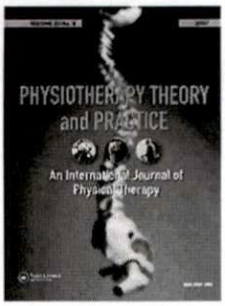

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CASE REPORT



# Using an exercise program to improve activity tolerance in a female with postural orthostatic tachycardia syndrome: A case report

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**ABSTRACT**

The incidence of postural orthostatic tachycardia syndrome (POTS) is estimated to be at least 500,000 in the United States and is most commonly found in premenopausal females. This syndrome shares clinical features with orthostatic hypotension (OH); however, the inclusion criteria and clinical features for POTS are not well known. The purposes of this case report are to: 1) describe the common clinical features of POTS and highlight the differences to orthostatic hypotension and 2) discuss physical therapy management of patients with POTS using exercise. A 34-year-old female with a POTS exacerbation completed a 4-week physical therapy endurance and strengthening 'reconditioning' program. Initial symptoms included the following: dyspnea with mild exertion, light-headedness, fatigue, leg "heaviness," and the inability to perform normal work duties. One-mile track walk test (1-MWT) estimated $VO_{2max}$ improved from the 45–50th percentile to the 65–70th percentile at 8 weeks post-discharge. She returned to work full-time and resumed all previous fitness activities. The patient demonstrated clinically meaningful improvements in estimated $VO_{2max}$ after the "reconditioning" training. Physical therapists should be able to recognize the clinical features and inclusion criteria for POTS as part of a differential diagnosing process for patients complaining of orthostatic symptoms.

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Exercise; orthostatic hypotension; tachycardia

## Introduction and purpose

Postural orthostatic tachycardia syndrome (POTS) is a subset of orthostatic intolerance (OI) disorders which are characterized by the inability to remain upright for extended periods of time due to decreased venous return to the heart when transitioning from a recumbent position to a standing position (Low, Sandroni, Joyner, and Shen, 2009). The incidence of POTS is estimated to be at least 500,000 individuals in the United States (Robertson, 1999; Stewart, 2004) and is most commonly found in premenopausal females (Fu, Witkowski, Okazaki, and Levine, 2005; Fu et al., 2004; Low, Sandroni, Joyner, and Shen, 2009). The most frequent symptoms are listed in Table 1. Symptoms of POTS typically worsen in standing and often quickly improve after assuming a recumbent position (Raj, 2013). No specific timeframes for symptom improvement have been reported in the literature. However, from online forums and the patient's experience, the recovery was quick upon assuming recumbency. Postural orthostatic tachycardia syndrome is diagnosed when the heart rate increases at least 30 beats per minute (bpm) during 10 minutes of quiet standing when compared with supine heart rate at rest and/or a standing heart rate of at least 120 bpm during 10 minutes of quiet standing. If there is evidence of orthostatic hypotension (OH) during POTS testing, then the patient is diagnosed with OH and not POTS (Carew et al., 2009; Fu, Vangundy, Galbreath, and Shibata, 2011; Shibata et al., 2012) (Table 2).

For a person without POTS or OH, moving to an upright position rapidly shifts 300–800 mL of blood from the thorax toward the lower body (Carew et al., 2009). In addition, a secondary shift of plasma volume from the vasculature into the interstitial tissue occurs (Raj, 2013). These mechanisms result in reduced venous return to the heart, which unloads the arterial and cardiopulmonary mechanoceptors. This alteration in sensory input triggers inhibition of the parasympathetic nervous system and excitation of the sympathetic nervous system resulting in compensatory vasoconstriction and increased heart rate (Carew et al., 2009; Raj, 2013). Additionally, a valsalva maneuver can also be performed when moving into an upright

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Table 1. Comparison of symptoms.

| SYMPTOMS ASSOCIATED WITH **POTS** (Carew et al., 2009; Freeman et al, 2011; Fu, Vangundy, Galbreath, and Shibata, 2011; Low et al, 2009) | SYMPTOMS ASSOCIATED WITH **OH** (Shibao, Lipitz, and Biaggioni, 2013) |
|---|---|
| **MOST COMMON:** | **MOST COMMON:** |
| Light-headedness (Dizziness) | Light-headedness (Dizziness) |
| Palpitations | Syncope (Pre-syncope) |
| Pre-syncope | Dim, Blurred, or Tunnel Vision |
| Muscle Weakness (commonly in legs) | Dull Neck or Shoulder Pain |
| Fatigue | |
| **LESS COMMON:** | **LESS COMMON:** |
| Nausea | Fatigue |
| Tremulousness | |
| Sleep Disturbance | |
| Dyspnea | |
| Migraine Headache | |

POTS = postural orthostatic tachycardia syndrome, OH = orthostatic hypotension.

