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## **Impact of Postural Orthostatic Tachycardia Syndrome (POTS) on Physical Limitations and Cognitive Functioning**

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### **Abstract**

Postural Orthostatic Tachycardia Syndrome (POTS) is a complex disorder characterized by an abnormal increase in heart rate upon assuming an upright position. While POTS primarily affects the cardiovascular system, it also exerts significant repercussions on physical limitations and cognitive functioning. This research aims to explore the multifaceted impact of POTS on these aspects. In terms of physical limitations, POTS patients commonly experience exercise intolerance, rendering them unable to engage in physical activities or exercise for extended periods without triggering distressing symptoms, including dizziness, rapid heart rate, fatigue, and lightheadedness. Furthermore, orthostatic intolerance poses a challenge for POTS patients as they frequently encounter symptoms such as lightheadedness, dizziness, and fainting when standing upright. Consequently, tasks that necessitate prolonged standing become arduous, thus impinging on activities of daily living and work-related activities. Additionally, chronic fatigue, a prevalent

manifestation among POTS patients, further curtails their physical capabilities, as even simple tasks can be exhaustive, often necessitating frequent rest or periods of inactivity to manage symptoms. In the realm of cognitive impairment, POTS patients frequently report experiencing cognitive symptoms colloquially known as "brain fog." These symptoms encompass difficulties with concentration, memory problems, mental fatigue, and slowed information processing. Such cognitive impairments substantially impact daily functioning, work productivity, and academic performance. POTS patients may encounter challenges in maintaining attention and focus, making it difficult to complete tasks requiring sustained concentration or engage in activities demanding cognitive effort. The chronic nature of POTS, coupled with the associated physical limitations and cognitive impairments, can have a profound impact on the mental health of affected individuals. Psychological distress, including anxiety and depression, frequently manifests due to the challenges posed by POTS. These mental health challenges further contribute to cognitive difficulties, exacerbating impairments in attention, memory, and overall cognitive performance.

**Keywords:** Postural Orthostatic Tachycardia Syndrome (POTS), Exercise intolerance, Orthostatic intolerance, Brain fog, Mental health impact

## Introduction

Postural orthostatic tachycardia syndrome (POTS) is a type of dysautonomia, a condition affecting the autonomic nervous system [1]. POTS is classified as a form of orthostatic intolerance, a condition where the body experiences difficulties in adjusting to an upright position. One of the hallmark symptoms of POTS is the presence of excessive tachycardia, characterized by an abnormally high heart rate, when an individual stands up. In addition to tachycardia, patients with POTS may also experience a wide range of other symptoms, further exacerbating their condition [2]. These symptoms can include dizziness, lightheadedness, fatigue, brain fog, and in some cases, even fainting spells. Consequently, POTS significantly impacts the daily lives of those affected, making simple tasks such as standing or walking a challenge [3], [4].

Postural orthostatic tachycardia syndrome (POTS) is characterized by a wide range of symptoms that can significantly impact an individual's quality of life. When affected individuals assume an upright position, they typically experience excessive tachycardia, which refers to a rapid increase in heart rate. This elevated heart rate can be quite dramatic, often exceeding 30 beats per minute or reaching a heart rate of over 120 beats per minute within the first 10 minutes of standing. This tachycardic response is accompanied by a variety of other symptoms, which can include

dizziness, lightheadedness, and a feeling of impending fainting [5]. These symptoms are often relieved when individuals assume a supine or reclining position.

In addition to tachycardia and postural symptoms, POTS can manifest with a host of other challenging symptoms. Fatigue is a common complaint among POTS patients and can be debilitating, hindering their ability to engage in daily activities. Cognitive impairments, commonly referred to as "brain fog," are also prevalent in individuals with POTS. This can manifest as difficulties with concentration, memory problems, and a general sense of mental cloudiness. Gastrointestinal symptoms such as nausea, bloating, and abdominal pain are also reported by many POTS patients [6].

