Exercise Training & Lifestyle Modification for the Postural Orthostatic Tachycardia Syndrome Patient

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Disclosures

I have no disclosures.

Objectives

1. Pathophysiology of POTS

2. Levine Protocol

3. Patient Results

Postural Orthostatic Tachycardia Syndrome (POTS)

- **POTS vs. Orthostatic Intolerance**
- **POTS vs. Dysautonomia**
- **Demographics and Symptoms**
  - Typically young women
  - Symptoms: fatigue, sleep disturbance, headache, pre-syncopal episodes.

Bryarly et al., 2019

FIGURE 1 Definition of POTS

Postural Orthostatic Tachycardia Syndrome Definition:

Postural orthostatic tachycardia syndrome (POTS) is defined as a clinical syndrome lasting at least 6 months that is characterized by:

1) an increase in heart rate ≥30 bpm within 5 to 10 min of quiet standing or upright tilt (or ≥40 bpm in individuals 12 to 19 years of age);

2) the absence of orthostatic hypotension (>20 mm Hg drop in systolic blood pressure); and

3) frequent symptoms that occur with standing such as lightheadedness, palpitations, tremulousness, generalized weakness, blurred vision, exercise intolerance, and fatigue.

Definition of POTS is adapted from the 2011 and 2015 consensus statements on the diagnosis and treatment of postural tachycardia syndrome (1,3). bpm = beats/min; POTS = postural orthostatic tachycardia syndrome.

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POTS Response to Orthostasis

- **Healthy patient vs POTS patient**
  - Most hemodynamic changes occur in the first 30 seconds
  - Critical role in central blood volume
  - Relationship between HR and SV

Bryarly et al., 2019

Pathophysiology of POTS

- **Cardiovascular Deconditioning**
  - Cardiac atrophy and hypovolemia

- **Pathophysiological variants contributing to the susceptibility of developing POTS**
  - Peripheral autonomic neuropathy
  - Excessive venous pooling
  - Hyperadrenergic states
  - Mast cell activation disorders
  - Autoimmunity

Bryarly et al., 2019
Fu & Levine, 2017

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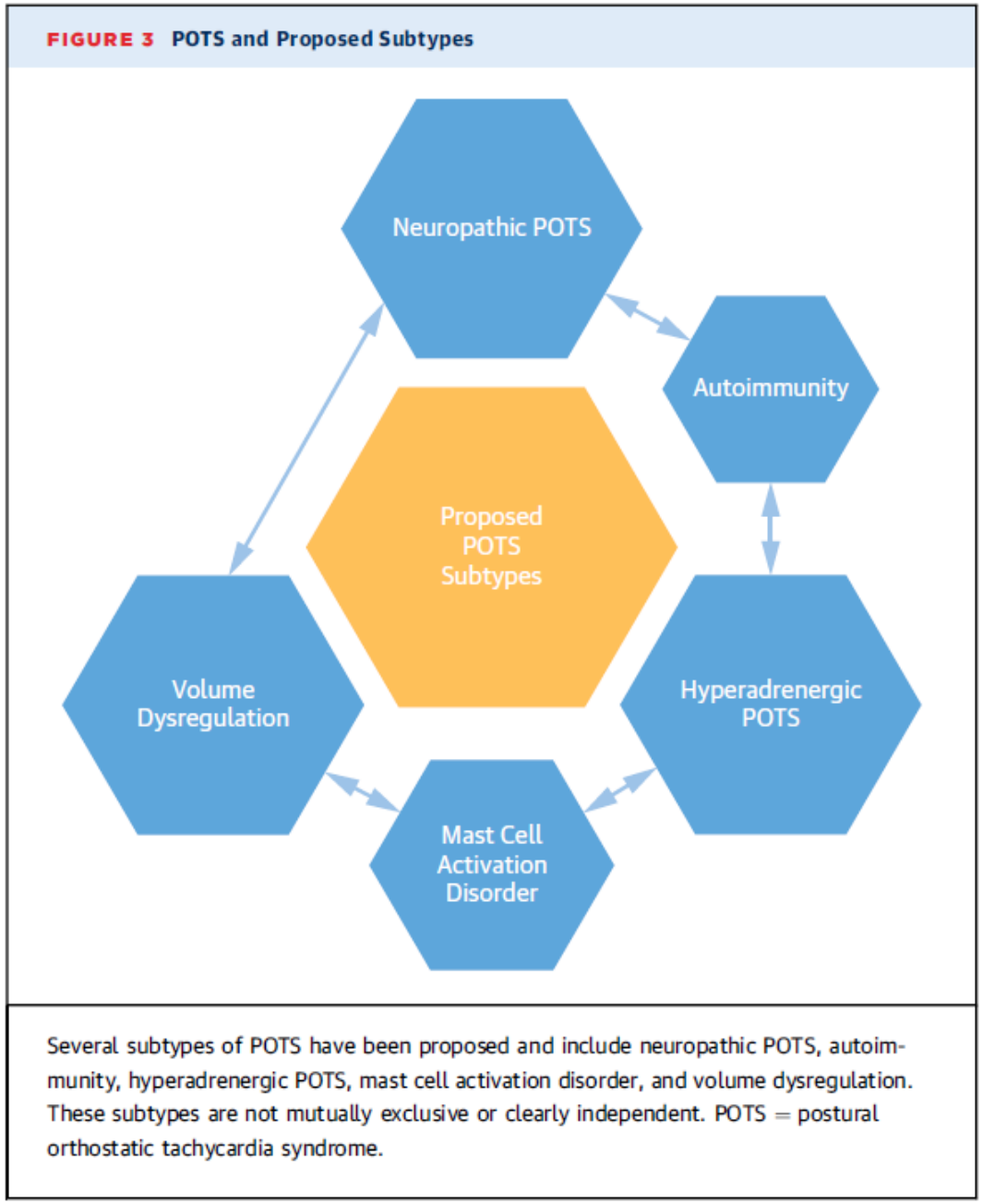
POTS Subtypes



Bryarly et al., 2019

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Neuropathic POTS

- **Peripheral sympathetic denervation causing impaired vasoconstriction and increased venous pooling.**
  - Exaggerated HR and CO required to maintain MAP
- **Lower supine and standing HR**
- **Less anxiety and depression**
- **Greater self-perceived health related QOL**

