HIIT and Aerobic Exercise after Stroke

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Objectives

Objective 1: Describe the components of high intensity interval training (HIIT)

Objective 2: Identify the benefits of HIIT and aerobic exercise for overall health

Objective 3: Understand the impact of HIIT and moderate intensity on walking and stroke recovery

Objective 4: Describe patient interventions and modifications used to increase independence of the post-acute stroke patient as it relates to mobility, ADLs, and communication

STROKE RECOVERY: AN EVOLVING CHALLENGE

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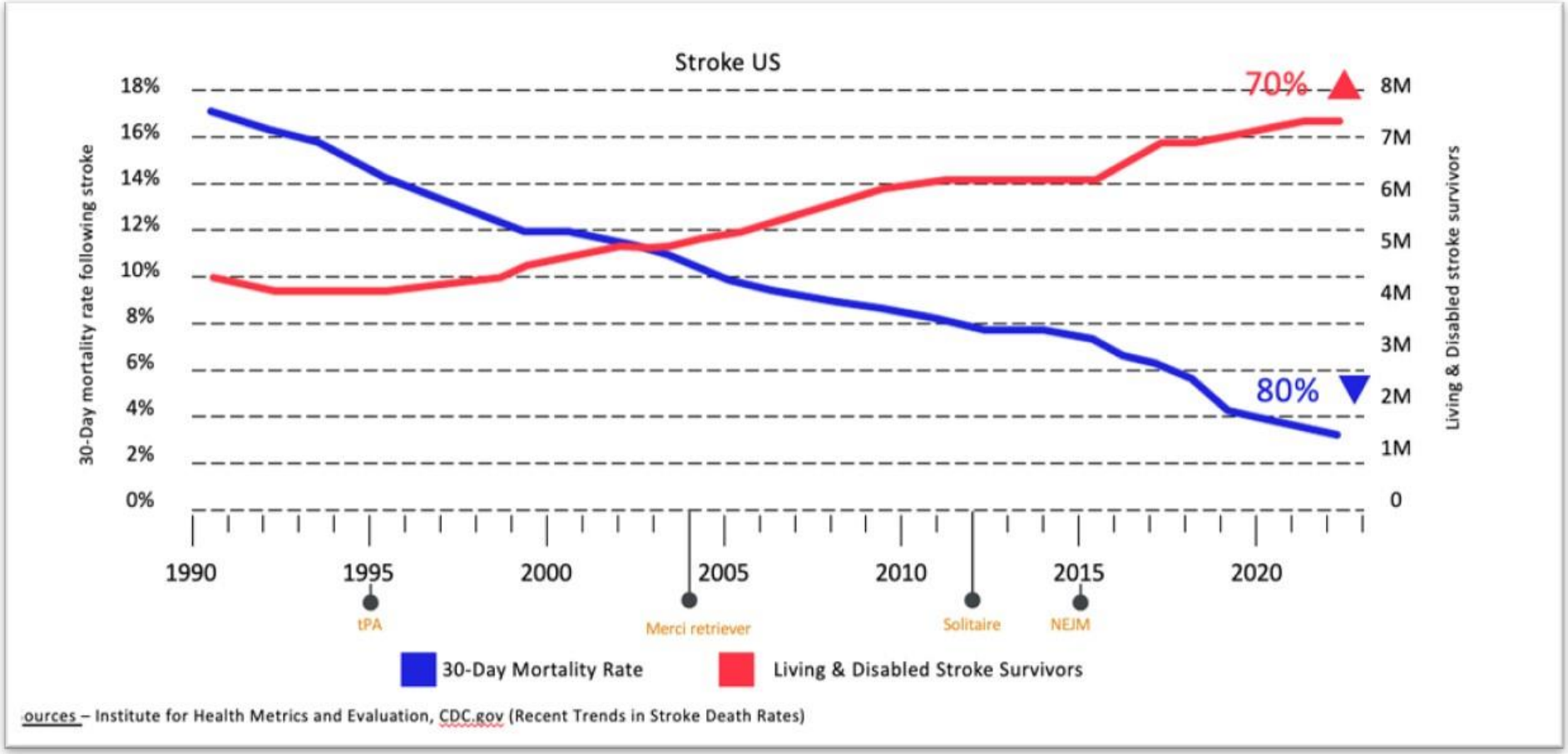

Borrowed from Jeff Saver, MD

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Influencing Change- Time is Now

- Stroke Recovery Program
  - Sarah Cuccurullo, MD and Talya Fleming, MD
  - Presented to CMS → reimbursement policy
- Exercise Testing in Inpatient Rehabilitation
  - Miriam Rafferty, PT; Shirley Ryan Ability Lab
- Integrated Care across Stroke Recovery
  - Shamala Thilarajah, physiotherapist; Singapore

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Stroke
JOURNAL OF THE AMERICAN HEART ASSOCIATION

Physical Activity and Exercise Recommendations for Stroke Survivors: A Statement for Healthcare Professionals From the American Heart Association/American Stroke Association

Sandra A. Billinger, Ross Arena, Julie Bernhardt, Janice J. Eng, Barry A. Franklin, Cheryl Mortag Johnson, Marilyn MacKay-Lyons, Richard F. Macko, Gillian E. Mead, Elliot J. Roth, Marianne Shaughnessy and Ada Tang
on behalf of the American Heart Association Stroke Council, Council on Cardiovascular and Stroke Nursing, Council on Lifestyle and Cardiometabolic Health, Council on Epidemiology and Prevention, and Council on Clinical Cardiology

Stroke. published online May 20, 2014;
Stroke is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231

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Challenges to Delivery of Aerobic Exercise in Practice

Common challenges in clinical/rehabilitation setting

- Patient concerns
  - Cardiac/cardiovascular disease
  - Cognitive
  - Fatigue
- Environment
  - Lack of staff
  - Lack of time
  - Unsure of screening tools
  - Unsure of exercise prescription

(Doyle, 2013)

- Patient concerns
  - Cardiac/cardiovascular disease
  - Cognitive
  - Fatigue
- Environment
  - Lack of staff
  - Lack of time
  - Lack of equipment

(Boyne, 2017)

