Feasibility, safety, adherence, and efficacy of high intensity interval training in a hospital-initiated rehabilitation program for patients with coronary heart disease

Jenna Taylor
Exercise Physiologist & Dietitian – The Wesley Hospital
PhD Candidate – The University of Queensland
Cardiorespiratory Fitness and Survival

For every 1ml/kg/min increase in fitness, survival improved by 9%

High intensity aerobic interval exercise is superior to moderate intensity exercise for increasing aerobic capacity in patients with coronary artery disease

Olavind Rognmo, Eva Hetland, Jan Helgerud, Jan Hoff and Stig A. Slørdahl

High intensity Interval Training (HIIT) increased cardiorespiratory fitness compared to moderate intensity continuous training (MICT)

6ml/kg/min

2.7ml/kg/min
HIIT increases VO₂peak by 19.4% compared to moderate intensity 10.9%

Equivalent to ~ 10-20% reduction in risk of death over 8 years

Weston, Wisloff and Coombes, British Journal of Sports Medicine, Published Online First: [23 Oct, 2013]
RATIONALE

RELEVANCE TO REAL WORLD

Maximal exercise testing not routinely conducted → No Peak HR data
Cardiac medications can affect HR
AIM

To compare High Intensity Interval Training (HIIT) with Moderate Intensity Continuous Training (MICT) in patients with Coronary Artery Disease (CAD) completing a hospital-based cardiac rehabilitation program, using subjective measures of exercise intensity:

Primary outcome = cardiorespiratory fitness (VO$_{2peak}$) after 4 weeks

Secondary outcomes = feasibility, safety, and exercise adherence
METHODS

- The FITR Heart Study
- Single centre randomised controlled trial (The Wesley Hospital)
- HIIT (intervention) vs MICT (usual care)

<table>
<thead>
<tr>
<th>Stage</th>
<th>Timeframe</th>
<th>Weekly Exercise Training</th>
<th>Level of support</th>
</tr>
</thead>
</table>
| Stage 1 | 1 month   | Hospital Cardiac Rehab Program  
= 2 x supervised sessions  
+ 1 home-based session       | Supervised exercise classes     |
| Stage 2 | 2 months  | Home-based Program  
≥3 x home-based sessions | Routine support                  |
| Stage 3 | 9 months  | Maintenance Program  
≥3 x home-based sessions   | No routine support               |
METHODS

Recruitment

• Recruited patients with angiographically proven coronary artery disease

• Commencing hospital-based cardiac rehabilitation

• Includes MI, Stent, CABG, Medical

• Main exclusion criteria = Contraindications to Maximal Exercise Testing
Absolute Exclusion Criteria

- < 4 weeks following ACS or CABG
- <3 weeks following PCI
- Obstructive left main artery disease
- Unstable angina
- Uncontrolled cardiac arrhythmia
- Acute endocarditis, myocarditis or pericarditis
- Moderate to severe aortic stenosis
- Decompensated heart failure
- Acute pulmonary embolism, or deep vein thrombosis
- Aortic dissection
- Higher degree heart block
- Hypertrophic obstructive cardiomyopathy
- Recent stroke or transient ischemic attack
- Uncontrolled diabetes
- Acute or chronic renal failure
- Pulmonary fibrosis or interstitial disease
- Severe neuropathy

Screening Process

- Angiographically proven CAD
- < 80 years old
- Screened by study medical advisor for eligibility
- Treating cardiologist informed of their patient’s participation, with opportunity to exclude involvement
- Baseline maximal exercise test supervised by medical doctor.
METHODS

Baseline Testing

EFFICACY

Cardiorespiratory Fitness (VO2peak)
## METHODS

<table>
<thead>
<tr>
<th></th>
<th>MICT</th>
<th>HIIT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Frequency</strong></td>
<td>3 sessions per week (2 supervised + 1 home-based)</td>
<td></td>
</tr>
<tr>
<td><strong>Warm-up</strong></td>
<td>3min RPE &lt; 11</td>
<td>3min RPE &lt; 11</td>
</tr>
<tr>
<td></td>
<td>1 min RPE 11-13</td>
<td>1 min RPE 11-13</td>
</tr>
<tr>
<td><strong>Exercise Intensity</strong></td>
<td>34min moderate intensity at RPE 11-13</td>
<td>4 x 4 min high intensity intervals at RPE 15-18 interspersed with 3min recovery at RPE 11-13</td>
</tr>
<tr>
<td><strong>Warm-down</strong></td>
<td>3min RPE &lt; 11</td>
<td>3min RPE &lt; 11</td>
</tr>
<tr>
<td><strong>Duration</strong></td>
<td>40 minutes</td>
<td>32 minutes</td>
</tr>
</tbody>
</table>

