International Journal of General Medicine and Pharmacy (IJGMP)
ISSN (P): 2319–3999; ISSN (E): 2319–4006
Vol. 13, Issue 1, Jan–Jun 2024; 77–86


International Academy of Science, Engineering and Technology
Connecting Researchers; Nurturing Innovations

# EFFECTIVENESS OF ENDURANCE AND STRENGTH TRAINING EXERCISES IN THE MANAGEMENT OF POSTURAL ORTHOSTATIC TACHYCARDIA SYNDROME SUBJECT

***Abijaya Jaya Krishnan[1], Karthika Govindaraj[2], Pradeepa Mani[3] & Sivakumar Chinnusamy[4]***

*[1]BPT Student, PPG College of Physiotherapy Affiliated to the Tamil Nadu Dr M.G.R Medical University, Chennai*

*[2]Associate Professor, PPG College of Physiotherapy Affiliated to the Tamil Nadu Dr M.G.R Medical University, Chennai*

*[3]Vice Principal, PPG College of Physiotherapy Affiliated to the Tamil Nadu Dr M.G.R Medical university, Chennai*

*[4]Principal, PPG College of Physiotherapy Affiliated to the Tamil Nadu Dr M.G.R Medical university, Chennai*

## *ABSTRACT*

***Background:*** *Postural Orthostatic Tachycardia syndrome (POTS) is defined as the presence of chronic symptoms of orthostatic intolerance accompanied by an increased heart rate ≥ 30 bpm within 10 minutes of assuming an upright posture in the absence of orthostatic hypotension associated with cardiac and noncardiac symptoms.*

***Objectives:*** *The study's primary objective was to find out the efficacy of endurance training and strength training exercises in the management of postural orthostatic tachycardia syndrome subject.*

***Subject and Methods****: A pre-test, post-test single case study design with a 30-year-old female patient who met the inclusion criteria of POTS diagnosis. She received exercise training which includes endurance and strength training exercises for 12 weeks for 4 alternative days per week in the first and second month and at the beginning of the third month the training was performed for 5 days per week. The total treatment duration was 50 minutes/ day in the first and second month and at the beginning of the third month the treatment duration progressed to 80 minutes/ day. The outcome measures are active stand test to assess the heart rate and blood pressure then EQ-5D-5L questionnaire which has a descriptive system and visual analogue used to assess the quality of life. The pre and post test for heart rate, blood pressure and quality of life were recorded. On the 1st week pre-test was taken before exercise and post test was taken after the exercise training and at the end of 1st, 3rd, 6th, 9th, and 12th week post-test were noted.*

***Result:*** *The result of this study showed a significant improvement in 30-year-old female with POTS. The heart rate of patient at rest was 70 bpm and after 5 minutes of standing the heart rate increased to 122 bpm and this is the pre-test value at the 1st week and after the exercise training the post test values are noted on standing for 5 minutes and it was recorded at the end of 1st, 3rd, 6th, 9th and 12th week the post test values were 120 bpm, 115 bpm, 100 bpm, 85 bpm, 75 bpm respectively using the active stand test. The blood pressure of the patient at rest was 110/62 mmHg and after 5 minutes of standing the blood pressure decreased to 80/53 mmHg and this is the pre-test value at the 1st week and after the exercise training the post test values are noted on standing for 5 minutes and it was recorded at the end of 1st, 3rd, 6th, 9th, and 12th week the post test values were 90/60 mmHg, 95/67 mmHg, 100/70 mmHg, 112/75 mmHg and 118/80 mmHg respectively using the active stand test. Also, the pre-test value for self-rated health at the 1st week was 30 and the post test values were 43, 64, 80, and 90 at the end of 3rd, 6th, 9th and 12th week respectively using EQ VAS and the descriptive system of EQ-5D-5L were assessed at 1st week as pre-test and at the end of 12th week as post test.*

***Conclusion:*** *There is a significant reduction in the symptoms and improvement in the quality of life of the patient following 12 weeks of endurance and strength training exercises in postural orthostatic tachycardia syndrome subject.*

***Clinical Implications****: Endurance training exercises is found to produce significant effect when combined with strength training exercises to manage postural orthostatic tachycardia syndrome subject.*