Bryarly et al., 2019

Hyperadrenergic POTS

- **Symptoms can correspond to 30-60% of POTS patients**
  - Palpitations, abdominal pain, nausea, hyperhidrosis

- **Elevated standing plasma NE levels**
  - Exaggerated sympathetic response

Bryarly et al., 2019

Volume Dysregulation

- **Low plasma volumes**
- **Impaired function of renin-angiotensin-aldosterone system**
  - Moderation of blood pressure regulation
  - Fluctuations affecting orthostatic hemodynamic response

Bryarly et al., 2019

Mast Cell Activation Disorder

- **Inappropriate release of histamine in response to physical activity or orthostatic stress**
  - Flushing
  - SOB
  - Headache
  - Lightheadedness

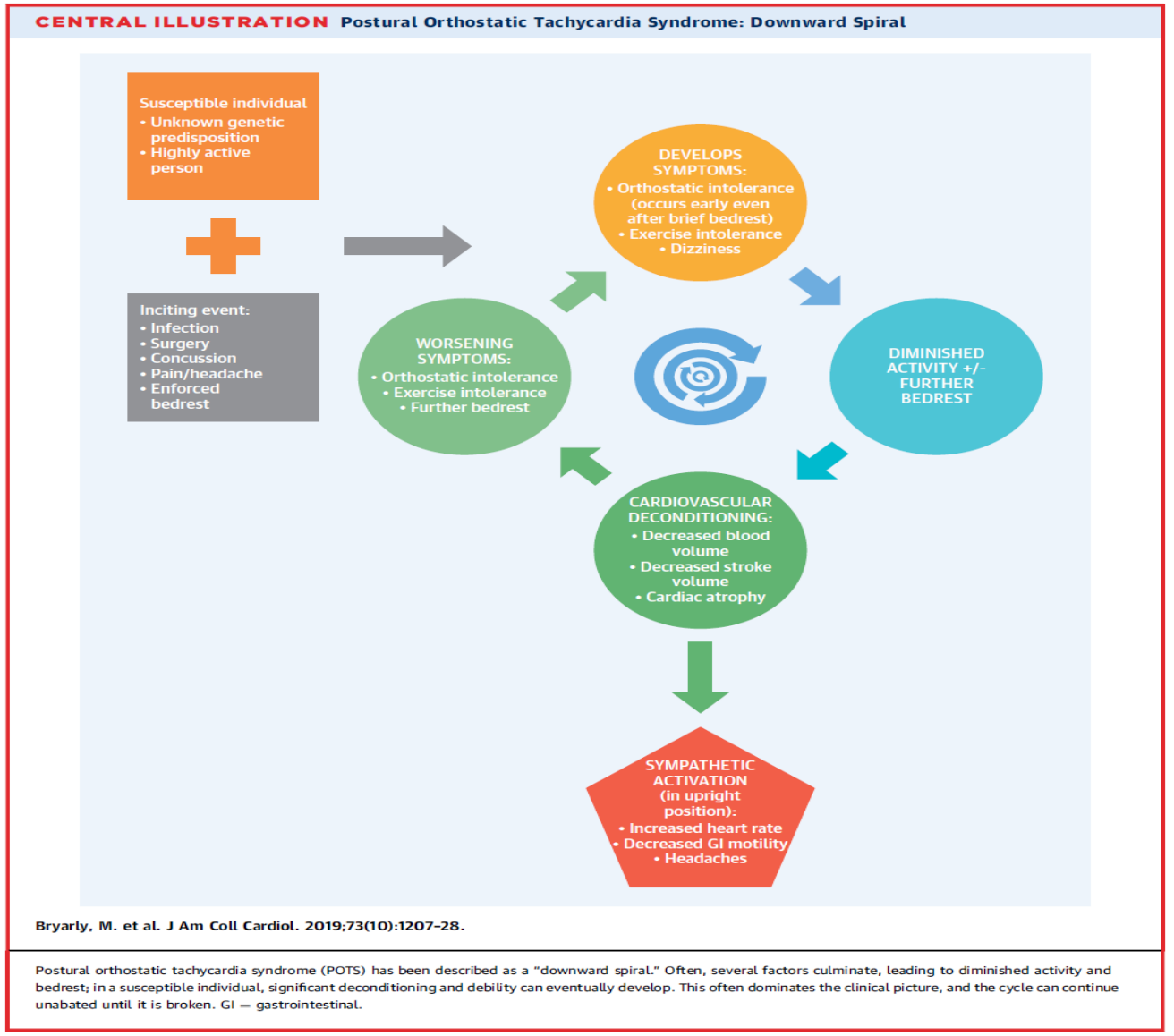
- **Diagnosis Criteria**
  - Increased levels of histamine metabolites in urine
  - Elevated plasma tryptase

