Aerobic Exercise and Nutrition as Tools in Stroke Recovery

Susan M. Linder, DPT, NCS

Cleveland Clinic

Disclosures

- I have no conflicts of interest to report related to this research
- I have received funding from the NIH and the American Heart Association/American Stroke Association

Course Objectives

At the end of the presentation, the participant will:

- Describe the potential mechanism underlying the recovery of motor function post-stroke via high intensity aerobic exercise
- Describe the methodology associated with applying aerobic exercise as an antecedent to motor task practice
- Discuss the motor and non-motor outcomes following aerobic exercise paradigms in individuals with chronic stroke
- Discuss the role of nutrition on stroke recovery

Historic Perspectives on Aerobic Exercise Training

Effects on cardiorespiratory fitness

- Stroke: diminished peak aerobic capacity
- Moderate to vigorous intensity exercise has greater training effect than low intensity training

Taking A Serendipitous Finding from the Field into the Laboratory

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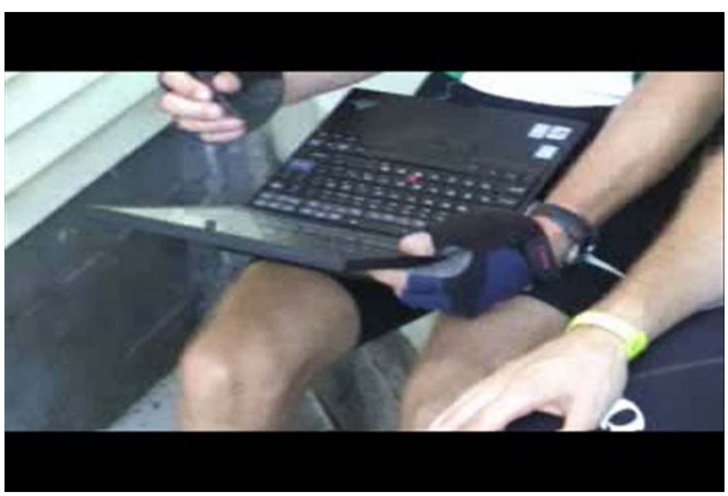
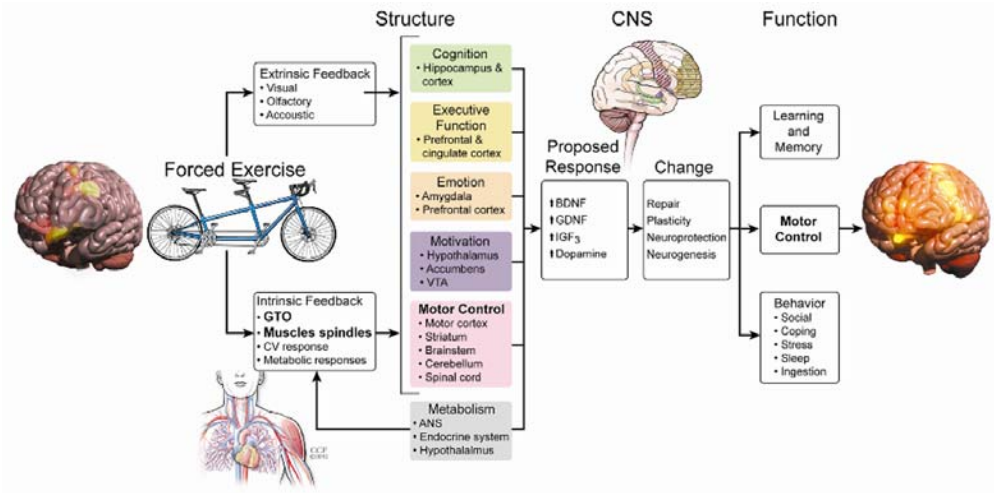