***KEYWORDS:*** *POTS, Endurance Training, Strength Training, Active Stand Test (AST), EQ-5D-5L Questionnaire, Heart Rate (HR), Blood Pressure (BP).*

***Article History***

***Received: 16 Jun 2024 | Revised: 16 Jun 2024 | Accepted: 25 Jun 2024***

## 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 bpmand in the absence of orthostatic hypotension (a decrease in BP >20/10 mmHg) within the 10 minutes of assuming an upright posture from supine lying. This postural change can occur in the form of either an active or passive stand (1).The increased heart rate must last for at least 30seconds. The increase in heart rate should also be accompanied by other symptoms of POTS. The prevalence of POTS ranges between 0.2% and 1.0%in US population approximately from 500,000-3,000,000 Americans are affected. POTS affects younger individuals 15-45 years old with a distinct female predominance (≈80%) (3). POTS affects females about five times more than males. Worldwide and Indian prevalence has not been well established although previous study population have estimated ranges 0.2 to 1% in developed countries.However, it predominates in women with a 4–5:1 ratio.POTS causes are varied and non-specific, probably reflecting various underlying pathophysiology mechanism. The multiple factors like moderate autonomic dysfunction, increased sympathetic tone, inadequate venous return or excessive blood venous pooling and severe deconditioning may be responsible for POTS symptoms (5). However, it has been observed that most people with this condition begin to notice their symptoms after major surgery, pregnancy, trauma, or viral illness. POTS symptoms are more pronounced after a meal when the blood is redirected to the digestive tract also experience the symptoms when stressed, standing in line, or in the shower. The symptoms include lightheadedness, palpitations, tremor, cognitive impairment, brain fog, syncope can also occur. Non-orthostatic symptoms such as migraine, fatigue, exercise intolerance, disturbed sleep, visual disturbances, phonophobia and gastrointestinal complaints such as nausea, are also common. Symptoms are frequently aggravated by heat and exercise. Even activities of daily living such as taking a bath or housekeeping work may significantly increase symptoms, resulting in fatigue (5).POTS patients commonly present with poor cardiovascular fitness and low activity levels, even those who were very active and athletic before they became ill.

The normal heart rate is about 60-100 bpm. In normal persons, 10-20 beat per minute increase in heart rate can occur on assuming the standing posture(4). The small heart coupled with reduced blood volume results in a large fall in stroke volume during orthostasis, leading to an excessive increase in heart rate via the baroreflex in patients with POTS.

POTS is a syndrome and not a disease. Normally, the assumption of upright posture results in a shift of blood from the chest to the lower abdomen and legs, and plasma volume out of the vasculature into the interstitial space, which

reduce venous return, causing a transient decrease in cardiac filling, stroke volume, and arterial pressure. Unloading of bar receptors triggers compensatory sympathetic activation, which increases HR and leads to systemic vasoconstriction. This compensation results in the restoration of venous return and cardiac output. These compensatory physiological regulations are impaired in POTS, so venous return remains declined, upright cardiac output and stroke volume are not normalized, and standing HR is elevated.The investigation for POTS includes; Tilt table test, Active stand test, Electrocardiogram, Echocardiogram, 24 hours blood pressure and heart rate monitoring, Blood test.Although there is no known cure for POTS, the condition can be managed in most patients with diet, exercise and medications. The medical management for POTS includes, Midodrine or low β-blockers, fludrocortisone and pyridostigmine, and clonidine or α-methyldopa. The physiotherapy management includes, utilizing compression garments and exercise training on improving aerobic fitness, as well as strengthening the lower limbs.

Most POTS patients have reduced quality of life and exhibit functional disability. Their recurrent, and often incessant, orthostatic intolerance likely leads to reduced physical activity. Up to date there were very less studies on endurance training and strength training Exercises on POTS. Hence, the need of the study is to find the effectiveness of endurance and strength training exercises in the management of postural orthostatic tachycardia syndrome subject.

## METHODOLOGY

***Study Design:*** A pre-test, post-test single case study design was used with two different interventions which consist of endurance training and strength training exercises on postural orthostatic tachycardia syndrome subject.

