Strength and Cardiovascular Training Post-Stroke: Applying the Evidence, Part 2 of 2

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Part 2 Learning Objectives
Upon completion of this session, you will be able to:
• Identify the relationships between cardiovascular fitness, quality of life, and functional mobility in patients post stroke, as per reported by the evidence.
• Describe and appropriately select the basic objective measures of the cardiovascular system for evaluation of patients post stroke (i.e. VO2 peak, 6 minute walk test).
• Appropriately select when to perform a submaximal exercise test, as well as describe how to perform various submaximal exercise tests in patients post stroke.
• Discuss and develop various treatment plans to improve cardiovascular function, and calculate appropriate treatment parameters for individuals with stroke across the continuum of care.

Session Outline
• Perspective on Stroke: A Cardiovascular Issue
• Exercise: What does that actually mean?
• Challenges, Barriers, Risks, oh my!
• We might have to do some math…
• Exercise Matters
• What’s the right prescription?
• Let’s apply it!

Cardiovascular (CV) Training POST Stroke
Let’s have a conversation about traditional Neuro PT Practice and the rehabilitation plans post stroke

ICF
Health Condition
Body Structure/Function
Activity
Participation
Personal Factors
Environmental Factors
Stroke Rehabilitation

- Focus is often on:
  - Walking recovery
  - Functional task specific training
  - Fall reduction
  - Forced use of the affected extremity

Focus is placed primarily on the recovery of the Neuromuscular system.

Risks for Primary (and secondary) Stroke

- Non Modifiable Factors
  - Age, gender, genes
- Modifiable
  - Behavior, sedentary lifestyle
  - Health choices: smoking, food intake, exercise
  - Cardiorespiratory fitness
  - Higher stroke severity is strongly correlated with sedentary behavior

Survivors of mild severity Stroke spend 81% of day sedentary (Tieges et al 2014)
  - Despite relatively good functional recovery

Effect of Stroke on the Systems

- Increased risk for fatigue
  - Chronic fatigue
  - Exertional Fatigue
- Negative cycles created and reinforced:
  - Motor impairments limit function, increase energy expenditure
  - Functional limitations limit activity, then increases risk for fatigue, thus more fatigue generated and more impaired CV and strength systems
- Mental Health
  - Increased risk of Depression
  - Will impact compliance and motivation with an exercise program

Exercise IS the NEW medicine

- Cardiorespiratory adaptation IS feasible and does occur in stroke population
- Subacute and Chronic populations benefit
- Sedentary adults gain 10-30% after training vs Cardiac Rehab 13-15% vs Stroke ~12.5%
- Modest gains, 6-8% can have profound impact on performance of ADL.
**Physical Fitness Defined:**
A set of measurable health and skill related attributes including: ability to carry out daily activities without undue fatigue.

**Physical Activity Defined:**
“Any bodily movement produced by skeletal muscles that results in energy expenditure”
*therapeutic activities*

**Exercise Defined:**
“A subset of physical activity that is structured, planned, and repetitive and has a final or intermediate objective for the improvement or maintenance of physical fitness”. Exercise is intentional.
*therapeutic exercise*

**Physical Therapists are Movement Specialists:**
But do/should we define ourselves as Exercise Specialists?

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**Goals of Exercise Training**
- Prevent secondary complications after acute stroke:
  - Learned disuse
  - Metabolic dysfunctions of the multiple organ systems
- Regain pre-stroke levels of activity as soon as possible
  - Interventions for motor recovery should include strength and CV training (VA/DoD CPG, 2010)
  - Increase in submax exercise tolerance improves ADL function
- Lower energy cost during functional mobility
- Self-management: confidence, empowerment
  - Physical activity counseling intervention plan (Joubert et al, 2009)

**Behavior of Exercise: Adherence Limitations**
- Self-efficacy
  - Family involvement may play a key role (Galvin 2011)
- Behavior modification/change required
- Trans-theoretical model (Prochaska, 1997)
  - Do you consider not doing your exercise to be a problem?
  - Are you bothered by not doing the exercise?
  - Are you interested in doing the exercise?
  - Are you prepared to do something to start doing the exercise?