RPE = Rating of Perceived Exertion
HIIT Protocol

4 x 4 minutes at RPE 15-18 (Hard to Very Hard)
Various exercise machines

Warm up
3 minute active recovery at RPE 11-13 (Fairly light to Somewhat hard)

Cool down

32 mins/session
METHODS

FEASIBILITY

Participants and Staff

• Questionnaires for quantitative + qualitative data

SAFETY

• Type, incidence and severity of adverse events.
• Grade 1: Mild; Grade 2: Moderate; Grade 3: Severe; Grade 4: Life-threatening; and Grade 5: Death

EXERCISE ADHERENCE

Measured as:
1. Completion of exercise sessions
2. Ability to achieve prescribed intensity & duration

Measured from

• Supervised exercise records
• Self-report weekly exercise training records
METHODS

Follow-Up Testing

TIME POINTS

- 5 Weeks
- 13 Weeks
- 6 Months
- 12 Months

STATISTICAL ANALYSIS

One-way ANCOVA

Independent Samples Kruskal-Wallis Test

Independent Sample T-Test
RESULTS – Inclusion/Exclusion

- Patients with CAD
  - Approached: N = 290
  - Referred to Cardiac Rehab: N = 406
  - Declined: N = 178

- Patients with no CAD (i.e. valve or PPM only)
  - N = 116

- Participants Recruited
  - N = 96

- Participants Randomised
  - N = 93

- Patients Excluded
  - N = 16
  - Reasons included:
    - No significant CAD
    - Severe pulmonary disease (n=1)
    - Orthopaedic limitation (n=1)
    - Planned operation (n=1)
    - New PPM insertion (n=2)
      - CKD < stage 3 (n=2)
    - Unstable arrhythmia (n=2)
    - Embolism risk (n=2)
    - Cardiologist declined (n=3)
# RESULTS – Baseline

<table>
<thead>
<tr>
<th>Participant Characteristics</th>
<th>HIIT (n= 47)</th>
<th>MICT (n= 46)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>65 ± 7</td>
<td>65 ± 8</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>VO$_2$peak (ml/kg/min)</td>
<td>27.7 ± 6.0</td>
<td>27.4 ± 7.3</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>BMI (kg/m$^2$)</td>
<td>28.0 ± 4.0</td>
<td>29.0 ± 4.0</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Males</td>
<td>39</td>
<td>39</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Females</td>
<td>7</td>
<td>8</td>
<td>&gt;0.05</td>
</tr>
</tbody>
</table>

**Cardiac event / intervention (n)**

<table>
<thead>
<tr>
<th></th>
<th>HIIT</th>
<th>MICT</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>CABG</td>
<td>15</td>
<td>10</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>PCI/Stent</td>
<td>23</td>
<td>24</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Medical</td>
<td>8</td>
<td>13</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Acute coronary syndrome</td>
<td>9</td>
<td>14</td>
<td>&gt;0.05</td>
</tr>
</tbody>
</table>

**Other risk factors (n)**

<table>
<thead>
<tr>
<th></th>
<th>HIIT</th>
<th>MICT</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diabetes</td>
<td>2</td>
<td>7</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Smoking</td>
<td>1</td>
<td>2</td>
<td>&gt;0.05</td>
</tr>
</tbody>
</table>
# RESULTS – Baseline

<table>
<thead>
<tr>
<th>Medications</th>
<th>HIIT (%)</th>
<th>MICT (%)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>B-Adrenergic blockers</td>
<td>40</td>
<td>41</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Statins</td>
<td>98</td>
<td>93</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>ACE inhibitor</td>
<td>19</td>
<td>37</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Angiotensin II receptor blockers</td>
<td>34</td>
<td>35</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Calcium channel blockers</td>
<td>4</td>
<td>15</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Antiplatelet agents</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Aspirin</td>
<td>96</td>
<td>91</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>• Other</td>
<td>53</td>
<td>59</td>
<td>&gt;0.05</td>
</tr>
</tbody>
</table>
RESULTS – 5 weeks

Cardiorespiratory Fitness (VO₂Peak)

<table>
<thead>
<tr>
<th>VO₂ ml/kg/min</th>
<th>Baseline</th>
<th>Week 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>HIIT</td>
<td>26</td>
<td>29.9</td>
</tr>
<tr>
<td>MICT</td>
<td>27</td>
<td>28.1</td>
</tr>
</tbody>
</table>

HIIT = +2.9 ± 3.5 ml/kg/min; MICT = 1.1 ± 0.0 ml/kg/min
RESULTS – Feasibility (Participants)

Feelings about Exercise Protocol

- Confidence in Exercise Protocol: Group p = 0.412
- Ease of Instructions: Group p = 0.335
- Ability to Manage Intensity: Group p = 0.032
- Enjoyment of Exercise: Group p = 0.933

