

EXERCISE IN THE MANAGEMENT OF POSTURAL ORTHOSTATIC TACHYCARDIA SYNDROME

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Adger K. and Lynch H. Postural Orthostatic Tachycardia Syndrome (POTS) is an autonomic dysfunction characterized by orthostatic symptoms including an increase in heart rate of at least 30 beats per minute (bpm) or reaching above 120 bpm soon after a postural change (Busmer, 2011). Symptoms include, but are not limited to, dizziness, nausea, palpitations, sweating, and fatigue. Twenty-five percent of those with POTS are unable to work (Busmer, 2013). One common pharmacologic treatment is beta-blockers (Lai et al 2009). There is little research into non-pharmacologic treatments, including exercise. The purpose of this case study was to determine if physical activity alleviates physical (heart rate) and psychological (depression and anxiety) symptoms of a patient with POTS. Following eight weeks of physical activity, the patient still met the diagnostic criteria of POTS. However, her quality of life improved based on the WHOQOL-100 AND HADS scores, and she reported being able to perform more tasks at home without feeling heart palpitations. The case study showed an improvement in quality of life for the participant with POTS, but minimal changes in heart rate response following standing post-intervention.

Key Words: Postural Orthostatic Tachycardia Syndrome (POTS), exercise, quality of life, American College of Sports Medicine (ACSM)

INTRODUCTION

Postural Orthostatic Tachycardia Syndrome (POTS) is an autonomic dysfunction characterized by orthostatic symptoms including an increase in heart rate of at least 30 beats per minute (bpm) or reaching above 120 bpm soon after a postural change (Busmer, 2011). This postural change can occur in the form of either an active or a passive stand. The passive stand is also referred to as a head tilt test. For the head tilt test, the patient is secured to a table with seatbelt-like straps across their legs and hips. The table begins parallel to the floor and slowly rises up to 60 degrees. This process can take about 30 minutes (Plash et al., 2013). For an active stand test, the patient or participant stands still after laying supine. Heart rate is

measured during the quiet stand (Richardson et al., 2017).

POTS affects females about five times more than males (Low, 2003). The highest prevalence of POTS is among premenopausal women (Low, 2003). Symptoms include, but are not limited to, dizziness, nausea, palpitations, sweating, and fatigue. Most people's symptoms vary greatly from day to day and 25% are unable to work (Busmer, 2013). Precise prevalence is unknown, but is likely 5-10 times more common than the similar condition orthostatic hypotension (Low et al., 2009). There are several options when treating POTS. Whether non-pharmacological or pharmacological treatments are most effective is still unknown (Busmer, 2013). While the most common treatment is

pharmacological, it is unclear if this is really the best treatment for the patient as a whole.

When lying down, about 25-30% of circulating blood is in the thorax (Busmer, 2011). Once standing, gravity causes blood to flow into the lower extremities, causing a decline in venous return. Sympathetic nervous system activity increases to maintain cardiac output. For a healthy individual, heart rate increases by about 10-15 bpm and diastolic blood pressure increases (Busmer, 2011). If this system fails for any reason, blood will pool in the lower extremities and heart rate will remain elevated in an attempt to reach homeostasis (Busmer, 2011). Several mechanisms may contribute to the excess increase in sympathetic tone and heart rate including insufficient vasoconstriction, decreased stroke volume, insufficient autonomic heart rate adjustments, cardiac contractile force, vascular tone, inadequate arterial pressure, and general deconditioning (Richardson et al., 2017).

Because of the sympathetic nervous system input, one common treatment for POTS is beta-blockers (Lai et al., 2009). In a retrospective study comparing treatment methods for POTS, surveys were sent to patients treated at the Mayo Clinic between 2002-2005. The surveys were used to examine the effectiveness of the treatments given while being treated there. Patients were given both pharmacologic and non-pharmacologic treatments. Sixty patients completed surveys. One of the groups was prescribed beta-blockers (n=14). Within that group, 57.1% said their symptoms improved. However, only 50% of the patients stayed on their medication for the duration of the study. The study does not explain why so many patients stopped taking medication. Only 46.2% of patients in the other pharmacologic group, which was prescribed Midodrine (n=13), showed improved symptoms (Lai et al., 2009). The non-pharmacologic treatments included increased fluid intake (n=40), increased salt intake (n=33), elevated head of the bed (n=19), physical therapy (n=16), and elastic support hose (n=2). For each treatment type, 74%, 58%, 59%, 43%, and 50%

saw improvements, respectively (Lai et al., 2009). One limitation of this study is the groups were not randomized; they already existed from previous treatments. The different sample sizes in each group and crossover of treatments makes it impossible to show what treatment actually caused changes.