Bryarly et al., 2019

POTS Spiral

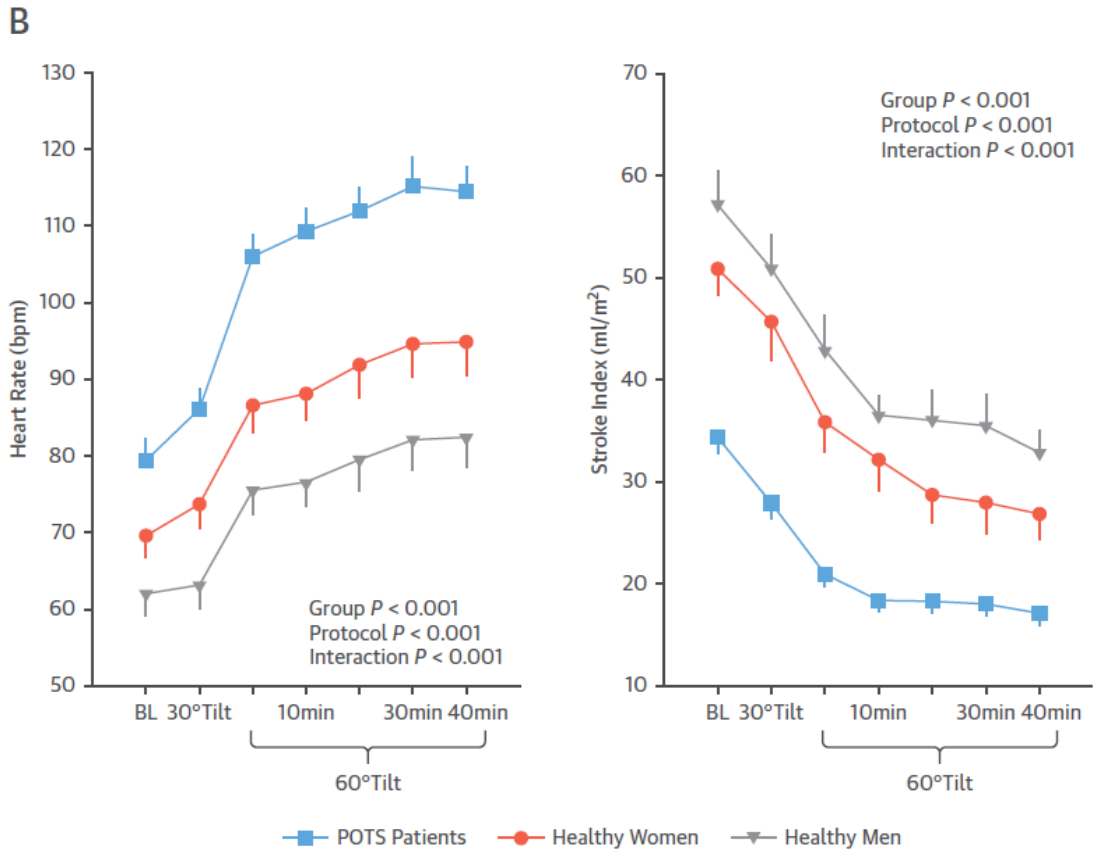
- **Development of Symptoms**
- **Diminished Activity**
- **Cardiovascular Deconditioning**
  - Sympathetic Activation
- **Worsening Symptoms**

Bryarly et al., 2019



Cardiovascular Deconditioning

- **Parameters associated with both deconditioning and POTS**
  - Cardiac size and mass
  - Blood volume
  - Stroke Volume
  - Peak oxygen uptake
- **Roll of orthostatic tachycardia**
- **Positive Responses to exercise training**



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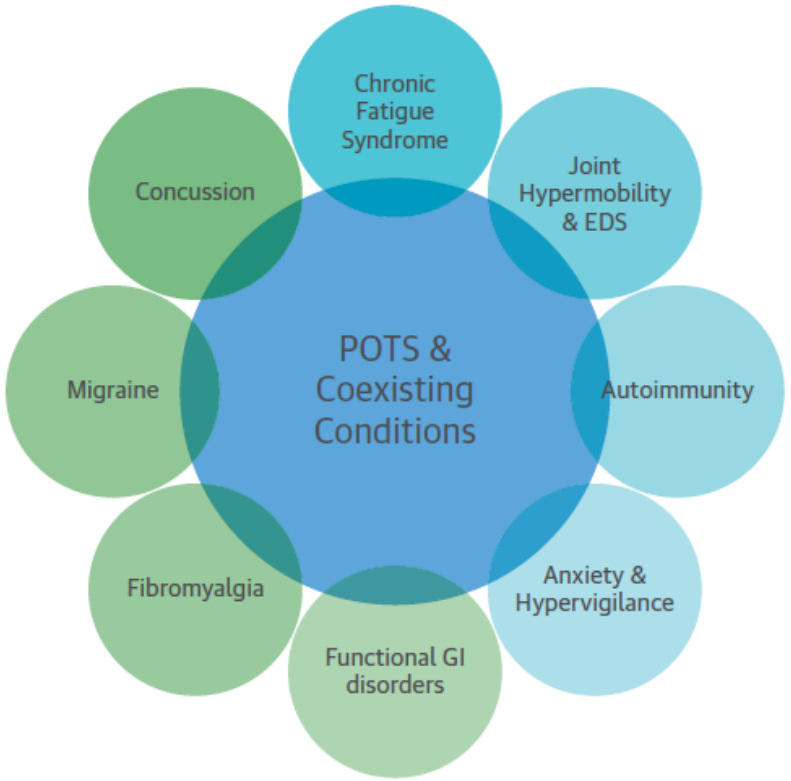
Commonly Associated Conditions

FIGURE 4 Coexisting Conditions in POTS



Patients often relate many other symptoms and comorbidities that are not physiologically explained by orthostatic tachycardia. Some of these persist even with resolution of orthostatic intolerance. These include chronic fatigue syndrome, joint hypermobility and EDS, autoimmune diseases, anxiety and hypervigilance, functional gastrointestinal disorders, fibromyalgia, migraine, and concussion. EDS = Ehlers-Danlos syndrome; GI = gastrointestinal; POTS = postural orthostatic tachycardia syndrome.

Bryarly et al., 2019

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POTS Evaluations

- **Active Stand Test**
  - Simplest evaluation
- **Tilt Table Testing**
- **Complete metabolic profile**
- **Complete blood count**
- **Thyroid function**

FIGURE 6 **Other Conditions That Can Cause Tachycardia**

Other medical problems that can cause or contribute to tachycardia:

Hypovolemia

Anemia

Hyperthyroidism

Pulmonary Embolism

Pheochromocytoma

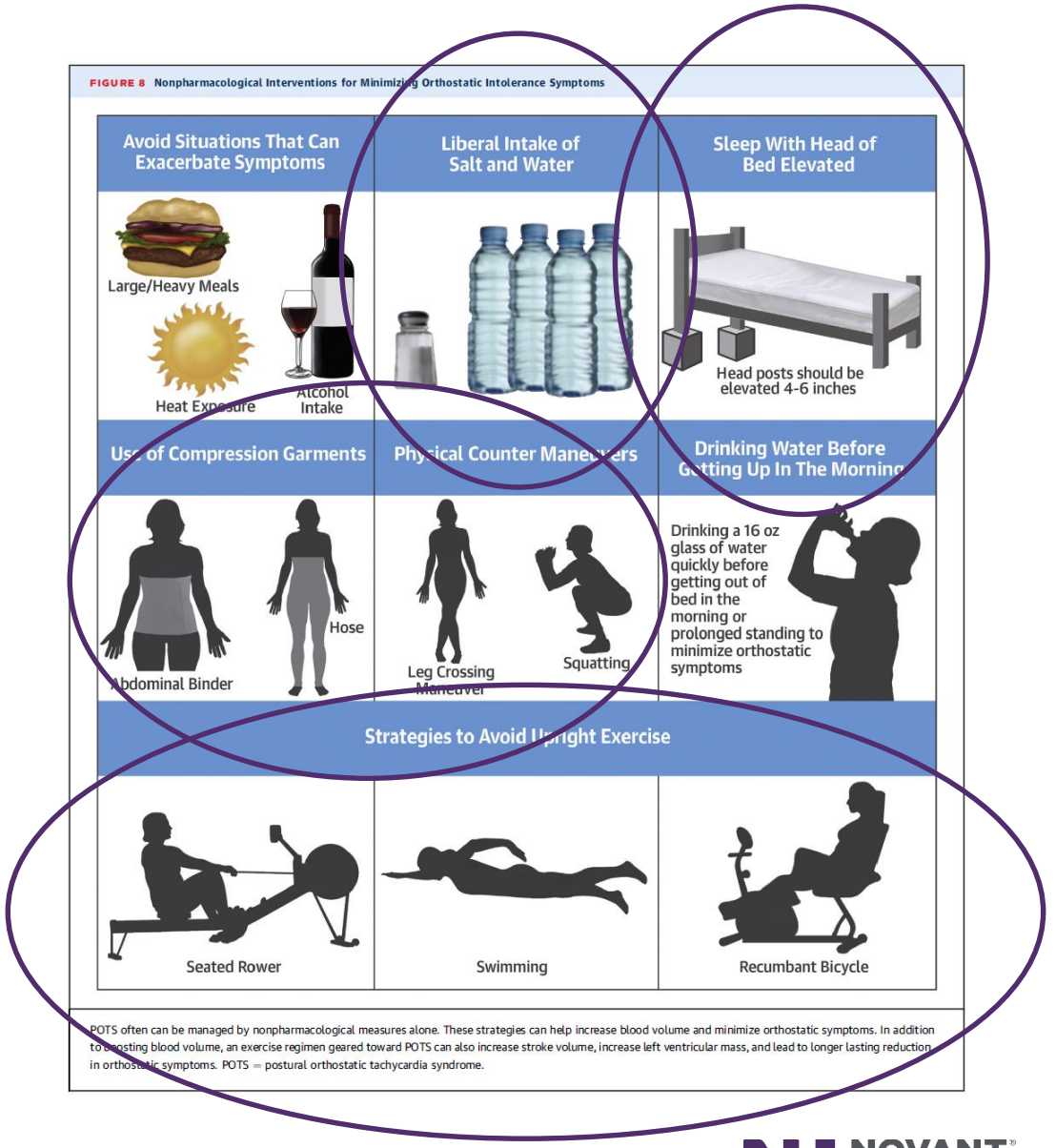
Medications

There are other etiologies that can cause tachycardia, and these must be excluded in order to diagnose postural orthostatic tachycardia syndrome. This is a list of some common etiologies that can contribute to tachycardia.

Bryarly et al., 2019

Management of POTS

- **Exercise**
  - Key treatment approach
  - Levine Protocol
- **Nonpharmacological Measures**



Bryarly et al., 2019
Fu & Levine, 2018

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Levine Protocol

- **Warm Up**
  - Can be done on any piece of equipment
  - HR should be approaching the target HR zone for the workout
- **Cool Down**
  - Remove all resistance from the piece of equipment
  - Allow time for HR to recover

Raj & Levine, 2013

Levine Protocol

- **Aerobic Training Protocol**
  - Various HR zones for workouts
  - Horizontal modalities for training
  - Spread out workouts throughout the week

Raj & Levine, 2013

Levine Protocol

HR Zone	HR Determination

Raj & Levine, 2013

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Levine Protocol

- **Months 1-3**
  - Horizontal or seated training
- **Months 4-5**
  - Upright exercise, as tolerated
- **Months 6-8**
  - Upright training