Table 2. Inclusion criteria comparison between POTS and OH.

| |
|---|
| **POTS (HR comparison between supine at rest & HR during 10 minutes of quiet standing)** (Carew et al, 2009; Fu, Vangundy, Galbreath, and Shibata 2011; Shibata et al, 2012) |
| 1. Increase in HR ≥30 bpm and/or a standing HR ≥ 120 bpm |
| 2. No evidence of orthostatic hypotension |
| **OH (BP comparison between supine at rest & BP during 3 minutes of quiet standing)** (Shibao, Lipitz, and Biaggioni, 2013) |
| 1. Decrease systole ≥ 20 mm Hg and/or |
| 2. Decrease diastole ≥ 10 mm Hg |

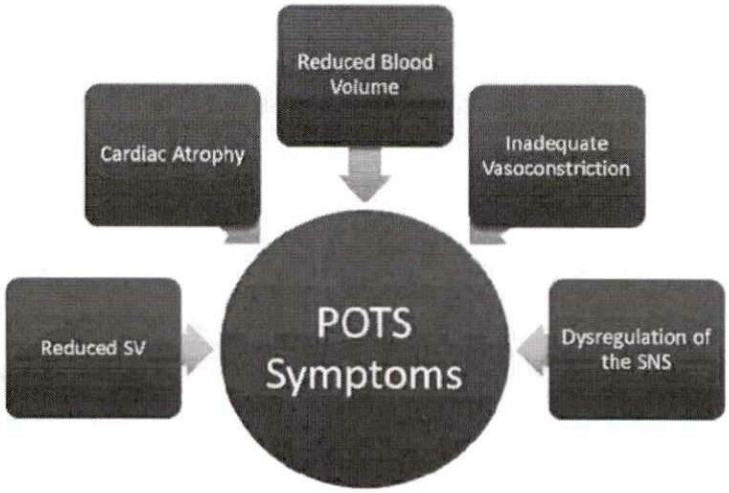
POTS = postural orthostatic tachycardia syndrome, OH = orthostatic hypotension, HR = heart rate, BP = blood pressure

position. This maneuver increases thoracic and intra-abdominal pressure resulting in reduced preload to the heart triggering vasoconstriction which helps maintain blood pressure (Vogel, Sandroni, and Low, 2005).

For individuals who fall under the larger category of orthostatic intolerance disorders, the inadequate response of the sympathetic nervous system to the decrease in cardiac filling after assuming an upright position may lead to insufficient compensatory reactions resulting in the classic symptoms of syncope, pre-syncope, dizziness, and light-headedness (Fu, Witkowski, Okazaki, and Levine, 2005). A variety of factors contribute to these symptoms including the following: inadequate vasoconstrictor mechanisms not providing sufficient control of the blood moving from the thorax into the abdomen and lower extremities when assuming an upright position (Freeman et al., 2011), inadequate stroke volume reducing cardiac output which compromises the ability to maintain orthostasis (Fu et al., 2004), ineffective autonomic adjustments such as increasing vascular tone, heart rate, and cardiac contractile force which do not adequately occur resulting in insufficient arterial pressure stabilization (Freeman et al., 2011), general deconditioning, and/or smaller and less compliant hearts resulting in tachycardia in an effort to maintain cardiac output in the upright position (Carew et al., 2009; Fu, Witkowski, Okazaki, and Levine, 2005; Raj, 2006) (Figure 1).

### *Pathophysiology of POTS*

POTS appears to be the result of an improperly functioning autonomic nervous system (Raj, 2013). Although the exact etiology and pathophysiology of POTS is unclear, the clinical manifestations of




POTS = Postural Orthostatic Tachycardia Syndrome, SV = stroke volume, SNS = sympathetic nervous system

**Figure 1.** Possible triggers of POTS (Carew et al, 2009; Fu, Vangundy, Galbreath, and Shibata, 2011; Low et al, 2009; Raj, 2006; Raj 2013; Raj et al, 2005; Shibata et al., 2012).

