

Role of NASA 10-minute Lean Test in diagnosing postural orthostatic tachycardia syndrome: a preliminary study in young population

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ABSTRACT

Postural orthostatic tachycardia syndrome (POTS) is a form of autonomic imbalance characterized by abnormally increased heart rate (HR) and various symptoms of orthostatic intolerance (OI). This study aimed to determine POTS in adolescents using the National Aeronautics and Space Administration (NASA) 10-minute Lean Test. This cross-sectional study was conducted at Government Medical College, Srinagar, J&K, India, between October 2017 and November 2019. Adolescents with symptoms of OI were enrolled for this study, and the NASA 10-minute Lean Test was performed. Characteristics of the POTS group were compared with the non-POTS group. There was a significant difference in BMI ($P < 0.0001$) between the POTS and non-POTS groups. However, the number of females with features of POTS was greater than males. There was a significant difference in resting HR between the two groups ($P < 0.0001$). During upright posture, there was a significant difference in maximum upright HR between the two groups ($P < 0.0001$), the highest increment in upright HR also differed significantly ($P < 0.0001$). POTS group had significantly higher HR than the non-POTS group. It may be inferred from this preliminary study that NASA 10-minute Lean Test can be used to diagnose POTS.

Introduction

Postural orthostatic tachycardia syndrome (POTS) is a form of cardiovascular autonomic im-

balance defined by an increased resting heart rate with features of chronic orthostatic intolerance (OI).^{1,2} In adolescents, POTS is characterized by an increase in heart rate (HR) ≥ 40 beats/minute (bpm) from the resting HR values in the first 10 minutes upon assuming an upright posture or if the HR remains ≥ 120 bpm in a supine position.³ It is accompanied by symptoms of OI such as lightheadedness, nausea, shortness of breath, diaphoresis, headache, fatigue, cognitive dysfunction usually described as *brain fog*, and other features of autonomic imbalance which sometimes may be severe enough to decrease the quality of life.^{2,4} Typically orthostatic hypotension (OH) is not seen in POTS.³ POTS is seen in all age groups, although it is more common in the young population, especially in premenopausal females with an overall prevalence of 0.2-1%.⁵ In adolescents, POTS has been seen to occur at a rate of 6.8%, affecting their quality of life.⁶ POTS has a multifactorial etiology such as catecholamine excess, autoimmune disorders, hypovolemia, vaccination, infection, and pregnancy.¹ In clinical settings, the tilt-table test remains the gold standard for the diagnosis of POTS.⁷

To the best of our knowledge, this is the first study to use the NASA 10-minute Lean Test, which is regarded as equivalent to the tilt-table test⁸ for the diagnosis of POTS in adolescents. Therefore, this study was aimed to see whether the NASA 10-minute Lean Test can be used to diagnose POTS in adolescents.

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Materials and Methods

This observational cross-sectional study was conducted in the Department of Physiology at GMC & SMHS Hospital, Srinagar, J&K, India, between October 2017 and November 2019 after obtaining approval from the Institutional Ethical Committee. In this study, 200 adolescent subjects, aged 12 to 19 years, were enrolled. They filled a questionnaire to report the symptoms of OI. Out of 200 subjects, 150 reported symptoms of OI. Eventually, 150 subjects with symptoms of OI were selected for this study. Participants who had a history of smoking, chronic diseases, infectious diseases, head trauma, diabetes mellitus, anemia, psychiatric disorders, and intake of drugs affecting autonomic functions were excluded from this study by taking a thorough history. OI was assessed with the help of an Orthostatic Intolerance Questionnaire (OIQ)⁹ which was filled by all the subjects. They were asked to report to the autonomic function testing laboratory in the Department of Physiology, at the GMC & SMHS Hospital. There, they were explained the protocol of the NASA 10-Minute Lean Testing in detail; such as limiting fluid and sodium intake at least 24 hours before testing, not to wear compression socks, and withhold medicine that might influence autonomic functions such as β blockers, Midodrine, fludrocortisone, antidepressants, and caffeine. The test was performed between 9:00 and 11:00 a.m., and standardized conditions were maintained throughout the procedure. Anthropometric measurements such as height, weight, and BMI were calculated. After that, all the participants were rested in a supine position for at least 10-15 minutes to achieve hemodynamic equilibrium. After 15 minutes of rest in the supine position, systolic blood pressure (SBP, mmHg), diastolic blood pressure (DBP, mmHg), and HR were recorded with the help of a digital sphygmomanometer (OMRON-HEM-7120, Kyoto, Japan). Vitals were again measured 1 minute later. Readings were retaken in case vitals were not similar until two consecutive readings were almost the same. This was done to determine true resting vitals. After the procedure mentioned above, participants were asked to stand up and walk to a specified wall and lean against the wall in such a way that only their shoulder blades touched the wall without arching the lower back. To avoid the contact of buttocks and wall, subjects were asked to place the heels at a specified mark that was 6 inches away from the wall (Figure 1). The test began once the subject leaned comfortably against the wall. After 1 minute of passive standing, SBP, DBP, and HR were recorded. The whole procedure was repeated every minute for the next 9 minutes. At the end of every minute, subjects were told to report symptoms of OI, if any. The NASA 10-minute Lean Test procedure was demonstrated to

each subject before the actual commencement of the test. Written consent was obtained from all participants or their caretakers, and the study was clarified beforehand. Participants had the choice to withdraw from the study at any time.