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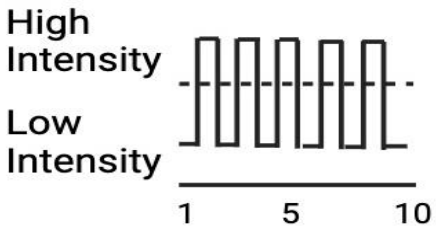
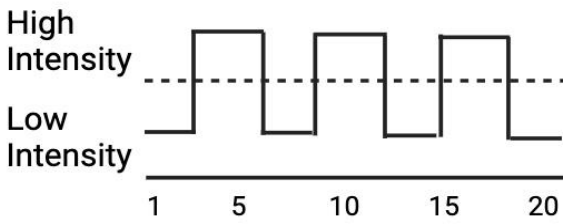
Global Challenges to Delivery of Aerobic Exercise in Practice

- Workgroup from 8 countries to understand challenges to exercise implementation
  - Determine whether physiotherapists and other healthcare professionals possess sufficient training and confidence to deliver WSO guideline recommendations on PA after stroke
- Online survey
  - Physiotherapists, Occupational therapists, Medical practitioners
  - 3 sections
    - Demographics
    - Knowledge, skills, training and confidence across 12 constructs
    - Educational preferences
- Results (n = 235; 74% female) from 33 countries
  - Median (IQR) proportion of physiotherapists reported sufficient training in promoting and delivering PA after stroke was 40% (7.8%) vs 29.5% (8.5%) of non-physiotherapists (P=0.015)
  - Median (IQR) proportion of physiotherapists reporting being sufficiently confident was 54% (7.8%) compared with 45% (8.3%) of non-physiotherapists (P=0.026).
  - The majority of respondents (56% of physiotherapists and 60% of non-physiotherapists) reported they had not received sufficient training in **safety aspects** of PA intervention delivery

Introduction

- High-intensity interval exercise (HIIT)
  - Repetitive switching
    - High-intensity or sprint interval
    - Active or passive recovery
  - Intervals
    - Short (i.e. 1 x 10)
    - Long (i.e. 4 x 4)
  - Volume
    - Low (<15 minutes)
    - High (≥ 15 minutes)





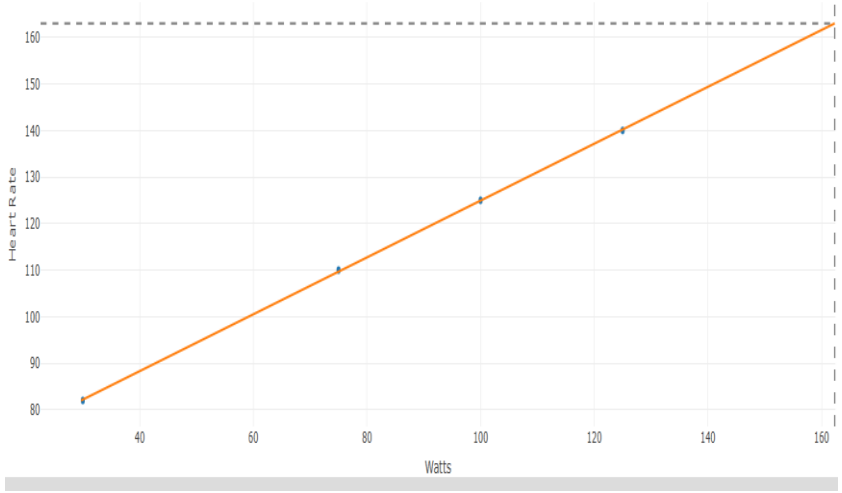
HIIT

- Modalities
  - Bike
  - Treadmill
  - Elliptical
  - Stepper
  - Track/Field

Prescribing HIIT

- Oxygen Uptake
- Heart rate
  - Percentage of maximal HR
- Rate of Perceived Exertion
  - 6-20
- Peak Power Output

Rating of Perceived Exertion Borg RPE Scale		
6 7 8	Very, very light	How you feel when lying in bed or sitting in a chair relaxed. Little or no effort.



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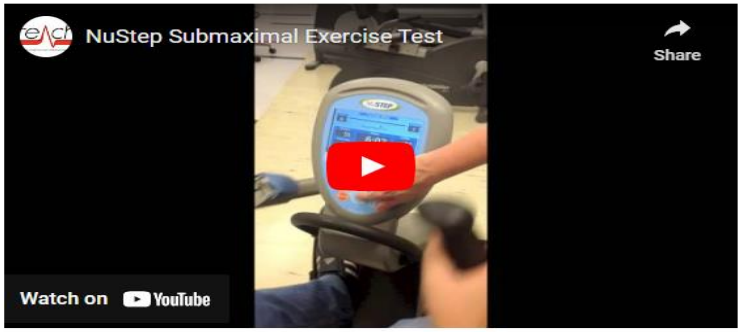
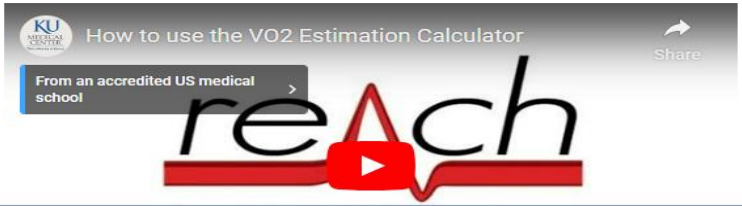
The following video provides all the information you need to perform your first TBRS Submaximal Exercise Test.

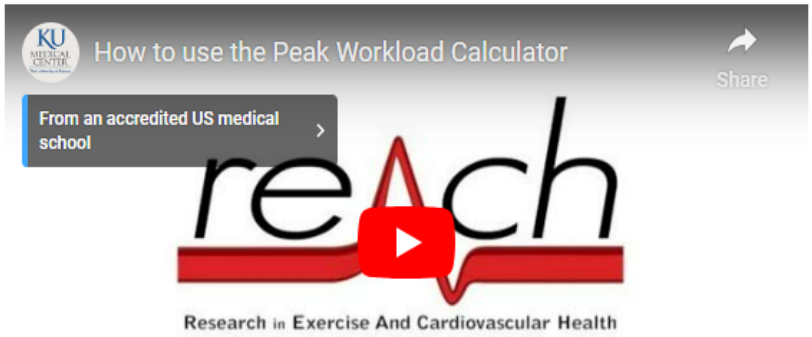


After completing the TBRS Submaximal Exercise Test, you can **use our convenient calculator to determine the predicted peak VO_2**.



Workload

Exercise intensity can be prescribed as a percentage of maximal heart rate (HR_{max}) or as a percentage of peak workload. You can use the TBRS Submaximal Exercise Test results to estimate the peak power output and prescribe exercise as a percentage of workload. The following video demonstrates using the **calculator** to determine the peak power output.



