Getting to the Heart of Stroke Rehab and Mobility - Considering Cardio
Combined Sections Meeting, February 4-7, 2015, Indianapolis, IN

Presenters:
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- Sandra A Billinger, PT, PhD, FAHA  Department of Physical Therapy and Rehabilitation Science, University of Kansas Medical Center
- Pierce Boyne PT, DPT, NCS  Neural Excitability, Therapeutics and Recovery (NET Recovery) Laboratory, Department of Rehabilitation Sciences, University of Cincinnati
- Kari Dunning, PT, PhD  Neural Excitability, Therapeutics and Recovery (NET Recovery) Laboratory, Department of Rehabilitation Sciences, University of Cincinnati

Objectives: By completion of this session, you will be able to:
1) Outline key benefits of aerobic exercise and physical activity for persons with stroke
2) Discuss guidelines for exercise testing and prescription for persons with stroke
3) Identify strategies (screening, testing, treatment and models of care) for implementing exercise and physical activity into your practice

Outline:
- Introduction
- Evaluation and Exercise Prescription
- Treatment Intensity
- Patient perspective, Practical Treatment Ideas & Models of Care
- Panel Discussion

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Marilyn MacKay-Lyons, PT, PhD – Introduction
School of Physiotherapy, Dalhousie University, Nova Scotia, Canada
Disclosure: I do not have financial interest or affiliation with any organizations that could be perceived as a real or apparent conflict of interest in the context of the subject of this presentation.

The perfect storm
- Increasing age + increased survival → multiple chronic diseases + disproportionate burden of care.
- Leading cause of death has changed from infections to chronic diseases.
- Cardiovascular disease is the greatest health risk worldwide.
- Heart disease and stroke leading cause of death over 65 year old.
- Globally, stroke #1 cause of adult disability.

Cardiac involvement post stroke
- ~75% of patients post-stroke have cardiac disease (Roth, 1993).
- Stroke & cardiac disease share the same risk factors (Wolf, 1999).
• Cardiac disease is the leading cause of death in stroke survivors (Roth, 1994).
• Physical activity is an independent predictor of stroke risk (Lee, 2003).

Cardiovascular fitness post stroke
• Stroke survivors are least active of all groups with chronic conditions (Sawatzky, 2007)
• Most people post-stroke are deconditioned (MacKay-Lyons, 2004).

Aerobic Exercise Post-Stroke: Benefits
• Compelling evidence of numerous benefits of aerobic training post-stroke.
• Quality of Life – C
• Balance & Mobility – B
• Vascular risks – B
• Muscle strength – B
• Employment status – C
• Bone health – B
• Exercise capacity – A
• Cognition – C
• Mood/Affect – C

Current practice
• Intensity of usual care stroke rehabilitation is inadequate to induce a cardiovascular training effect (MacKay-Lyons, 2002; Kuys, 2006).
• Survey (Doyle, 2013) of 155 Canadian neuro-PTs
  • 88% agreed that “aerobic exercise should be a component of neuro-rehabilitation”
  • 77% prescribed aerobic exercise
  • 2% used stress tests in screening
  • Overground walking most common mode
  • 3% calculated target heart rate to establish exercise intensity
  • 25% monitored blood pressure

Why?
• Aerobic exercise after stroke often requires behavior change
• Our nervous system is designed to Minimize energy expenditure & Maximize comfort

An Alternative Perspective: Exercise is a ‘normal’ behavior…..

Health behaviors are incredibly difficult to change

Compromised self efficacy for exercise after stroke
• Self efficacy = confidence in ability to do a specific activity in a specific circumstance in the face of specific barriers and facilitators.
• Important mediating factor re exercise behavior after stroke (Morris, 2012).

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• Correlated with involvement in physical activity after stroke.

Challenge Compromised self efficacy
• Self efficacy is modifiable through intervention (e.g., Cumming, 2011).
• In-patient aerobic training post-stroke did not increase physical activity 6 months post-discharge. Patients did not feel confident. Must “help patients identify and address individual barriers to physical activity participation” (Brown, 2014).
• ExStroke Pilot Trial - Repeated encouragement/instruction by PTs about being physically active did not result in increased physical activity (Boysen, 2009).