Data were analyzed using GraphPad Prism Version 6 (GraphPad Software, San Diego, CA-92108, USA). The normality of various parameters was determined using D'Agostino-Pearson omnibus test. Chi-square test with Yates correction was used for variables. An unpaired t-test was used to compare the two groups and the non-parametric data Mann-Whitney U test. Data were expressed in mean \pm standard deviation. P-value of <0.05 was considered statistically significant.

Results

A total of 200 subjects were enrolled in this study, and 150 out of them reported symptoms of OI filling out a questionnaire. Eventually, 150 subjects were en-



Figure 1. Passive lean posture during NASA 10-minute Lean Test. The feet should be placed straight and approximately 6 inches from the wall.

rolled for this study. NASA 10-minute Lean Test was performed in all the subjects to assess OI and POTS. During the NASA 10-minute Lean Test, the most common symptom reported was lightheadedness/dizziness (61.3%), which was followed by weakness (52.7%), tremulousness (46.7%), palpitations (46%), blurring of vision (41.3%), shortness of breath (38%), chest pain (30%), increased sweating (19.3%) and pre-syncope/syncope (13.3%) (Table 1). It was observed that 40 participants fulfilled the criteria of POTS using this test. Characteristics of the POTS group were compared with the 110 of non-POTS group. There was no significant difference in age (16.29 ± 2.64 years vs 17.23 ± 1.31 years; $P=0.381$) and gender ($\chi^2=0.679$; $P=0.410$) between the two groups. BMI of the POTS group was significantly lower than non-POTS group (18.50 ± 0.53 kg/m² vs 21.38 ± 0.33 kg/m²; $P<0.0001$) (Table 2). After a supine rest of about 10-15 minutes, systolic blood pressure (SBP), diastolic blood pressure (DBP), and heart rate (HR) were recorded. There was no significant difference between resting SBP (117.7 ± 9.38 mmHg vs 118 ± 10.47 mmHg; $P=0.823$) and resting DBP (72.71 ± 7.45 mmHg vs 73.80 ± 7.91 mmHg; $P=0.657$) between the two groups. However, the resting HR of the POTS group was significantly higher (93.94 ± 16.89 bpm vs 75.66 ± 9.29 bpm; $P<0.0001$) (Table 2). In the supine position, there was no significant difference between the average SBP (116 ± 10.11 mmHg vs 115 ± 9.16 mmHg; $P=0.531$) and average DBP (72.67 ± 8.21 mmHg vs 72.91 ± 8.72 mmHg; $P=0.814$) between the two groups. The average HR was significantly higher in the POTS group (92.61 ± 15.32 bpm vs 75.72 ± 9.01 bpm; $P<0.0001$) (Table 2). During the lean test, vitals were recorded at

the end of each minute for 10 minutes, and average SBP and DBP were calculated. There was no significant difference in average SBP (112 ± 10.11 mmHg vs 115 ± 9.16 mmHg; $P=0.531$) and DBP (70.81 ± 11.21 mmHg vs 71.10 ± 9.73 ; $P=0.645$) of 10 minutes between the two groups. It was observed that the highest rise in HR (133.6 ± 14.27 bpm vs 91.67 ± 9.94 bpm; $P<0.0001$) and the maximum increase in HR (40.91 ± 11.78 bpm vs 16.34 ± 6.97 bpm; $P<0.0001$) were significantly higher in the POTS group (Table 2).

Discussion

POTS is a form of dysautonomia characterized by an exaggerated HR and various symptoms of OI in the

Table 1. Symptoms of orthostatic intolerance in decreasing order as assessed by NASA Lean Test.

Orthostatic symptoms	Frequency (%) N=150
Light headedness/dizziness	92/150 (61.3%)
Weakness	79/150 (52.7%)
Tremulousness	70/150 (46.7%)
Palpitations symptoms	69/150 (46%)
Blurring of vision	62/150 (41.3%)
Shortness of breath	57/150 (38%)
Chest pain	45/150 (30%)
Increased sweating	29/150 (19.3%)
Pre-syncope/syncope	20/150 (13.3%)

NASA, National Aeronautics and Space Administration. N, total number of subjects.

Table 2. Comparison of characteristics between Type-1 diabetics with postural orthostatic tachycardia syndrome vs non-postural orthostatic tachycardia syndrome.