Furthermore, POTS is often associated with various forms of dysautonomia, leading to additional symptoms related to autonomic dysfunction. Orthostatic hypotension, which refers to a drop in blood pressure upon standing, is commonly observed in POTS patients. This can result in symptoms such as blurred vision, lightheadedness, and even fainting. Disturbances in temperature regulation are also common, leading to heat intolerance, excessive sweating, or cold extremities. Sleep disturbances, including insomnia and disrupted sleep patterns, are frequently reported in individuals with POTS, further contributing to their overall burden of symptoms [7].

Common signs of postural orthostatic tachycardia syndrome (POTS) encompass weariness, difficulty tolerating an upright position, rapid heartbeat, and challenges with cognitive function [8]. Individuals with POTS often experience physical limitations that can impact their daily activities. The symptoms of POTS, such as fatigue, dizziness, and exercise intolerance, can make it challenging for patients to engage in physical exertion or maintain an active lifestyle. This can result in decreased muscle strength, reduced endurance, and overall physical deconditioning. Managing these physical limitations becomes an essential aspect of POTS treatment to improve the quality of life for affected individuals [9], [10].

In addition to physical limitations, POTS can also have a significant impact on cognitive functioning. Many patients with POTS report experiencing brain fog, difficulty concentrating, and problems with memory. These cognitive symptoms can be attributed to the underlying autonomic dysfunction and reduced blood flow to the brain that occurs in POTS. The brain relies on a steady supply of oxygen and nutrients to function optimally, and any disruption in blood flow can lead to cognitive impairments. The cognitive challenges associated with POTS can affect various aspects of life, including academic performance, work productivity, and daily functioning [11].

## Physical Limitations

### *Exercise intolerance:*

Exercise intolerance refers to the reduced ability of an individual to engage in physical activity or exercise due to a range of physiological factors. It can manifest as an increased heart rate, shortness of breath, muscle fatigue, and overall reduced stamina during exercise [12]. One common underlying cause of exercise intolerance is cardiovascular or respiratory disorders, such as heart failure, chronic obstructive pulmonary disease (COPD), or asthma. These conditions impair the body's ability to deliver oxygen to the working muscles and remove carbon dioxide efficiently, leading to a quicker onset of fatigue and reduced exercise capacity [13].

Another factor contributing to exercise intolerance is mitochondrial dysfunction. Mitochondria are the powerhouses of our cells, responsible for producing energy in the form of adenosine triphosphate (ATP). When mitochondrial function is impaired, as seen in certain genetic disorders or diseases like mitochondrial myopathy, there is a diminished ability to generate ATP. This deficiency can lead to muscle weakness, fatigue, and an inability to sustain physical activity. Individuals with mitochondrial disorders often experience exercise intolerance, with symptoms worsening as the intensity or duration of exercise increases [14].

**Table 1. POTS led physical limitations**

Physical Limitation	Description
Exercise intolerance	POTS patients experience difficulty engaging in physical activities or exercise for prolonged periods without symptoms like dizziness and fatigue.
Orthostatic intolerance	POTS patients often have symptoms like lightheadedness, dizziness, and fainting when standing upright, making it challenging to perform tasks that involve prolonged standing.
Fatigue	POTS patients commonly experience chronic fatigue, which limits their physical capabilities. Simple tasks can be exhausting, requiring frequent rest or periods of inactivity.

One primary symptom experienced by POTS patients during exercise is dizziness. The act of physical exertion can trigger an excessive increase in heart rate and result in inadequate blood flow to the brain [15]. This reduced cerebral blood flow can lead

to a sensation of lightheadedness, dizziness, and even fainting. Consequently, POTS patients may need to limit the intensity and duration of their physical activities to avoid exacerbating these symptoms and prevent accidents or injuries.