Benefits of HIIT

- Shorter total exercise time
- Weight loss (Petersen et al., 2015)
- Blood pressure (Batacan et al., 2017; Costa et al., 2018)
  - Systolic BP
  - Diastolic BP
- Peripheral vascular function (Ramos et al., 2015)
- Body mass index (Batacan, 2016)
- Aerobic fitness or VO_2 peak (Foster et al., 2015; Petersen et al., 2015; Buchheit, 2013; Batacan, 2016)
- Memory?
  - Hippocampus size

HIIT IN STROKE

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Introduction

- Stroke
  - Leading cause of disability (Mozaffarian, 2016)
  - Over 1 million affected by 2025 (Broderick et al., 2004)
  - $94.3 billion by 2035 (Benjamin et al., 2019)

- HIIT within stroke rehabilitation
  - Walking (Hornby et al. 2020; Boyne et al., 2020; Marzolini, 2023)
  - Overcomes time barriers (Boyne et al., 2017)
  - Aerobic fitness with no serious adverse cardiovascular events (Gjellesvik et al., 2012; Boyne et al., 2016; Marzolini, 2023; Boyne, 2023)

Sandra Billinger, PT, PhD

Pierce Boyne, PT, DPT, PhD

Darcy Reisman, PT, PhD

HIT-Stroke Trial

Boyne P, Billinger SA, Reisman DS, et al. Optimal Intensity and Duration of Walking Rehabilitation in Patients with Chronic Stroke: A Randomized Clinical Trial. *JAMA Neurology*. Published online February 23, 2023.

Research Questions

For walking exercise in chronic stroke, what is:

- Optimal training intensity?
  - **Vigorous** or **Moderate**?
- What do we know?
  - Steps
  - Speed
  - Heart rate
  - Interval vs continuous
- Have findings been confirmed in large RCT?

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Research Questions

For walking exercise in chronic stroke, what is:

- Optimal training intensity?
  - **Vigorous** or **Moderate**?
- Minimum training duration to maximize gains?
  - **4**, **8,** or **12** weeks?

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	MAT	HIT
Intensity:	Moderate	Vigorous
Intensity Strategy:	Continuous Training	Max-Speed Interval Training
Other Factors	: Keep the same between groups Block randomized by site and gait speed	

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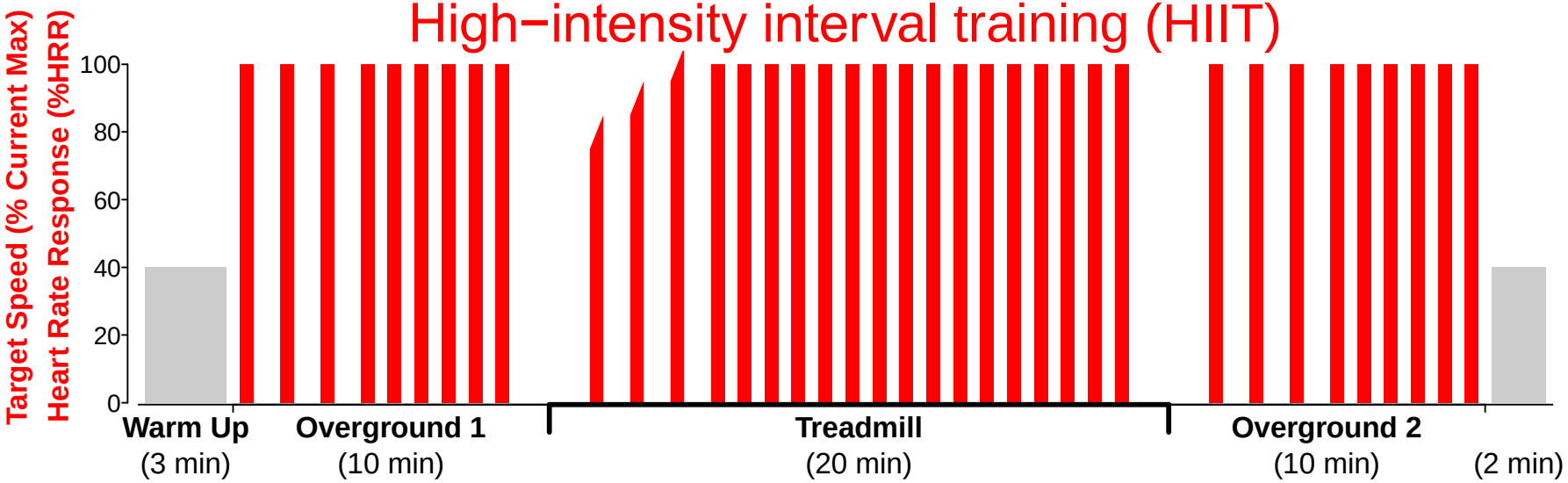
High−intensity interval training (HIIT)



