Up the Tempo: Intensity Training in Stroke Rehabilitation

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Objectives

• Attendees will be able to define "high intensity" exercise program
• Attendees will be able to identify indications for use of high intensity training in stroke rehabilitation.
• Attendees will describe the use of high intensity training within stroke rehabilitation.
Benefits of aerobic exercise

- Improved cardiovascular function
- Strengthens the immune system
- Improved memory and executive function
- Increased brain volume (both gray and white matter)
- Improved attention and processing speed
- Decreased depression
Parameters of Exercise Prescription (FITT)

Frequency

**Intensity**

Time

Type
What is intensity?

The rate of work performed (i.e. power or workload) during activities

How much energy is expended exercising
Exercise intensity is the most challenging parameter to establish, but is also the most critical because it ensures **safe, attainable, and adequate** dosing to provide the most **optimal training effect**.
Measurements of Intensity

- **Heart rate**
  - Heart rate reserve (HRR) → Karvonen Method
  - Heart rate max (HRmax) → 220-age

- **Perceived exertion**
  - 0-10 scale; 6-20 scale

- **Oxygen uptake / O2 consumption**
  - VO₂Max

- **METs (metabolic equivalent)**
  - 1 MET = 3.5 ml O₂ / kg / min
  - 3-5 METs for light work; >9 METs for heavy work
Factors That Affect Intensity

- Baseline fitness level
- Neurological status
- Cardiac status
- Comorbidities
- Motivation
Moderate Intensity

- Increased HR and breathing
- Able to hold conversation, but not sing
- 50 to 70% of max HR
- 11-14 on a scale of 6 to 20
- 3 to <6 METS

High Intensity

- Significant increase in HR and breathing
- Unable to say more than a few words
- 70 to 85% of max HR
- 17-19 on a scale of 6 to 20
- ≥ 6 METS
Moderate Intensity Activities

- Walking at a moderate or brisk pace at 3-4.5 mph on a level surface
- Bicycling 5-9 mph, level terrain, or with few hills
- Weight training using free weights

High Intensity Activities

- Aerobic walking 5 mph or faster
- Jogging or running
- Walking briskly up a hill/incline
- Bicycling > 10 mph or bicycling on steep uphill terrain
- Circuit weight training
Various recommendations have been made because the optimal training parameters have NOT been determined for the stroke population.

Current recommendations are based on:
- Tested protocols found to be effective for individuals post stroke
- General exercise guidelines
AHA/ASA Guidelines: Moderate Intensity

• Recommendations are based on stroke rehab research and guidelines from:
  – ACSM’s exercise management for persons with chronic diseases and disabilities
  – AACPR guidelines for cardiac rehab
  – AHA guidelines for healthy adults

• Training parameters:
  – 40% to 70% of heart rate reserve
  – 50% to 80% of maximal heart rate
  – RPE 11-14 (6-20 scale)
AHA/ASA Guidelines: Low Intensity

• Swain et. al, 2002
  – Minimum training intensity for low fit individuals = 30% of HHR

**Higher training intensities are generally more effective at improving VO\textsubscript{2} Max, but consideration must be made regarding injury, cardiovascular complications and compliance**
AHA/ASA Guidelines: High Intensity

• Globus 2012, Gjellesvik 2012
  – High intensity treadmill training was safe and effective in the chronic stroke population
  – Training parameters:
    • 60%–80% of heart rate reserve
    • 85%–95% of heart rate max
Is more better?

• In healthy controls and other populations, high intensity exercise and high intensity interval training (HIIT) has demonstrated profound improvements in:
  – Aerobic capacity and muscle strength (*Sloth 2013, Ryamond 2013*)
  – Reduced subcutaneous and abdominal fat (*Boutcher 2011*)
  – Improved functional recovery for individuals with multiple sclerosis (*Wens, 2015*)
  – Improved cardiovascular health (*Kemi 2010*)

• High intensity interval training (HIIT) has been shown to be more effective than continuous aerobic training for improving aerobic capacity, as well as gait economy, ventilatory threshold among healthy adults and individuals with heart disease. (*Boyne, 2013*)
Is more better?

- 2 RCT’s (Lau 2011, Pohl 2002) done in CVA found that compared to conventional therapy or other forms of treadmill training, treadmill HIIT produced greater improvements in:
  - Gait speed
  - Spatiotemporal parameters
  - Functional ambulation category
- Askim 2014, Gjellesvik 2012 also found in chronic and subacute stroke that treadmill HIIT showed significant improvements in:
  - Gait speed
  - Timed up and go
  - Gait endurance
  - Gait economy
  - Aerobic capacity
So why is there so much controversy?
HIIT is being more widely studied within the stroke population, **BUT** the protocols vary in approach.
High Intensity Interval Training

- High intensity interval training (HIIT): maximizes exercise intensity through bursts of concentrated effort (Boyne 2013)
  - High intensity bursts alternated with recovery periods, designed to mitigate fatigue and increase cardiovascular safety
HIIT in Practice