The Effects of Aerobic Exercise on Brain Function

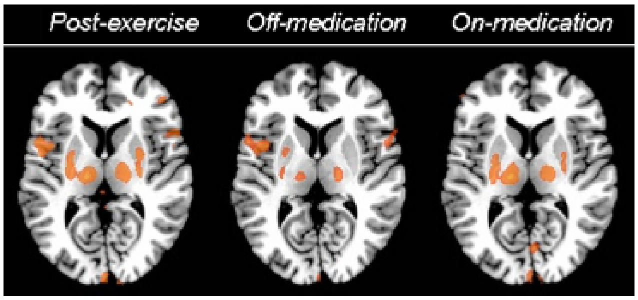


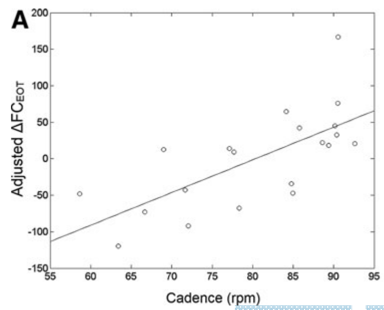
Alberts, 2011

What is Forced-Exercise in Humans?

- Augmenting voluntary exercise effort
  - Exercise rate (cadence) increased by 30%
  - Consistent pedaling rate at high RPMs
- Designed to overcome barriers to intensive aerobic exercise training
- 60-80% target HR zone
- Participant is not passive

High Intensity Exercise Induces CNS Changes Measured with fMRI





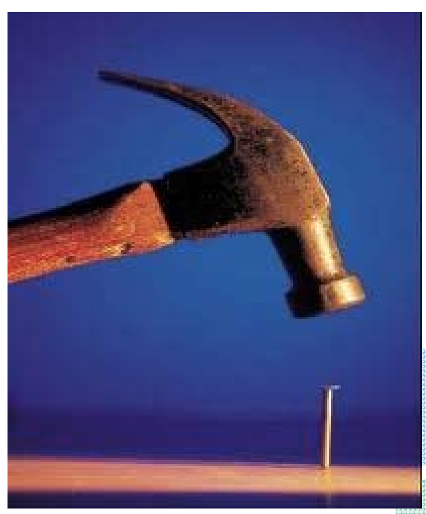
FE and PD medication result in similar patterns of cortical and subcortical activation

Alberts 2011
Beall 2013
Alberts 2016

Can FE Enhance Recovery of Function after Stroke?

"I suppose it is tempting, if the only tool you have is a hammer, to treat everything as if it were a nail"

-Maslow, 1966



How Does Aerobic Exercise Relate to Stroke Recovery?

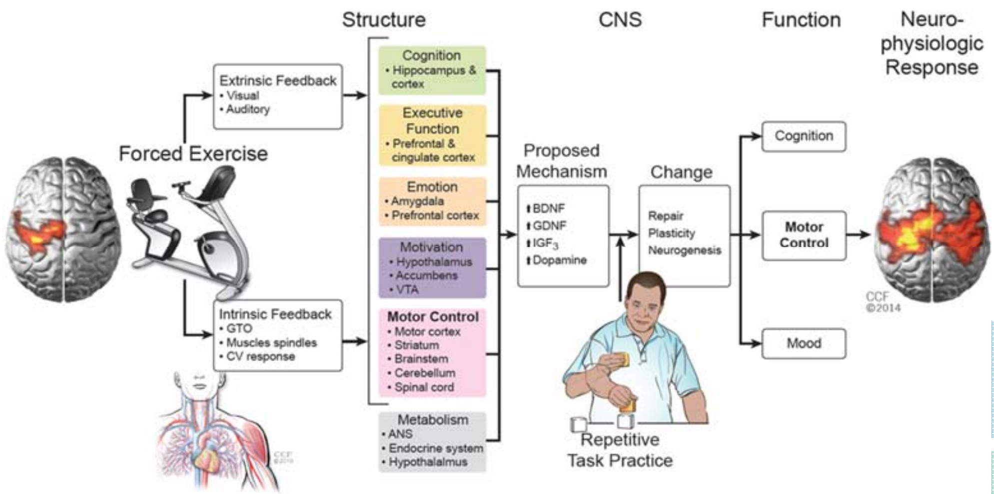
- Motor recovery post-stroke is largely reliant on motor learning-related neuroplasticity
  - BDNF, GDNF, IGF are mediators of neuroplasticity and motor learning post-stroke
  - Aerobic exercise has been shown to cause an endogenous upregulation of neurotrophic factors, including BDNF, GDNF, and IGF

