Ramping up Stroke Rehabilitation using Aerobic Exercise

Liam P Kelly
PhD(c), MSc, CSEP-CEP
Discuss the importance of moderate to vigorous intensity aerobic exercise during stroke recovery

Describe and highlight results from 3 studies conducted through our stroke rehabilitation unit at the LA Miller Center in St, John’s
Stroke survivors have very low levels of aerobic fitness

\[ \text{VO}_{2\max} (\text{ml min}^{-1} \text{ kg}^{-1}) \]

- ACSM
- ADL's
- 1995
- 2013
Why such low aerobic fitness?

Premorbid PA levels

Neuromotor impairment

What about the inpatient environment?
Stroke hospitalization rate by midlife cardiorespiratory fitness (METs) among the Cooper Center Longitudinal Study participants.

Why such low aerobic fitness?

Premorbid PA levels

Neuromotor impairment

What about the inpatient environment?
Parallels between motor recovery and aerobic fitness

Recovery after stroke—the first 3 months


Why such low aerobic fitness?

Premorbid PA levels

Neuromotor impairment

What about the inpatient environment?
Study 1

Question: how much moderate to vigorous intensity aerobic exercise is currently offered during inpatient stroke rehabilitation and does the intensity / volume increase over time?
Research design

• Prospective cohort
• Consecutive sampling over 3 month period
• Admission week: observation 24 hrs. / day 7-day
• Discharge week: observation 24 hrs. / day 7-day
Outcome measures:

1. Physical activity log (PAL)
2. Actiheart (15 sec epochs: activity counts, HR, and metabolic equivalents (METs))
## Results

<table>
<thead>
<tr>
<th>Admission / Discharge</th>
<th>n = 19 / n = 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>7 females; 12 males</td>
</tr>
<tr>
<td>Age</td>
<td>68.2 ± 9.8 (48-88)</td>
</tr>
<tr>
<td>Type of stroke</td>
<td>2 hemorrhagic; 16 ischemic</td>
</tr>
<tr>
<td>Days since stroke</td>
<td>38.8 ± 33.4 (16-150)</td>
</tr>
</tbody>
</table>
Admission Week
Average time spent by participants on activities during weekdays

- Rest: 21%
- ADL: 13%
- Leisure: 18%
- PT: 40%
- OT: 3%
- Other Therapies: 3%
- Miscellaneous: 1%
Average time spent by participants on activities during weekends

- Sleep: 41%
- Leisure: 27%
- ADL: 11%
- Miscellaneous: 21%
- Rest: 0%
Discharge Week
Discharge week

Average time spent by participants on activities during weekdays

- Rest: 17%
- ADL: 42%
- Leisure: 12%
- PT: 1%
- OT: 3%
- Other Therapies: 4%
- Sleep: 21%
- Miscellaneous: 0%
## Summary

<table>
<thead>
<tr>
<th>Therapy per week (hours)</th>
<th>% Sedentary</th>
<th>Average MET</th>
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<tbody>
<tr>
<td>PT</td>
<td>3.87 (1.16)</td>
<td>61.57 (36.63)</td>
</tr>
<tr>
<td>OT</td>
<td>3.26 (1.04)</td>
<td>76.83 (28.74)</td>
</tr>
<tr>
<td>Other</td>
<td>1.53 (1.47)</td>
<td>79.65 (28.59)</td>
</tr>
<tr>
<td>Totals</td>
<td>~9</td>
<td>~73</td>
</tr>
</tbody>
</table>

lpkelly@mun.ca
Key Points

1. Very little activity could be considered moderate-to-vigorous intensity aerobic exercise and no progression observed.

2. Large blocks of sedentary time in the evening and on the weekend, which could be a good target to add aerobic exercise.

3. The intensity of rehabilitation is insufficient to increase cardiorespiratory fitness and the inpatient environment may even contribute to the physical deconditioning observed in stroke survivors.
Missed opportunity?

