AT/Ref 69.86 %），HR@AT：93 bpm
HRrest：60 bpm，HRmax：129 bpm（max/pred 84 %），HRR：24 bpm
O₂ Pulse：15 ml/beat（max/pred 105 %），VE/VCO₂：28.3

终止原因： 双下肢疲劳

制单日期：2014.4.2

2016/11/29

测试日期：2014.4.2

Overweight
综合结论：

1) 运动终止于双下肢疲劳
2) 测试期间未见心肌缺血，频发室早
3) 静态肺通气功能提示：轻度限制性通气功能障碍
4) 运动耐量正常，运动受限于双下肢疲劳，心率储备（服用 Betaloc）未用尽，呼吸储备 49%（正常参考值范围 >20%）
5) 心功能 B 级

运动处方：
靶心率：90-110 bpm RPE: 12-14（稍用力） MET: 运动时间：隔天一次

<table>
<thead>
<tr>
<th>运动方式</th>
<th>预热</th>
<th>踏车</th>
<th>手臂摇车</th>
<th>划船</th>
<th>步行</th>
<th>放松</th>
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</thead>
<tbody>
<tr>
<td>时间分配(分钟)</td>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td>30-40</td>
<td>5</td>
</tr>
</tbody>
</table>

Individualized

①
广东省人民医院心血管病研究所
CPET report and Exercise prescription

制订日期：2014/12/4
住院号：P 区 床
姓名：
性别：男 年龄：68 岁 身高：173 cm 体重：109 Kg BMI：36.4 kg/m²
联系电话：
临床诊断：扩张型心肌病、HT、T2DM 目前用药：康忻 5mg qd

心肺运动测试评价：
运动试验方案采用 踏车试验（Ramp方案，休息3min，预热3min，递增12watt/min）
运动负荷测试时间 12 min 29 sec，最大负荷 147 Watt，负荷@AT 85 Watt
Peak VO₂：2355 ml/min，Peak VO₂/kg：21.6 ml/Kg/min（peak/pred 109 %，Mets 6.6），
VO₂@AT：1608 ml/min，VO₂/kg@AT：14.75 ml/Kg/min（AT/Ref 75 %，Mets 4.2）
VE/VO₂@AT：22.8，VE/VO₂Slope：26.8，RER 0.91
Peak VE：67.9 L/min（peak/pred 116.8 %），O₂ Pulse：21 ml/beat（peak/pred 149 %）
HRrest：76 bpm，HR@AT：103 bpm，PeakHR：120 bpm（peak/pred 78 %），
BPrest：155/73 mmHg，Peak BP：224/85 mmHg
终止主要原因：双下肢疲劳
**综合结论：**

1) 静态肺功能提示：肺通气功能正常。
2) 运动终止于双下肢疲劳。
3) 测试期间见可疑心肌缺血，未见心律失常。
4) 运动耐量正常，心率储备未用尽（HRR 33 bpm，服用康忻），呼吸储备 41%（正常参考值范围＞20%）。
5) 心功能 A 级（Weber KT 标准）。

<table>
<thead>
<tr>
<th>运动处方：</th>
<th>靶心率：90-100 bpm</th>
<th>RPE: 12-14（稍用力）</th>
<th>MET:</th>
<th>运动时间： 隔天一次</th>
</tr>
</thead>
<tbody>
<tr>
<td>运动方式</td>
<td>预热</td>
<td>踏车</td>
<td>手臂摇车</td>
<td>划船</td>
</tr>
<tr>
<td>时间分配（分钟）</td>
<td>10</td>
<td></td>
<td></td>
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</table>
### UCG（201404 vs 201412）

<table>
<thead>
<tr>
<th>超声图像</th>
<th>左室射血分数</th>
<th>LVEF 38%</th>
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<table>
<thead>
<tr>
<th>超声图像</th>
<th>左室射血分数</th>
<th>LVEF 48%</th>
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</table>

2016/11/29
<table>
<thead>
<tr>
<th></th>
<th>First</th>
<th>Second</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMI (kg/m²)</td>
<td>38.4</td>
<td>36.4</td>
</tr>
<tr>
<td>Forced vital capacity</td>
<td>Mild obstructive pulmonary dysfunction</td>
<td>Normal</td>
</tr>
<tr>
<td>Maximum load (Watt)</td>
<td>122</td>
<td>147</td>
</tr>
<tr>
<td>Peak VO₂/kg (ml/Kg/min)</td>
<td>16.32</td>
<td>21.61</td>
</tr>
<tr>
<td>VO₂@AT (ml/Kg/min)</td>
<td>13.33</td>
<td>14.75</td>
</tr>
<tr>
<td>Heart function (Weber KT standard)</td>
<td>B</td>
<td>A</td>
</tr>
<tr>
<td>VE/ VCO₂ Slope</td>
<td>26.8</td>
<td>26.9</td>
</tr>
<tr>
<td>ST segment</td>
<td>No ischemic change, frequent ventricular premature beat</td>
<td>Suspicious ischemic change and no arrhythmia</td>
</tr>
</tbody>
</table>
Exercise rehabilitation is beneficial to patients with heart failure; aerobic exercise, resistance exercise and respiratory muscle training are the most commonly utilized exercise forms. Aiming to enhance the safety and efficiency of exercise, a scientific and individualized exercise prescription is essential.
Thank you
Our Team @ 2016

Q & A