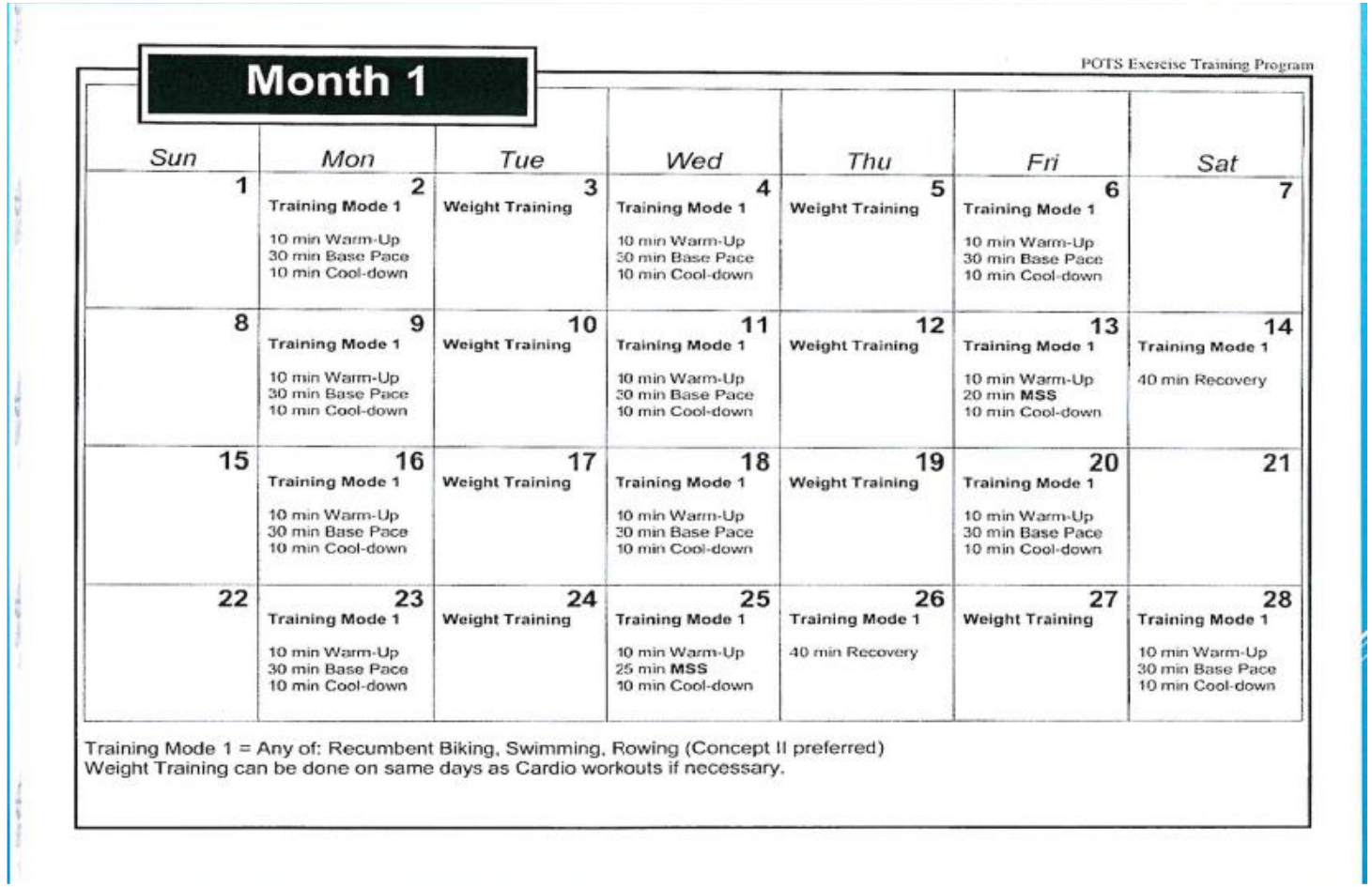
Fu & Levine, 2018

Levine Protocol

- **Strength Training**
  - Lower body exercises
  - Body weight or seated modalities
  - Allow for recovery time

Fu & Levine, 2018

Levine Protocol



POTS Exercise Training Program

Month 1

Sun	Mon	Tue	Wed	Thu	Fri	Sat
1	2 **Training Mode 1** 10 min Warm-Up 30 min Base Pace 10 min Cool-down	3 **Weight Training**	4 **Training Mode 1** 10 min Warm-Up 30 min Base Pace 10 min Cool-down	5 **Weight Training**	6 **Training Mode 1** 10 min Warm-Up 30 min Base Pace 10 min Cool-down	7
8	9 **Training Mode 1** 10 min Warm-Up 30 min Base Pace 10 min Cool-down	10 **Weight Training**	11 **Training Mode 1** 10 min Warm-Up 30 min Base Pace 10 min Cool-down	12 **Weight Training**	13 **Training Mode 1** 10 min Warm-Up 20 min **MSS** 10 min Cool-down	14 **Training Mode 1** 40 min Recovery
15	16 **Training Mode 1** 10 min Warm-Up 30 min Base Pace 10 min Cool-down	17 **Weight Training**	18 **Training Mode 1** 10 min Warm-Up 30 min Base Pace 10 min Cool-down	19 **Weight Training**	20 **Training Mode 1** 10 min Warm-Up 30 min Base Pace 10 min Cool-down	21
22	23 **Training Mode 1** 10 min Warm-Up 30 min Base Pace 10 min Cool-down	24 **Weight Training**	25 **Training Mode 1** 10 min Warm-Up 25 min **MSS** 10 min Cool-down	26 **Training Mode 1** 40 min Recovery	27 **Weight Training**	28 **Training Mode 1** 10 min Warm-Up 30 min Base Pace 10 min Cool-down

Training Mode 1 = Any of: Recumbent Biking, Swimming, Rowing (Concept II preferred)
Weight Training can be done on same days as Cardio workouts if necessary.

Children's Hospital of Philadelphia, 2016

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POTS Case Study—Testing, Protocol, & Lifestyle Modifications

- **Serial orthostatic and cardiopulmonary exercise testing**
  - Performed every 45 days
- **Training protocol HR ranges based off of testing results**
  - Training HR updated into exercise prescription after each CPET
- **Various lifestyle modifications made by patient to help relieve symptoms**
  - Sodium intake
    - Monitored via dietary app with RD
  - Bed risers
  - Compression socks

POTS Case Study

- **Orthostatic Evaluations**
  - Performed every 45 days
  - Supine for 5 minutes prior to initial BP and HR
  - Immediately into standing position, BP and HR measured every minute for 10 minutes
  - Noted change in symptoms each minute
  - Following completion of the assessment, the change in HR and change in BP were calculated

POTS Case Study

- **Cardiopulmonary Exercise Testing**
  - 15 Watt protocol on a cycle ergometer
  - RPE and symptoms evaluated every two minutes
  - CPET used to:
    - Determine changes in peak HR for exercise prescription adjustment
    - Evaluate improvements in cardiorespiratory fitness
    - Assess changes in the heart rate-oxygen consumption relationship

POTS Case Study—Training Intervention

POTS Case Study—Results

Table 1. Physiologic Changes with Serial CPET

	Test 1	Test 2	Test 3	Test 4	Test 5
Test Duration (min)	9.3	10.3	11.6	11.9	12.1
Peak HR (beats·min^{-1})					
Percent of Max HR (%)					
Peak RER					
Peak VO_2 (mL · kg^{-1} · min^{-1})					
Peak Power Output (Watts)					
VO_2 at VAT (mL · kg^{-1} · min^{-1})					
HR at VAT (beats·min^{-1})					

Changes in various physiologic variables with serial cardiopulmonary exercise tests performed at 45-day intervals. HR, heart rate; RER, respiratory exchange ratio; VO_2, oxygen consumption; VAT, ventilatory anaerobic threshold.