***Subject:*** The subject was a 30 years old female, who works in music industry. She was diagnosed with pneumonia and treated with inhalers few months back. Shortly afterwards, she developed spells of tachycardia. Her episodes of tachycardia were primarily associated with upright posture. In addition to rapid palpitations, she complained of light-headedness and fainting on standing, stabbing chest pain typically on standing, inability to concentrate, severe fatigue and exercise intolerance. The patient was referred by a cardiologist at Ashwin multi-speciality hospital through the detailed evaluation of medical history, physical examination with orthostatic vitals, electrocardio gramand 24 hours blood pressure and heart rate monitoring she was diagnosed with Postural Orthostatic Tachycardia Syndrome. Then the subject was preferred to physiotherapy department. The subject was assessed with Active stand test to assess the heart rate and blood pressure variation on resting and standing position and with EQ-5D-5L questionnaire to assess the quality of life. The Orthostatic vital signs recorded a supine heart rate (HR) of 70 bpm with a blood pressure (BP) of 110/62 mmHg. After standing for 2 minutes, her HR increased to 106 bpm with a BP of 109/60 mmHg, and after 5 minutes her HR was 122 bpm with a BP of 80/53 mmHg.

The severity of her symptoms limited the patient's quality of life and limited her to live in her normal sedentary life style. The subject's goal for physical therapy was to manage the symptoms and to improve her quality of life.

***Methods:*** After obtaining the informed consent, subject were received a clear explanation about the training procedure prior to the study.The participant was instructed to exercise at moderate intensity. The subject was performed endurance and strength training exercises for 12 weeks. After the endurance training exercise, the strength training exercise are performed on the same day, initially for the first two months the training was on alternative days for 4 times per week for 50 minutes. At the beginning of the third month i.e., $9^{th}$ week the subject was instructed to perform exercises for 5 times per week. The time duration for exercise training was progressed to 80 minutes per session. The heart rate and blood

pressure were assessed through Active stand test and the quality of life were assessed by EQ-5D-5L questionnaire. The heart rate and blood pressure were measured before and after the training session and during the session the variations in the vitals are monitored using digital sphygmomanometer. The pre-test and post-test for heart rate, blood pressure and quality of life were noted before the treatment at the 1st week and at the end of 1st, 3rd, 6th, 9th, and 12th week post-test were noted.

The patient should not take more than 2 days off from exercising. If the patient cannot complete all the sessions for that week, they need to repeat that entire week again before moving forward. If for some reasons the patient misses a period of workouts due to illness, injury, or other reasons, they should back up in the schedule and repeat cardio workouts.

## DESCRIPTION OF INTERVENTIONS

### Endurance Training Exercises

In endurance exercise three training zones were determined

- Base pace
- Maximal steady state
- Recovery

The early phases of training were prescribed as "base pace" training with targeted heart rate equivalent to approximately 75% of maximal predicted heart rate. Initially the subject was trained 4 times per week for 20 minute per session by using **recumbent bike.** As the patient become increasingly fit, the duration of the base pace training was prolonged and subsequently sessions of increased intensity i.e., maximal steady state was added and were always followed by recovery sessions. Recovery session included slow cycling at a low level on the recumbent bike and taking a walk outdoor or playing in the yard. By the beginning of third month upright exercise i.e., waking on a **treadmill** was performed 5 times per week for 20 minute per session along with recumbent bike cycling for 20 minutes. Endurance training was preceded by 5-minute warm up and 5-minute cool down.

### Strength Training Exercises

In addition to endurance training strength training was performed focusing on lower body and core. This was intentional since lower body muscles acts as pumps when they contract to increase venous return to heart during orthostasis. It includes bridging, side lying straight leg raise, leg presses inwards, clamshells, Pilates hold, wall sit. Strength training was performed at the end of endurance training instead of a separate day for 4 days per week 30 minutes per session and at the beginning of third month training is progressed to 5 days per week 40 minutes per session. Strength training utilize a floor mat, resistance bandand Pilates based exercises. There should be at least a day off between resistance training workout as the muscle can become sore. The sore sensation will be improved as training continues.

### Home Programmes

### Increased Salt and Fluid Intake

A slow, progressive increase in daily sodium intake in/on the food and eating salty snacks are recommended. Patients are also encouraged to increase water intake up to 3 Liters per day. Increasing salt and water intake throughout the day and

consuming them together are recommended, as water alone is not effective in long-term volume expansion. Increased salt and fluid intake is recommended in POTS and should be started prior to or at the time when exercise training is initiated.