**Table 3.** Summary of sub-types of pots.

| POTS CATEGORY: | Pathophysiology: | Manifestation: |
|---|---|---|
| **NEUROPATHIC:** | Denervation of sympathetic sudomotor ganglion in lower extremities | Decreased sweating<br>Impaired vasoconstriction |
| **CENTRAL HYPERADRENERGIC:** | Increased plasma norepinephrine | Increased SNS response |
| **HYPOVOLEMIC:** | Decreased serum concentrations of renin and aldosterone;<br>Altered renin-angiotensin-aldosterone axis | Decreased blood volume |

POTS = postural orthostatic tachycardia syndrome, SNS = sympathetic nervous system.

intermittent orthostatic tachycardia and pre-syncope in standing are hallmarks of the disorder (Freeman et al., 2011; Raj, 2006). The most commonly recognized categories are neuropathic, hyperadrenergic, and hypovolemic (Carew et al., 2009; Low, Sandroni, Joyner, and Shen, 2009; Raj, 2006; Raj, 2013; Raj et al., 2005). Table 3 provides a comparison of the common pathophysiological categories of POTS. Deconditioning and chronic fatigue syndrome have been linked to POTS (Carew et al., 2009), and in some cases, surgery, pregnancy, or a recent illness (especially viral) may trigger POTS or lead to a relapse of previously controlled POTS (Carew et al., 2009; Freeman et al., 2011; Raj, 2006; Raj, 2013). Dependent acrocyanosis which is peripheral extremities that are cold to the touch with dark discoloration occur in the legs of about 50% of patients with POTS (Raj, 2013).

### *Lifestyle management of POTS*

Successful management of POTS symptoms includes medication management and lifestyle modifications including exercise. Based on the suspected etiology and at the direction of the physician, medications that reduce sympathetic nervous system response and/or decrease tachycardia such as the beta-adrenergic blocker propranolol may be indicated. In addition, tricyclic and/or serotonin-norepinephrine reuptake inhibitor (SNRI) antidepressants and/or attention deficit/hyperactivity disorder (ADHD) medications may be withdrawn since those medications block the norepinephrine transporter resulting in an increase concentration of norepinephrine in the blood which increases sympathetic nervous system response and exacerbates tachycardia (Raj, 2013). Currently, there are no approved medications for the treatment of POTS (Raj, 2013). Lifestyle modifications such as consistent water and salt intake are also recommended. These are summarized in Table 4.

**Table 4.** Lifestyle modification strategies for patients with POTS (Carew et al, 2009; Low et al, 2009; Raj, 2006).

| | |
|---|---|
| Water intake: | 2.2.5L/day (8–10 cups/day) |
| Increase Dietary Salt Intake: | 200–300 mEq/day |
| NaCl tablets: | 1 gm tablet PO TID |
| Exercise (Endurance and Strengthening) | as outlined below |
| Avoid aggravating factors of such as: | Dehydration and extreme heat |
| **Alcohol intake: | Avoid |
| **Caffeine intake: | Avoid |

**per recommendations of patient's cardiologist
POTS = postural orthostatic tachycardia syndrome, NaCl = sodium chloride, PO = by mouth, TID = three times per day.

### *Exercise management of POTS*

Research by Fu, Vangundy, Galbreath, and Shibata (2011) and Shibata et al. (2012) described aerobic protocols consisting of 30–45 minute sessions of semi-recumbent cardiovascular activity at a targeted range of 75–85% $HR_{max}$ for 2–4 sessions per week. To improve fitness levels without eliciting symptoms of POTS, the authors implemented an initial strategy of avoiding upright activities. As fitness levels improved, the frequency was increased up to 4 sessions per week. The duration of the semi-recumbent activity was lengthened to 45 minutes per session followed by a progression of activity intensity. Within 2–3 months of training, general fitness levels sufficiently improved, as measured by HR recovery and $VO_{2peak}$, to a threshold that allowed the subjects to be progressed from recumbent activity to upright activity as tolerated by the patient (Fu, Vangundy, Galbreath, and Shibata, 2011). At this point, most patients tolerated 5–6 hours of weekly cardiovascular training including upright activities such as walking, jogging, or upright biking without triggering their symptoms. Resistance training was also included which typically consisted of one weekly session (15–20 minutes per session) of semi-recumbent exercises that gradually increased to twice weekly sessions (30–40 minutes per session) including upright exercises as tolerated by the patient (Fu, Vangundy, Galbreath, and Shibata, 2011; Fu et al., 2011; Shibata et al., 2012).

Recent intervention studies support the theory that "deconditioning" (including cardiac atrophy and hypovolemia), decreased stroke volume, and reduced blood volume are underlying components of POTS (Fu, Vangundy, Galbreath, and Shibata, 2011; Fu et al., 2011; Raj et al., 2005; Shibata et al., 2012). Exercise training is accepted as increasing blood volume, cardiac size, and mass in various populations including recent

studies in patients with POTS (Fu, Vangundy, Galbreath, and Shibata, 2011; Shibata et al., 2012; Winker et al., 2005). The "reconditioning" program previously outlined consisted of aerobic conditioning (endurance training) as the main component and strength training as the minor component. Current published literature only described the broad category of POTS when reporting patient response to the "reconditioning" approach and did not specify patient response based on the different sub-categories of POTS (neuropathic, hyperadrenergic, and hypovolemic).