Another option for POTS would be a non-pharmacological treatment, such as endurance exercise. Since the cardiovascular system adapts to decrease heart rate at rest and during submaximal exercise with endurance exercise training, it may be a good way to decrease likelihood of tachycardia for patients with POTS (U.S. Department of Health and Human Services, 1996). Patients with POTS may have a lower total blood volume and are often recommended to increase fluid intake accordingly. Exercise also increases blood volume (U.S. Department of Health and Human Services, 1996). Mtinangi and Hainsworth conducted a study using exercise training for patients with postural orthostatic intolerance. The training protocol combined both endurance and strength training and took 11 minutes per day. Participants increased blood volume, decreased heart rate and blood pressure when supine and during head tilt, increased orthostatic tolerance, and decreased baroreceptor sensitivity (Mtinangi, 1998).

A case study from 2017 used exercise and physical therapy as a treatment for POTS. The patient was self-referred to physical therapy to treat her relapsed POTS symptoms (Richardson et al., 2017). After the four-week intervention, the patient's heart rate increased by 23 bpm, which no longer met the diagnostic criteria for POTS of a 30 bpm increase upon postural change. The patient was discharged from therapy (Richardson et al., 2017). These intervention studies support the theory that deconditioning could be a cause of POTS (Fu et al., 2011).

A study by Winker and associates (2004) found a decrease in symptoms in patients with POTS after exercise. They also found a significant improvement in low frequency/high frequency ratio tilt table (passive stand) heart rate

outcomes. The improvements were considered to be due to the increased blood volume after exercise. There were, however, some participants who had increased blood volume, but no mitigation of symptoms. This means that the mechanism for POTS may be different between “responders” and “non-responders” to exercise. An increase in stroke volume, normalization in the head tilt, and a decrease in heart rate indicated greater parasympathetic tone after training. This seems to be the mechanism behind the decrease in symptoms for the “responders”. It is unclear if the “non-responders” would have responded to pharmacotherapy. However, Fu and Levine (2014) found in patients with POTS that short-term exercise, as little as three months, resulted in an increase in cardiac mass, VO₂ peak, and blood volume as well, supporting Winker’s findings (Fu & Levine, 2014).

In addition to the physical symptoms of POTS, patients with POTS also report psychological symptoms including depression and overall decreased quality of life questionnaire. Using the Center of Disease Control Health Related Quality of Life, Pederson and Brook (2017) examined quality of life and suicide risk of patients with POTS compared to healthy individuals and found that patients with POTS have a decreased quality of life. POTS patients are frequently prescribed Selective Serotonin Reuptake Inhibitors (SSRIs) in order to treat these symptoms (Grubb, 2005). About half of the patients with POTS were at a high risk for suicide (Grubb, 2005). This is likely due to how the symptoms of POTS affect everyday life in patients, but there could be an underlying psychological disorder. Moon and associates found that depression and orthostatic intolerance symptoms were significantly correlated (Moon et al., 2016).

In spite of much work in this area, the optimal treatment for patients with POTS remains unclear. Beta-blockers and other pharmacological treatments improve some patients’ symptoms, but other studies demonstrate that exercise improves symptoms as well (Lai et al., 2009, Fu et al., 2010,

Richardson et al., 2017). In both types of intervention, there appear to be “non-responders” and patients with a low quality of life (Pederson & Brook, 2017). This case study will look at how physical activity meeting public health recommendations for aerobic exercise by the American College of Sports Medicine (ACSM) impacts POTS symptoms. To the authors’ knowledge, no study has been published looking at these specific guidelines and POTS patients.

The purpose of this study is to assess physical (heart rate during a quiet stand) and psychological (depression and anxiety measured using the HADS scale) symptoms of a patient with POTS, and to identify if eight weeks of physical activity meeting ACSM recommendations alleviates these symptoms. It is hypothesized that moderate intensity physical activity will improve physical and psychological symptoms for the patient with POTS, thus improving quality of life.

METHODS

Participants

This case study followed all National Institutes of Health guidelines for human testing and was approved by the Institutional Review Board at Point Loma Nazarene University. The subject provided written informed consent and approval from her doctor to participate in this study. The participant was a 25-year-old female, 172 cm tall, and 49 kg with a body mass index (BMI) of 16.5. The patient met the inclusion criteria of Postural Orthostatic Tachycardia Syndrome diagnosis and was not taking medication or following an exercise program.