### Sleeping Head Up Position

Patients are encouraged to elevate the head of the bed off the ground 4 to 6 inches in order to increase circulating plasma and blood volume. Bed risers placed under the feet at the top of the bed work best for placing the entire body at a slight angle during sleeping at night. This approach is different from sleeping on a few extra pillows under the head.

### Leg Crossing and Muscle Tensing

Crossing one foot in front of the other and squeezing the thighs and gluteal muscles together, theso-called Dutch leg-crossing manoeuvre, is very potent at restoring venous return, preventing further blood pooling in the lower body, and increasing cardiac output and mean arterial pressure in the upright position. This manoeuvre increases intramuscular pressure and decreases transmural pressure of the vein, as such venous distension is reduced and blood is shifted centrally, and thus, cardiac output increases.

### Squatting, Sitting, or Lying Down

Squatting is a combination of sitting, bending and muscle tensing, which facilitates venous return from the legs and increases central blood volume and cardiac output. The greater the amount of blood pooled in the legs, the more robust the effect of squatting. Sitting decreases the gravitational stress and increases venous return to the heart, resulting in increases in cardiac filling pressure, stroke volume, cardiac output, and mean arterial pressure. Lying down eliminates the gravitational stress and shifts blood centrally, leading to increases in cardiac output and mean arterial pressure.

### Squeezing a Rubber Ball

Squeezing a rubber ball by hand using static hand-gripping combined with contraction of leg and abdominal muscle, would be equally or perhaps more effective for increasing mean arterial pressure. This manoeuvre could be used to counter or delay the onset of neurally mediated syncope, which is common among young women including patients with POTS.

**Statical Analysis:** Data were analysed using active stand test and EQ-5D-5L questionnaire. The pre and post test scores were recorded separately. The result shows a significant reduction in symptoms and improvement in quality of life in POTS subject.

**Results:** Descriptive analysis of pre and post-test values for heart rate are shown in Table-1.

**Table 1: Heart Rate**

| SCALE | PRE TEST | POST TEST | | | | |
|---|---|---|---|---|---|---|
| | | At the end of 1st week | At the end of 3rd week | At the end of 6th week | At the end of 9th week | At the end of 12th week |
| ACTIVE STAND TEST | 122 bpm | 120 bpm | 115 bpm | 100 bpm | 85 bpm | 75 bpm |

The pre-test value was 122 bpm and post-test value were 75 bpm for heart rate.

**Table 2: Descriptive Analysis of Pre and Post-Test Value for Blood Pressure**

| SCALE | PRE TEST | POST TEST | | | | |
|---|---|---|---|---|---|---|
| | | At the end of 1st week | At the end of 3rd week | At the end of 6th week | At the end of 9th week | At the end of 12th week |
| ACTIVE STAND TEST | 80/53 mmHg | 90/60 mmHg | 95/67 mmHg | 100/70 mmHg | 112/75 mmHg | 118/80 mmHg |

The pre-test value was 80/53 mmHg and post-test value were 118/80 mmHg for bp.

**Table 3: Descriptive Analysis of Pre and Post-Test Values for Self-Rated Health**

| SCALE | PRE TEST 1st week | POST TEST | | | |
|---|---|---|---|---|---|
| | | At the end of 3rd week | At the end of 6th week | At the end of 9th week | At the end of 12thweek |
| EQ VAS | 30 | 43 | 64 | 80 | 90 |

The pre-test value was 30 and post-test value were 90 for self-rated health.

**Table 4: Descriptive Analysis of Pre and Post Test Value for Quality of Life**

| SCALE- EQ-5D-5L QUESTIONNAIRE | | |
|---|---|---|
| | PRE TEST (1ST WEEK) | POST TEST (12TH WEEK) |
| **MOBILITY** | Severe problem - 4 | No problem - 1 |
| **SELF CARE** | Sever problem - 4 | Slight problem - 2 |
| **USUAL ACTIVITIES** | Unable to do - 5 | No problem - 1 |
| **PAIN / DISCOMFORT** | Severe pain or discomfort - 4 | Slight problem - 2 |
| **ANXIETY / DEPRESSION** | Extreme anxious/ depressed - 5 | Not anxious/ depressed - 1 |

## DISCUSSION

This study is the documentation of the effectiveness of endurance and strength training exercises in the management of postural orthostatic tachycardia syndrome subject. To execute this research work, the researchers advocated an intervention of endurance training which included recumbent bike and thread mill walking along with strength training which includes bridging, leg presses inwards, side lying straight leg raise, clamshells, Pilates hold and wall sit. The significant improvement was recorded on regarding two outcome parameters [i.e., active stand test and EQ-5D-5L questionnaire].