Forced Exercise Model Adapted to Stroke

➡ Prime the CNS ➡

➡ Improved Rehabilitation Outcomes

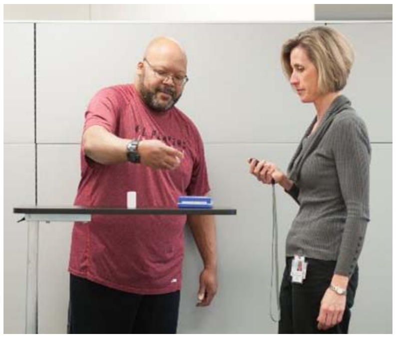
Proposed Mechanism of Aerobic Exercise after Stroke



Investigating Two Time-Matched Modes of Aerobic Exercise Training

	Forced Exercise	Voluntary Exercise
Exposure (sessions)	24	24
Duration (including 5-min warm up/cool down)	45 min	45 min
HR intensity	60-80% HRR	60-80% HRR
Rate (Cadence)	Self-selected + 30%	Self-selected

Repetitive Task Practice (RTP)



- Focus on maximizing reps
  - Selected 3-5 tasks/session
  - 75-100+ reps of each task
- Type of practice
  - ACTIVE
  - Incorporate ROM into functional activity
  - Blocked, target/goal-oriented, specificity of training
- Standing vs. Sitting
- Minimize rest time
- Grading of activities

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Study Aims

- To determine the effects of forced and voluntary exercise on motor function, non-motor function, and cardiovascular fitness in individuals with chronic stroke

Applying High Intensity Exercise to Individuals with Stroke

Hypothesis: Aerobic exercise will enhance motor recovery and non-motor function in individuals with stroke

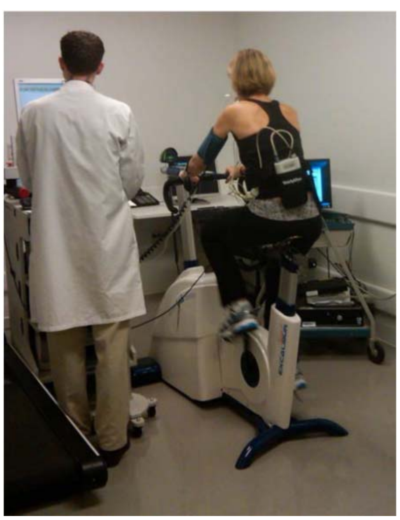
Anticipated Outcome: Those in the FE group will have a greater recovery of motor and non-motor function than VE and RTP alone

Inclusion/Exclusion Criteria

Inclusion
- 18-85 years old
- >6 months post ischemic stroke
- Approval from physician for stress test
- 19-55 on Fugl-Meyer upper extremity motor assessment
- Ability to follow 1-2 step commands

Exclusion
- Cardiac or pulmonary contraindication to exercise (cardiomyopathy, PE, A-fib, MI, etc.)
- Musculoskeletal contraindication to exercise
- Major psychiatric disorder
- Anti-spasticity injections (botox) within the past 3 mo
- Uncontrolled HTN