Instrumentation

A Polar H10 heart rate monitor was used to measure resting and standing heart rate. The Hospital Anxiety and Depression Scale (HADS) was used to evaluate psychological symptoms of anxiety and depression. On the HADS Scale, 0-7 is normal, 8-10 is borderline abnormal, and 11-21 is abnormal. In a review by Bjelland and associates (2002) of 747 papers, it was found

that the HADS questionnaire is valid and reliable for assessing the severity of anxiety and depression symptoms not only in-patient care, but in the general population as well. The HADS questionnaire includes questions such as “I still enjoy the things I used to enjoy”. The participant then selected a response on a scale of 0-3 with 0 indicating “Definitely as much” and 3 being “Hardly at all”. The participant selected the response based on how she had been feeling during the past week. The World Health Organization Quality of Life (WHOQOL 100) questionnaire was used to assess quality of life. The WHOQOL 100 is scored with higher numbers equating to higher quality of life. This applies to all facets except Pain & Discomfort, Negative Feelings, and Dependence on Medication. For these facets, a decrease in scores would show an improvement (World Health Organization, 2012, p. 52). The World Health Organization examined 8294 questionnaires and determined that the WHOQOL- 100 is valid, consistent, and reliable (World Health Organization, 2012, p. 25-27). An example of a question from the WHOQOL questionnaire is “How much are you bothered by any limitations in performing everyday living activities?” The participant selects a response on a scale of 1-5, 1 being “Not at all” and 5 being “An extreme amount”. This was selected based off how the participant has felt over the past two weeks.

Procedure

After providing written informed consent, the participant completed the HADS and WHOQOL-100 questionnaires. The participant received a list of local mental health resources such as the San Diego County Health and Human Services and National Alliance on Mental Illness (NAMI) San Diego available to her at this time. Age, height, and weight were then measured. Height was measured using the Seca 206 wall-mounted stadiometer (Seca, Birmingham, United Kingdom). Weight was measured on the Cosmed integrated digital scale (Cosmed, Concord, CA, USA). The participant's

resting heart rate was collected after 30 minutes lying supine in a dark room. Heart rate was recorded every minute for the last five minutes and an average was taken. The participant was then instructed to move from lying down to standing still. Heart rate was measured at the start of every minute for the first five minutes of standing. This test, called the active stand test, was selected over the passive head tilt due to findings that indicated that the head tilt gave 80% of healthy controls a false positive for POTS (Plash et al., 2013).

Exercise Prescription

After all measurements were taken, the exercise prescription was explained. The participant was instructed to exercise at moderate intensity for 150 minutes per week for eight weeks, to match ACSM recommendations, (Riebe et al., 2018. p. 151). As the participant's heart rate is elevated due to POTS, percent of maximum heart rate would not accurately depict intensity. Instead, the Borg rating of perceived exertion (RPE 6-20) was used. Using a printed scale of the Borg RPE 6-20, a researcher explained different ways the participant might perceive intensity when exercising at home, including using the Talk Test. In a review of recent literature, Reed and associates found in 2014 that the talk test is a valid tool for prescribing and monitoring exercise intensity in athletes, healthy adults, and those with cardiovascular disease. Exercising above the ventilatory threshold makes it difficult to speak comfortably. The Talk Test uses this to estimate the ventilatory threshold without using heart rate or other exercise testing. Any time a patient can continue conversation, the Talk Test estimates their intensity between 50-75% of maximal oxygen uptake (VO₂ max) or moderate intensity (Reed & Pipe, 2014). The participant completed the physical activity at home and was instructed to maintain an intensity of 11-14 (moderate) on the RPE 6-20. A researcher checked in weekly via text message to confirm that she completed the 150 minutes each week and how she felt. The mode of exercise was

selected by the participant to encourage adherence. She chose to dance and walk for the physical activity. After the eight weeks, the participant returned to the lab to repeat all baseline measures.

Data Analysis

As this was a case study with $n=1$, data were assessed visually to determine change from baseline, and no statistical tests were conducted. The WHOQOL questionnaire was scored according to the Users' Manual. Those values were all changed to be on a scale of 1-100 as per the User's Manual to be more comparable (World Health Organization, 2012. pp. 104-105). The HADS questionnaire responses were summed as indicated on the questionnaire itself.

RESULTS

The participant successfully completed at least 150 minutes of moderate intensity physical activity each week for the eight weeks. The physical activity consisted of aerobic dancing at home and walking in her neighborhood for 30 minutes per day, five days per week. The participant lost two pounds, and her BMI decreased from 16.57-16.26.