Rapid heart rate, or tachycardia, is another common symptom that POTS patients encounter during exercise. POTS is characterized by a heart rate increase of at least 30 beats per minute (or a heart rate greater than 120 beats per minute) within ten minutes of assuming an upright position. When combined with physical exertion, this excessive heart rate response can become even more pronounced, leading to palpitations, discomfort, and fatigue. To manage this symptom, POTS patients may need to carefully monitor their heart rate during exercise and modify their activity levels accordingly [16].

Fatigue is a prevalent symptom that contributes to exercise intolerance in POTS patients. Even mild physical exertion can result in extreme fatigue and a prolonged recovery period. The underlying autonomic dysfunction in POTS affects the body's ability to regulate blood pressure and heart rate efficiently, leading to excessive energy expenditure during exercise. Consequently, POTS patients often find it challenging to engage in sustained physical activities, and their fatigue can persist long after exercise has ended.

Lightheadedness is yet another symptom that adversely affects POTS patients during exercise. The combination of inadequate blood flow to the brain and autonomic dysregulation can result in feelings of lightheadedness and a sense of imbalance. This symptom can significantly impact balance and coordination, making activities such as running, cycling, or even walking challenging for POTS patients. The fear of falling or injuring oneself can further contribute to exercise intolerance and limit the patient's ability to engage in physical activities [17].

#### *Orthostatic intolerance:*

POTS (Postural Orthostatic Tachycardia Syndrome) patients commonly face a range of symptoms when assuming an upright position, presenting significant challenges in performing tasks that involve prolonged standing. Lightheadedness, dizziness, and fainting episodes are among the prevalent symptoms experienced by individuals with POTS, which can severely impact their ability to engage in activities of daily living or work-related tasks that require them to remain upright [18].

Lightheadedness is a distressing symptom for POTS patients when standing upright. Due to autonomic dysfunction, the body struggles to maintain proper blood circulation and regulate blood pressure effectively. As a result, inadequate blood

flow to the brain can lead to feelings of lightheadedness, a sense of floating, or even a temporary loss of consciousness. These symptoms make it challenging for POTS patients to stand for prolonged periods and can hinder their ability to carry out tasks that necessitate a consistent upright position [19].

Dizziness is another common symptom experienced by POTS patients when standing. It is characterized by a spinning sensation or a feeling of being off-balance. When individuals with POTS assume an upright posture, abnormal blood circulation and autonomic dysregulation can cause a sudden drop in blood pressure, depriving the brain of adequate oxygen and nutrients. This can result in dizziness and significantly impair the patient's ability to perform tasks that involve standing, such as cooking, cleaning, or even simply showering [20].

Fainting, also known as syncope, is a severe manifestation of POTS symptoms when standing. It occurs when the brain does not receive sufficient blood flow and oxygen, leading to a temporary loss of consciousness. Fainting episodes can be unpredictable and pose significant safety risks for POTS patients. Engaging in activities that require prolonged standing, such as working in a standing position or participating in social events, becomes highly challenging and potentially dangerous for individuals with POTS due to the risk of sudden loss of consciousness [21].

These symptoms collectively contribute to physical limitations in activities of daily living or work-related activities for POTS patients. Tasks that require individuals to maintain an upright position for an extended duration become daunting and often impossible to complete. Consequently, individuals with POTS may need to modify their activities, seek accommodations, or even explore alternative work arrangements to mitigate the impact of their symptoms on their ability to function in daily life or meet occupational demands.

*Fatigue:*

Chronic fatigue is a pervasive symptom experienced by many individuals with POTS (Postural Orthostatic Tachycardia Syndrome). This debilitating fatigue significantly impacts the physical capabilities of POTS patients, making even simple tasks exhausting and challenging to accomplish. As a result, individuals with POTS often find themselves needing frequent rest or periods of inactivity to manage their symptoms effectively [22].

The underlying autonomic dysfunction in POTS disrupts the body's ability to regulate blood flow, heart rate, and other physiological functions efficiently. This dysregulation can lead to a constant state of heightened physiological arousal and

increased energy expenditure [23]. As a consequence, POTS patients often experience a profound sense of fatigue, which persists even with minimal physical exertion. Activities that are typically considered routine or effortless for healthy individuals can quickly drain the energy reserves of someone with POTS.