Exercise training offers the possibility to enlarge the heart and expand blood volume, while improving baroreflex sensitivity and increasing peak oxygen uptake. The training programaim to improve physical fitness, while avoiding excessive stress on the circulatory system. Exercise training in orthostatic intolerance is focused on improving aerobic fitness, as well as strengthening the lower limbs to improve the 'muscle pump' function. It starts with exercise that imposes a mild stress on the cardiovascular system, and progress very gradually to more circulatory challenging physical activities. The patient responds to exercise with an insufficient increase in stroke volume, which can lead to symptoms of circulatory distress (dyspnea, feeling faint, light-headedness, weakness). Therefore, exercising in the horizontal position (e.g., Recumbent bike, strength training in supine position) is preferred in the first stages of training. Supine activity is better tolerated than upright activity, because a recumbent position increases cardiac filling, since venous return is facilitated when gravity is excluded. The upright activities were added at the beginning of the third month of the training program. The upright position is significantly more stressful for the sympathetic nervous system, because active vaso constriction is required to compensate for the gravity induced downward displacement of blood.

The physical fitness that are thought to counteract orthostatic intolerance consist of a larger blood volume, a larger heart and cardiac output, enhanced vascular compression by increased muscle tissue, improved endothelial function, and possibly also improved baroreflex function. The moderate gradual endurance and strength training can increase orthostatic tolerance in POTS, decrease upright heart rate, improve baroreflex sensitivity and heart rate variability, and improve quality of life.

In this study, I have taken 30-year-old female who was diagnosed with postural orthostatic tachycardia syndrome. The subject received the intervention of endurance training and strength training exercises of moderate intensity initially for 4 times per week for 50 minutes per session and at the beginning of the third month the session became 5 times per week for 80 minutes per session. Through active stand test the patients resting heart rate and blood pressure were noted (70 bpm, 110/62 mmHg) after that the patient was instructed to stand up. The heart rate and blood pressure were monitored throughout the standing position and the heart rate and blood pressure at the $5^{th}$ minute of standing were taken as the pre-test value (122 bpm, 80/53 mmHg). There was a marked increase in heart rate and decrease in systolic and diastolic blood pressure. The post-test value for heart rate and blood pressure was assessed at the end of $1^{st}$ week (120 bpm, 90/60 mmHg), $3^{rd}$ week (115 bpm, 95/67 mmHg), $6^{th}$ week (100 bpm, 100/70 mmHg), $9^{th}$ week (85 bpm, 112/75 mmHg) and $12^{th}$ week (75 bpm, 118/80 mmHg). The post test showed a significant improvement in heart rate and blood pressure. The quality of life was measured using EQ-5D-5L descriptive system and EQ VAS. The EQ VAS records the respondent's self-rated health on vertical visual analogue scale. The pre-test value recorded at the $1^{st}$ week was 30 and post-test value at the end of $3^{rd}$ week, $6^{th}$ week, $9^{th}$ week and $12^{th}$ week were 43, 64, 80 and 90. Thus, the post test on patients self-rated health showed a significant increase. The descriptive system of EQ-5D-5L questionnaire with 5 dimensions was assessed at the $1^{st}$ week as pre-test and at the $12^{th}$ week as post-test. The pre-test and post-test of the descriptive system showed significant improvement in the quality of life. Thus, the study showed a significant improvement in the management of postural orthostatic tachycardia syndrome subject.

Following 12 weeks of moderate intensity physical activity, the participant in this study has an improvement in her symptoms. After five minutes of quiet standing, the participant reported that the active quiet stand during final data collection felt easier than the first time. Also, the participant reported feeling less heart palpitations as the 12 weeks progressed, and that after two weeks she did not feel any symptoms at all during physical activity or regular daily activities. Such changes make a meaningful difference in quality of life. The patient in the study showed a low initial quality of life. Following exercise training, she reported improvement in the dimensions of EQ-5D-5L questionnaire. Thus, the patient experienced improvement in physical and psychological symptoms of POTS after 12 weeks of moderate intensity physical training.