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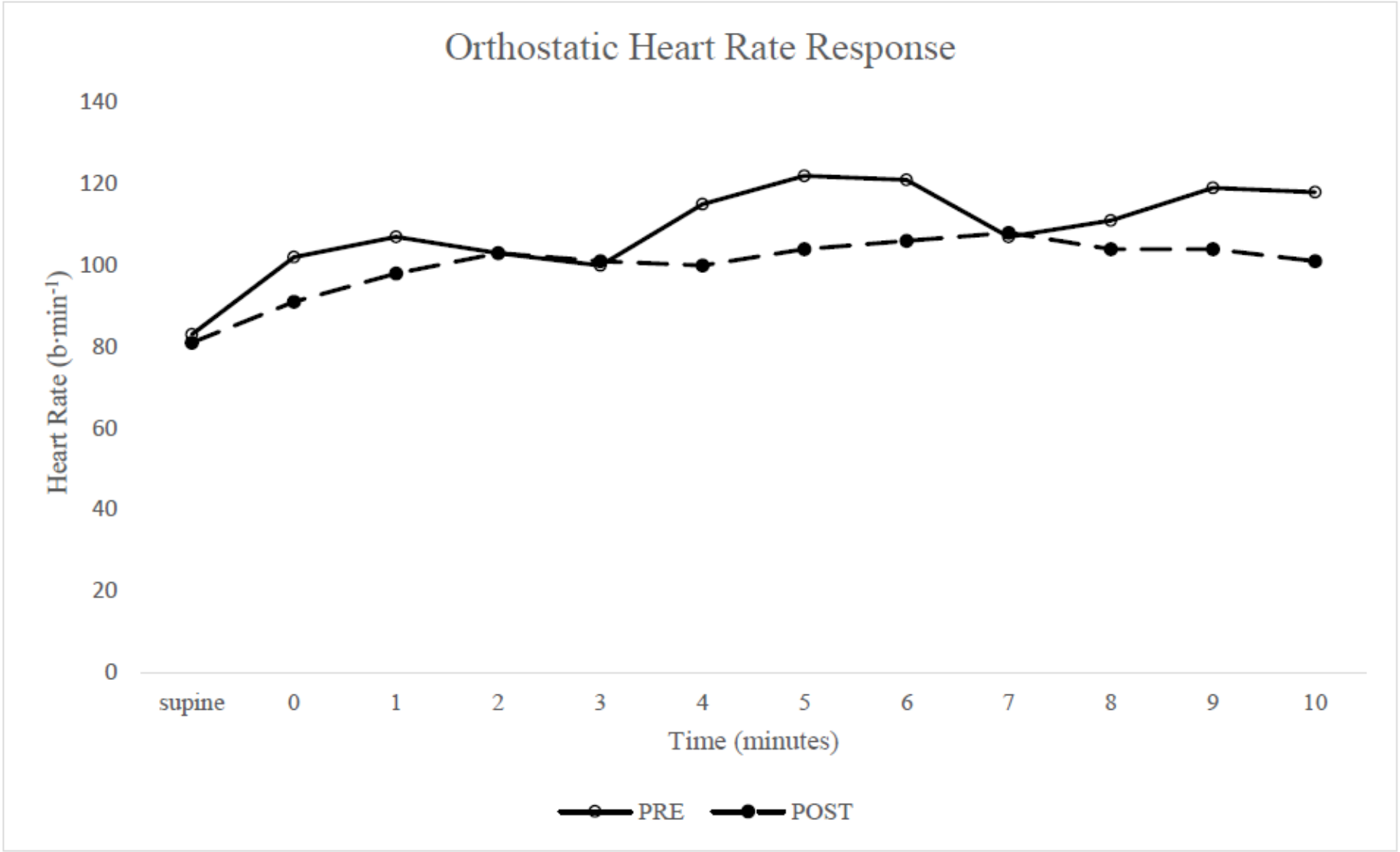
POTS Case Study—Results



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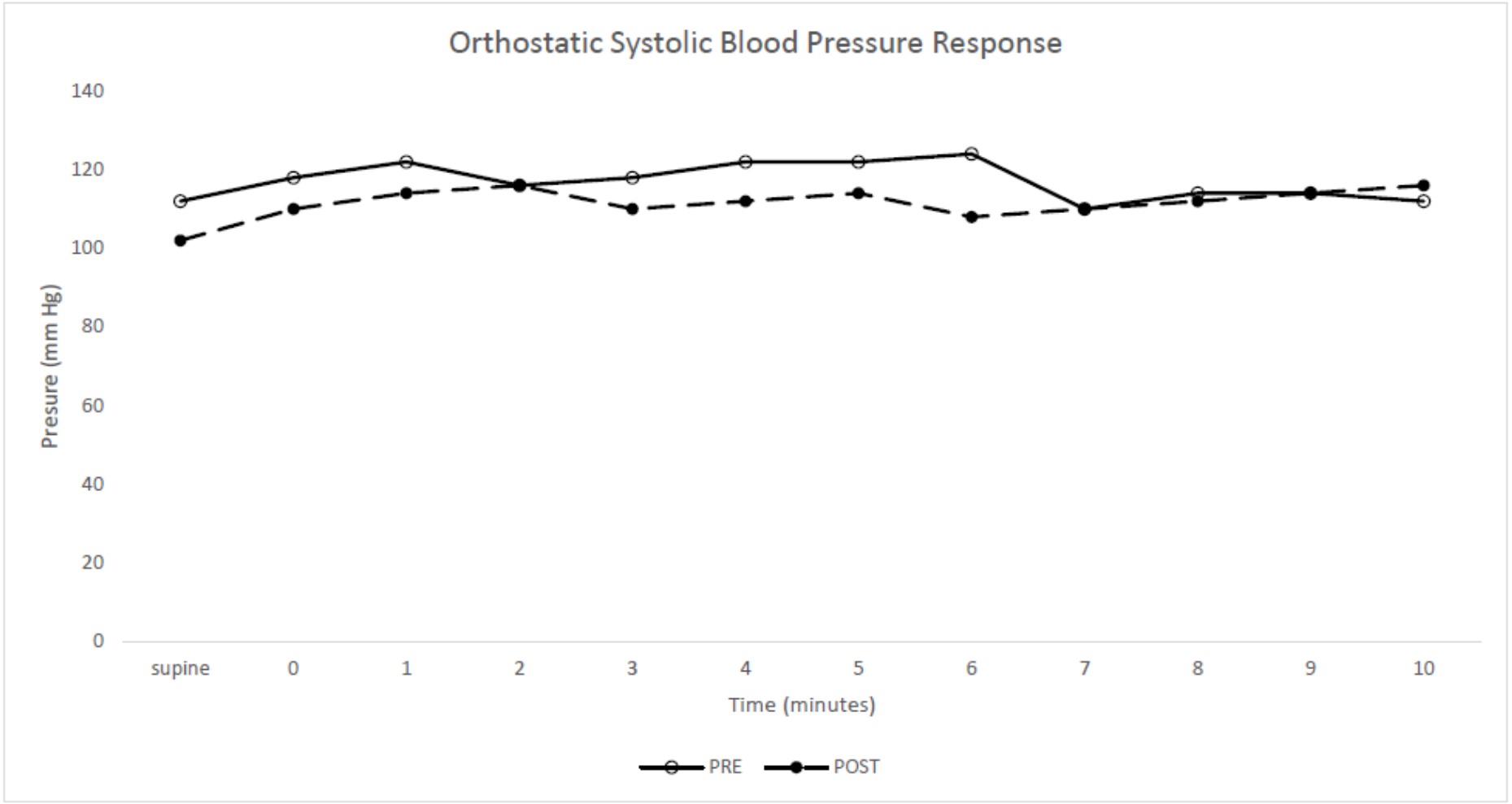