The fatigue experienced by POTS patients goes beyond the usual tiredness one might feel after physical exertion. It is an overwhelming and persistent exhaustion that can significantly impact their quality of life and functional abilities. Simple tasks like showering, preparing meals, or doing household chores can become arduous and require significant effort. POTS patients may find themselves needing to rest or lie down frequently throughout the day to alleviate their fatigue and manage their symptoms effectively [24].

The nature of chronic fatigue in POTS patients makes it difficult for them to engage in sustained physical activities or exercise. While regular exercise is generally recommended for maintaining overall health, managing POTS-related fatigue can present unique challenges. Even mild exercise can quickly deplete their energy reserves and exacerbate their symptoms. As a result, individuals with POTS often require careful planning and pacing of activities to avoid overexertion and the subsequent worsening of fatigue [25].

Furthermore, the impact of chronic fatigue extends beyond physical limitations. POTS patients may also experience cognitive fatigue, which manifests as difficulties with concentration, memory, and mental processing. This mental exhaustion further hampers their ability to perform daily tasks, work, or engage in social activities. The combination of physical and cognitive fatigue places significant constraints on the daily lives of POTS patients and necessitates the need for adequate rest and self-care strategies to manage their symptoms effectively.

## Cognitive Impairment

### *Brain fog:*

Cognitive symptoms, commonly known as "brain fog," are frequently reported by individuals with POTS (Postural Orthostatic Tachycardia Syndrome). These symptoms encompass a range of cognitive impairments, including difficulties with concentration, memory problems, mental fatigue, and slowed information processing. The presence of cognitive symptoms in POTS patients can have a profound impact on their daily functioning, work productivity, and academic performance.

One of the prominent cognitive symptoms experienced by POTS patients is difficulty with concentration. They often struggle to maintain focus on tasks, find it challenging to stay engaged in conversations or activities, and may have a shortened attention span. This inability to concentrate can hinder their ability to complete work assignments, follow instructions, or even participate in social interactions effectively [26], [27].

Table 2. POTS led cognitive impairments	
Cognitive Impairment	Description
Brain Fog	POTS patients commonly experience cognitive symptoms referred to as "brain fog." This includes difficulties with concentration, memory problems, mental fatigue, and slowed information processing.
Decreased Attention and Focus	POTS patients may struggle to maintain attention and focus, making it challenging to engage in tasks requiring sustained concentration or complete complex mental tasks.
Mental Health Impact	The chronic nature of POTS, along with physical limitations and cognitive impairments, can contribute to psychological distress, including anxiety and depression. This can further impact cognitive functioning.

Memory problems are also commonly reported by individuals with POTS. They may experience difficulties with both short-term and long-term memory, making it challenging to remember information, appointments, or even simple daily tasks. Forgetfulness and the need for constant reminders become a part of their everyday life, further adding to the cognitive burden they face [28].

Mental fatigue is a significant cognitive symptom in POTS patients. The combination of autonomic dysregulation and the energy demands of coping with other physical symptoms can quickly exhaust their mental resources. As a result, cognitive tasks that would typically be manageable become mentally draining and overwhelming. This mental fatigue can further contribute to difficulties with concentration, memory, and overall cognitive performance [29].

Slowed information processing is another common cognitive impairment experienced by POTS patients. They may find it takes longer to understand and process new information, respond to questions or tasks, or make decisions. This slowed cognitive processing can significantly impact their ability to keep up with



the demands of work or school, leading to decreased productivity and increased frustration.

The cognitive impairments associated with POTS can have far-reaching consequences on daily life, work, and academic performance. Tasks that were once routine may become challenging to accomplish, leading to decreased productivity and a sense of frustration. POTS patients may find it difficult to meet the cognitive demands of their jobs, leading to decreased work efficiency and potential career limitations [30]. In educational settings, these cognitive symptoms can interfere with learning, concentration, and memory, making it harder for POTS patients to succeed academically.