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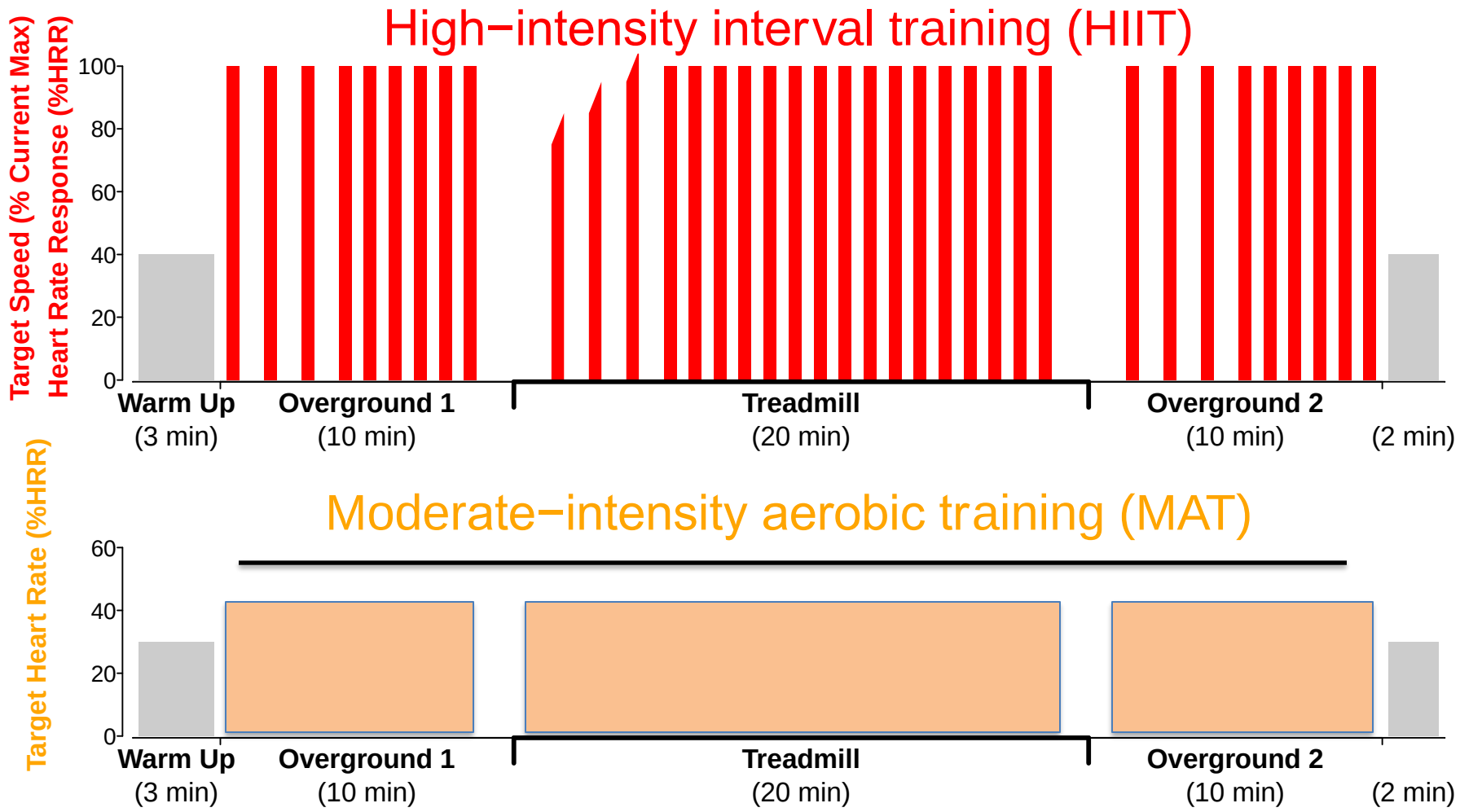
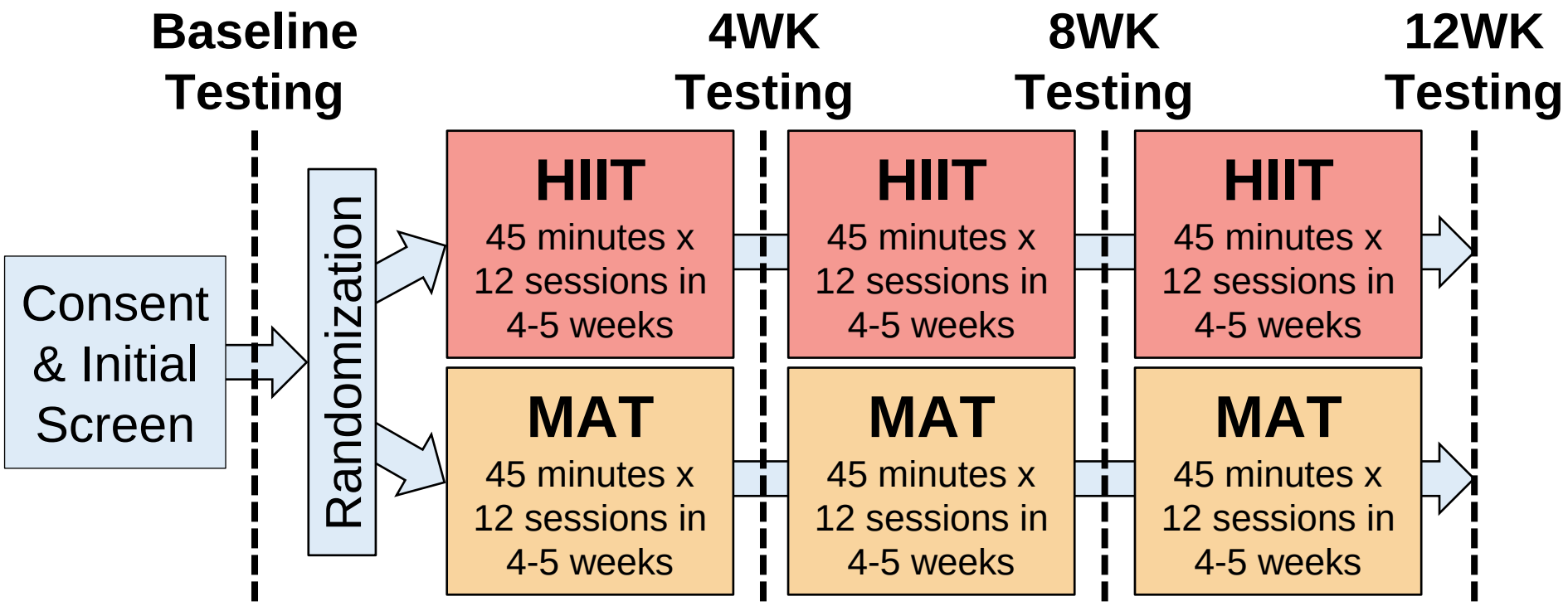

High−intensity interval training (HIIT)
Target Speed (% Current Max)
Heart Rate Response (%HRR)
100
80
60
40
20
0
Warm Up
(3 min)
Overground 1
(10 min)
Treadmill
(20 min)
Overground 2
(10 min)
(2 min)
Moderate−intensity aerobic training (MAT)
Target Heart Rate (%HRR)
60
40
20
0
Warm Up
(3 min)
Overground 1
(10 min)
Treadmill
(20 min)
Overground 2
(10 min)
(2 min)

Study Procedures



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Eligibility Criteria – Medical History Screen

1) Age 40-80 years at time of consenting
2) Single stroke, 6 months to 5 years prior to consent date
3) Able to walk outside the home prior to stroke
4) Walking speed $\leq$1.0 m/s on the 10-meter walk test
5) Stable cardiovascular condition and no hospitalization for cardiac or pulmonary disease within past 3 months
6) No pacemaker or defibrillator
7) No recent botulinum toxin injection to the paretic lower limb (<3 months) or plan to have in the next 4 months
8) Not currently participating in physical therapy or another interventional study
9) No previous exposure to fast treadmill walking (>3 cumulative hours) during clinical or research therapy in the past year
10) Able to communicate with investigators, follow a 2-step command and correctly answer consent comprehension questions
11) No major post-stroke depression without medical management
12) No severe lower limb spasticity (Ashworth <3)
13) No significant ataxia or neglect (NIHSS items 7 and 11 < 2)