The purposes of this case report are to: 1) describe the common clinical features of POTS and highlight the differences to orthostatic hypotension and 2) discuss physical therapy management of patients with POTS using exercise. The focus of the intervention was to improve the patient's exercise and work tolerance. Informed consent of the patient was obtained to present this case, and the rights of the patient were protected.

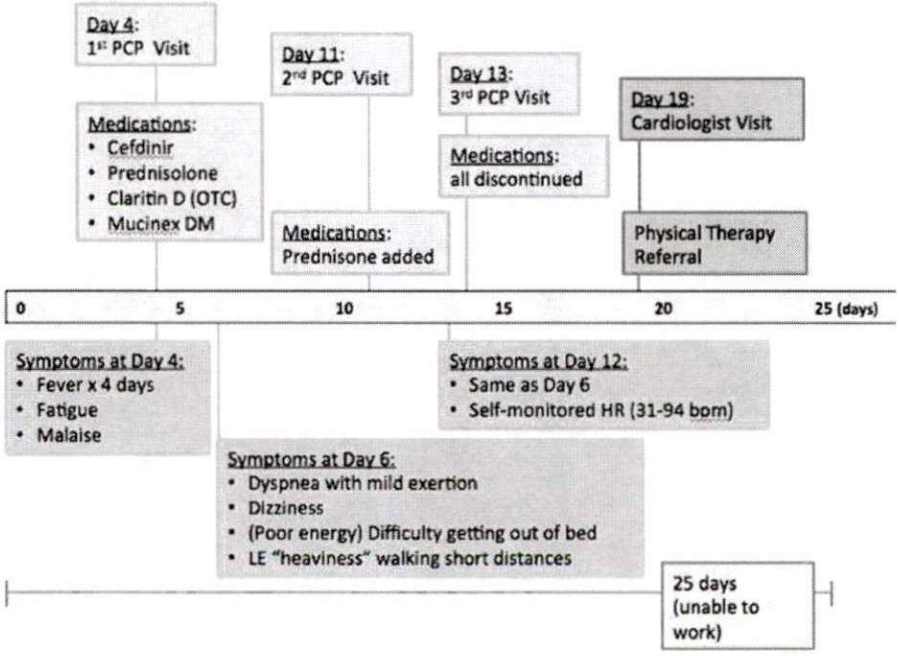
## Case description and examination

### *History*

The patient is a 34-year-old female who was seeking physical therapy because of a POTS exacerbation. Over the past three years, she had successfully managed her symptoms without medication by following her cardiologist's recommendations of consistent exercise, proper hydration and nutrition, daily sodium pills as symptoms dictated, as well as alcohol and caffeine in moderation. The normal exercise routine for the patient was 30 minutes on the elliptical trainer or 10,000 steps as measured on a pedometer 4–5 times per week. For hydration, the patient drank 20 ounces of water with each meal (3 times per day for a total of 60 ounces).

During a recent, stressful four-day business trip, the patient maintained her normal exercise routine during the first 2 days. However, she did not maintain her activity level during the final days of the trip because of fatigue. She reported a decrease in fluid intake during the entire business trip of approximately 40–50 ounces of water daily instead of her normal 60 ounces of daily consumption. Upon returning home, she experienced four days of a fever (100–103°F) of unknown etiology, fatigue, and malaise resulting in the patient remaining in bed without exercise or activity. Because her symptoms did not improve, the patient visited the office of her primary care physician (PCP) who ultimately referred her to her cardiologist where an exacerbation of POTS was confirmed. Please see the timeline in Figure 2.

The patient self-referred to physical therapy 25 days after the onset of fever. At the initial visit, she noted continued light headedness, fatigue, increased time and




PCP = primary care physician, OTC = over-the-counter, LE = lower extremities, bpm = beats per minute

**Figure 2.** Medications and symptoms (Time Line: 0–25 days).

effort getting out of bed upon waking due to poor energy levels, "heaviness" in her legs, and dyspnea walking short household distances. She denied any pain issues. Other than the history of POTS and a left hairline, non-displaced, proximal radial fracture 3 years previously, the patient's past medical history was unremarkable including no history of joint dislocations or abnormalities. The patient stated her goals as: 1) tolerating her normal 9-hour work day without difficulty; 2) walking 5 minutes from her parking spot to her office without shortness of breath or fatigue; and 3) tolerating the walking tours for her vacation in 6 weeks. Please see the timeline in Figure 3.