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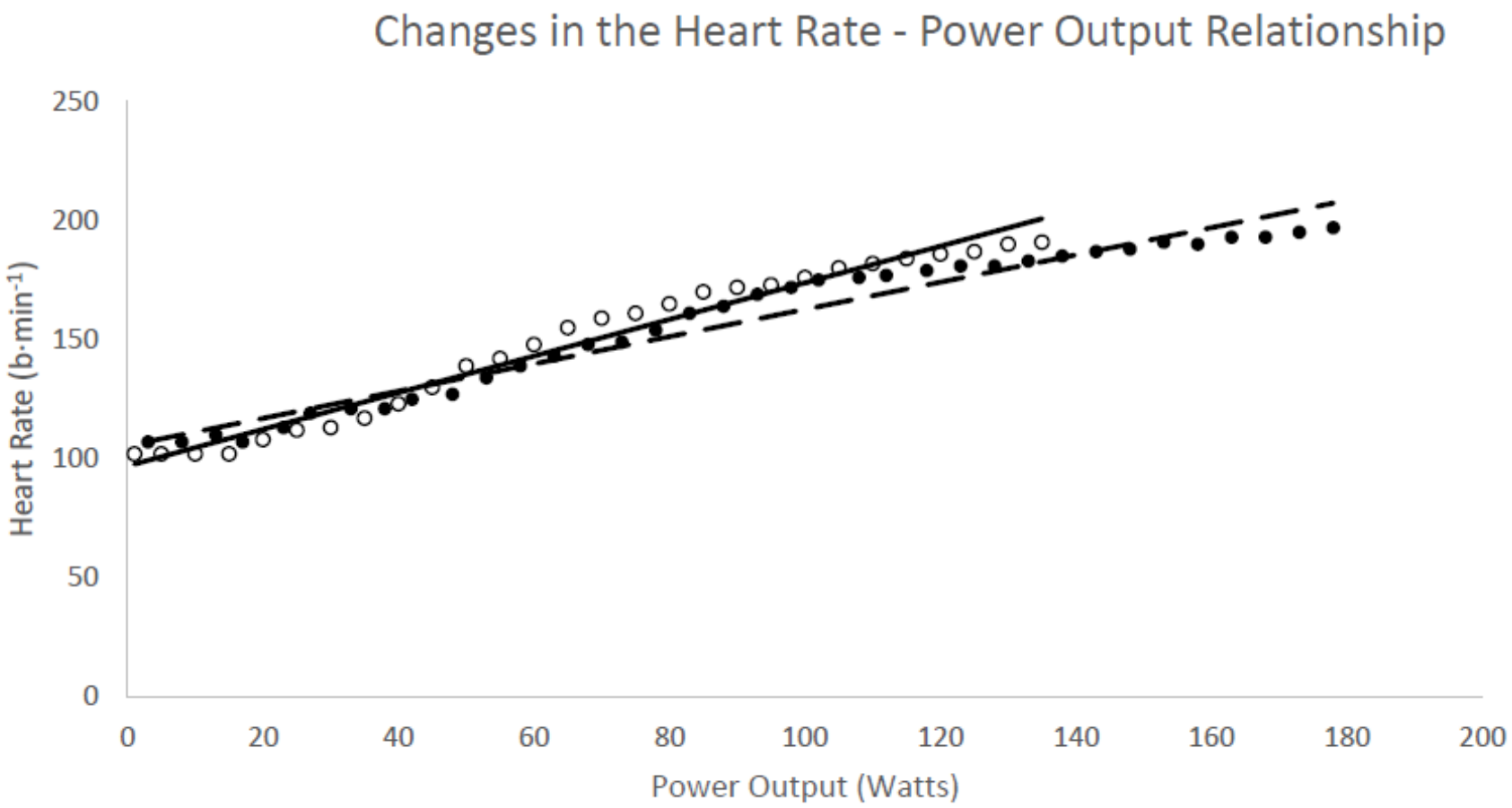
POTS Case Study—Results