Characteristics	POTS with OI n=40	Non-POTS with OI n=110	χ^2	P value
Female:Male	31:08	100:20	0.679	0.410
Age (yrs)	16.29 ± 2.64	17.23 ± 1.31		0.381
BMI (kg/m ²)	18.50 ± 0.53	21.38 ± 0.33		<0.0001**
Supine position				
Resting SBP (mmHg)	117.7 ± 9.38	118 ± 10.47		0.823
Resting DBP (mmHg)	72.71 ± 7.45	73.80 ± 7.91		0.657
Resting HR (bpm)	93.94 ± 16.89	75.66 ± 9.29		<0.0001**
Average SBP (mmHg)	116 ± 10.11	115 ± 9.16		0.531
Average DBP (mmHg)	72.67 ± 8.21	72.91 ± 8.72		0.814
Average HR (bpm)	92.61 ± 15.32	75.72 ± 9.01		<0.0001**
Passive standing (Lean test)				
Average SBP (mmHg) of 10 minutes	112 ± 10.11	115 ± 9.16		0.531
Average DBP (mmHg) of 10 minutes	70.81 ± 11.21	71.10 ± 9.73		0.645
Highest HR (bpm)	133.6 ± 14.27	91.67 ± 9.94		<0.0001**
Highest increment in HR (bpm)	40.91 ± 11.78	16.34 ± 6.97		<0.0001**

All the data were expressed as mean±standard deviation. POTS, postural orthostatic tachycardia syndrome; OI, orthostatic intolerance; χ^2 , Chi-square test; n, number of subjects; BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure; HR, heart rate. **Data is very highly significant.

absence of OH.^{10,11} POTS can occur in any age group; however, it is more common in people aged 15-50 years, predominantly in females compared to males with a ratio of 4:1, which may be attributed to the dilation of vessels caused by female sex hormones.^{12,13} Symptoms of OI such as lightheadedness, chest pain, blurring of vision, and palpitations are usually seen in POTS. These symptoms arise due to decreased venous return, reduced cardiac output, and hypoperfusion.¹³ POTS has an abrupt onset with a multifactorial etiology and negatively impacts quality of life, so its timely diagnosis is important, especially in the young population.^{13,14} POTS is commonly diagnosed in clinical settings by a head-up tilt table test (HUTT), which is considered the gold standard for its diagnosis.¹⁵ In this study, a simple, bedside, and passive standing test called NASA 10-minute Lean Test was used to evaluate POTS. NASA researchers used this test to assess OI symptoms in astronauts. Since it is a passive test, it reduces the muscular impact on venous return. This test has been ratified as an equivalent measure of OI as compared to HUTT.⁸

To the best of our knowledge, this is the first study to use the NASA 10-minute Lean Test to diagnose POTS in adolescents who had symptoms of OI.

Literature shows that POTS can cause decreased appetite in humans, leading to increased sympathetic activity and muscle wasting, thus causing lower BMI in them.¹¹ Lin *et al.* in a study, compared the BMI of 111 children and adolescents having POTS with BMI of 154 children and adolescents having vaso-vagal syncope (VVS) and 82 healthy controls. They observed that BMI in the POTS group was significantly lower (18.3 ± 3.4) than in VVS (20 ± 4.2) and the control group [(20.5 ± 2.9) ; $P<0.05$].¹⁵ Findings in our study were similar. This study observed no significant difference between the resting BP of the two groups; however, resting HR in the POTS group was significantly higher, which may be a result of autonomic imbalance characterized by increased cardiac sympathetic activity. Roernik *et al.* made similar observations in a study in which they demonstrated that HR in the POTS group was significantly higher than the non-POTS group [71 ± 11 bpm vs 65 ± 9 bpm; $P=0.009$].¹⁶

During the NASA 10-minute Lean Test, no significant differences were observed between the upright BP of the two groups; however, upright HR was significantly higher in the POTS group. Upon assuming an upright posture, venous pooling and diminished cardiac output occur in patients with POTS ensuing reflex increase in HR.¹³ An increase in HR ≥ 40 bpm from the resting levels upon assuming an upright posture or a resting HR ≥ 120 bpm are characteristic of POTS. Lin *et al.* in a cross-sectional study, compared children with POTS vs non-POTS. They observed that the upright HR

in the POTS group was significantly higher than the non-POTS group [32 ± 12 bpm vs 22 ± 7 bpm; $P<0.01$], and they also observed that the resting HR in the POTS group was significantly higher than non-POTS group [126 ± 10 bpm vs 107 ± 11 bpm; $P<0.001$].¹⁵ This study observed that the maximum upright increment in HR in adolescent diabetics with POTS was significantly higher than the non-POTS group (40.91 ± 11.78 bpm vs 16.34 ± 6.97 bpm; $P<0.0001$).

The current study has limitations. A major limitation is that NASA 10-minute Lean Test has not been used before, so there are very scarce data regarding this test. Another major limitation is that very few studies have been done to evaluate POTS, especially in the young population. Physiological POTS, which may be seen in some adolescents, was not ruled out. A small sample size may have caused variability in comparisons. Since this is a preliminary study, further studies using NASA 10-minute Lean Test are needed in the future to assess POTS.

Conclusions

Based on the observations of this preliminary study, it may be concluded that a simple, time-saving, and inexpensive Lean Test may be used to diagnose POTS in the young population.

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