We cannot ignore the behavioral component that exists within the practice of physical therapy, which may be our biggest barrier

**Challenges in our Practice**
- Limited time in therapy: Priorities
- Mode of aerobic exercise
- Access to equipment
- Limited knowledge of therapist regarding:
  - Testing capacity of cardiorespiratory fitness
  - Implementing and progressing programs
- Physical limitations
- Risk of a cardiovascular event, or second stroke
- Social Support

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**Considering the Risks of Exercise Post Stroke**
- Secondary Stroke
- Myocardial Infarction
- Muscular Injury
  *Benefits of exercise outweigh the risks!*

**Evidence Supports CV Exercise**
- Moderate Intensity Steady State Aerobic Exercise (Gordon, 2013; Pang, 2013; Austin, 2014)
- HIIT Protocols (Globas, 2012; Boyne 2016)
- Feasibility/Safety (Tang, 2010; Zehr 2011; Burr, 2012; Globas 2012; Marzolini, 2012; Billinger 2015)
- Neuro Protection (Mang, 2013; Austin, 2014)

**Considering the Risks of Exercise Post Stroke**
- Limited evidence regarding sentinel events during exercise tolerance testing (Zehr, 2011; Burr 2012)
- 75% survivors have concomitant CV disease (Billinger, 2014)

**Properties of Lomaglio, M and Perry, L: Not to be copied without permission**
Evidence: Chronicity Specific

- **Acute**: A VERT study: “early mobilization” (Bernhardt, 2008)
  - Begin physical activity within 24 hrs post stroke
  - Associated with improved functional outcomes 3 months post
- **Subacute**: Aerobic Exercise Training
  - 40-59% HRR, moderate (Billinger, 2014)
  - Robot assisted, cycle ergometers, TM with BWS, VR (Chang, 2009; Laver, 2011; Tang, 2012;)
  - Varying time frames of duration/ fx, dependent on LOS
- **Chronic**: (Herbert, 2015)
  - Consider High intensity interval training
  - Add resistance training
  - Minimum: 8 weeks, 3x/week, 20 minutes

AHA/ASA Physical Activity and Exercise Recommendations

<table>
<thead>
<tr>
<th>Vo2 reserve</th>
<th>HRR</th>
<th>Max HR</th>
<th>BORG (6-20)</th>
</tr>
</thead>
<tbody>
<tr>
<td>40-70%</td>
<td>40-70%</td>
<td>55-80%</td>
<td>11-14</td>
</tr>
</tbody>
</table>

How do we Measure our Patient’s CV Endurance?

- **Body Structure/Function**
  - Blood pressure
  - SpO2
  - Heart Rate
    - Heart Rate Reserve (HRR) to determine low to moderate intensity
    - Subjective complaints, i.e. angina, fatigue, etc.
    - Measuring Effort
      - BORG: 12 to 14 on the Borg Scale suggest a moderate level of intensity of physical activity (Ammann et al, 2014)

Heart Rate Calculations

**STEP 1**: Calculate Predicted Max Heart Rate (Mx HR)

\[ = 206.9 - (0.67 \times \text{age}) \]

**NOTE**: Predicted Max HR if on Beta Blocker

\[ = 164 - (0.7 \times \text{age}) \]

**STEP 2**: Calculate Heart Rate Reserve (HRR)

\[ = \text{Max HR} - \text{HRrest} \]

**STEP 3**: Calculate Target Heart Rate (THR)

\[ = \text{HRrest} + (\% \text{age of HRR; i.e. desired training intensity}) \]

**STEP 4**: Determine Intensity you will apply

<table>
<thead>
<tr>
<th>Intensity</th>
<th>HRR (relative)</th>
<th>HR Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>60-84%</td>
<td>56-76%</td>
</tr>
<tr>
<td>Moderate</td>
<td>40-59%</td>
<td>64-76%</td>
</tr>
<tr>
<td>Vigorous</td>
<td>60-84%</td>
<td>77-93%</td>
</tr>
</tbody>
</table>