## Limitations

- The study has been conducted as a single case study with a POTS subject.
- Only two parameters used.
- The study only assessed heart rate, blood pressure and quality of life.

  Further directions of this study

- Further study can be conducted as experimental study/ comparative study.

- Further study can be done in different age group.
- A similar study can be done with longer duration to know the prognosis.
- Further study can be compared with various techniques.
- Further study can be done with different scales for assessing the outcome measures.

## CONCLUSION

There is a significant reduction in symptoms and improvement in quality of life after the application of 12 weeks of endurance and strength training exercises in postural orthostatic tachycardia syndrome subject.

## ACKNOWLEDGEMENT

First of all, I would like to express my gratitude to ALMIGHTY for providing me with wisdom and knowledge to complete this study successfully. I thank my parents, who had given me the opportunity, guidance, encouragement and support throughout the course of my study. I convey my sincere gratefulness to Chairman Dr. L.P. THANGAVELU, M.S F.R.C.S and Correspondent Mrs. SHANTI THANGAVELU M.A P.P.G. Group of Institutions, Coimbatore for their encouragement and providing the source for the success of the study. I would like to express my sincere thanks to my PRINCIPAL Dr. C SIVAKUMAR M.P.T Ph.D. who gave me his precious time and his vast experience helped me to complete this dissertation successfully. I express my special thanks and gratitude to my guide Mrs G. KARTHIKA, MPT, ASSOCIATE PROFESSOR for offering me perceptive inputs and guiding me entirely through the course of my work and without her tired less guidance, support, and constant encouragement this project would not have come through. I gratefully acknowledge the assistance of my under graduate faculty members, who helped me a lot in finishing this project. Without their creative suggestion and unwavering support, the study would have never taken in shape. I privileged to express my thanks to my dearest friends especially “Conquerors” for their marvellous support, help, motivation and encouragement throughout the study.

## AUTHOR’S CONTRIBUTION

I understand my agreement to participation in this study and I am not waiving any of my legal rights. I confirm that Ms. ABIJAYA J/ Mrs G. KARTHIKA, MPT, ASSOCIATE PROFESSOR have explained me the purpose of study, the study procedure and possible risk that I may experience. I have read and I have understood this concern to participate as a subject in this study.

## REFERENCE

1. *Adger K, Lynch H. Exercise in the management of postural orthostatic tachycardia syndrome. Journal of Kinesiology & Wellness. 2020 Oct 15;9(28-37):28–37. DOI:10.56980/jkw.v9i.70.*
2. *Fu Q, Levine BD. Exercise and non-pharmacological treatment of POTS. Autonomic Neuroscience. 2018 Dec;215(December 215: 20-27):20–7. .doi:10.1016/j.autneu.2018.07.001.*
3. *Fedorowski A. Postural orthostatic tachycardia syndrome: clinical presentation, aetiology and management. Journal of Internal Medicine. 2018 Nov 23;285(4):352–66.doi: 10.1111/joim.12852.*
4. *B D Chourasia’s, Human anatomy, edition 1.*

5. *Chouksey D, Rathi P, Sodani A, Jain R, Ishar HS. Postural orthostatic tachycardia syndrome in patients of orthostatic intolerance symptoms: an ambispective study. AIMS Neuroscience [Internet]. 2020 Dec 8 [cited 2021 May 29];8(1):74–85. Available from:https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7815479/#:~:text=POTS%20is%20a%20clinical%20syndrome.*

6. *Zadourian A, Doherty TA, Swiatkiewicz I, Taub PR. Postural Orthostatic Tachycardia Syndrome: Prevalence, Pathophysiology, and Management. Drugs. 2018 Jun 15;78(10):983–94. doi: 10.1007/s40265-018-0931-5https://www.researchgate.net/publication/325782477.*

7. *Shibata S, Fu Q, Bivens TB, Hastings JL, Wang W, Levine BD. Short-term exercise training improves the cardiovascular response to exercise in the postural orthostatic tachycardia syndrome. The Journal of Physiology. 2012 Jun 27;590(15):3495–505. JPhysiol590.15(2012) pp3495–3505.*