### Systems review

The patient demonstrated normal range of motion, gait, and strength except bilateral hip flexors 4/5, bilateral hip abductors and internal/external rotators 4-/5, and abdominals 4/5. There was no joint hypermobility noted. No dependent acrocyanosis or edema was seen distally in standing or sitting. The digits of her hands and feet were warm to touch. Her resting seated radial pulse rate was 50 bpm (regular), and blood pressure was 100/80 mmHg. The patient was 1.7 m (67 inches) tall and weighed 64.0 kg (141 pounds) resulting in a BMI of 22.1 (normal weight).

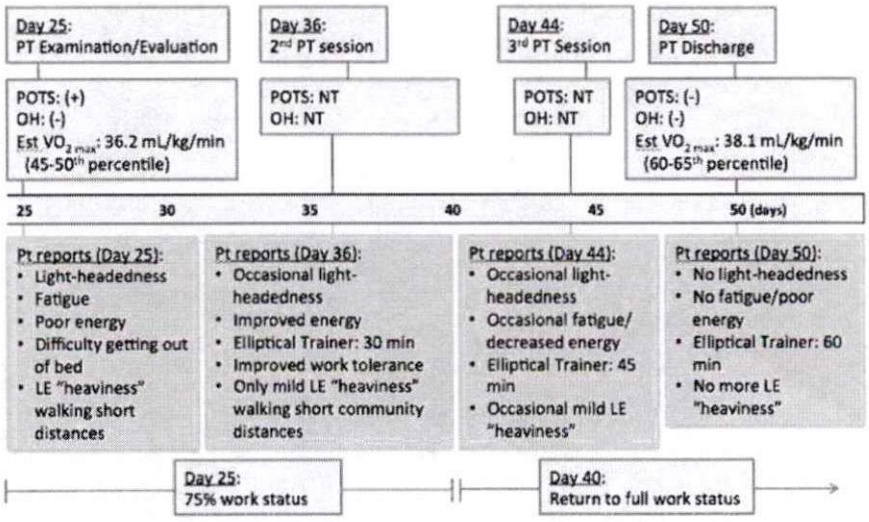
### Tests and measures

To assess upright tolerance (POTS inclusion criteria), the physical therapist monitored the patient's HR during 10 minutes of quiet standing using a heart rate monitor and following the current accepted inclusion criteria for POTS as described in Table 2. In supine, HR was 50 bpm and blood pressure was 100/80. During quiet standing, HR ranged from 80 to 100 bpm and blood pressure ranged 112/70–115/88, which is consistent with the POTS criteria (Fu, Vangundy, Galbreath, and Shibata, 2011). With the exception of feeling nervous during testing, no patient concerns were reported.

The physical therapist utilized the 1-Mile Track Walk Test (1-MWT) also known as the Rockport Fitness Test to predict the maximal aerobic capacity (estimated $VO_{2\ max}$). Correlation values between predicted $VO_{2\ max}$ and actual $VO_{2\ max}$ have been well validated for healthy men and women aged 30–69 (Kline et al., 1987). On an outdoor track, the patient completed two trials of the 1-MWT on subsequent days with estimated $VO_{2\ max}$ of 36.2 mL/kg/min (15:47 minutes and HR 133 bpm) on day 1 and 36.3 mL/kg/min (14:56 minutes and HR 150 bpm) on the following day. This information can be found in Table 7. Noonan and Dean (2000) recommended performing the 1-MWT until subsequent results were within 30 seconds of each other. The patient's 1-MWT on consecutive days differed by 51 seconds; however, the schedule of the patient did not allow another test. The patient stated that she felt that trial 2 was more reflective of her current status because during trial 1, she was concerned that vigorous walking would trigger her POTS symptoms.

### Evaluation and clinical impression

The patient's examination confirmed continued abnormal vital sign response consistent with POTS given a




(+) = positive test, (-) = negative test, NT = not tested, Est = estimated, LE = lower extremities

**Figure 3.** Physical therapy interventions and symptoms (Time line: 25–50 days).

Table 5. Frequency, intensity, time, and type (FITT) prescription.

| | | |
|---|---|---|
| **FREQUENCY:** | **Physical Therapy:** | 1 time per week sessions (4 total visits over 4 weeks) |
| | **Home program:** | 4 times per week ENDURANCE training sessions (see below).<br>1–2 times per week STRENGTHENING sessions (see below). |
| **INTENSITY:** | **Endurance training:** | Ideal target HR range: 159–170 bpm (75–85% $HR_{max}$); and/or;<br>BORG RPE scale (6–20):11–12 for warm up & cool down; 13–16 during endurance training. |
| | **Strength training:** | 2–3 interval circuits with each exercise done for 30–40 seconds followed by rest for 20–30 seconds |
| **TIME:** | **Endurance training:** | Target duration of 30–45 min (10 min warm up & cool down) |
| | **Strength training:** | Target duration of 20–40 min |
| **TYPE:** | **Endurance training:** | The patient only had access to an elliptical trainer at home. Since the patient safely performed the 1-MWT, the physical therapist felt that this was a safe option that would improve patient adherence. |
| | **Strength training:** | The physical therapist collaborated with the patient to design an interval resistance program of 9–11 general exercises that progressed from semi-recumbent to upright positions and addressed the hip and trunk weakness. |

HR = heart rate, bpm = beats per minute, RPE = rate of perceived exertion, 1 MWT = 1 mile track walk test, min = minutes.