Cardiovascular Screening & Monitoring



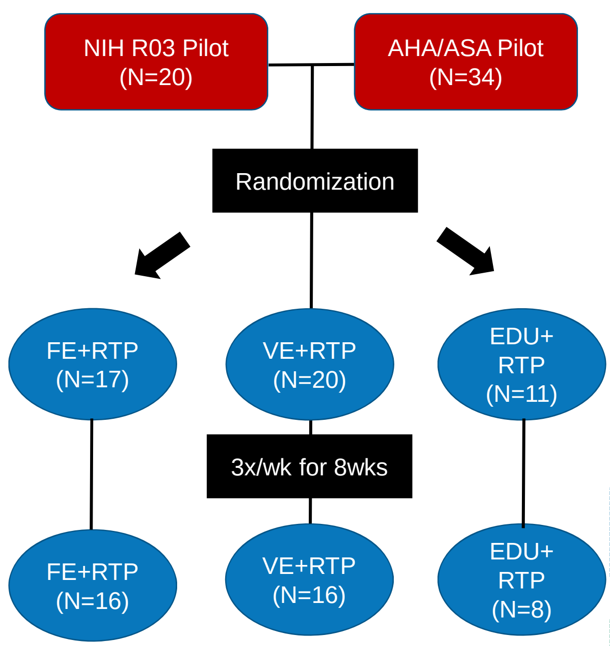
Cardiopulmonary Exercise Test
- Target Heart Rate Established: 60-80% HRR

Monitoring During Exercise
- Continuous Heart Rate
- RPE
- Blood Pressure

Cardiovascular Monitoring

- Continuous Heart Rate
- RPE
- Blood Pressure

Study Overview: 2 Pilot RCT's



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Baseline Demographics

Factor	FE + RTP (N=16)	VE + RTP (N=16)	RTP + Education (N=8)	p-value
Age	51±12	60±14	58±12	0.14
Female gender (versus male)	12 (75%)	10 (62%)	7 (88%)	0.43
Race:				0.11
African American	8 (50%)	3 (19%)	4 (50%)	
Asian	1 (6%)	1 (6%)	0 (0%)	
Other	2 (12%)	0 (0%)	1 (12%)	
White	5 (31%)	12 (75%)	3 (38%)	
Hispanic ethnicity	1 (6%)	0 (0%)	1 (12%)	0.67
Dominant side affected (versus non-dominant)	10 (62%)	7 (44%)	5 (62%)	0.65
Months since stroke	12 [7,16]	16 [11,32]	17 [12,35]	0.23
Baseline Fugl Meyer score	37±8	33±11	33±9	0.40

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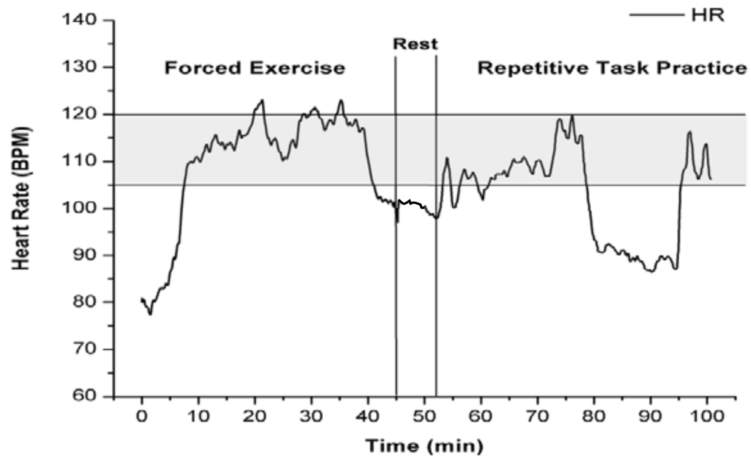
Training Variables

