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Physiotherapy Section

Association between Physical Activity and Autonomic Nervous System in Young Sedentary Adults: A Cross-sectional Study

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ABSTRACT

Introduction: A sedentary lifestyle is a key driver of early onset Non Communicable Diseases (NCDs). The Autonomic Nervous System (ANS), which governs involuntary functions and maintains internal balance, may be disrupted by physical inactivity in young adults-an area still under debate. Understanding these early changes could guide timely preventive strategies.

Aim: To investigate the association between physical activity levels, ANS function, and functional capacity in young sedentary adult.

Materials and Methods: This cross-sectional study was conducted at SRIHER (DU), Chennai, Tamil Nadu, India from March 2023 to May 2024. A total of 112 participants (aged 18-30 years; both sexes) with low to moderate physical activity levels, as assessed by the International Physical Activity Questionnaire (IPAQ), were enrolled. Demographic data (age, sex, height, and weight) were collected, along with baseline assessments including Body Mass Index (BMI), waist-hip circumference, perceived stress using Perceived Stress Scale (PSS), autonomic function (Ewing's battery), and functional capacity (Six Minute Walk Test [SMWT]). Associations among variables were examined using Chi-square tests and One-way ANOVA.

Results: A total of 112 participants were included in the study. Of these, 46 were male with a mean age of 25.22±4.38 years, and 66 were female with a mean age of 24.27±4.02 years. Physical activity levels showed significant associations with total Cardiac Autonomic Neuropathy (CAN) scores, particularly in sympathetic (p=0.026) and parasympathetic (p=0.044) functions. The SMWT also associated with CAN scores (p=0.005) and parasympathetic activity (p=0.011), but not with sympathetic activity (p=0.237).

Conclusion: The study highlights that physical activity levels significantly impact ANS functionality, especially parasympathetic activity. The SMWT further underscores its importance in assessing CAN, stressing the need for active lifestyles to maintain autonomic homeostasis and prevent lifestyle related diseases.

Keywords: Ewing's battery of test, Exercise test, Health behaviour, Lifestyle sedentary behaviour

INTRODUCTION

The ANS regulates the internal body functions such as heart rate, respiratory rate, digestion, pupillary action, bladder action, and sexual function involuntarily and maintaining body homeostasis. The ANS functions as sympathetic, parasympathetic, and enteric nervous system. The sympathetic system predominates in "fight or flight" reactions, preparing the body for stressful situations by increasing heart rate and blood pressure, dilating pupils, and reducing digestive activity. In contrast, the parasympathetic system is responsible for "rest and digestion," which slow heart rate, enhancing digestive processes, and promoting relaxation. The enteric nervous system, referred to as the "second brain," manages gastrointestinal functions by controlling peristalsis and enzyme secretion [1].

Regular physical activity is considered a key protective mechanism for the prevention and management of NCDs, which are a global health concern. But it is estimated that around 1.8 billion adults, or 31% of adult population and 80% of adolescents, do not meet the adequate physical activity levels [2]. Memarian et al. stated that the low physical activity impair autonomic function [3]. Additionally, a study in US found that 8.3% of early deaths were attributed to insufficient level of physical activity [4].

Physical inactivity, stress, and alcohol consumption can significantly impact the ANS, leading to early dysfunction and an increased risk of NCDs such as cardiovascular diseases, diabetes, and mental health disorders [5]. Physical inactivity reduces the efficiency of the ANS, resulting in poor blood pressure regulation and heightened stress responses. Chronic stress can overactivate the Sympathetic Nervous System (SNS), causing prolonged increases in heart rate and blood pressure, which may lead to cardiovascular issues [6].

The sympathetic function predominates in the younger age group and starts to decline at older ages. The sympathetic function begins to alters after 15 years of age and becomes predominant after 50 years of age [7]. However, lifestyle factors such as physical inactivity, stress, and tobacco usage can accelerate this decline, leading to autonomic dysfunction at an earlier age [8], thereby increasing the risk of developing NCDs.

The study of the association between physical activity and ANS function in young sedentary adults is crucial due to the growing prevalence of sedentary lifestyles among youth, which increases the risk of chronic diseases. Previous research has shown that regular physical activity enhances ANS balance, improving Heart Rate Variability (HRV) and reducing sympathetic overactivity linked to cardiovascular and metabolic disorders [8]. However, most studies focus on active or older populations [8,9], leaving a gap in understanding ANS adaptations in young sedentary adults—a critical group for early preventive strategies. Also, the ANS has often been assessed using the HRV method or the deep breathing test.