8. *Schmidt LL, Karabin BL, Malone AC. Postural Orthostatic Tachycardia Syndrome (POTS): Assess, Diagnose, and Evaluate for POTS Treatment (ADEPT). Integrative Medicine International [Internet]. 2017 Nov 30;4(3-4):142–53. Available from: https://www.karger.com/Article/PDF/484205 DOI:10.1159/000484205.*

9. *Benarroch EE. Postural Tachycardia Syndrome: A Heterogeneous and Multifactorial Disorder. Mayo Clinic Proceedings [Internet]. 2012 Dec;87(12):1214–25. Available from: https://www.mayoclinicproceedings.org/article/S0025-6196(12)00896-8/pdf.*

10. *George SA, Bivens TB, Howden EJ, Saleem Y, Galbreath MM, Hendrickson D, et al. The international POTS registry: Evaluating the efficacy of an exercise training intervention in a community setting. Heart Rhythm. 2016 Apr;13(4):943–50. DOI: 10.1016/j.hrthm.2015.12.012.*

11. *Lloyd MG, Bourne K, Raj SR. The Active Stand and Tilt Tests. Springer eBooks. 2020 Oct 21;(ISBN 978-3-030-54164-4):47–51.https://doi.org/10.1007/978-3-030-54165-1_8.*

12. *Finucane C, van Wijnen VK, Fan CW, Soraghan C, Byrne L, Westerhof BE, et al. A practical guide to active stand testing and analysis using continuous beat-to-beat non-invasive blood pressure monitoring. Clinical Autonomic Research. 2019 May 10;29(4):427–41.doi:10.1007/s10286-019-0060-y.*

13. *Bagai K; Song Y; Ling JF; Malow B; Black BK; Biaggioni I; Robertson D; Raj SR. Sleep disturbances and diminished quality of life in postural tachycardia syndrome. J Clin Sleep Med 2011;7(2):204-210. PMID: 21509337PMCID: PMC3077350.*

14. *Gibbons CH, Silva G, Freeman R. Cardiovascular exercise as a treatment of postural orthostatic tachycardia syndrome: A pragmatic treatment trial. Heart Rhythm. 2021 Jan;2021 Aug;18(8):1361-1368(Epub 2021 Jan 19.). DOI: 10.1016/j.hrthm.2021.01.017.*

15. *Bryarly M, Phillips LT, Fu Q, Vernino S, Levine BD. Postural Orthostatic Tachycardia Syndrome. Journal of the American College of Cardiology. 2019 Mar;73(10):1207–28. https://doi.org/10.1016/j.jacc.2018.11.059.*

16. *Raj SR. Postural Tachycardia Syndrome (POTS). Circulation. 2013 Jun 11;127(23):2336–42. DOI: 10.1161/CIRCULATIONAHA.112.144501.*

17. *Gall N, Kavi L, Lobo MD, editors. Postural Tachycardia Syndrome. Cham: Springer International Publishing; 2021. UK ISBN 978-3-030-54165-1 (eBook) https://doi.org/10.1007/978-3-030-54165-1.*

18. *Lei LY, Chew DS, Sheldon RS, Raj SR. Evaluating and managing postural tachycardia syndrome. Cleveland Clinic Journal of Medicine [Internet]. 2019 May 1 [cited 2020 Mar 18];86(5):333–44. Available from: https://www.ccjm.org/content/86/5/333.longdoi:10.3949/ccjm.86a.18002.*

19. *Breslin D, Synnott P, Byrne C. Active Stand Testing for Identification of Postural Orthostatic Tachycardia Syndrome. Cureus. 2023 Apr 29;2023 Apr; 15(4): e38281. Published online 2023 Apr 29. (PMCID: PMC10226153 PMID: 37255912.). doi: 10.7759/cureus.38281.*

20. *Active standing testLeaflet code: PIL202106 Created: 01 AST.*

21. *Parthasarathy B, Grace Roy A. O-AD003. Postural Orthostatic Tachycardia Syndrome (POTS): A case series from India. Clinical Neurophysiology. 2021 Aug;132(8): e71. https://doi.org/10.1016/j.clinph.2021.02.138.*