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Outcome Measures

Gait Testing

- 6-Minute Walk Test (*Primary Outcome Measure at 4 weeks*)
- 10-meter Walk Test (Self-Selected and Fast Speeds)

Graded Exercise Test (GXT)

- Aerobic Fitness / Exercise Capacity
  - Time to Exhaustion, Ventilatory Threshold, Peak VO_2
- Metabolic Cost of Gait

Questionnaires

- EQ-5D, ABC scale, PROMIS-Fatigue, Ratings of Change

Daily Stepping Activity

- StepWatch Activity Monitor (worn throughout study participation)

Vitals

- Resting blood pressure and heart rate

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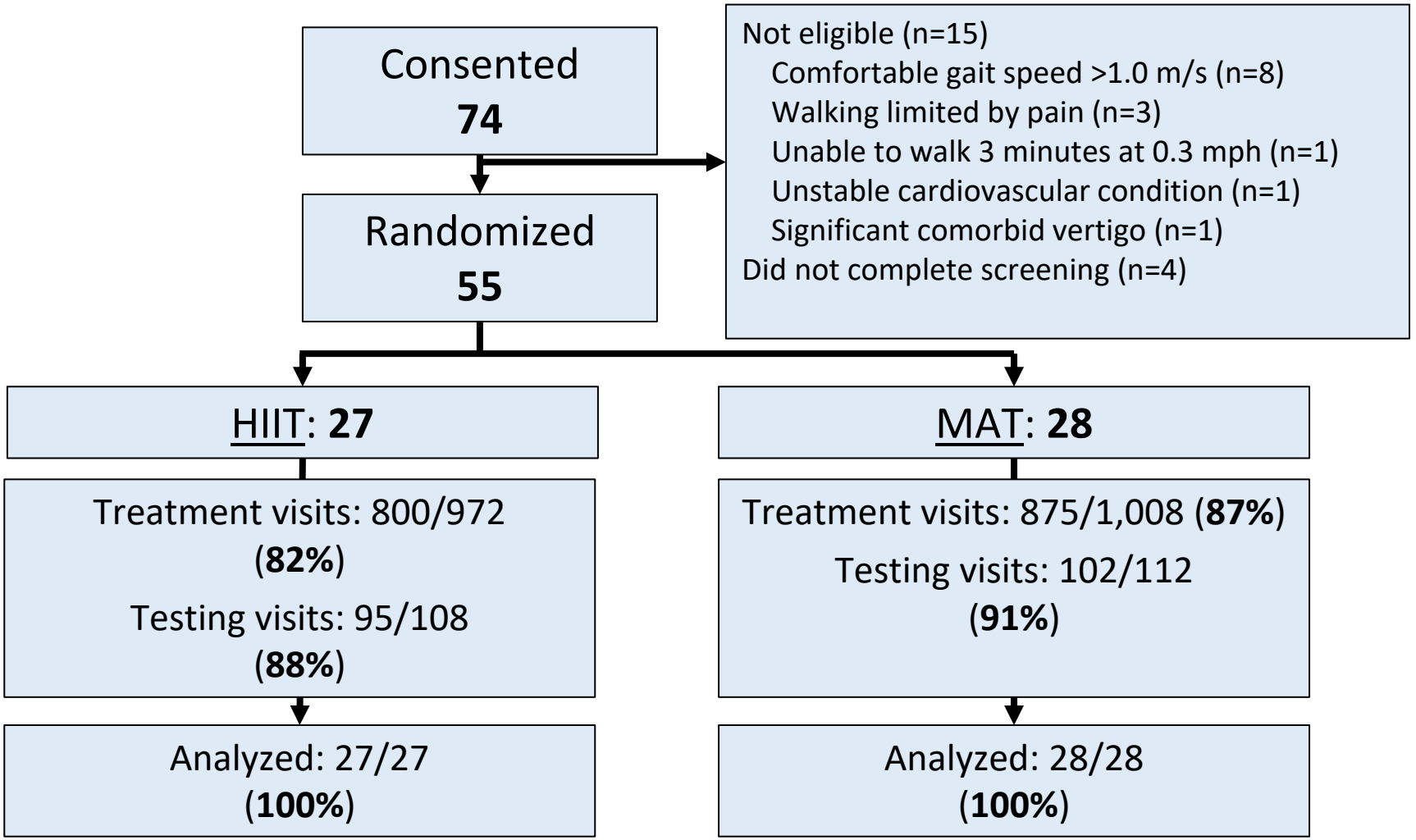
CONSORT Diagram



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Results

Participant Characteristics. *Mean (SD) or N (%)*		
	HIIT (N=27)	**MAT (N=28)**
Age, years	63.8 (9.9)	61.5 (9.9)
Stroke chronicity, years	2.7 (1.4)	2.2 (1.2)
Aphasia, N (%)	7 (25.9%)	7 (25.0%)
Comorbid conditions, N (%)	26 (96.3%)	27 (96.4%)
Prescribed β-blocker	7 (25.9%)	11 (39.3%)

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Fall in past 3 months, N (%)	8 (29.6%)	7 (25.0%)
Orthotic/assistive device, N (%)	18 (66.7%)	19 (67.9%)
Self-selected gait speed, m/s	0.65 (0.29)	0.62 (0.33)
Self-selected gait speed, % predicted	50.5 (23.3)	47.3 (25.1)

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6-minute walk test, m	248 (136)	230 (130)
6-minute walk test, % predicted	48.5 (26.3)	44.3 (26.8)
Ventilatory threshold VO_2, mL/kg/min	12.1 (3.9)	11.6 (3.9)
Ventilatory threshold VO_2, % predicted	93.1 (24.4)	82.5 (26.2)