HR increase of 50 bpm from a supine measurement compared with HR during 10 minutes of quiet standing without exhibiting orthostatic hypotension (Fu, Vangundy, Galbreath, and Shibata, 2011). Her initial aerobic capacity testing via the 1-MWT test placed her in the 45-50$^{th}$ percentile for white females 30–39 years old (Pescatello, Arena, Riebe, and Thompson, 2013). The patient's ROM and strength were unremarkable other than an ancillary finding of weakness in bilateral hip and trunk musculature, which could be addressed in the strength component of the home program.

### *Intervention*

No published literature was found that specifically addressed physical therapy management of patients diagnosed with POTS. There is literature demonstrating that a prescribed and monitored exercise program composed of aerobic and strengthening components that is gradually progressed from semi-recumbent activities to upright exercises (as tolerated by the patient) improves POTS (Fu et al., 2011; Shibata et al., 2012).

Based on the evidence, the patient's history managing a previous POTS exacerbation, and the patient's examination, the physical therapist determined the patient would benefit from one time per week treatment sessions focusing on cardiovascular training and general strengthening over a 4-week timeframe in order to monitor and progress the general strengthening program from semi-recumbent to more upright activities as POTS symptoms dictated. Ideally, the patient's cardiovascular training would also be progressed from semi-recumbent to upright; however, the patient only had access to an elliptical trainer at home. Since the patient safely performed the 1 MWT and was familiar with her POTS symptoms and management from a previous exacerbation, the physical therapist felt that starting in an upright posture on the elliptical trainer was a safe option that would improve patient adherence. The role of the physical therapist was to monitor the patient's heart rate and symptoms while safely progressing her cardiovascular activity on the elliptical trainer and progressing her resistance training to more upright activities. The patient agreed to participate with this plan of care. Please see Table 5 for a general overview and Table 6 for the strength training program and its progression.

#### *Aerobic training*

The protocol from Fu et al. (2011) and Shibata et al. (2012) used target HR ranges of 75–85% $HR_{max}$ with semi-recumbent equipment during the early phases of training which they described as "base training." A three times per week jogging program of 12 weeks duration from Winker (Winker et al., 2005) involved patients in the broader category of orthostatic intolerance and used a target training range at 60% $HR_{max}$. The jogging goal progressed from 30–50 minutes over the course of this program. Because the Fu et al. (2011) training protocol was tested specifically on patients with POTS, the physical therapist decided to follow that protocol for the "reconditioning" training. However, the patient was concerned that initially she would not be able to obtain the 75% threshold without triggering symptoms. Based on the patient's concerns and in an effort to improve patient adherence, the physical therapist used 60% $HR_{max}$ for the low end of the training range as described by Winker et al. (2005) with the 75–85% $HR_{max}$ as described by Fu et al. (2011) and Shibata et al. (2012) for the ideal range.

The patient was instructed to maintain her HR in the range of 132–166 bpm (60–85% $HR_{max}$) with an ideal range of 152–166 bpm (75–85% $HR_{max}$) unless pre-syncope or other POTS symptoms dictated otherwise. The patient was educated to decrease her intensity or assume recumbency if she experienced dizziness, palpitations, faintness, and/or pronounced fatigue. $HR_{max}$ was determined using the formula 220-age and the target training range used the Karvonen formula:

Table 6. Strength training program.