*Decreased attention and focus:*

Maintaining attention and focus is indeed a common challenge faced by individuals with POTS (Postural Orthostatic Tachycardia Syndrome). The autonomic dysregulation present in POTS can disrupt the brain's ability to allocate and sustain attention effectively, leading to difficulties in tasks that require prolonged concentration. As a result, individuals with POTS may find it challenging to complete complex mental tasks or engage in activities that demand sustained cognitive effort.

The fluctuating nature of POTS symptoms, including changes in heart rate, blood pressure, and cerebral blood flow, can contribute to difficulties in maintaining attention. Fluctuations in blood flow to the brain, especially during postural changes or periods of physical or mental exertion, can disrupt the neural networks involved in attention regulation. Consequently, POTS patients may experience frequent lapses in attention, have difficulty filtering out distractions, or struggle to stay engaged in tasks for an extended period.

Completing complex mental tasks can be particularly challenging for individuals with POTS. Activities that require sustained concentration, such as studying, problem-solving, or engaging in intellectually demanding work, can become overwhelming. POTS patients may find it difficult to maintain a consistent level of attention necessary for tackling intricate or lengthy tasks. These difficulties can impact productivity, work performance, and academic achievement, adding an additional layer of challenge to their daily lives [31].

In addition to difficulties with sustained attention, individuals with POTS may also experience cognitive fatigue, which further compounds their challenges in completing mentally demanding tasks. Mental fatigue refers to the subjective feeling

of exhaustion and decreased mental energy. POTS patients often experience mental fatigue due to the combination of autonomic dysregulation, physical symptoms, and the cognitive effort required to manage their condition. As a result, they may find it harder to concentrate and may require frequent breaks or periods of rest to recharge their cognitive resources.

It is important to note that the impact of attention and concentration difficulties in POTS can vary among individuals. Some patients may experience more pronounced challenges, while others may have milder symptoms. Nonetheless, the struggle to maintain attention and focus can significantly affect the daily lives, educational pursuits, and professional endeavors of individuals with POTS [32].

*Mental health impact:*

The chronic nature of POTS (Postural Orthostatic Tachycardia Syndrome) coupled with the physical limitations and cognitive impairments it entails can have a profound impact on the psychological well-being of individuals. It is not uncommon for POTS patients to experience psychological distress, including anxiety and depression, which can further affect cognitive functioning and exacerbate difficulties with attention, memory, and overall cognitive performance.

Living with a chronic condition like POTS can be emotionally challenging. Dealing with the physical symptoms, limitations, and uncertainties associated with the condition can lead to feelings of frustration, hopelessness, and loss of control. The unpredictable nature of symptom flare-ups and the impact they have on daily life can contribute to heightened anxiety and distress. Moreover, the significant adjustments individuals with POTS often have to make in their personal and professional lives can lead to feelings of isolation and a sense of loss of identity, further impacting their mental well-being [33].

Anxiety is a prevalent mental health challenge among POTS patients. The constant vigilance and worry about experiencing symptoms, the fear of fainting or losing control in public settings, and the uncertainty surrounding their condition can significantly contribute to anxiety symptoms. Heightened anxiety can further impact cognitive functioning, making it even more challenging to concentrate, focus, and retain information. The persistent worries and intrusive thoughts can create cognitive overload, hindering effective cognitive processing and exacerbating attentional difficulties.

Depression is another psychological challenge that individuals with POTS may face. The limitations imposed by the condition, the impact on daily functioning, and the

perceived loss of independence and quality of life can lead to feelings of sadness, hopelessness, and despair. Depression can further exacerbate cognitive impairments, including difficulties with attention, memory, and decision-making. The lack of motivation and decreased energy levels associated with depression can also make it harder to engage in cognitive tasks and sustain mental effort.