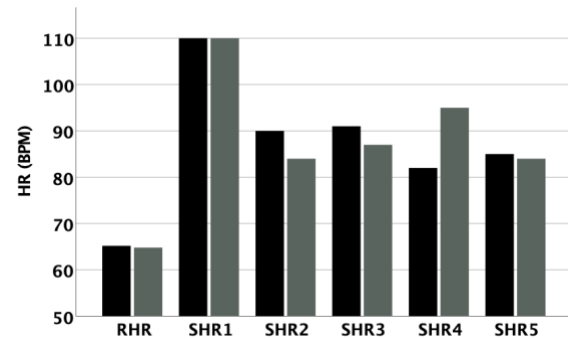
Heart Rate

Figure 1 shows the changes in heart rate during the quiet stand before and after the eight weeks of exercise. Resting heart rate was slightly lower after exercise training. Standing heart rate

decreased sooner after exercise training. There was an increase in heart rate at minute four of standing post exercise intervention.

Figure 1

Heart rate pre and post exercise training



Note: Heart rate pre (black) and post (gray) exercise training in beats per minute (BPM).

Questionnaires

Table 1 shows the changes in WHOQOL-100 facet score before and after exercise training. Pain, Energy, Sleep, Positive Feelings, Body Image, Activities of Daily Living, Dependence on Medical Aids, Work Capacity, Social Support, Sexual Activity, Safety, Financial Resources, Leisure Activities, Transport, and Overall scores improved. Thinking, Home Environment, Access to Services, Access to Information, and Spirituality all worsened. Self-Esteem, Negative Feelings, Mobility, Personal Relationships, and Physical Environment remained the same.

Table 1

WHOQOL questionnaire facet scores before and after exercise training

Facet	Initial	Final	Facet	Initial	Final
Pain	68.8	62.5	Personal Relationships	50	50
Energy	6.3	62.5	Social Support	56.3	75
Sleep	50	100	Sexual Activity	75	81.3
Positive Feelings	43.8	68.8	Safety	37.5	56.3
Thinking	62.5	56.3	Home Environment	62.5	25
Self - Esteem	62.5	62.5	Financial Resources	6.3	12.5

Facet	Initial	Final	Facet	Initial	Final
Body Image	56.3	75	Service	75	56.3
Negative Feelings	43.8	43.8	Information	100	93.8
Mobility	43.8	43.8	Leisure	37.5	62.5
Activities of Daily Living	31.3	56.3	Physical Environment	62.5	62.5
Dependence on Medical Aids	12.5	0	Transport	37.5	43.8
Work Capacity	12.5	37.5	Spirituality	100	87.5
			Overall	37.5	62.5

Note. WHOQOL questionnaire facet scores before and after exercise training. Scores are out of 100.

Table 2 shows WHOQOL domain score changes before and after exercise prescription. The Physical, Psychological, Independence, and Social domain scores improved while Environment and Spirituality worsened.

Table 2

WHOQOL questionnaire domain scores

Domain	Initial	Final
Physical	29.17	66.67
Psychological	56.25	63.75
Independence	43.75	59.38
Social	60.42	68.75
Environment	54.69	51.56
Spirituality	100	87.5

Note. WHOQOL questionnaire domain scores before and after exercise training program. Scores are out of 100.

Table 3 shows HADS score changes before and after exercise training. While the Anxiety score remained in the abnormal range and the Depression score remained in the normal range, both scores showed improvement after the exercise intervention.

Table 3

HADS Scores before and after exercise training

Variable	Initial	Final
Anxiety	13	12
Depression	5	2

Note. HADS Scores before and after exercise training program. 0-7: normal, 8-10: borderline abnormal, 11-21: abnormal.

DISCUSSION

Following eight-weeks of moderate intensity physical activity, the participant in this study still met the diagnostic criteria for POTS. Our findings differ from those of Richardson and associates (2017), who found their participant no longer met the diagnostic criteria for POTS following exercise training. The authors of this case report designed their intervention based off a previous study that used aerobic activity with 30-45-minute sessions, 2-4 times per week (Fu et al., 2011). The purpose of supine instead of standing exercise is to minimize POTS symptoms. After about 2-3 months, most patients could tolerate more activity, including upright activity (Fu et al., 2011).