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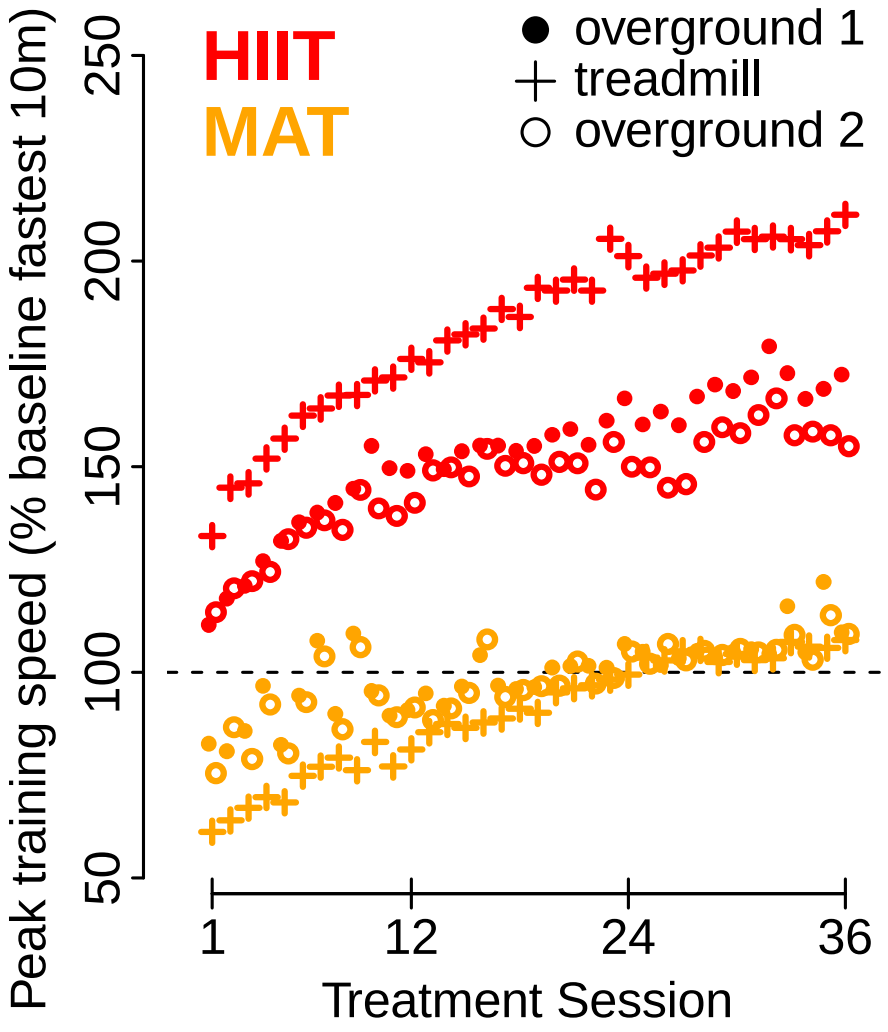

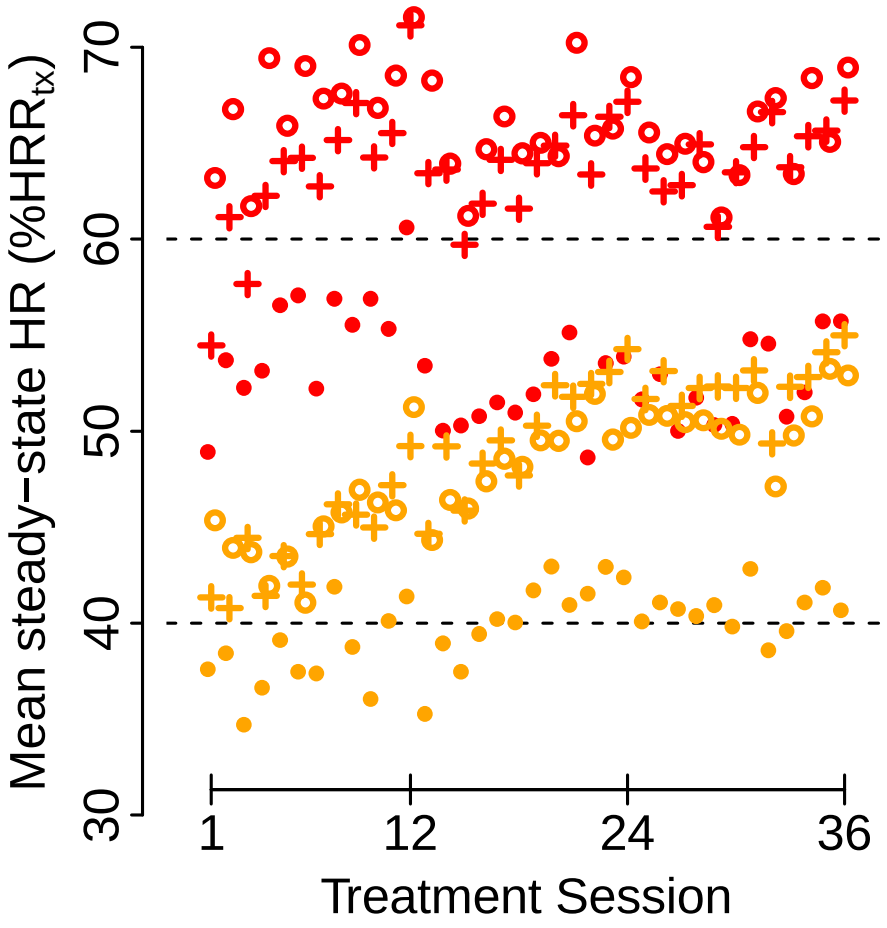

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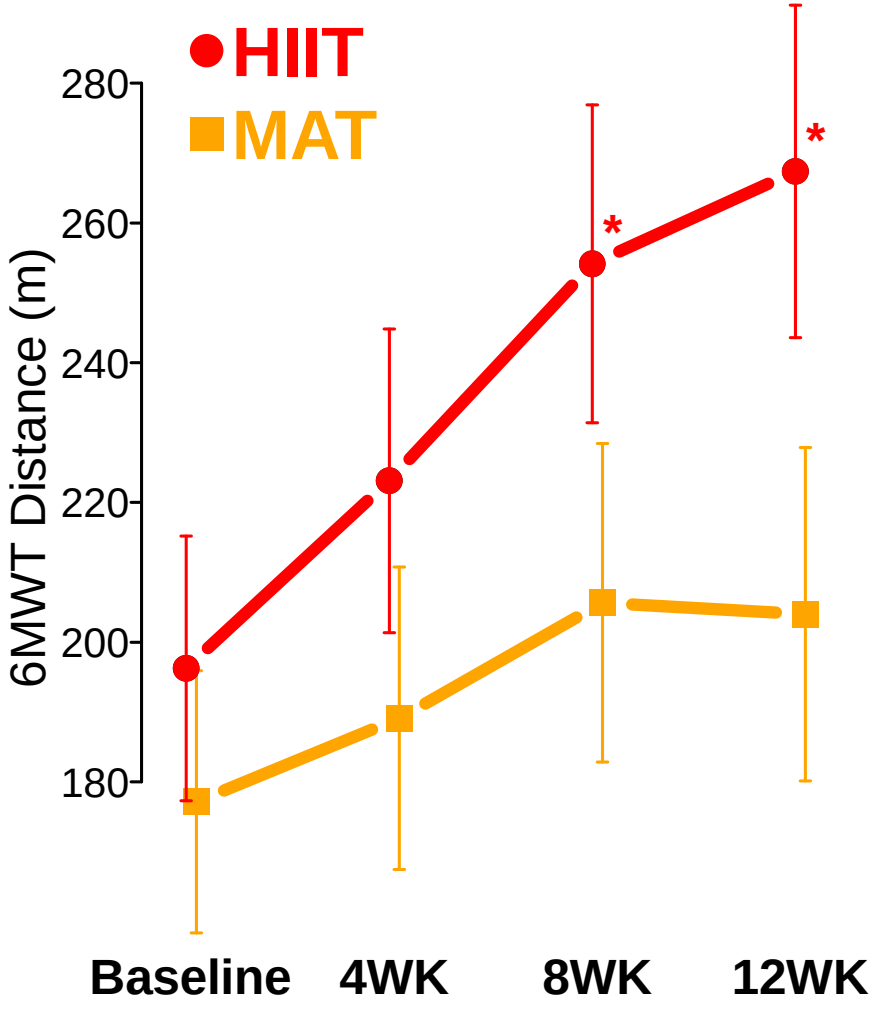