The interplay between psychological distress and cognitive functioning in POTS is complex and bidirectional. Psychological distress can negatively impact cognitive abilities, while cognitive impairments can contribute to increased psychological distress. This cycle can create a significant burden on individuals with POTS, affecting their overall well-being and quality of life [34].

Recognizing the psychological impact of POTS and addressing mental health challenges is crucial in providing comprehensive care for individuals with the condition. A multidisciplinary approach that integrates medical management, psychological support, and cognitive interventions can be beneficial. This may involve working with mental health professionals, such as psychologists or psychiatrists, to address anxiety and depression through therapy and, if necessary, medication [35]. Additionally, implementing strategies for stress management, relaxation techniques, and cognitive rehabilitation can help individuals with POTS optimize their cognitive functioning and alleviate psychological distress.

## Conclusion

POTS is caused by dysregulation of the autonomic nervous system, which controls many automatic bodily functions. This dysregulation can extend beyond the cardiovascular system and affect other autonomic functions such as digestion, temperature regulation, and sleep. Digestive symptoms like nausea, bloating, and constipation are common in POTS patients, further impacting their physical well-being and overall quality of life.

POTS patients often experience sleep disturbances, including difficulty falling asleep, frequent awakenings during the night, and non-restorative sleep. These sleep disruptions can worsen the symptoms of fatigue and cognitive impairment, leading to a vicious cycle of reduced productivity and diminished cognitive functioning.

**Impaired quality of life:** Due to the physical limitations, cognitive impairments, and associated symptoms, POTS can significantly impair an individual's overall quality of life. The inability to engage in normal physical activities, perform work or

academic tasks effectively, and maintain social relationships can lead to feelings of frustration, isolation, and reduced self-esteem.

While there is currently no cure for POTS, various treatment approaches can help manage symptoms and improve daily functioning. These may include lifestyle modifications, such as increasing fluid and salt intake, wearing compression garments, and engaging in graded exercise programs. Medications like beta blockers, fludrocortisone, and selective serotonin reuptake inhibitors (SSRIs) may also be prescribed to alleviate symptoms and improve cardiovascular and cognitive function.

POTS management often requires a multidisciplinary approach involving healthcare professionals from various disciplines. This may include cardiologists, neurologists, physiotherapists, occupational therapists, psychologists, and nutritionists working together to provide comprehensive care tailored to the individual's needs. POTS patients can benefit greatly from support groups and advocacy organizations that provide information, resources, and a sense of community. These groups offer a platform for individuals to share experiences, coping strategies, and emotional support, helping them navigate the challenges of living with POTS and promoting self-advocacy.

## References

- [1] A. K. Agarwal, R. Garg, A. Ritch, and P. Sarkar, "Postural orthostatic tachycardia syndrome," *Postgrad. Med. J.*, vol. 83, no. 981, pp. 478–480, Jul. 2007.
- [2] J. M. Spahic *et al.*, "Malmö POTS symptom score: Assessing symptom burden in postural orthostatic tachycardia syndrome," *J. Intern. Med.*, vol. 293, no. 1, pp. 91–99, Jan. 2023.
- [3] S. Dahan, L. Tomljenovic, and Y. Shoenfeld, "Postural Orthostatic Tachycardia Syndrome (POTS)--A novel member of the autoimmune family," *Lupus*, vol. 25, no. 4, pp. 339–342, Apr. 2016.
- [4] A. Fedorowski, "Postural orthostatic tachycardia syndrome: clinical presentation, aetiology and management," *J. Intern. Med.*, vol. 285, no. 4, pp. 352–366, Apr. 2019.
- [5] K. Kanjwal, B. Saeed, B. Karabin, Y. Kanjwal, and B. P. Grubb, "Clinical presentation and management of patients with hyperadrenergic postural orthostatic tachycardia syndrome. A single center experience," *Cardiol. J.*, vol. 18, no. 5, pp. 527–531, 2011.