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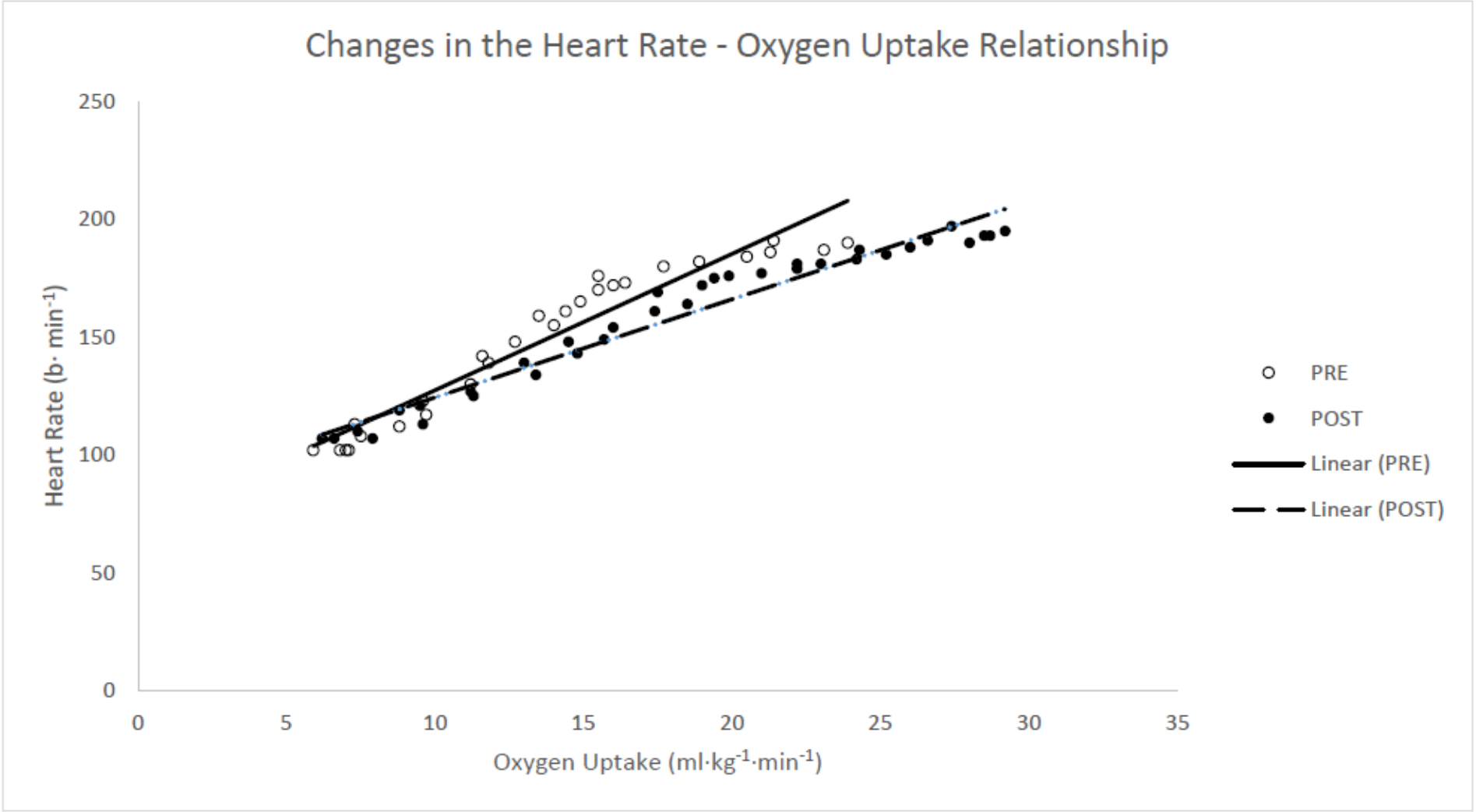

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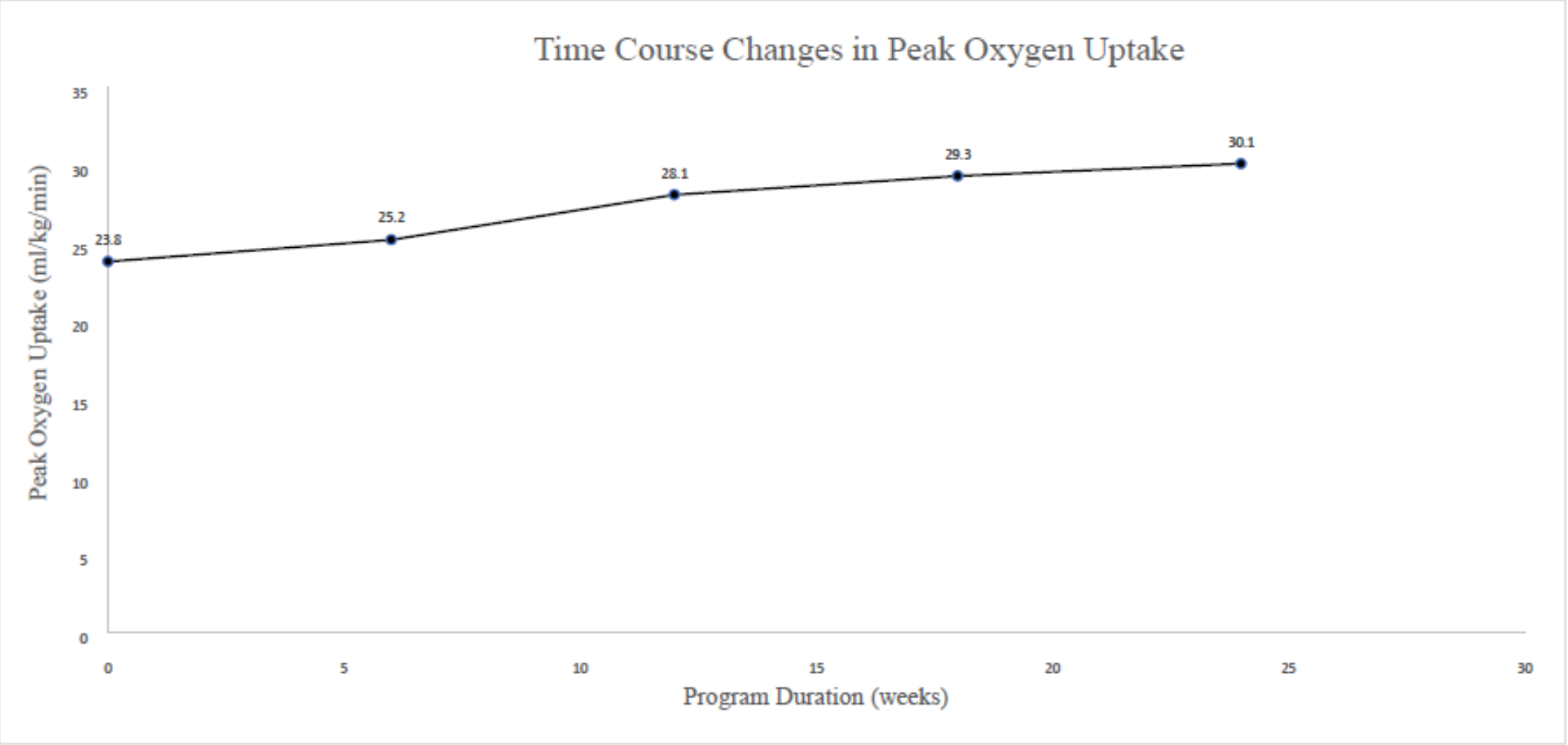

Conclusions

1. **POTS has various subtypes and can be diagnosed and evaluated by different testing methods.**
2. **The Levine Protocol is the widely accepted exercise intervention to help alleviate symptoms.**
3. **Case study results show that modifying the Levine protocol can:**
    1. Improve orthostatic intolerance
    2. Improve exercise capacity
    3. Reduce self-reported symptoms

Thank You.

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