| Semi Recumbent Strength Training Program (Weeks 1–2) | Exercise Duration (sec) | Rest Interval (sec) | Repetitions |
|---|---|---|---|
| **On Back** | | | |
| Bridge | 30 | 30 | 2–3 |
| Lower Trunk Rotation | 30 | 30 | 2–3 |
| Abdominal Curl | 30 | 30 | 2–3 |
| Dumbbell Flies (3-5 lbs) | 30 | 30 | 2–3 |
| Rest Interval | 1–2 minutes | | |
| **In Sidelying** | | | |
| Hip ABD | 30 | 30 | 2–3 |
| Side Plank | 30 | 30 | 2–3 |
| Rest Interval | 1–2 minutes | | |
| **On Stomach** | | | |
| Plank on elbows | 30 | 30 | 2–3 |
| Rest Interval | 1–2 minutes | | |
| **With Chair** | | | |
| Reverse Dip | 30 | 30 | 2–3 |
| Arm Curls (3-5 lbs) | 30 | 30 | 2–3 |
| **Upright Progression Strength Training Program (Weeks 3-4)** | | | |
| **Physio Ball (lying on back)** | | | |
| Abdominal Curl | 30–40 | 20–30 | 2–3 |
| Dumbbell Bench Press (3-5 lbs) | 30–40 | 20–30 | 2–3 |
| Dumbbell Flies (3-5 lbs) | 30–40 | 20–30 | 2–3 |
| Rest Interval | 1–2 minutes | | |
| **In Sidelying** | | | |
| Side Plank (on elbow or hand) with arm opening | 30–40 | 20–30 | 2–3 |
| Rest Interval | 1–2 minutes | | |
| **On Stomach** | | | |
| Plank on elbows or hands | 30–40 | 20–30 | 2–3 |
| Rest Interval | 1–2 minutes | | |
| **With Chair** | | | |
| Reverse Dip (feet propped if tolerated) | 30–40 | 20–30 | 2–3 |
| Seated Alt overhead press with twist (3-5 lbs) | 30–40 | 20–30 | 2–3 |
| Sit to Stand (pushing with arms only as needed) | 30–40 | 20–30 | 2–3 |
| Rest Interval | 1–2 minutes | | |
| **In Standing** | | | |
| Arm Curls (3-5 lbs) | 30–40 | 20–30 | 2–3 |
| Hip ABD (with Elastic Band as tolerated) | 30–40 | 20–30 | 2–3 |

2 weekly sessions initially 15–25 minutes & gradually progressing to 30–40 minutes as tolerated. 5–10 minute warm up and cool down with walking or on Elliptical machine. The 30–40 second exercise interval should allow you to complete 20–30 reps. All Rest Intervals are as needed. Slow down or stop immediately and take a break if any of your POTS symptoms occur.

training HR = ([$HR_{max}$ - $HR_{rest}$] x % intensity) + $HR_{rest}$. Due to the known dysregulation of the cardiovascular system in patients with POTS, the physical therapist felt that HR might not be the most reliable measure of patient exertion. Therefore, the patient was also educated on the Borg Rating of Perceived Exertion Scale (RPE) (Borg, 1982) which has well researched validity and is recommended by the American College of Sports Medicine for training threshold guidelines in cardiac rehabilitation settings as well the general population. The patient was instructed to warm up and cool down for at least 10 minutes at an intensity of 11–12 RPE on the 20 point BORG RPE scale. Furthermore, she was asked to maintain 13–16 RPE during the endurance training on her elliptical machine. She was asked to complete 30–45 minute sessions, 4 times per week, progressing over the 4 weeks of physical therapy.

### *Strengthening*

Strength training was utilized as outlined by Fu et al. (2011) and Shibata et al. (2012). Other than noting that the exercises progressed from semi-recumbent to upright activities, neither study elaborated on any specific routine of exercises. Therefore, the physical therapist and the patient collaborated together to design a general strengthening program that progressed from semi-recumbent exercises to upright exercises including hip and trunk strengthening to address the weaknesses noted during the examination. The strategy that the patient preferred was 2 times per week sessions of interval training consisting of 9–11 exercises done for 30–40 seconds followed by rest for 20–30 seconds for 2–3 circuits.

## Outcomes

Outcomes were evaluated upon the patient's discharge as well as a follow-up phone call 4 weeks after discharge and the 1-MWT 8 weeks after discharge. The patient had a 75% participation rate with the strengthening home exercise program (6 of the 8 sessions) and a 100% participation rate with the endurance home exercise program (16 of 16 sessions). She chose to use her elliptical machine for the endurance component.

**Table 7.** 1 Mile track walk test.

| DATE: | TIME (min:sec) | HEART RATE (bpm) | Estimated $VO_{2\ max}$ (mL/kg/min) | Percentile |
|---|---|---|---|---|
| Evaluation | 15:47 | 133 | 36.2 | 45–50% |
| Day 2 | 14:56 | 150 | 36.3 | 45–50% |
| Discharge (at 4 weeks) | 14:17 | 152 | 38.1 | 60–65% |
| Discharge + 8 weeks | 13:42 | 161 | 38.6 | 65–70% |

min = minutes, sec = seconds, bpm = beats per minute, mL = milliliters, kg = kilograms.

Table 7 shows the patient's improvement for estimated $VO_{2\ max}$ testing on the 1-MWT.