- [6] I. Knoop and L. Dunwoody, “‘You’re always fighting’: the lived experience of people with postural orthostatic tachycardia syndrome (POTS),” *Disabil. Rehabil.*, vol. 45, no. 10, pp. 1629–1635, May 2023.
- [7] C. McDonald, J. Frith, and J. L. Newton, “Single centre experience of ivabradine in postural orthostatic tachycardia syndrome,” *Europace*, vol. 13, no. 3, pp. 427–430, Mar. 2011.
- [8] D. Mallick, L. Goyal, P. Chourasia, M. R. Zapata, K. Yashi, and S. Surani, “COVID-19 Induced Postural Orthostatic Tachycardia Syndrome (POTS): A Review,” *Cureus*, vol. 15, no. 3, p. e36955, Mar. 2023.
- [9] M. Bryarly, L. T. Phillips, Q. Fu, S. Vernino, and B. D. Levine, “Postural Orthostatic Tachycardia Syndrome: JACC Focus Seminar,” *J. Am. Coll. Cardiol.*, vol. 73, no. 10, pp. 1207–1228, Mar. 2019.
- [10] P. A. Low, V. Novak, J. M. Spies, P. Novak, and G. W. Petty, “Cerebrovascular regulation in the postural orthostatic tachycardia syndrome (POTS),” *Am. J. Med. Sci.*, vol. 317, no. 2, pp. 124–133, Feb. 1999.
- [11] P. Safavi-Naeini and M. Razavi, “Postural Orthostatic Tachycardia Syndrome,” *Tex. Heart Inst. J.*, vol. 47, no. 1, pp. 57–59, Feb. 2020.
- [12] M. Watari *et al.*, “Autoimmune postural orthostatic tachycardia syndrome,” *Ann Clin Transl Neurol*, vol. 5, no. 4, pp. 486–492, Apr. 2018.
- [13] L. L. Schmidt, B. L. Karabin, and A. C. Malone, “Postural orthostatic tachycardia syndrome (POTS): assess, diagnose, and evaluate for POTS treatment (ADEPT),” *Integrative Medicine International*, vol. 4, no. 3–4, pp. 142–153, 2019.
- [14] S. Blitshteyn, “Is postural orthostatic tachycardia syndrome (POTS) a central nervous system disorder?,” *J. Neurol.*, vol. 269, no. 2, pp. 725–732, Feb. 2022.
- [15] C. K. Ormiston, I. Świątkiewicz, and P. R. Taub, “Postural orthostatic tachycardia syndrome as a sequela of COVID-19,” *Heart Rhythm*, vol. 19, no. 11, pp. 1880–1889, Jul. 2022.
- [16] C. J. Fisher, I. Katzan, L. J. Heinberg, A. T. Schuster, N. R. Thompson, and R. Wilson, “Psychological correlates of patients with postural orthostatic tachycardia syndrome (POTS),” *Auton. Neurosci.*, vol. 227, p. 102690, Sep. 2020.
- [17] R. A. Ocher, E. Padilla, J. C. Hsu, and P. R. Taub, “Clinical and Laboratory Improvement in Hyperadrenergic Postural Orthostatic Tachycardia Syndrome (POTS) after COVID-19 Infection,” *Case Rep Cardiol*, vol. 2021, p. 7809231, Aug. 2021.
- [18] A. Kohn and C. Chang, “The Relationship Between Hypermobility Ehlers-Danlos Syndrome (hEDS), Postural Orthostatic Tachycardia Syndrome

