The Art and Science of Exercise Prescription in Patients with Cardiovascular Disease
Prescribe Exercise
FITT Principle

- **Frequency**
- **Intensity**
- **Time or duration**
- **Type or modality**
Exercise Prescription with or without a GXT

• Frequency: same
• Time / duration: same
• Modalities: same

* The only difference is how you prescribe exercise intensity!
The whole idea is to ideally get people into some sort of therapeutic window...which corresponds to 40-80% of VO$_2$max or maximal METS.
HR/VO\textsubscript{2} Relationship

![Graph showing the relationship between heart rate (beats•min\(^{-1}\)) and \(\dot{V}\text{O}_2\) (mL•kg\(^{-1}\)•min\(^{-1}\)) with a range of 40-80%]
HR/VO$_2$ Relationship

\[
\frac{\dot{V}O_2 \text{ (mL} \cdot \text{kg}^{-1} \cdot \text{min}^{-1})}{3.5} = \text{METs}
\]
Exercise prescription...which approach do you take?

- Top-down

or

- Bottom-up
If the patient has completed a SLM, you have maximal HR and VO$_2$max...you then take various percentages of those (e.g., %HRmax, %HRR, %VO$_2$max, %VO$_2$R, % maximal METs).

- Relative percent concept
If you don’t have a maximal exercise test... where do you start?

Bottom Up Approach
If you don’t have a maximal exercise test on someone, you have no idea what their maximal heart rate is, especially if they have disease and are on medications. Thus, do not use predicted HRmax for exercise prescription!
Problem with predicted maximal HR:

- $\ 220 - \text{age}; \ SD = \pm 12 \text{ bpm}; \ on \ BB: \ SD = \pm 43 \text{ bpm}$
For patients on beta blockers:

- Keteyian et al., MSSE, 44(3): 371-376, 2012

  Predicted HRmax = 119 + .5 (RHR) – .5 (age) – 5 (if on bike; 0 if on treadmill)

- Standard deviation: ± 18 bpm

- Time of day when took medication:
  - Once a day vs. twice a day
A new patient walks in the door:

- What the heck do you do?
Intensity

- If you do not have an exercise test:
  
  - AACVPR
    - 2 - 4 METs
    - 11 - 14 RPE
  
  - ACSM
    - Use Phase I recommendations
      - Post MI: Rest + 20 bpm (arbitrary upper limit)
      - CABG: Rest + 30 bpm (arbitrary upper limit)
      - RPE < 13
      - To tolerance if asymptomatic
Nobody I talked to uses HR as a primary exercise prescription tool...in the absence of a maximal graded exercise test!!!
Intensity Violators
Signs and Symptoms Below Which an Upper Limit for Exercise Intensity Should be Set

- Angina
- Drop in SBP
- Significant ST depression on previous GXT
- Increased frequency of ventricular ectopy
- Onset of heart blocks (e.g., BBBs, 2\textdegree{} or 3\textdegree{} AV block)
- Other signs/symptoms of intolerance to exercise (e.g., extreme SOB)

**Exercise heart rate should be set at least 10 bpm below the HR associated with any of the above criteria.**
Meds: Cardizem 30 mg TID, NTG SR 6.5 mg TID; ASA: 81; NTG Spray SL Pen.

Mets: 9.9

Protocol: Bruce

Graph showing heart rate (circles) and blood pressure (triangles) over time. Symbols represent different stages:

- ○ = SBP
- △ = Heart Rate
- ● = DBP

Stage indicators: 3, 4, 5, 6, 7, 8, 8:59, TPE, 2s, 4s, 6s, 8s

Speed (MPH):

- 1.7 2.5 3.4 3.9

Percentage:

- 10 12 14 14
Subjective Methods

- Ratings of Perceived Exertion (RPE)
- Talk Test

Surveys have found that ~ 80% of exercisers prefer subjective methods to guide their exercise program.
• 11 - 13 moderate intensity = 40 - 59% HR reserve
• 14 - 16 high intensity = 60 - 80% HR reserve

6 - 20 Scale

6
7 Very, very light
8
9 Very light
10
11 Fairly light
12
13 Somewhat hard
14
15 Hard
16
17 Very hard
18
19 Very, very hard
20
No BB: 135/155 = 87%
On BB: 115/130 = 87%

RPE 13
Subjects exercised 3x/wk for 30 min/day for 8 weeks

- \( \text{VO}_2\text{max} \) increased 17%
- Total cholesterol ↓ from 186 to 162 mg/dl
- Mean arterial BP ↓ from 99.4 to 92.4 mm Hg

- Results should not be surprising since subjects exercised between 61-64% of \( \text{VO}_2\text{max} \)
• If you use RPE only...you still record exercise HRs on each modality to get an idea of what they are.....