Understanding the intricate relationship between the ANS and lifestyle factors is crucial for developing effective interventions to prevent and manage NCDs. Promoting regular physical activity, stress management, and responsible alcohol consumption are essential strategies for maintaining autonomic balance and overall health. This study aims to find out the association between physical activity levels and ANS function, and functional capacity in young sedentary adults.

Primary objective: To determine the association between physical activity levels and autonomic function in young sedentary adults.

Secondary objective: To find the association between the SMWT and CAN in young sedentary adults.

Null hypothesis: There is no significant association between physical activity level and ANS function in young sedentary adults.

Alternate hypothesis: There is significant association between physical activity level and ANS function in young sedentary adults.

MATERIALS AND METHODS

A cross-sectional study design was conducted to evaluate the relationship between physical activity levels and ANS function in young sedentary adults at Sri Ramachandra Institute of Higher Education and Research (DU), Porur, Chennai, Tamil Nadu, India from March 2023 to May 2024. The study was approved by the Institutional Ethical Committee (IEC/20/JAN/156/14). All the participants were explained about the study and obtained informed consent for agreeing to take part in the research and can withdraw at any time from the study.

Inclusion and Exclusion criteria: The inclusion criteria for this study were adults aged 18 to 30 years with sedentary lifestyle of low or moderate physical activity level in the IPAQ, and participants with no known co-morbidities. The participants with known co-morbidities, issues with the ambulatory status, participants engaged in regular physical activity for more than 150 minutes per week per week, or those involved in sports activities, smokers, alcoholics, and tobacco chewers were excluded from the study.

Sample size calculation: The sample size was determined using a correlation value of r=0.23, which represents the association between physical activity and cardiac autonomic function based on the previous research [10]. With the statistical power of 80% and a significance level of 5%, a minimum required sample size was 100 participants. Also, considering the dropouts, another 10% was added, resulting in a final sample size of 112 participants.

Study Procedure

In the sample collection process, the participants were recruited from health workers in hospitals, administrative staff, students from various health care and the volunteers. The pre-evaluation data were collected, and participants were given appointment within next three days for the CANWIN-AFT, an autonomic function test. The participants were instructed not to take alcohol, smoke, exercise the previous day or take food, caffeine prior to the test.

Baseline screening: All participants underwent a basic assessment that included age, sex, co-morbid status, height, weight, and BMI classified as per Asian and South Asian population needs [11]. Hip circumference was measured at the widest part of the buttock while standing, and waist circumference was measured at the midpoint between the anterior superior iliac spine (hip bone) and below the rib during the expiration phase while standing. Resting heart rate was measured using a pulse oximeter, IPAQ and PSS questionnaire, as well as the SMWT.

Physical activity level: The physical activity levels were assessed using IPAQ, which assessed the physical activity level in the past seven days. The physical activity is assessed in various domains, including occupational activity, transportation, household tasks, leisure time activity, and the sitting time. The questionnaire assesses the physical activity in terms of moderate and vigorous intensity levels. At the end, this questionnaire offers the physical activity as high where the participant performs at least three days of vigorous activity totaling ≥1500 MET-min/week, or seven days of any combination of walking, moderate, or vigorous activity totaling ≥3000 MET-min/week, moderate: where the participant performs ≥3 days/week of vigorous activity and/or walking ≥30 min/day, or ≥5 days/week of moderate activity and/or walking ≥30 min/day, or 5 days/week of mixed activities totaling ≥600 MET-min/week, low (<600 MET-minutes/week): where the participant is not to meet the high or moderate criteria.

Autonomic Nervous System (ANS) assessment: The ANS function was evaluated using non invasive measures of Ewing's battery of test as recommended by the task force of neurology to assess the ANS. This test assesses the sympathetic and parasympathetic function separately. The subjects were asked to come in the morning within 10 am. The participants were assessed for the sympathetic and the parasympathetic responses.

The parameters assessed for parasympathetic responses were heart rate response to deep breathing, heart rate response to standing (30:15), and heart rate response to Valsalva manoeuvre. The sympathetic parameters include the blood pressure response to sustained hand grip. Based on Bellavere's criteria, its interpretation was no CAN (0-1), early CAN (2-4), and severe CAN (5-10) as shown in [Table/Fig-1-4] [12-16].