Statistical Test = Non-Parametric Independent Samples Kruskal-Wallis Test
RESULTS – Feasibility (Staff)

Comparison of Exercise Protocol

<table>
<thead>
<tr>
<th></th>
<th>Group (p)</th>
<th>Group (p)</th>
<th>Group (p)</th>
<th>Group (p)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Confidence in delivery of protocol</td>
<td>0.147</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Patient acceptance of protocol</td>
<td>0.382</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Patient's ability to manage intensity</td>
<td>0.336</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Work associated with monitoring</td>
<td>0.562</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Statistical Test = Non-Parametric Independent Samples Kruskal-Wallis Test
## RESULTS – Feasibility (Staff)

<table>
<thead>
<tr>
<th>Feasibility of HIIT</th>
<th>Number of Staff</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is HIIT feasible (n=6):</td>
<td></td>
</tr>
<tr>
<td>• Definitely feasible</td>
<td>4</td>
</tr>
<tr>
<td>• Some-what feasible</td>
<td>2</td>
</tr>
<tr>
<td>• Not feasible</td>
<td>0</td>
</tr>
</tbody>
</table>
RESULTS – Safety

Serious Adverse Events – life-threatening OR requiring hospitalisation
- None related to exercise intervention

Mild or moderate symptoms with exercise

<table>
<thead>
<tr>
<th>Reported symptoms</th>
<th>Severity</th>
<th>HIIT (n)</th>
<th>MICT (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fatigue</td>
<td>Grade 2 Moderate</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Soreness (muscle/joint/feet)</td>
<td>Grade 2 Moderate</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Shortness of breath</td>
<td>Grade 2 Moderate</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Angina pain (chest/throat)</td>
<td>Grade 2 Moderate</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Feeling light-headed</td>
<td>Grade 2 Moderate</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>12</td>
<td>11</td>
</tr>
</tbody>
</table>
## RESULTS – Exercise Adherence

<table>
<thead>
<tr>
<th>Adherence to intensity &amp; duration</th>
<th>HIIT (n=43)</th>
<th>MICT (n=43)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adherence to exercise protocol</td>
<td>84 ± 19</td>
<td>90 ± 19</td>
<td>0.094</td>
</tr>
<tr>
<td>Average Training RPE</td>
<td>16 ± 1</td>
<td>12 ± 1</td>
<td>0.000</td>
</tr>
<tr>
<td>Peak Training RPE</td>
<td>17 ± 2</td>
<td>13 ± 1</td>
<td>0.000</td>
</tr>
<tr>
<td>Average Training %HRpeak</td>
<td>90 ± 7</td>
<td>74 ± 8</td>
<td>0.000</td>
</tr>
<tr>
<td>Peak Training %HRpeak</td>
<td>95 ± 7</td>
<td>77 ± 8</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Statistical Test = Independent Sample T Test
# RESULTS – Exercise Adherence

<table>
<thead>
<tr>
<th>Completion of exercise sessions</th>
<th>HIIT (n=43)</th>
<th>MICT (n=43)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Completion of sessions (%)</td>
<td>91 ± 14</td>
<td>90 ± 19</td>
<td>0.918</td>
</tr>
<tr>
<td>Average sessions per week</td>
<td>3 ± 1</td>
<td>4 ± 2</td>
<td>0.010</td>
</tr>
<tr>
<td>Total exercise minutes per week</td>
<td>125 ± 59</td>
<td>222 ± 146</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Statistical Test = Independent Sample T Test
SIGNIFICANCE / INNOVATION

Our RPE-based HIIT protocol:

• Overcomes the limitations of HR-based HIIT protocols
• Allows for continual progression of workload
• Can be applied to various exercise modes (TM, bike, rower, cross-trainer)
• Can be implemented in cardiac rehab classes alongside MICT
• Allows for a broader range of exercise goals to be achieved
• Fosters independence with regards to managing exercise intensity
CONCLUSIONS

HIIT improved cardiorespiratory fitness by almost 3-fold compared to MICT.

HIIT was equally feasible and safe compared to MICT.

Exercise adherence was high in both groups.

HIIT is more time efficient for improving fitness.
FUTURE DIRECTIONS

- The FITR Heart Study - 12 Month Follow-Up
- Incorporate HIIT into Australian Cardiac Rehab Guidelines
- Offer guidance to clinicians around HIIT implementation
ACKNOWLEDGMENTS

Wesley Hospital Cardiac Rehabilitation

TEAM – University of Queensland
• Dr David Holland, MBBS, PhD
• Dr Shelley Keating, PhD
• Dr Michael Leveritt, PhD
• Professor Jeff Coombes, PhD

FUNDING
• Wesley Medical Research
• NHMRC Postgraduate Scholarship