• That allows you to recognize deviations from that, which may indicate:
  – some sort of dysrhythmia
  – heart block
  – if patient forgot to take their meds
Aerobic Exercise Intensity Assessment and Prescription in Cardiac Rehabilitation

**JCRP, 32: 327-350, 2012**

- Joint Position Statement of:
  - AACVPR
  - CACR
  - EACPR

“the joint statement provides evidence-based indication for a shift from “range-based” to a “threshold-based” aerobic exercise intensity prescription”
Minute ventilation (L·min⁻¹, BTPS) vs. Oxygen consumption (L·min⁻¹).

- **50-70% HRR**
- **Anaerobic threshold**

The graph shows a linear relationship between minute ventilation and oxygen consumption, with a highlighted region indicating the 50-70% heart rate reserve (HRR) zone.
Research Evidence

Katch et al., 1978

Dwyer et al., 1994

- At 55% of HR reserve, 50% of cardiac patients were above their anaerobic threshold and 50% were below
What about Resting HR + 20 bpm?

*Wake Forest Group*

- 11 cardiac rehab patients
- 4 were < 40% of VO$_2$max
- 6 were within 40-60% of VO$_2$max
- 1 was > 60% VO$_2$max
- range was 25-65% of VO$_2$max
Talk Test

The poor man’s “stress” test

Exercise at an intensity where you can still carry on a conversation!

- Last positive stage: + TT
- Equivocal stage: +/- TT
- First negative stage: - TT
Talk Test Movie
y = 1.0584x - 0.4951

\( R^2 = 0.8453 \)
Figure B

\[ y = 1.2013x - 0.567 \]
\[ R^2 = 0.9104 \]
• A study in cardiac patients found that the “equivocal” stage (+/-) of the Talk Test corresponded to 64% of VO\textsubscript{2}\text{max}, 70% of HR\text{max}, and an RPE of 13.2.

• In subjects who had exertional ischemia, 18/19 subjects were below the ischemic threshold when they could still pass the Talk Test. Ischemia did not occur until after they could no longer speak comfortably.
$y = 0.4254x + 0.8629$

$R^2 = 0.2962$
Does the Talk Test work?
Talk Test vs. %HRR Training Study

- 5 minute warm-up
- 30 minute workout
- 5 minute cool-down

► Talk Test Group
  - Rainbow Passage recited every 5 minutes to access speech comfort
  - If (+), PO increased 30 W
  - If (+/- or -), PO decreased 30 W

► Heart Rate Reserve Group
  - %HRR ranges calculated from maximal exercise test; workloads adjusted every 5 minutes to stay within prescribed ranges
    - Week 1-4: 40-59%
    - Week 5-8: 50-69%
    - Week 9-10: 60-79%
Changes in aerobic capacity ($\text{VO}_2\text{max}$)
Changes in ventilatory threshold (VT)
What about Interval Training in Cardiac Patients?

![Diagram showing repeated intervals of 30 seconds with anaerobic or ventilatory threshold indicated.](image)
Steady state exercise

Interval training

Anaerobic threshold
Aerobic Interval Training

Wisloff et al., Norway (2007)

- Uphill treadmill walking
- 10-minute warm-up at 50-60% HRmax
- 4, 4-minute intervals at 90-95% HRmax; separated by 3 minutes of active rest
- 3-minute cool-down at 50-70% HRmax
- Total exercise time of 38 minutes

* Had a symptom-limited maximal exercise test prior to starting
Aerobic interval training compared to steady-state exercise:

- Greater increase in aerobic capacity (46 vs. 14%)
- 35% increase in ejection fraction
- Lower ED and ES volumes
- 40% lower BNP levels
- Better endothelial function
- Improved QOL
Greater Improvement in Cardiorespiratory Fitness Using Higher-Intensity Interval Training in the Standard Cardiac Rehabilitation Setting

Keteyian et al., JCRP: March/April, 2014

- 2 wks (6 sessions) standard CR
- Symptom-limited GXT
- 3-min warm-up at 60-70% HRR
- 4, 4-min intervals at 80-90% HRR with 3 min between intervals
- 3 min cool-down
- 3.6 vs. 1.7 ml/kg/min increase in $\text{VO}_2\text{max}$
- 3.0 vs. 0.7 ml/kg/min increase in VT
Interval Training

Break up into 2-4 minute blocks (alternate hard/easy segments)
Do hard segments at RPE of 14-16; easy segments at RPE 10-11
Gradually increase length of hard segments
Build up to 4-5 blocks

![Interval Training - 1:3](image)

**Total Exercise Time = 10 minutes**
EXAMPLES
Model 1

- Patient chosen modality
- Warm-up at easy workload (3 min)
- Exercise at a “comfortable” pace (patient choice)
- Try for a total of 20 min of exercise
- Cool-down (3 min)

- Go up to 25 min 2nd week
- Go up to 30 min 3rd week
- Once can do 30 min continuously for 2 weeks…
- Introduce 2-4, 30-60 sec intervals with 3 min rest
Model 2

- 5 min warm-up; RPE 10-11
- Aim for 20 min steady-state exercise; RPE 12-13
- Add 5 min per week to total of 30 min
- Once can do 30 min, work 4-5 intervals into last 10 min—typically 30 sec/90 seconds; RPE 15-16 (can start at 10-15 sec with longer rest period; can build up to 60 sec/60 sec)
- 5 min cool-down
- Total exercise time - ~ 40 min
Model 3

- 1 on 1 “mini stress test” with EKG and BP monitoring
- Go up to RPE of 13 (max)
- 1st exercise session
  - 3 min warm-up/cool-down: very easy
  - Try for 20 minutes on one modality (start at workload where RPE was 11 on mini stress test)
  - Increase to 30 min by end of 2nd week by adding 5 min on two other modalities (RPE 11-13)
  - Increase to 40 min 3rd week by having do 10 min on other two modalities (RPE 11-13)
  - Replace steady-steady state exercise on main modality with intervals
    - 4 min blocks: 1 min/3 min; 2 min/2 min; 3 min/1 min
    - RPE 14/15 for hard segments/10-11 for easy segments
Model 4

• Perform Talk Test up to “equivocal” stage
• 5 min warm-up at LP-1 stage (RPE 11)
• 10-20 min at LP stage…do TT every 5 min (RPE 12-13)
  – If can talk comfortably…increase workload
  – If can’t talk comfortably…decrease workload
• Once can do 20 min continuously, add in 3-5 intervals
  – 2 min segments; 30 sec at RPE ~15-16/90 sec at RPE 10-11; build toward 60 sec/60 sec hard/easy segments
• 5 min cool-down at LP-1 stage (RPE 11)
• Can do redo incremental TT every 2 weeks to adjust workloads and determine progress
Bottom Line:
One size fits NONE!
Give Them Homework

• Make exercising 5-7 days per week the expectation!
• You may only start with 1 additional day per week…and build up.
• Recommendations vary…
  – Some people back off on intensity
  – Others try to match same intensity as CR
  – Same for duration (i.e., you don’t want them to come to CR the next day too tired)
  – Main thing is to get them moving
“walk often and walk far”  
Ades et al., Circulation: 2009

- **Standard Cardiac Rehabilitation**
  - 3 days week
  - 25-40 minutes/session
  - 65-75% peak VO$_2$
  - goal of 1200-1500 kcal/week

- **High Caloric Exercise for Cardiac Patients**
  - 5-7 days week
  - 45-60 minutes/session
  - 50-60% peak VO$_2$
  - goal of 3,000-3,500 kcal/week
Results – 5 months