Four birds with one stone? Reparative, neuroplastic, cardiorespiratory, and metabolic benefits of aerobic exercise poststroke

Michelle Ploughman and Liam P. Kelly
Poor aerobic capacity creates a ceiling for neuromotor recovery

High volume and intensity of task-specific exercise needed to optimize neuroplastic changes...
Barriers for Aerobic Exercise

AE can target multiple outcomes during stroke recovery, however, access to this potent intervention is limited

[time | equipment | assessment]
## Barrier #1: Time

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Need to add 6-hr of task specific training each week

Need to add > 1.5-hr aerobic exercise training each week
Barrier #2: Equipment
Barrier #3: Assessment

1. Contraindication to aerobic exercise training
   * Cardiovascular | respiratory | Metabolic
   * Neurological | cognitive
   * Orthopedic

2. Exercise prescription and outcome assessment
   * $\text{VO}_2\text{max}$ | Maximal heart rate | peak power output
   * 40 – 60 % heart rate reserve
<table>
<thead>
<tr>
<th>Signs and symptoms</th>
<th>Contraindications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Myocardial infarction</td>
<td>Acute myocardial infarction</td>
</tr>
<tr>
<td>Angina</td>
<td>Unstable angina (not controlled with medication/intervention)</td>
</tr>
<tr>
<td>Cardiac arrhythmias</td>
<td>Uncontrolled cardiac arrhythmias causing symptoms or hemodynamic compromise</td>
</tr>
<tr>
<td>Resting ST segment displacement</td>
<td>&gt;1mm displacement in more than one lead</td>
</tr>
<tr>
<td>Heart failure</td>
<td>Uncontrolled symptomatic heart failure</td>
</tr>
<tr>
<td>Aortic stenosis</td>
<td>Symptomatic severe aortic stenosis</td>
</tr>
<tr>
<td>Large vessel intracranial stenosis</td>
<td>Severe stenosis</td>
</tr>
<tr>
<td>Aortic dissection</td>
<td>Acute aortic dissection</td>
</tr>
<tr>
<td>Myocarditis/pericarditis</td>
<td>Suspected or known acute myocarditis or pericarditis</td>
</tr>
<tr>
<td>Hypertension</td>
<td>Resting SBP &gt;200 mmHg or resting DBP &gt;110 mmHg</td>
</tr>
<tr>
<td>Pulmonary embolus or infarction</td>
<td>Acute pulmonary embolus or pulmonary infarction</td>
</tr>
<tr>
<td>Metabolic diseases</td>
<td>Uncontrolled diabetes, thyrotoxicosis, or myxedema</td>
</tr>
<tr>
<td>Acute systemic infection</td>
<td>Accompanied by fever, body aches, or swollen lymph glands</td>
</tr>
<tr>
<td>Impaired cognitive function</td>
<td>Only if inability to understand risks associated with exercise and/or to express pain or distress presents a safety concern</td>
</tr>
<tr>
<td>Dysphasia</td>
<td>Inability to understand risks associated with exercise and/or to express pain or distress</td>
</tr>
<tr>
<td>Emotional distress/psychosis</td>
<td>Significant emotional distress</td>
</tr>
<tr>
<td>Dizziness</td>
<td>Severe motion-induced dizziness/vertigo</td>
</tr>
<tr>
<td>Arthritis</td>
<td>Severe pain on weight bearing or exercise</td>
</tr>
<tr>
<td>Seizures</td>
<td>Uncontrolled seizure disorder</td>
</tr>
</tbody>
</table>
Stress Testing?

- AEROBICS guidelines
  - Not necessary if patient has a normal resting ECG and target intensity < 45% HRmax (220 – age, beta blockers)
  - Recommended for exercise intensities beyond 45% of HRmax
GXT Protocols

- Exercise prescription and monitor changes
- Rhythmical movement incorporating large muscle mass
- Monitor hemodynamic response
- Submaximal vs maximal
- Field tests (e.g. 6 MWT)
Study 2

**Question:** can task-oriented exercise be structured in such a way to meet AE training guidelines for stroke survivors (≥ 40% Oxygen uptake reserve for 20 min) without the use of ergometers or other specialized equipment?
Study design

• Cross-sectional study (convenience sampling)

• Participants: N = 10 (3F) chronic (>6months) stroke

• Protocol:
  • Day 1: Demographic information and maximal GXT (\(\dot{V}O_{2\text{max}}\))
  • Day 2: seated rest (10), intermittent functional exercise (30), seated rest (10)

• Primary outcome: attainment of minimum training criteria (i.e. \(\geq 40\%\) of \(VO_{2R} \mid HRR \mid HRR_{\text{pred}}\))
Intermittent Functional Training (IFT)

Key points

• Sufficient workloads can be maintained during IFT to achieve the minimum threshold to be considered moderate intensity AE in chronic stroke

• May help to overcome barriers to aerobic exercise training in stroke survivors
  • No specialized equipment needed
  • Time: incorporates task oriented training
  • Progression based on difficulty of task
Study 3

• Can sufficient workloads be maintained over a 10-week period using the intermittent functional training paradigm?
• Dose IFT lead to clinically meaningful changes in aerobic fitness and cardiovascular risk
Experimental design