Health Behavior Models
• Social Cognitive Theory
• Self-Determination Theory
• Theory of Self Efficacy
• Theory of Planned Behavior*
• Transtheoretical Model*

Transtheoretical Model (Stages of Change) (Prochaska, 1997) - 4 basic questions
1. Do you consider not doing your exercises to be a problem? [Problem identification]
2. Are you bothered by not doing the exercises? [Distress – Emotional]
3. Are you interested in doing the exercises? [Desire/intention to change]
4. Are you prepared to do something to start doing the exercises? [Willingness to change]

Challenge - Goal Setting
• Appears to enhance self-efficacy for participation in physical activity after stroke (Morris, 2012).
• Is an important mediator of participation in treadmill training after stroke (Resnick, 2008).
• Integral to self-management.

Challenge – Social Support
• Support from friends and families is a known mediator of changing exercise behavior.
• 91% of patients in a stroke exercise study agreed that family members had a role in motivating the patient to exercise after stroke (Galvin, 2000).

Family-Mediated Exercise (FAME)
• Family involvement in in-patient rehab 35 min/day x 8 weeks ➔ greater walking ability and community integration at 3 months after discharge (Galvin, 2011).
• WHY?? “Gave patients more confidence and experience and reduced caregiver burden…. Structured inpatient program may serve to empower consenting informal caregivers in their future role by teaching them appropriate skills.”

Challenge – Understanding the Patient’s Perspective

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Stroke survivors prefer exercise to be:
- Structured
- Demonstrated to them first
- Done in a group
- Done at a gym or fitness centre
- Done with people with similar life experiences who understand their life situation (Banks, 2012)

Challenge – Limited Therapy Time
- One third of survey respondents had insufficient time available in rehab to increase the ‘dose’ of exercise (Doyle, 2013).
- However, therapists have also been shown to overestimate active time patients post-stroke spent in therapy sessions by 28% & underestimated inactive time by 36% (Kaur, 2012).

Challenge – Mode of ‘Aerobic’ Exercise
- Three quarters of survey respondents used overground walking for aerobic training (Doyle, 2013).
- Patients ~ 1 month post-stroke walked at “speeds well below a level that has meaningful cardiorespiratory health benefits” (e.g., <40% heart rate reserve) (Prajapati, 2013).

Challenge – Neurological Involvement
- About half of survey respondents identified cognitive impairments, physical inability and fatigue as barriers to aerobic training (Doyle, 2013).
- Aerobic training post-stroke is more complicated than with purely cardiac condition:
  - About half of survey respondents identified cognitive impairments, physical inability and fatigue as barriers to aerobic training (Doyle, 2013).
  - About 60% of people post-stroke report excessive fatigue (van Eijsden, 2012).
  - Aerobic training post-stroke is more complicated than with purely cardiac condition:

Summary
- Level A evidence exists regarding the benefits of aerobic exercise post-stroke in some domains and levels B and C in other domains.
- Current doses of aerobic exercise or physical activity are inadequate to drive the vascular adaptations needed to optimize stroke recovery.
- Many challenges exist regarding changing exercise behaviors of people post-stroke.

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Sandra A Billinger, PT, PhD, FAHA - Evaluation and Exercise Prescription after Stroke
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“If exercise could be purchased in a pill, it would be the single most widely prescribed and beneficial medicine in the nation.” - Robert H. Butler

Prescription
- How often do we tell our patients to take their exercise “medicine”
- How much of this “medicine” do we prescribe?
- How many times per day should the “medicine” be taken?
- What type of “medicine”?
- F.I.T.T Principle

Moving Forward
- Implement more evidence-based approach:
  - Screen to ensure safety for aerobic exercise
  - Exercise Testing
  - Exercise prescription
  - Monitor safety


Exercise Intensity for Cardiorespiratory (CR) Fitness
- Most challenging task in designing the exercise program
  Requires individualization
  Monitoring/supervision
  - Expressed as a percent of aerobic capacity
  VO₂ max/peak
  Age adjusted maximum heart rate (AAMHR)
  - Monitor intensity during exercise
  HR, VO₂ (via METS), RPE
  - HR
  THR (% of HR max or AAMHR)
  0.65(220-age)
  Karvonen formula
  0.65(HRmax - HRrest) + HRrest
  Keep in mind diagnosis with exercise prescription
  Low % EF, severe pulmonary disease, co-morbidities
  - METS
  Can use % of METS from maximal GXT for exercise prescription
  Predicted values from submax exercise test