Representative Day of HR Data



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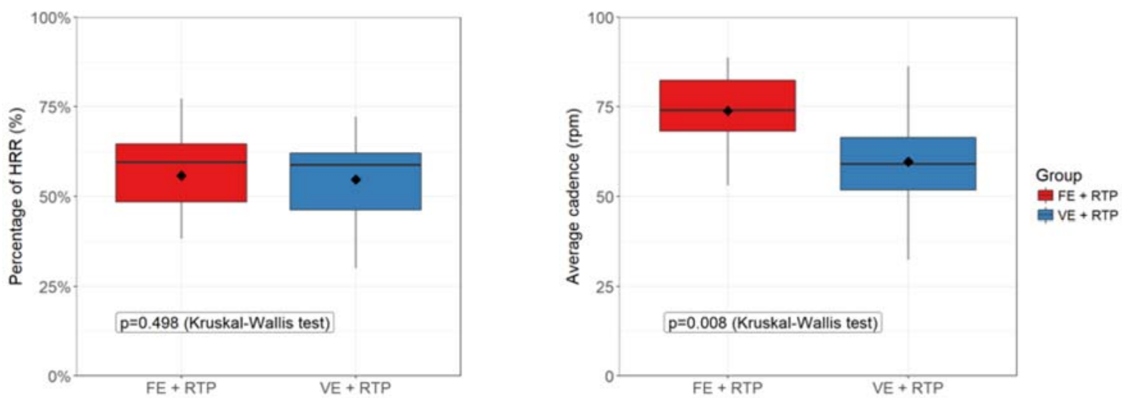
Aerobic Exercise Training Variables



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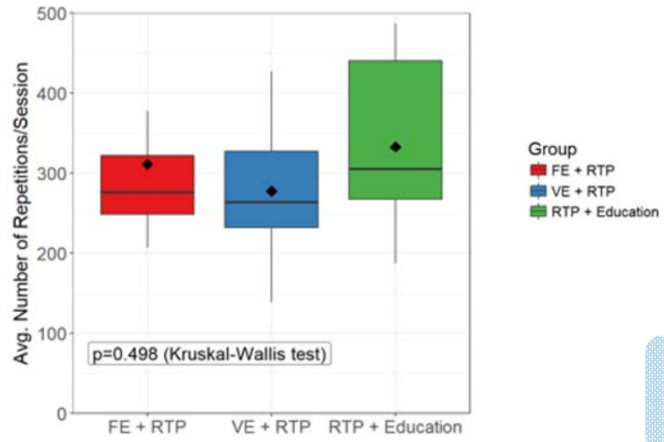
RTP Training Variables



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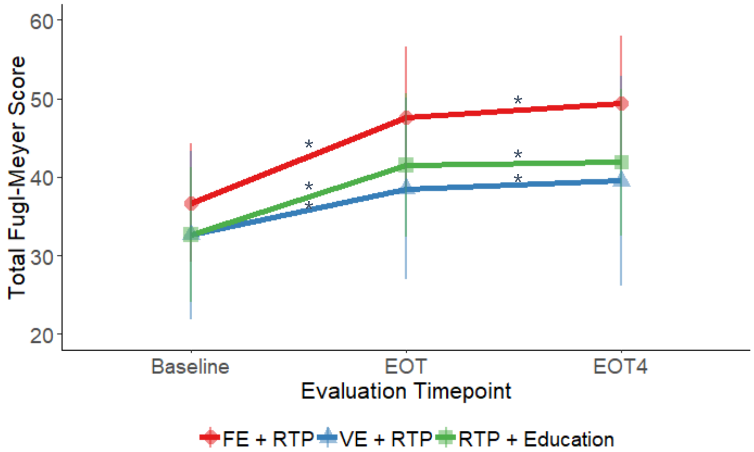
Motor Outcomes