The patient's strength remained unchanged during the 4 weeks of physical therapy intervention. The patient no longer met the inclusion criteria for POTS at physical therapy discharge. At discharge, baseline HR was 67 bpm in supine with a resulting increase to 90 bpm during the 10 minutes of quiet standing. She did not report or exhibit orthostatic hypotension during testing.

After 4 weeks of one time per week physical therapy sessions, the patient was discharged from this episode of care. Rationale for discharge included the following: no continued POTS symptoms, independence with IADLs, and home exercise program. During the post-discharge phone follow-up at 4 weeks, she noted that she completed 30 days of at least 10,000 steps as monitored on her pedometer. The patient noted that she was very satisfied with her progress and how the physical therapy intervention assisted with her recovery from the exacerbation of POTS.

## Discussion

This case report shows that clinically significant changes (from the patient's perspective) consistent with previous research on the effect exercise have on patients with POTS. The patient had steady improvements with her estimated $VO_{2max}$ testing at discharge (4 weeks after the evaluation) and continued improvement at 8 weeks post-discharge. Previous research used a 12-week training program for patients with POTS initially utilizing a recumbent bike, rowing, or swimming before progressing to upright cardiovascular activities. This patient was evaluated by the physical therapist 25 days after the onset of fever and seen in physical therapy for only 4 weeks. She was able to start with upright activity on her elliptical trainer. This may be attributed to the patient's previous experience with an exacerbation of POTS and therefore a familiarity with POTS management strategies that allowed her to begin the recovery phase prior to the physical therapy evaluation. If physical therapy was initiated earlier, then the patient may have needed to start with recumbent cardiovascular activities as previously described in the literature.

This case description demonstrates that a "reconditioning" program comprised of endurance and strengthening training can successfully manage POTS. The literature refers to patients being "cured" of POTS if they no longer meet the POTS diagnostic indicators as outlined in Table 2 (Fu, Vangundy, Galbreath, and Shibata, 2011). Based upon physical therapy program curricula consisting of courses such as exercise physiology as well as cardiovascular-pulmonary, neuromuscular, and musculoskeletal patient management, physical therapists are expertly qualified to design and monitor exercise programs for the population in general and especially for patients and clients with chronic disease or disability (Gappmaier, 2012).

The "reconditioning" program is intended to improve the patient's overall endurance by gradually increasing the exercise intensity while progressing from semi-recumbent to upright activity based on patient's tolerance. This patient had excellent adherence with the endurance component 8 weeks after discharge. She had less enthusiasm toward the strengthening component and did not maintain this component after physical therapy discharge.

### *The role of the physical therapist in POTS management*

As our profession moves further along the pathway of direct access, a physical therapist should be able to recognize the symptoms of POTS as well as understand the diagnostic indicators as part of the differential diagnosing process. A patient could be suffering from undiagnosed POTS and present in a variety of different physical therapy settings with a variety of different diagnoses commonly seen by physical therapists such as Chronic Fatigue Syndrome, muscle weakness, deconditioning, difficulty walking, vestibular dysfunction, and migraines. The awareness of the symptoms and diagnostic indicators for POTS allows a physical therapist to make the appropriate decision to treat, treat and refer, or refer only.

Lightheadedness, dizziness, and/or near syncope after standing are classic symptoms with orthostatic hypotension (Shibao, Lipsitz, and Biaggioni, 2013). These symptoms also occur in patients with POTS. Clinicians may monitor blood pressure at 1 and 3 minutes after standing to screen for orthostatic hypotension (Shibao, Lipsitz, and Biaggioni, 2013), but it is important to monitor heart rate for 10 minutes during quiet standing to screen for POTS.

### *Limitations*

The patient achieved her goals of improved work and life tolerance as evidenced by successfully returning to full days at work, tolerating the 5-minute walk from the parking lot to her office, and enjoying her planned vacation without any POTS issues. She met her personal goal to walk at least 10,000 steps daily after discharge as monitored on her pedometer. However, this cannot be attributed to the intervention alone since causality is beyond the purpose of a case report. The patient's improvement could be the result of the natural course of recovery from an illness or simply due to following the recommended lifestyle modifications listed in Table 3.

## Conclusion

This case report presented the symptoms of POTS, the diagnostic indicators for POTS, and an evidence-based approach to manage a patient with POTS with a "reconditioning" program of endurance and strength training. The patient was able to make significant gains during 4 weeks of physical therapy and continued improvement 8 weeks after discharge. This type of improvement is consistent with what has been found in the literature. This patient's outcomes are similar to results reported by Fu et al. (2011) and Shibata et al. (2012).

## Declaration of interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the article.

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