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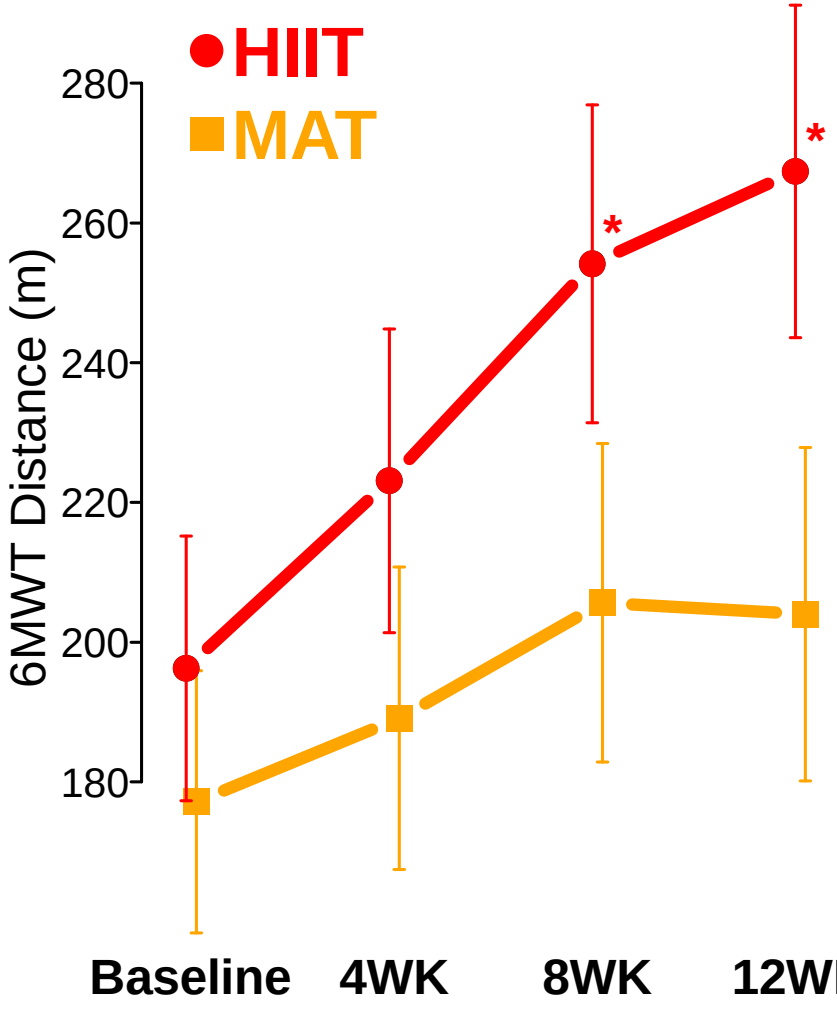