• Pilot RCT with a 3-month follow-up period

• 40 chronic stroke survivors (follow 2-step commands and walk 20 m)

• Aerobic exercise interventions (30 sessions over a 10-week period)
  • Treadmill aerobic exercise training (T-AET)
  • Intermittent functional training (IFT)

• Main outcome measures
  • Maximal oxygen uptake (assessed on TBRS)
  • Cardiac Risk (C-reactive protein, Cardiac Risk Score)
IFT (HR 30-50 bpm above resting)
T-AET 45-60 % HRR
Results
Screened (n=49)

Eligible & randomized (n=40)

Dropout prior to intervention
  T-AET (n=2); IFT (n=1)

Dropout during intervention
  T-AET (n=5)

T-AET (n=13); IFT (=19)
<table>
<thead>
<tr>
<th>Characteristic</th>
<th>T-AET</th>
<th>IFT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>61 (9)</td>
<td>68.4 (9)</td>
</tr>
<tr>
<td>Sex</td>
<td>11M 4F</td>
<td>13M 6F</td>
</tr>
<tr>
<td>Months since stroke</td>
<td>26 (14)</td>
<td>39 (32)</td>
</tr>
<tr>
<td>Type of stroke Ischemic/Hemorrhagic</td>
<td>14/1</td>
<td>12/7</td>
</tr>
<tr>
<td>Stroke severity (NIHSS) #&gt;5/15</td>
<td>9/0</td>
<td>7/2</td>
</tr>
<tr>
<td>Chedoke Impairment (Leg) &lt;=6</td>
<td>13 (87%)</td>
<td>15 (74%)</td>
</tr>
<tr>
<td>Walking velocity</td>
<td>65.1 (26.8)</td>
<td>67.2 (37.7)</td>
</tr>
<tr>
<td>Maximal oxygen uptake (VO2max)</td>
<td>15.8 (4.6)</td>
<td>16.3 (4.6)</td>
</tr>
<tr>
<td>Co-morbid conditions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Hypertension</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>Diabetes</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Dyslipidemia</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Cardiovascular disease</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Kidney Disease</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Myocardial infarction</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>
Target Training Zones

Heart Rate Reserve (%)
Maximal Oxygen Uptake (ml kg\(^{-1}\) min\(^{-1}\))

Participant Number

Intermittent Functional Training (IFT)
## Cardiac Risk

<table>
<thead>
<tr>
<th>Parameter</th>
<th>T-AET</th>
<th>IFT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
</tr>
<tr>
<td>Triglycerides</td>
<td>1.25 (0.35)</td>
<td>1.19 (0.29)</td>
</tr>
<tr>
<td>Cholesterol</td>
<td>3.51 (1.00)</td>
<td>3.49 (1.10)</td>
</tr>
<tr>
<td>HDL</td>
<td>1.11 (0.25)</td>
<td>1.13 (0.30)</td>
</tr>
<tr>
<td>Systolic BP</td>
<td>129 (18)</td>
<td>124 (16)</td>
</tr>
<tr>
<td>Diastolic BP</td>
<td>73 (11)</td>
<td>69 (20)</td>
</tr>
<tr>
<td>CRS</td>
<td>7 (14)</td>
<td>4 (14)</td>
</tr>
</tbody>
</table>
CRP (mg L⁻¹) vs. Time (Pre, Post, Fup)

- **T-AET**
- **IFT**

— CRP levels variability over time in different conditions.

† sig different from Pre, * sig different from Post; # sig different from Fup
**Key points**

- Chronic stroke were able to maintain moderate levels of aerobic exercise intensity throughout the 30 sessions of IFT.
- Retain their ability to improve their aerobic fitness and reduce cardiovascular risk through aerobic exercise.
- T-AET seems superior to IFT at increasing $\text{VO}_{2\text{max}}$, however, both protocols caused clinically meaningful changes.
- Participants were more willing to participate in IFT.
Conclusions

• Current inpatient rehab is not intense enough to increase cardiorespiratory fitness and may even contribute to the level of deconditioning

• Poor cardiorespiratory fitness limits participation in rehabilitation and may even contribute to a ceiling for neuromotor recovery

• Innovative ideas are needed to increase the aerobic exercise demands throughout the continuum of stroke care
Target Training Zones

Heart Rate Reserve (%)

T-AET  IFT

lpkelly@mun.ca
Altitude training to break the recovery plateau after stroke
Acknowledgments

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