The participant's HR increased from resting (65 bpm) to 110 bpm upon standing both before and after exercise training. This increase was well over the 30 bpm increase required for a

POTS diagnosis. This persistence of symptoms may have been due to the exercise intensity. The patient from Richardson and associates' (2017) study exercised at 60-85% of heart rate max and the patients from Fu and associates (2011) worked at 75-85% of heart rate max. Fu and associates in 2010 found 9 of 19 participants also no longer met the diagnostic criteria for POTS after exercising at 75-85% of their maximum heart rate for three months. Moderate intensity on the Borg 6-20 scale corresponds to about 64-70% of heart rate max (Riebe et al., 2018. p. 146). The slightly lower exercise intensity of this study might explain the differing results from Richardson and associates (2017) and Fu and associates in 2010 and 2011.

Forty-seven percent of participants in a study by Fu and colleagues (2010) no longer met POTS diagnostic criteria after three months of aerobic activity at 75-85% of heart rate maximum. Based on these two studies, it appears that a higher exercise intensity might have helped the participant in this study to experience greater improvements in HR variability and no longer to meet the diagnostic criteria for POTS.

Following two minutes of standing, the participant's HR was lower after exercise training (pre: 90, post: 84 bpm). Before exercise training, HR was 90 bpm after one minute of quiet standing. After training, the HR was 84 bpm at this same time point. After two minutes of standing, heart rate was 90 bpm before exercise training and 84 bpm after. At minute four of standing, post-exercise training HR returned to 95 bpm (Figure 1). One possible explanation of the increase in HR at minute four post-exercise training is that the participant began to laugh. After five minutes of quiet standing, the participant reported that the active quiet stand during final data collection felt easier than the first time. These improvements were similar to the improvements that Winker and associates found in 2005. Even though she still met the criteria for POTS, the participant reported feeling less heart palpitations as the eight weeks progressed, and that after two weeks she did not feel them at all during physical activity or regular

daily activities. Such changes make a meaningful difference in quality of life.

Similar to what Pederson & Brook found with their participant in 2017, the participant in the present study showed a low initial QOL. Following exercise training, the participant reported improvements in several facets of the WHOQOL questionnaire. The participant reported less pain, more energy, better sleep, increased positive feelings and body image, better ability to complete activities of daily living, improved work capacity, more social support, increased sexual activity, improvements in safety and finance, better and more comfortable participation in leisure time, easier transport and an overall improved quality of life. The participant also reported worse thinking and concentration, home environment, access to services and information, and spirituality. The participant reported personal issues with members of her family at home prior to coming in for final testing. This might explain the decrease in QOL in some of the other facets. The participant reported in the activity journal that she was able to participate in four all-day activities in one week without unreasonable fatigue. According to the participant, this is not something she would have been able to accomplish before the exercise intervention. This reflection supports the facet score changes in the WHOQOL survey. This also supports the increase in the Physical domain of the WHOQOL questionnaire. These results are similar to those of Fu and associates (2010). The participant's change in HADS scores did not change the category into which she was classified. Depression remained in the normal category while anxiety remained in the borderline abnormal category. Unlike participants in the study by Moon and associates (2016), this participant did not initially fall into the abnormal range for depression on the HADS. The participant reported that she was having a bad anxiety week when she came in for final data collection due primarily to family issues. This may have skewed the HADS results for anxiety. Even with this self-reported increase in anxiety, the post-intervention anxiety score was

still lower, meaning that even though she felt anxious, her anxiety still decreased compared to before the exercise training.

The primary limitation of this study was the small sample size. A larger sample would not only allow for statistical analysis, but with a sufficiently large sample size, multiple groups could exercise at varying intensity levels for the eight weeks. This could help to determine which exercise intensity would improve symptoms the most. Results may have been skewed by the participant's laughter during the final quiet stand. Another limitation is that all of the physical activity was self-reported. A future option would be to have participants complete supervised physical activity or wear an activity tracker when completing exercise unsupervised. Future research could also measure heart rate continuously throughout the eight-week period to track how many episodes of symptoms a patient has during activities of daily living. Future research should also monitor weight loss for underweight participants to ensure they do not unintentionally lose weight.

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CONCLUSION

The participant in this case study experienced a slight improvement in physical and psychological symptoms of POTS after eight weeks of moderate intensity physical activity for 150 minutes per week. While the participant still met the diagnostic criteria for POTS, the increased ability for heart rate recovery, decreased RHR, and participant-reported decrease in palpitations still show improved physical symptoms. The WHOQOL results also show an improvement in physical and psychological symptoms after eight weeks of 150 minutes of moderate intensity physical activity. This study demonstrates that moderate intensity physical activity that meets ACSM public health guidelines may provide modest improvements in some symptoms of POTS.

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