• 3 parameters
  – High intensity burst duration
  – Recovery period duration
  – Recovery type duration
    • Passive, light active, active

• Main categories of HIIT
  – Short-interval HIIT
  – Low-volume HIIT
  – Long-interval HIIT
Short Interval HIT

- Designed to maximize time spent at a high percentage of peak oxygen uptake (aerobic intensity)
  - Short, high-intensity bursts (usually 15-30 sec but up to 60 sec)
  - 50-80% of maximal workload
  - 1:1 burst to recovery time ratio
  - Passive recovery
Low-Volume HIT

- Designed to achieve the highest possible neuromuscular intensity
  - Short high-intensity bursts (usually 10-30 sec but up to 60 sec)
  - Max or near max workload (90-100%)
  - 1:4 to 1:12 burst to recovery time ratio
  - Light active recovery
Long-Interval HIT

- Designed to maximize time spent at a high percentage of peak oxygen uptake (aerobic intensity)
  - Long high intensity bursts (3-4 min)
  - Submax workload (85% to 95% HR_{pea} or 30-40% of max capacity)
  - 1:1 or 4:3 burst to recovery time ratio
  - Active recovery
Comparison of recovery duration

Boyne (2015) studied exercise responses between 3 HIIT protocols, which differed by recovery duration (30s, 60s, or 120s) in chronic stroke

Protocols included:

• 5-min warm up 30-50% VO2_{peak}
• 20 min of HIIT
  – 30s bursts at max tolerated speed (0% incline), alternated with recovery periods (either 30s, 60s, or 120s)
• 5-min cooldown
Comparison of recovery duration

Boyne et al. 2015

• **Results**
  – All 3 protocols elicited high relative treadmill speeds and step counts and achieved at least moderate aerobic intensity levels
  – **P60**
    • Higher intensity, increased steps (compared to P120) without decreasing speed or ending their session early
  – **P30**
    • Some were unable to tolerate the full session and they ambulated at slower speeds, BUT, they achieved even higher aerobic intensity and step count than P60

*Suggestion*: combination of P30 and P60 may be optimal for treadmill HIIT in chronic stroke
Treadmill Sample HIT Protocol

Boyne et al. 2016

• Baseline questioning
• Setup, baseline measures and safety monitoring
  – Baseline ECG
  – Calculate target HR zones using HRR method
    • Target HR = Target %HRR $\times$ (HRpeak - HResting) + HResting
  – Monitor HR ECG continuously during session
  – Take BP at 5:00 and 10:00 of HIT
• Starting speed determined with steep ramp test
  – Begin at fastest comfortable speed 0% grade
  – Increase by 0.1 mph every 5 sec until reaching max limit where pt demonstrates mechanical fault (drift backward or marked gait instability), or requests to stop
  – HIT protocol started at 0.1 mph below that limit
Treadmill Sample HIT Protocol

• Warm-up (3 min)
  – Gradually increase treadmill speed to achieve 40% +/- 10% HRR within 2 min
  – At 2:15 begin ramp test - increase speed 0.1 mph/5 s and stop at gait fault

• HIIT (20 min)
  – Start HIIT timer and begin recording HR
    • Timer beeps every 30s for 20 min
    • HIIT begins w/ 30s of rest
  – Determine starting speed
    • 0.1% below fault speed from ramp test or end speed if no fault
  – 30 sec bursts: performed of fast treadmill walking and progress speed based on previous performance
Treadmill Sample HIT Protocol

• HIIT (continued)
  – Recovery periods: 60-s rest period b/n burts initially, then progress to 30-s rest periods
  – Handhold progression
  – Cool-down (2 min)
  – Post session questioning, monitoring and data collection
    • Monitor until HR and BP return to near-baseline levels

*See appendix to Boyne 2016 for full protocol used
Ways to increase intensity...

- Higher speeds
- Incline
- Added resistance (i.e. weights, resistance bands)
- Interval/circuit training
- Dual tasks
Should we re-evaluate our practice?

- VIEWS study by Hornby et al.
  - High-intensity, variable stepping training vs. conventional PT on walking and non-walking outcomes in individuals with subacute stroke
    - Post-test found 3-4 fold greater improvement for experimental group for change in SSS and 6MWT (surpassed MCID)
    - Greater improvement in paretic single-limb stance in experimental group
    - Improved SF-36 in experimental group
    - No between group difference for improvements on BBS, 5xSTS, and ABC
Other keys to success...

- **Educate** the patient
  - Teach them how the brain can change with neuroplasticity
  - Educate them how they can make improvements
  - Reinforce that the challenge increases opportunity to improve

- Use of **objective measures** to show improvement
Take home points...

• High intensity training can improve both speed and quality of ambulation in both sub-acute and chronic phase post stroke

• Impairment based approaches can be utilized, but also should focus on intensity and variability of tasks to maximize outcomes

• It’s not just the type of practice, but the intensity which are keys to maximize gains
References