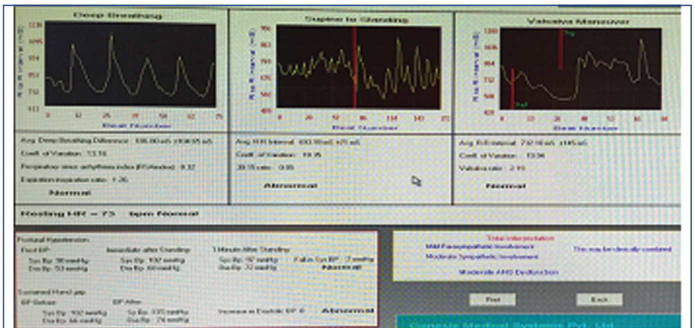
Responses	Normal (0)	Borderline (1)	Abnormal (2)
Parasympathetic test			
Deep breathing test	>15	11-20	<10
Supine to standing test	>1.04	1.01-1.03	<1.01
Valsalva manoeuvre test	>1.21	1.11-1.20	<1.10
Sympathetic test			
Isometric hand grip test	>16 mmHg	11-15 mmHg	<10 mmHg
Postural hypotension	<10 mmHg	11-20 mmHg	>20 mmHg

[Table/Fig-1]: Bellavere's criteria for Cardiac Autonomic Neuropathy (CAN) [12-14,16].

Diagnosis	Parasympathetic function	Sympathetic function	Total score (Both sympathetic and parasympathetic)
Normal	0-1	0	0-1
Early	2-4	1	2-4
Definite	>4	≥2	>5

[Table/Fig-2]: EWING'S Score -Interpretation (Bellavere criteria) [12-14,16].

[Table/Fig-3]: CANWIN- AFT Test.



[Table/Fig-4]: Autonomic function report.

Perceived Stress Scale (PSS): The stress was assessed using the PSS. This questionnaire assesses the subject's emotions and perceptions in the last month. The questionnaire assesses both the positive and negative aspect of the individual and is a most valid and reliable tool [17-19]. The scores from 0-13 is considered as low stress, 14-26 is considered as moderate stress, and 27-40 is considered as high perceived stress [20].

Six-Minute Walk Test (SMWT): The functional capacity was assessed using the SMWT which is a highly reliable and a validated tool [21]. The participant was allowed to rest for few minutes before the test. The pretest vitals were taken and the participant was asked to walk back and forth along 30 meter marked corridor indicated with cone at each end for about six minutes at their maximum pace. Following six-minutes walk, post vitals and after two minutes or the maximum time taken for the recovery vitals was measured. The total distance walked for six minutes was measured and analysed.

STATISTICAL ANALYSIS

All the analysis was performed using the Statistical Package for the Social Sciences (SPSS) for Windows version 17. Continuous data were presented as mean and standard deviation, and confidence interval. The Chi-square test was used to find out the association between the categorical data and the ANOVA test was used to find out the association between the continuous variables.

RESULTS

The [Table/Fig-5] gives the mean, standard deviation, and the confidence interval for the baseline characteristics data. All participants had a normal BMI. Based on IPAQ scores, their physical activity levels ranged from low to moderate, and they exhibited moderate to high levels of stress.

Variables	Gender	N	Mean±SD
Age (Years)	Male	46	25.22±4.38
	Female	66	24.27±4.02
Height (cm)	Male	46	168.60±7.80
	Female	66	157.56±5.23
Weight (Kg)	Male	46	65.24±10.05
	Female	66	56.44±8.32
BMI (Kg/m²)	Male	46	22.93±2.76
	Female	66	22.81±3.15
HR (beats/min)	Male	46	71.43±13.30
	Female	66	71.02±11.15
Hip circumference (cm)	Male	46	92.46±6.43
	Female	66	83.91±6.25
Waist circumference (cm)	Male	46	83.91±6.25
	Female	66	77.67±8.40
PSS	Male	46	21.65±3.91
	Female	66	22.11±3.48
IPAQ	Male	46	524.54±164.49
	Female	66	537.80±173.28
SMWT (meter)	Male	46	513±48.64
	Female	66	484.94±60.53

[Table/Fig-5]: Descriptive data of the participants.
BMI: Basal metabolic index; HR: Heart rate; PSS: Perceived stress scale; IPAQ: International physical activity questionnaire; SD: Standard deviation

[Table/Fig-6] represents the distribution of ANS function using Ewing's score. The findings indicates that only 17% participants exhibited a normal total cardiac autonomic function, while 69% fell into the early CAN category, suggesting the onset of autonomic dysfunction. A smaller subset, around 14%, demonstrated definite CAN, indicating advanced stages of autonomic impairment.

Ewing's score	Parasympathetic (n=112)	Sympathetic (n=112)	Total CAN score (n=112)
Normal	47	19	19
Early	62	40	77
Definite CAN	3	53	16

[Table/Fig-6]: ANS and its division with physical Activity level.
CAN: Cardiac autonomic neuropathy

[Table/Fig-7] suggests that definite CAN was higher in the low physical activity group compared to the moderate group, while normal ANS function was more prevalent in the moderately active group. Early CAN was common in both the groups.