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• **RPE**
  Educate on RPE so pts become familiar with the feeling of exertion during exercise at appropriate THRR
  - RPE of 12 or 13 (somewhat hard) corresponds to ~ 60% of HRR
  - RPE of 16 (hard) ~85% of HRR
  - If using the 6-20 scale, adding a zero (0) to the RPE scale, corresponds to the working HR
    - Example: RPE of 13 corresponds to 130 bpm
• **Talk Test**

Exercise after stroke

How do we help our patients?
• When
• How
  - Exercise Testing
  - Exercise Prescription
  - FITT Principles
    - Frequency, Intensity, Time, Type

When?
• Screening (AHA Physical Activity and Exercise Recommendations, 2014; AEROBICS Best Practice Recommendations, MacKay-Lyons)
  - Medically stable (neurologic, cardiopulmonary)
  - Consider hemodynamic response
  - Consensus that out of bed activity should begin early but no information on how early

Early activity/exercise
• Early “exercise”
  - How is early defined?
  - No protocols for the F.I.T.T principle
  - Limited data from smaller trials

Challenges of exercise for stroke
• Under utilized by healthcare professionals
• Gap in transitions of care
  - Rehab to community
  - Uncertainty
  - Where to exercise
  - How often, how much, how long, type?
  - Safety

FITT principle and Stroke
• 37 Randomized trials in subacute and chronic stroke (Amman, 2014)
• Lack of consistent reporting on F.I.T.T principle
  - Frequency and type (of modality) = 94.6%
  - Intensity = 59%**
  - Time = 91.9%

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Exercise after stroke – How?
Exercise Testing and Prescription
• FITT Principles
  Frequency
  Intensity
  Time
  Type
  • Peak exercise testing
    Recommended before exercise (Billinger, 2014)
    Physician determines unnecessary
    • Walking or exercise <40%HRR (AEROBICS)
  • Submaximal exercise testing
  • Functional testing

Submax Testing
  – TM
  Bruce protocol
    – Cycle
  YMCA cycle protocol
  Astrand-Rhyning
    – Over ground protocols
  Rockport walk test
    – Recumbent stepper
      http://pt.kumc.edu/research/georgia-holland-lab/reach-lab.html
      https://www.youtube.com/watch?v=wZe9TJQVc1Q
    – Recumbent stepper (Billinger, 2012)
    – YMCA protocol (ACSM, Exercise Testing and Prescription, 2014)
      – Modified the protocol for recumbent stepper

TBRS Submaximal Exercise Test
• Older adults (Herda, 2014)
  60-80 years of age
  Heart disease, Parkinson’s disease, stroke, diabetes, thyroid, dyslipidemia, knee OA
  Community ambulators
  Same prediction equation
  Performed max test on TM

Reliability of TBRS
• 50 participants
  18-70 years of age
  TBRS submax completed on 2 separate days
  24 hours- 5 days
  ICC (2,1) = 0.97
  Bringing participants back 6-8 weeks for follow up
  Max test and submax test
11 participants; $r = 0.91$ (TBRS 49.4; TM 52.4 ml*kg^{-1}*min^{-1})

- Recruiting patients during in-patient rehabilitation

### TBRS Submax and Stroke

- Ten people after stroke (Mattlage, 2013)
- Subacute period of recovery (15 – 124 days)
- $61.2 +/- 4.7$ years
- Fugl-Myer = $100.3/126 +/- 29.3$
- Peak exercise test and TBRS submax
- Strong correlation ($r = 0.80$, $p = 0.006$) between predicted peak VO$_2$ and actual value

### Measures during exercise

- Heart Rate
- Rate of Perceived Exertion
- Blood pressure
- Work
- Watts
- METS (metabolic equivalents)
- Distance walked

### Exercise Prescription Post-Stroke - Aerobic Exercise (Billinger, 2014)

- Frequency
  - 3-5 days per week
- Activity on most days per week
- Intensity
  - 40-75% VO$_2$ peak
- Heart rate (Beta Blockers)
- Time
  - 20-60 minutes (or multiple 10-minute sessions)
- Type

### Evidence for Why We Should Care

- Improved cardiorespiratory fitness (Macko, 2002; Macko, 2004; Tang, 2009; Billinger, 2012; Marzolini, 2014)
- Cognition (Quaney, 2009; Kluding, 2011)
- Vascular health (Billinger, 2012)
- Cardiovascular risk factors (Prior, 2011)
- Walking endurance (Tang, 2009; Billinger, 2012; Marzolini, 2014)

### Summary

- Physical therapists need to consider cardiorespiratory fitness and training
- Evaluate and prescribe exercise

### Evidence-based methods

- Powerful medication

### Improves

- Cardiorespiratory fitness
- Cognition

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Brain health
Vascular health (risk factors)

Thank you!