Improved Motor Recovery: UE Fugl-Meyer Motor Score



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Cardiovascular Outcomes

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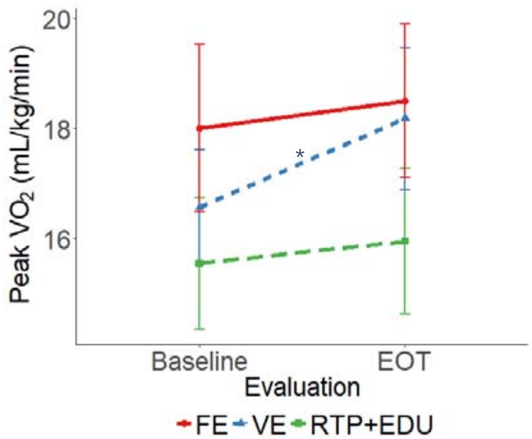
Improved Cardiovascular Function and Endurance

Maximal Aerobic Capacity (Peak VO_2)



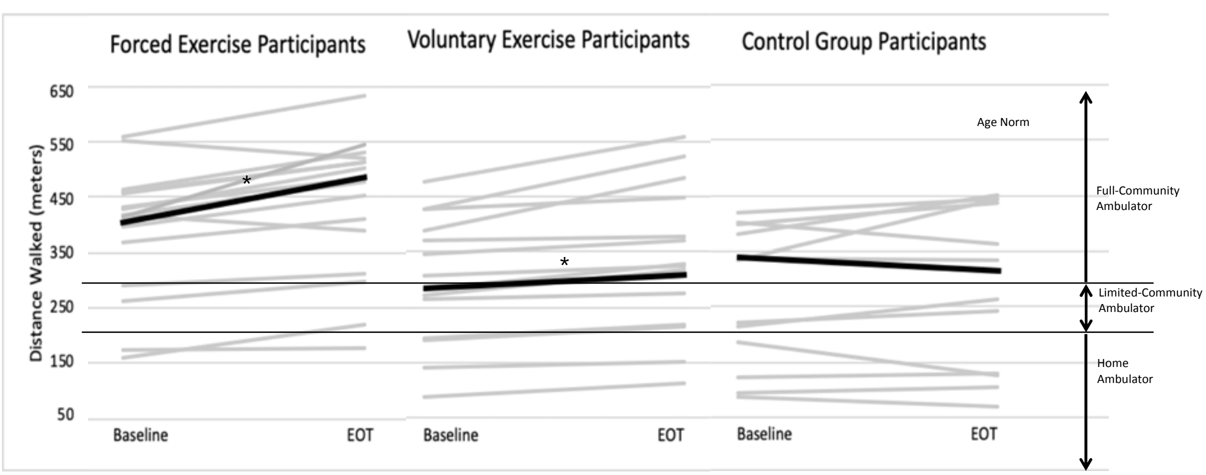
* Denotes P<0.05

Linder, et al, 2020

Improved Walking Capacity

Six-Minute Walk Test

* Denotes P<0.05



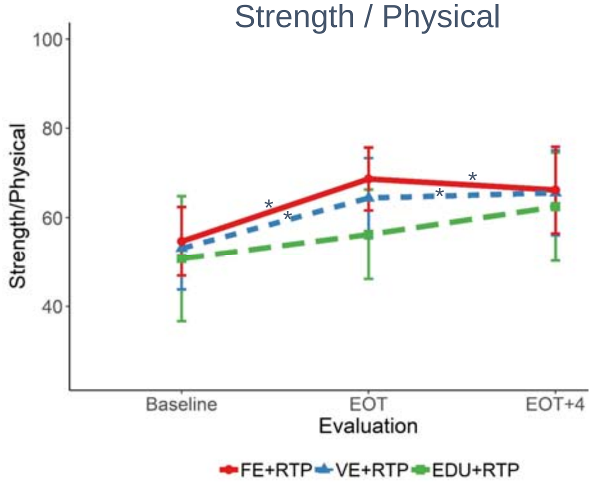
Quality of Life Outcomes

Stroke Impact Scale

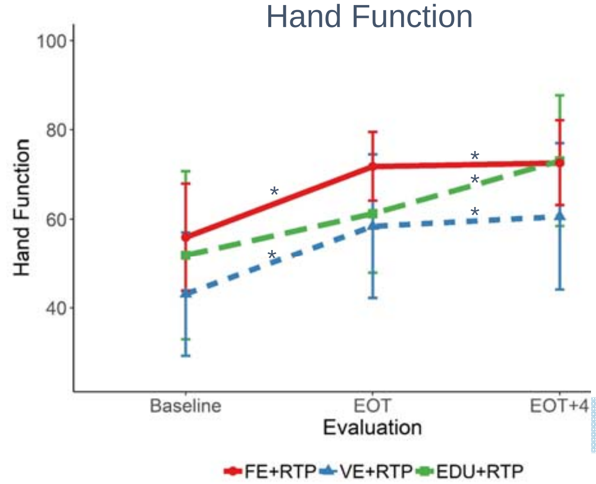
- Physical / Strength
- Mobility
- Hand Function
- Activities of Daily Living
- Memory / Thinking
- Communication
- Mood / Emotions
- Meaningful Activities (Participation)
- Stroke Recovery (self-reported)