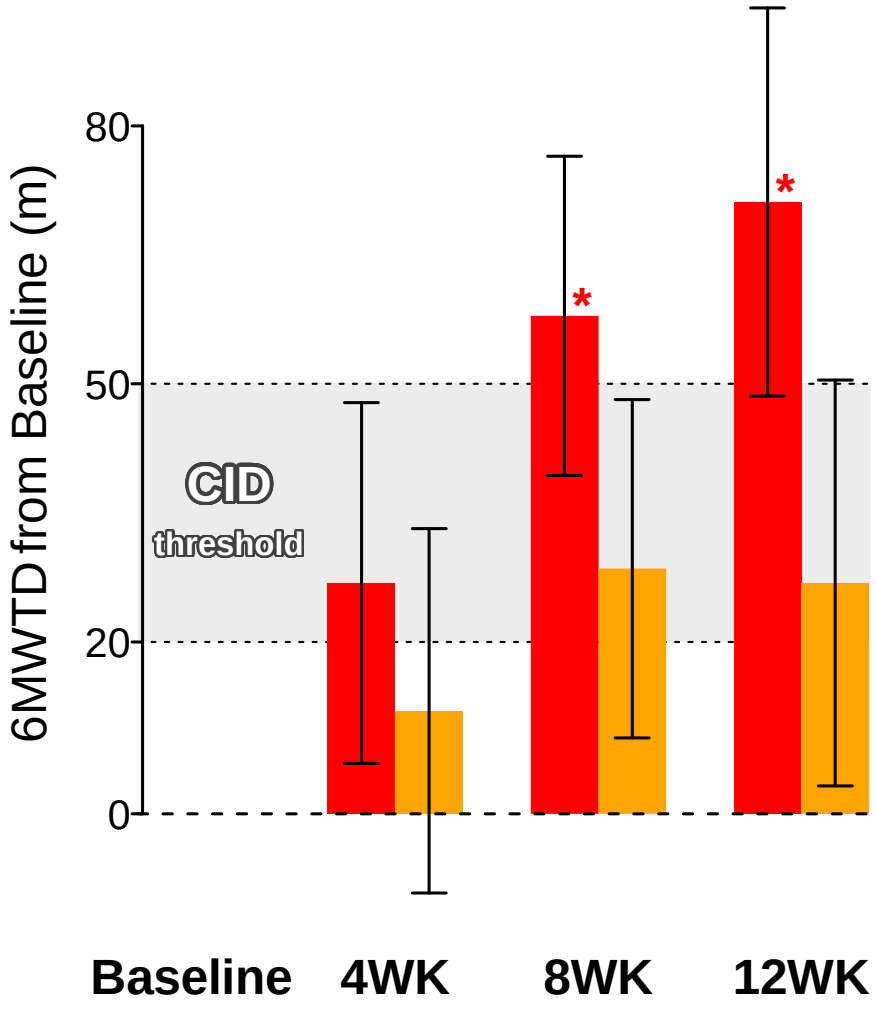

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	HIIT (N=27)	MAT (N=28)	p-value *pFDR<.05
Self-Selected Gait Speed, m/s			
4-Week Change	0.11 [0.06, 0.15]	0.02 [-0.02, 0.07]	0.0091*
8-Week Change	0.14 [0.08, 0.20]	0.06 [0.00, 0.12]	0.0426
12-Week Change	0.19 [0.13, 0.25]	0.06 [0.00, 0.12]	0.0026*
Fastest Gait Speed, m/s			
4-Week Change	0.22 [0.16, 0.28]	0.01 [-0.05, 0.07]	<0.0001*
8-Week Change	0.24 [0.17, 0.32]	0.09 [0.01, 0.17]	0.0029*
12-Week Change	0.28 [0.19, 0.37]	0.09 [-0.01, 0.18]	0.0016*

*Greatest gain for those with slower gait speeds 0.4m/s

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Conclusions

For walking exercise in chronic stroke,

- Vigorous intensity is a critical dosing parameter
- Meaningful gains within **4 weeks**
- At least **12 weeks** to maximize gains

Commentary:

Vigorous intensity was feasible, with no serious AE's

Over 12 weeks, drop out was higher in HIIT (30% vs 18%)

Strict inclusion

GXT for safety and prescription

Feasibility of 12 weeks in clinical practice and global considerations

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HIT Stroke 2

Addresses limitations in HIT Stroke

- Same protocol as HIT Stroke
- Larger sample size (55/site)
- Chronic (6 months+)
- Include more with lower walking speed
- Allow for botox injections
- Allow for atrial fibrillation and those with pacemaker and ICD as long as no upper limit for HR

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FAST
FITNESS AFTER STROKE

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Fitness After Stroke (FASt)

- **Investigating Exercise Prescription Parameters on Aerobic Fitness and Vascular Health after Stroke**
  - High intensity interval exercise vs moderate intensity continuous exercise
  - Recumbent stepper
  - People with chronic stroke
  - Assess the feasibly of a HIIT exercise program and preliminary efficacy on measures of vascular health
- Double-blind RCT
- Enroll 50 participants with chronic stroke, age 20-85 years, into 4-week exercise program.
- Participants will exercise in one of the following groups
  - MICT
  - HIIT
    - Short interval, high volume using peak power output (PPO)

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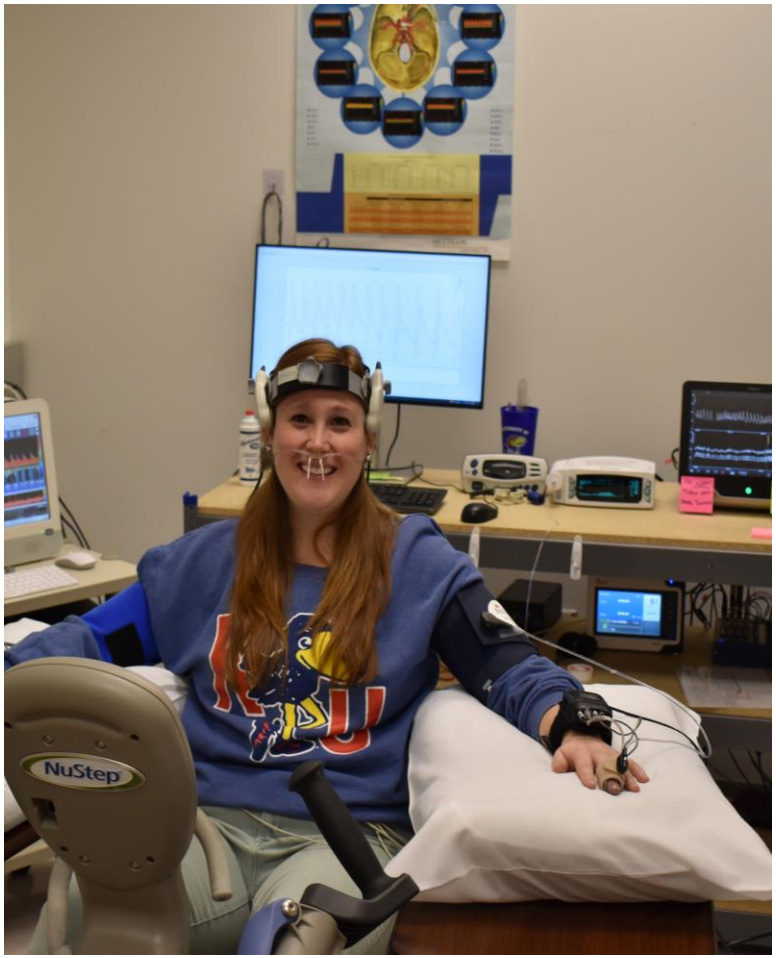
Study Aims

- Aim 1: Assess preliminary efficacy of HIIT on aerobic fitness
- Aim 2: Examine the preliminary efficacy of a HIIT program on cerebrovascular hemodynamics
- Aim 3: Examine the preliminary efficacy of a HIIT program on improving vascular function



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FAST

- Capturing exercise enjoyment on the PACES
- Feasibility for reaching target HR zones
- Safety related to short-interval; high volume HIIT
- Results:
  - 33 participants completed the 4-week intervention
  - 2 in screening
  - 3 screen fail; 1 withdrew

PUSHING BOUNDARIES

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Goals

- Develop tools to reduce barriers to exercise
- Prescribe exercise using submaximal exercise test
  - 85% age predicted HR max
  - Various equations
- Safety (Adverse Events)
- Is HIIT on recumbent stepper effective?
  - Treadmill vs stepper
- HIIT model be applied to healthcare setting

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Thank you

- AHA Conference Planning Committee
- REACH Laboratory team
- Research Participants
- Funding
  - NIH
  - American Heart Association
  - Philanthropy

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