<table>
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<tr>
<th></th>
<th>High Caloric</th>
<th>Standard CR</th>
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<tbody>
<tr>
<td>Kcal/day</td>
<td>615</td>
<td>269</td>
</tr>
<tr>
<td>Kcal/wk</td>
<td>3037</td>
<td>807</td>
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<tr>
<td>Weight Loss (kg)</td>
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<tr>
<td>↓ Waist (cm)</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>Met Syndrome ( % ↓ )</td>
<td>47</td>
<td>17</td>
</tr>
</tbody>
</table>
• Provide home exercise (activity) guidelines
  – Duration
  – How to monitor intensity – RPE, Talk Test, HR monitors
  – Walking
  – Home exercise equipment
  – Lifting restrictions

• Make them keep a log and turn it in!
Gizmos and Gadgets

- Pedometers
- Activity trackers
- iPhone apps
Give Them a Pedometer

• Can be used to give guidance on their “off” days.

• Big difference in steps taken on CR days vs. non-CR days:
  – CR = 10,047 vs. non-CR = 6,907 steps (46%)

• Giving patients a pedometer increases step count by 19-27%.

Feito et al., JCEP, 1(1): 15-19, 2012
Pedometer Tips

- Order them in bulk through your state organization
- Give them at program entry
- Give them as a graduation present
The Gun Show!!
When do you start?

- MI and CABG patients should not participate in a “traditional weight training” program until at least 5 weeks post-event, including 4 weeks of participation in a supervised CR program.

- For PCI/MID-CAB patients, the recommended time frame is at least 3 weeks post-procedure, including 2 weeks in a supervised CR program.
Recommendations also say:

- Can start light weights (1-5 lbs) or resistance bands earlier…depending upon individual

- Also depends on your surgeons (e.g., some surgeons…no upper body exercise for 6-8 weeks)

- No biking outside, riding or pushing a lawn mower, golf…or shooting a gun for at least 8 weeks (don’t want vibration or sudden trauma)
Outpatient Rehab (Phase II)

• 1st 5-6 weeks
  – Therabands
  – Dumbbells
  – Use a weight that they can do 10-15 times
  – If perceived exertion is < 13 on the Borg Scale, increase the weight
Outpatient Rehab (Phase II)

- **Weeks 7-12**
  - Transition to “traditional weight training” program (machines)…if possible
  - Start with 30-50% of 1 RM
    - You can either measure 1 RM and take 30-50% of that value
    - Or titrate the weights based on RPE and trial and error
    - Once they can do 12 reps (upper body) or 15 reps (lower body) with an RPE < 13, increase the weight
## Resistance Training Intensity

- Test for one repetition maximum (1 RM)
- Titrate weight based upon RPE

RPE for different exercises at the same % of 1 RM

<table>
<thead>
<tr>
<th>% 1RM</th>
<th>40%</th>
<th>50%</th>
<th>60%</th>
<th>70%</th>
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</thead>
<tbody>
<tr>
<td>Arm Curl</td>
<td>12.9</td>
<td>13.7</td>
<td>14.8</td>
<td>17.5</td>
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<tr>
<td>Leg Extension</td>
<td>12.2</td>
<td>12.9</td>
<td>14.4</td>
<td>16.5</td>
</tr>
<tr>
<td>Chest Press</td>
<td>10.9</td>
<td>12.3</td>
<td>13.4</td>
<td>15.4</td>
</tr>
<tr>
<td>Lat Pulls</td>
<td>8.9</td>
<td>10.7</td>
<td>12.9</td>
<td>14.4</td>
</tr>
</tbody>
</table>
All Current Recommendations Suggest: (ACSM, AHA, AACVPR)

• 1 set
• 8-10 exercises
• 10-15 repetitions
• 2 or more non-consecutive days per week
• Moderate – high intensity: RPE of 11-15

• Muscle strengthening activities can include lifting weights, using surgical tubing or resistance bands, and weight bearing calisthenics.
Outpatient Rehab (Phase III)

• Most people can safely work at 40-70% of 1 RM
  • Once they can do 12 reps (upper body) or 15 reps (lower body) with an RPE < 15, increase the weight

If they have the time and want to do 2-3 sets, that is fine also.
Questions?