Aerobic Exercise Improved QOL

Strength / Physical



Hand Function

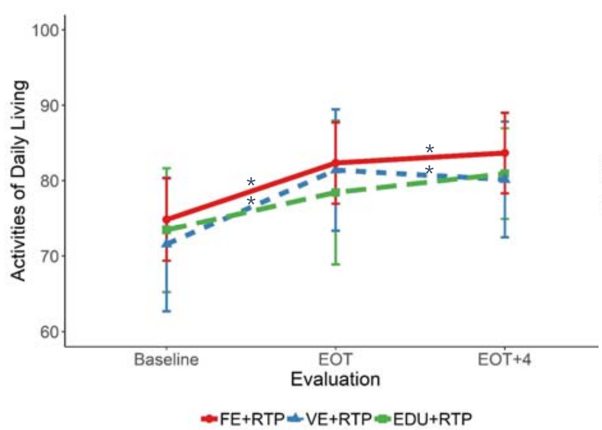


* Denotes P<0.05

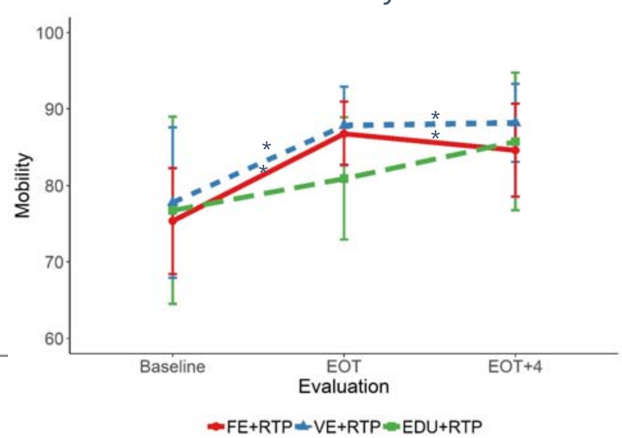
Rosenfeldt, et al, 2019

Aerobic Exercise Improved QOL

ADL's



Mobility



* Denotes P<0.05

Conclusions

- Motor Function
  - All 3 groups improved significantly on the FMA
  - Improvements on the FMA by the FE+RTP group were greater than the other groups
- Cardiovascular Function
  - Significant improvements in cardiovascular fitness and walking capacity for exercisers

Conclusions

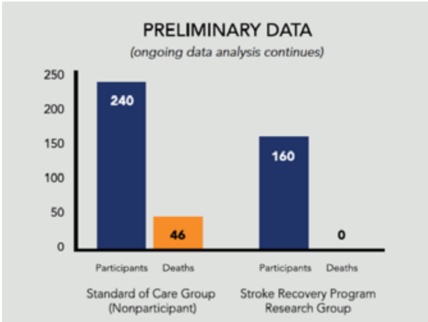
- Quality of Life
  - FE and VE groups improved in all motor domains
- Killing 4 birds with 1 stone? (Ploughman, 2016)
  - Reparative
  - Neuroplastic
  - Cardiorespiratory
  - Metabolic