Heart Rate Calculations

**STEP 1**: predicted Mx HR*

\[ = 206.9 - (0.67 \times \text{age}) \]

\[ = 206.9 - (0.67 \times 77) = 155.31 \]

**STEP 2**: HRR

\[ = \text{Max HR} - \text{HRrest} \]

\[ = 155.31 - 85 = 70.31 \]

**Step 3**: THR

\[ = \text{HRrest} + \% \text{age of HRR; i.e. desired training intensity} \]

\[ = 85 + (0.39 \times 70.31) = 112 \]

\[ = 85 + (0.40 \times 70.31) = 113 \]

\[ = 85 + (0.59 \times 70.31) = 126 \]

\[ = 85 + (0.60 \times 70.31) = 127 \]

\[ = 85 + (0.89 \times 70.31) = 148 \]

*Remember to change the predicted Max HR formula if on a Beta Blocker

A patient is 77 years old, Resting heart rate is 85 bpm. He is NOT on a Beta blocker

- Calculate the Heart Rate Reserve (HRR) and Target Heart Rate (THR) range using HRR for low (<40%), moderate (40-59%), and vigorous (60-89%) activity.

Heart Rate Calculations

**STEP 3**: Calculate Target Heart Rate (THR)

\[ = \text{HRrest} + (\% \text{age of HRR; i.e. desired training intensity}) \]

**STEP 4**: Determine Intensity you will apply

Intensity | HRR (relative) | HR Max |
-----------|----------------|--------|
Low        | 60-84%         | 56-76% |
Moderate   | 40-59%         | 64-76% |
Vigorous   | 60-84%         | 77-93% |
Measuring CV Capacity

- Graded Exercise Tolerance Testing with ECG Recommended (Billinger, 2014)
  - Bruce Protocol: Treadmill
  - YMCA Protocol: Cycle Ergometer
  - Total-body recumbent stepper Protocol (Billinger, 2008)
    - [Video](https://youtu.be/wZe9TJQVc1Q)

- Non-graded Exercise Tolerance Test (ETT)
  - 6 Minute Walk Test

- Graded ETT Guides prescription of intensity as a % Vo2 reserve or of Max Heart Rate

Estimating VO2 max via 6MWT (Burr et al, 2012)

- You will need:
  - Pt’s weight in kg and age in years
  - Distance walked in meters
  - Resting HR in bpm
  - Below formula:
    \[ \text{VO2 max} = 70.161 + (0.023 \times 6\text{MWT}) - (0.276 \times \text{weight}) - (6.79 \times \text{sex}) - (0.193 \times \text{resting HR}) - (0.191 \times \text{age}). \]
  - Sex: m = 0, f = 1

Note: associations b/w 6MWT and peak VO2 are low to moderate

Contraindications for Exercise

- Medical instability of diabetes, angina, arrhythmias
- Uncontrolled HRrest, >100 bpm or <50 bpm
- Resting Systolic BP >200 mmHg or <90mmHg
- Resting Diastolic BP >110mmHg
- Oxygen Saturation < 90%

ACSM Cardiovascular Guidelines: Older Adult

- 30 minutes minimum per session of Moderate intensity, 5 days/wk (150mins/wk) OR
- 20 minutes minimum per session of vigorous intensity, 3 days/ wk (60mins/wk) OR
- Multiple shorter sessions are also acceptable (at least 10min bouts)

AHA/ASA Cardiovascular Guidelines: Stroke

- 20-60 minutes per session (or multiple 10 min sessions) at 40-70% of HRR, 3-5x/week

Prescription Considerations

- Aerobic intensity: %VO2, %Heart Rate Reserve, BP
  - FITT Principle (Billinger, 2015)
- Neuromuscular intensity: Speed, Watts, reps/time: Rate
  - Intensity within this system promotes neuroplasticity
  - Aerobic intensity reflects NM intensity (Hornby, 2011)
- Intensity leads to greater production of Brain Derived Neurotrophic Factors (BDNF) (Mang 2013)
**BDNF - Brain Derived Neurotrophic Factor**