- (POTS), and Mast Cell Activation Syndrome (MCAS),” *Clin. Rev. Allergy Immunol.*, vol. 58, no. 3, pp. 273–297, Jun. 2020.
- [19] M. Johansson *et al.*, “Plasma proteomic profiling in postural orthostatic tachycardia syndrome (POTS) reveals new disease pathways,” *Sci. Rep.*, vol. 12, no. 1, p. 20051, Nov. 2022.
- [20] S. Reddy, S. Reddy, and M. Arora, “A Case of Postural Orthostatic Tachycardia Syndrome Secondary to the Messenger RNA COVID-19 Vaccine,” *Cureus*, vol. 13, no. 5, p. e14837, May 2021.
- [21] S. R. Raj *et al.*, “Postural orthostatic tachycardia syndrome (POTS): Priorities for POTS care and research from a 2019 National Institutes of Health Expert Consensus Meeting – Part 2,” *Auton. Neurosci.*, vol. 235, p. 102836, Nov. 2021.
- [22] A. Ojha, T. C. Chelimsky, and G. Chelimsky, “Comorbidities in pediatric patients with postural orthostatic tachycardia syndrome,” *J. Pediatr.*, vol. 158, no. 1, pp. 20–23, Jan. 2011.
- [23] Q. Fu *et al.*, “Cardiac origins of the postural orthostatic tachycardia syndrome,” *J. Am. Coll. Cardiol.*, vol. 55, no. 25, pp. 2858–2868, Jun. 2010.
- [24] F. Dipaola *et al.*, “Time Course of Autonomic Symptoms in Postural Orthostatic Tachycardia Syndrome (POTS) Patients: Two-Year Follow-Up Results,” *Int. J. Environ. Res. Public Health*, vol. 17, no. 16, Aug. 2020.
- [25] A. Hoad, G. Spickett, J. Elliott, and J. Newton, “Postural orthostatic tachycardia syndrome is an under-recognized condition in chronic fatigue syndrome,” *QJM*, vol. 101, no. 12, pp. 961–965, Dec. 2008.
- [26] K. Mizumaki, “Postural Orthostatic Tachycardia Syndrome (POTS),” *Journal of Arrhythmia*, vol. 27, no. 4, pp. 289–306, Jan. 2011.
- [27] Q. Fu and B. D. Levine, “Exercise in the postural orthostatic tachycardia syndrome,” *Auton. Neurosci.*, vol. 188, pp. 86–89, Mar. 2015.
- [28] S. Vernino and L. E. Stiles, “Autoimmunity in postural orthostatic tachycardia syndrome: Current understanding,” *Auton. Neurosci.*, vol. 215, pp. 78–82, Dec. 2018.
- [29] T. Öner, B. Guven, V. Tavli, T. Mese, M. M. Yilmazer, and S. Demirpençe, “Postural orthostatic tachycardia syndrome (POTS) and vitamin B12 deficiency in adolescents,” *Pediatrics*, vol. 133, no. 1, pp. e138–42, Jan. 2014.
- [30] S. R. Raj, A. Fedorowski, and R. S. Sheldon, “Diagnosis and management of postural orthostatic tachycardia syndrome,” *CMAJ*, vol. 194, no. 10, pp. E378–E385, Mar. 2022.
- [31] J. W. Anderson *et al.*, “Cognitive function, health-related quality of life, and symptoms of depression and anxiety sensitivity are impaired in patients with the postural orthostatic tachycardia syndrome (POTS),” *Front. Physiol.*, vol. 5, 2014.

- [32] R. Schondorf and P. A. Low, “Idiopathic postural orthostatic tachycardia syndrome: an attenuated form of acute pandysautonomia?,” *Neurology*, vol. 43, no. 1, pp. 132–137, Jan. 1993.
- [33] A. Zadourian, T. A. Doherty, I. Swiatkiewicz, and P. R. Taub, “Postural Orthostatic Tachycardia Syndrome: Prevalence, Pathophysiology, and Management,” *Drugs*, vol. 78, no. 10, pp. 983–994, Jul. 2018.
- [34] A. Deb, K. Morgenshtern, C. J. Culbertson, L. B. Wang, and A. D. Hohler, “A survey-based analysis of symptoms in patients with postural orthostatic tachycardia syndrome,” *Proc.*, vol. 28, no. 2, pp. 157–159, Apr. 2015.
- [35] P. L. Mar and S. R. Raj, “Postural Orthostatic Tachycardia Syndrome: Mechanisms and New Therapies,” *Annu. Rev. Med.*, vol. 71, pp. 235–248, Jan. 2020.