Other Studies Corroborate Our Findings

- High intensity interval training (Boyne, 2019)
  - Improved recovery of gait
  - Higher levels of peripheral BDNF
  - Increased corticospinal excitability (TMS)
  - Intensity sufficient to accumulate blood lactate was important for eliciting BDNF response
- Single bout of high-intensity cycling (Mang, 2014)
  - Improved implicit motor learning

JFK Rehabilitation Institute

Stroke Recovery Program- Stroke HEART^{TM} Trials



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Clinical Translation

Motor Task Practice

Aerobic exercise

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StEP: Long-term Group Exercise Program

- Hospital-based group cycling class for stroke survivors
- Supervised by PT or PTA

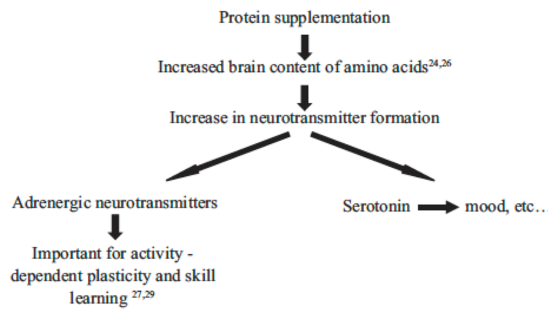
Nutritional Considerations in Stroke Recovery

Nutrition for Brain Recovery – Acute Ischemic Stroke

- Acute ischemia induces profound alterations of brain protein synthesis and brain glucose metabolism
- Primarily due to alterations in cellular homeostasis

Nutrition for Brain Recovery – Acute Ischemic Stroke

- Protein supplementation
  - Greater reductions in NIHSS scores at 21 days
- Excess carbohydrate intake
  - May increase lactate production leading to greater neuronal destruction



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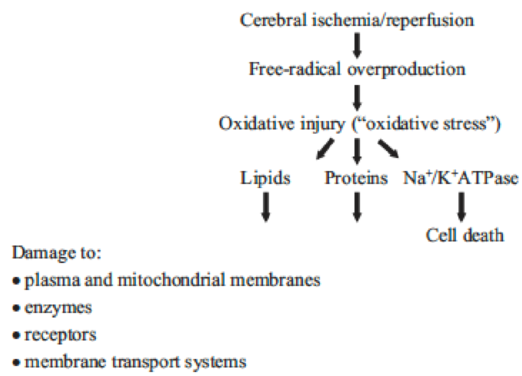
Nutrition for Brain Recovery – Acute Ischemic Stroke

- Cellular damage in cerebral ischemia partly caused by oxidative damage due to free radical formation and lipid peroxidation
- Vitamins E & C – potent anti-oxidants
- B-group vitamins may also mitigate oxidative damage



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Nutrition for Brain Recovery – Considerations for Chronic Stroke

- Most common factors associated with suboptimal nutritional status
  - Excess caloric intake
  - Reduced protein intake
  - Micronutrient deficiencies (B-vitamins, Vitamin D, Omega 3's)
- Mitigating the risk of recurrent stroke by addressing cardiovascular risk factors

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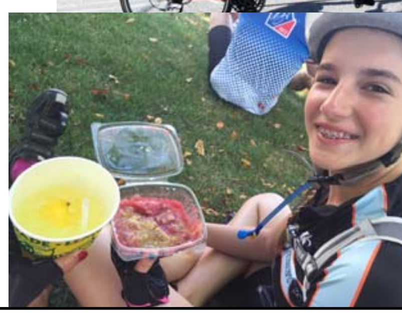
Pedaling for Parkinson's - Iowa



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Every life deserves world class care.

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