- APTA & Neuro Section
- REACH laboratory

PhD Students
Anna Mattlage
Jason-Flor Sisante

DPT students
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Treatment Intensity
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- FITT principle
  - Important to differentiate intensity from frequency and time
- Intensity = effort level or work rate
  - Aerobic intensity: heart rate, VO2
  - Neuromuscular intensity: speed, watts, reps/time

- Aerobic intensity reflects underlying neuromuscular intensity (Hornby 2011)
- A challenging intensity is a critical ingredient for both aerobic conditioning and neuroplasticity

Evidence for Neuromuscular Intensity Prescription After Stroke
- Higher rate of movement repetitions during training
  → better motor outcomes after training
  - Gait speed (Rose 2010)
  - Barthel Index, Functional Ambulation Category, Action Research Arm Test (Kwakkel 1999)
• Faster treadmill speed during training
  → better gait outcomes after training
    • Functional Ambulation Category (Pohl 2002)

Summary of Evidence for Aerobic Intensity Prescription After Stroke
• Low Intensity (e.g. <40% HR reserve)
  – Does not require a baseline exercise test (Billinger 2014)
  – Important to address sedentary lifestyle (Manns 2012)
• Moderate Intensity (e.g. 40-59% HR reserve)
• High Intensity (e.g. 60-84% HR reserve)
  – Even greater improvement in aerobic fitness (Lam 2010)

Why might higher intensity be more effective?
Greater physiologic demand to drive adaptation
• Higher neuromuscular intensity
  → greater neuromuscular activation during training (Hornby 2011)
→ greater adaptive neuroplasticity?
  • Faster gait training speed
    → more normal kinematics during training (Tyrell 2011, Lamontagne 2004)
    → more normal muscle activation patterns during training (Lamontagne 2004)
    → more efficient gait during training (Reisman 2009)
    → better learning to improve kinematics, kinetics & efficiency?
  • Higher aerobic intensity
    → greater release of neurotrophic factors during training (Knaepen 2010, Mang 2013 [both non-stroke])
      • Especially BDNF, a key facilitator of neuroplasticity involved with motor learning and cognition (Mang 2013)

High-intensity Interval Training (HIT)
• Bursts of concentrated effort alternated with recovery periods
  – Goal: safely maximize intensity by mitigating fatigue
• Allows separate control of aerobic and neuromuscular intensity
  – Shorter bursts and longer recovery allow ↑ neuromuscular intensity and ↓ aerobic intensity

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• More effective/efficient than moderate intensity
  – Healthy adults
    • 2 RCTs: Greater VO2max improvement with time-matched HIT
    • 3 RCTs: Same physiologic adaptations with up to 76% less time for HIT
  – Persons with heart disease (stable CHD or HF):
    • 6 RCTs: Greater VO2max improvement with up to 53% less time for HIT
    • No adverse events
    • Clinical populations: 2 non-fatal cardiac arrests in 46,364 exercise hours

**HIT in Stroke Rehabilitation (All treadmill based)**
• 2 RCTs in subacute stroke (2 wks – 6 mo post): (Lau 2011, Pohl 2002)
• Significantly greater improvements in gait function than constant speed treadmill walking or PT based on PNF/NDT
• 1 pre-post test study in chronic stroke (Gjellesvik 2012)
  • Significant improvements in aerobic fitness and gait function
• 1 pre-post test study 3-9 months post-stroke (Askim 2013)
  • Significant improvement in walking capacity (6MWT)

**HIT in Chronic Stroke Study**
• Funded in part by a Magistro Family Research grant from the Foundation for Physical Therapy (PI: Dunning)
• **Aim 1:** Optimization of treadmill HIT for chronic stroke
• **Aim 2:** Pilot RCT of HIT vs Moderate-intensity Aerobic Training (MAT)