- Neurotrophin family
- Involved in
  - Neuroprotection
  - Neurogenesis
  - Neuroplasticity
- Is a key mediator of motor learning and “priming the brain” for neuroplasticity
- Secreted by 2 mechanisms: constitutive and activity dependent pathways
- Evidence that 30 min at 60% max HR is effective for increasing BDNF in pts with chronic disorders

**Individualized Prescription**

- Complete Medical History
- Neurological complications examination including balance, neuromuscular function, cognition and behavior
- Graded Exercise Testing with ECG, if feasible
  - Submaximal Testing
  - If neither, exercise is “not to be delayed” (Billinger, 2014)

**Parameters for Dosage: FITT**

- FREQUENCY
  - 3-5 days/week

- INTENSITIES
  - 40-70% HRR
  - 55-80% HRmax

- TIME per session
  - 20 minutes, 30 minutes, 60 minutes (pending intensity)
  - Multiple 10 minute bouts (for prior sedentary, greater fatigability)

- TYPE: Steady State versus Interval Training

**Alternative forms to Deliver Aerobic Training**

- TM with or without BWS: Adapting for walking impairments, limited gait speed
  - 2mph at 3.5% grade = 3 METS or low to mod intensity exercise, at 7% grade = 4 METS etc
  - 3mph at 2.5% grade = 4 METS or mod intensity
- Stroke Adapted Cardiac Rehab Models
- Virtual Reality Gaming
- Robot Assisted
- Seated cycle ergometers
- Recumbent bike
- Nu step

**Aerobic Exercise and Function**

Using Aerobic Exercise to Improve Health Outcomes and Quality of Life in Stroke: Evidence-Based Exercise Prescription Recommendations

**Effects of Aerobic Conditioning on Individuals Post-Stroke: What Is the Evidence?**

Physical Activity and Exercise After Stroke

Potential Contributions of Training Intensity on Locomotor Performance in Individuals With Chronic Stroke

**Multi-dimensional examination process**

**NEXT**
Discussion of the evidence: what say you?

Barriers to application?
- Time
- Education
- Access
- Reimbursement
- Concerns for safety, sentinel events

Support for application?
- Feasible
- Safe: Benefits outweigh risks
- Foundational principles of exercise
- Evidence supports implementation across the continuum
- Can impact motor performance outcomes

Clinical Cases/ Lab/ Discussion

CASE 1: A 65 yo male referred to outpatient PT 6 mo post R MCA stroke. History of 2 falls and HTN. MD clearance for vigorous exercise.
BP: sitting 135/87, standing 131/85; HTN controlled with Atenolol. Resting HR: 75 bpm
Gait: mod L with SPC for household distances. Mod R with SPC on level terrain, supervision / sitting 135/87, Standing 133/85; HTN controlled with Atenolol

CASE 2: A 66 yo female is 3 weeks status post Right ACA stroke and is being seen in an inpatient rehab. The patient is medically stable. The patient has a history of HTN and previous MI 6 years prior. The patient completed a cardiac rehab program post MI.
BP: sitting 125/82, standing 118/77, HTN controlled with Lisinopril (Indapamide), Resting HR: 88 bpm
Gait: mod R for 130 ft. The pt can initiate swing but with decreased force production and assist for initial contact. Pt has reduced knee flexion to 30 d during initial swing. Stance requires stability assist at both knee and hip.

BERG: 28/56 (high fall risk) Fugl-Meyer Motor Function: UE 35/66, LE: 15/34
1. Will you perform an exercised tolerance test? If yes, what protocol?
2. Calculate the pt’s age predicted Max HR. Calculate the Heart Rate Reserve (HRR).
3. Calculate low, moderate and vigorous ranges using HRR

Functional strength testing:
Sit to Stand (18in chair): pt accomplishes task with CGA to Mina with heavy reliance of the less affected UE & LE throughout. The patient is unable to complete a 6th repetition without physical lifting assistance.
Stair climbing: Pt requires UE assist for climbing a 6” step with the more affected LE. Patient is able to repeat this 4 times with good form and no more.

Key References and Resources
Full list available in handouts

Position Statements:

Critical Analysis/ Systematic Reviews