**HIT Safety Precautions & Monitoring**
• Before training
  – PT evaluation
  – Maximal-effort ECG stress test
  – During training
  – Harness for fall prevention
    • No BWS
  – Individualized speed
  – ECG & BP monitoring
  – Monitoring for signs/symptoms
    • Cardiovascular intolerance
    • Hypotensive response
    • Orthopedic injury

**Optimized HIT Protocol**
• Begin with 60 sec recovery (maximize speed)
  – e.g. 1st 3 sessions

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– Progress to 30 sec recovery (maximize aerobic intensity and step count)
– Still begin each session with 60 sec recovery (allow continued speed progression)
  • e.g. 1st 3 bursts

Pilot RCT: HiT vs Moderate Aerobic Training
• Subjects with chronic stroke and residual gait impairment randomized to HiT or moderate-intensity aerobic training in 2:1 ratio
  – Both treadmill based, 25 min, 3x/week for 4 weeks
  – Clinically feasible volume based on survey
    • Lower volume than previous moderate-intensity studies
• Aerobic fitness assessed by a blinded rater before and after training
  – VO2 at the ventilatory aerobic threshold

Conclusions
• Intensity is a critical variable for both aerobic and neuromuscular adaptation
• HiT is a promising intervention for stroke rehab
  – Further study needed to fully evaluate overall risk/benefit ratio

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**Patient perspective, practical treatment ideas and models of care**

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The client perspective of high intensity
• Qualitative interviews after 4 wks of HiT
• Eight subjects ranging from 40-77 years old and 1-10 years post stroke.
• 4 themes
  – Apprehension
  – Confidence
  – Enjoyment
  – Intensity

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**Practical treatment ideas & Models of care**

Functional circuit training
- Task specific training, Progressive functional strengthening, Cardiovascular training
- Challenge and motivate the client
- Time stations
- Borg perceived exertion
- Examples

Functional circuit training articles
- >6 mo post (Pang 2005; Yang 2006; Mudge 2009; Wevers 2009, systematic review)
- Groups >3 mo post (van de Port 2009; English 2011 systematic review 2011)
- 3-6 mo post (Dean 2000; Salbach 2004; Mead 2007)
- < 3 mo post outpatient (Blennerhasset 2004; English 2007; Verma 2011; van de Port 2012; Dean 2012)
- Inpatient Rehab (Rose 2011)

Start early
- Establish the importance and benefits of exercise – raise expectations
- Teach methods of safe exercise
- Modes & Setting
  - Inpatient rehab – recumbant bike (Tang 2010)
  - Inpatient rehab – leg cycle ergometer (Katz-Leurer 2003)
  - 2 weeks post - adapted physical activity program (Letombe 2010)
  - 11 days post – leg cycle ergometry, treadmill or handbike (Toledano-Zarhi 2011)
  - 22 days post – functional circuit class (Outermans 2010)
  - 1 mo post – treadmill training (w body weight support as needed) (Eich 2004)
  - 2 mo post - recumbant bike (Billinger 2012)
  - 1-4 mo post - leg cycle ergometer (Duncan 2003)

Encourage aerobic exercise across the continuum of care
- Inpatient/outpatient → community-based fitness
- Community exercise/activity programs
- Transitional therapist to trainer system (Rimmer 2013)
  - ACSM certifications: registered clinical exercise physiologist (RCEP) (MS); certified inclusive fitness trainer (CIFT) (BS)
- Example of a partnership program (Rose 2013)
  - Healthcare system and a local fitness center
  - Affordable, safe, accessible, community based program
  - Real life roadmap for program including development, structure and operations

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Adapted Cardiac Rehab for Stroke
• Interprofessional team
• Aerobic exercise, risk factor management
• Feasibility (Tang 2010; Marzolini 2012)
  – Toronto Rehabilitation Institute's Cardiac Rehabilitation and Secondary Prevention Program
  – n38, 3 mo to 9 yrs post stroke
  – 1x/wk 90’ group (1:5) education and supervised aerobic and resistance exercise
    + 4 sessions at home
  – Individualized (e.g. treadmill, overground walking, cycle)
  – Results: ↑VO2 peak and ventilatory threshold

Panel Discussion / Wrap Up
• Overcoming barriers
• The role of stress testing
• Keeping patients safe
• Case studies

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Sandy Billinger references


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**Dunning References**


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