Ewing's score- CAN	Low physical activity	Moderate physical activity
Normal	12%	27%
Early CAN	69%	70%
Definite CAN	19%	3%

[Table/Fig-7]: Distribution of EWING'S total score with low and moderate Physical activity level.
CAN: Cardiac autonomic neuropathy

[Table/Fig-8] results suggests that there is significant association between the ANS and physical activity level at 5% significance level, between the total CAN score of ANS and IPAQ level,with χ^2=7.09, N=112, df=2, p=0.029. The Chi-square value is significant for the parasympathetic division with χ^2=7.28, N=112, df=2, p=0.026, and also significant for the sympathetic division with χ^2=6.23, N=112, df=2, p=0.044. This suggests that the physical activity is associated for the parasympathetic division and not for the sympathetic division. Thus, the results suggest a significant relationship indicating that the total CAN score varies with IPAQ and also the same for parasympathetic and sympathetic division of ANS.

Variables	Autonomic function	IPAQ-Low (%)	IPAQ-Moderate (%)	N	χ^2	Df	p-value
Total CAN score	Normal	10(9)	9 (8)	112	7.09	2	0.029*
	Early CAN	54 (48)	23 (21)				
	Definite CAN	15 (13)	1(1)				
Parasympathetic division	Normal	27 (24)	20 (18)	112	7.28	2	0.026*
	Early CAN	49 (44)	13 (12)				
	Definite CAN	3 (3)	0 (0)				
Sympathetic division	Normal	9 (8)	11(10)	112	6.23	2	0.044*
	Early CAN	27 (24)	13(11)				
	Definite CAN	40 (36)	13 (11)				

[Table/Fig-8]: Association between IPAQ and total Cardiac Autonomic Neuropathy (CAN) and the Divisions of ANS.
IPAQ: International physical activity questionnaire; CAN: Cardiac autonomic neuropathy; ANS: Autonomic nervous system; Pearson's Chi-square test; *p-value <0.05

[Table/Fig-9] results suggest that there is significant association between the SMWT and the total CAN score, with p-value of 0.005, and also with the parasympathetic division of the ANS, with p-value of 0.00. However, no significant association was found for the sympathetic division of the ANS where the p-value is 0.237. This indicates that there is progressive decrease in the six-minute walk distance as the severity of the ANS increases for both the total CAN score and parasympathetic division of ANS. It also suggests that the six-minute walk distance progressively less but shows no significant difference for the sympathetic division of the ANS.

Variables	N	Mean	Standard deviation	F Value	p-value
SMWT and total Cardiac Autonomic Neuropathy (CAN) score					
SMWT - Normal	19	525.26	55.73	5.68	0.005*
SMWT - Early CAN	77	496.58	50.00		
SMWT - Definite CAN	16	462.19	75.60		
SMWT and Parasympathetic Division of Cardiac Autonomic Neuropathy (CAN)					
SMWT - Normal	47	513.68	56.71	4.67	0.011*
SMWT - Early CAN	62	486.08	53.99		
SMWT - Definite CAN	3	444.00	76.00		

SMWT AND Sympathetic Division of Cardiac Autonomic Neuropathy (CAN)					
SMWT - Normal	19	511.15	55.69	1.46	0.237
SMWT - Early CAN	40	501.36	58.04		
SMWT - Definite CAN	53	487.47	57.13		

[Table/Fig-9]: Association between Six-Minute Walk Test (SMWT) and total Cardiac Autonomic Neuropathy (CAN) and the divisions of ANS.
SMWT: Six minute walk test; CAN: Cardiac autonomic neuropathy; ANS: Autonomic nervous system; ANOVA test; *p-value <0.05

DISCUSSION

The study reveals the association between the ANS and its divisions with the physical activity level and also the changes in the functional capacity in relation to the autonomic function in the young sedentary adults. As age increases, there is withdrawal of the parasympathetic nervous system (PNS) alongside an increase in the sympathetic activity [22]. The same changes are noted in the sedentary lifestyle where overactivity of the SNS affecting the balanced activity of the ANS [7]. This study reveals that the low and moderate physical activity level have a strong relationship with the changes in both the divisions of ANS in young sedentary adults.

In a comparative analysis, Mueller PJ demonstrated that lower levels of physical activity lead to alterations in the neuronal structures in the rostral ventrolateral medulla, leading to the over excitation of the SNS, ultimately results in the imbalance in autonomic function [23]. Additionally, it has been found that the increased physical activity levels significant changes in the central brain structure thus reducing the cardiometabolic risks. Other studies reveals that the reduced physical activity level lowers the metabolic activity and overall blood circulation [24,25]. This, in turn, increases SNS activity, leading to the reduced insulin sensitivity and impaired vascular function. It also results in increased oxidative stress, triggering a chain reaction of the low-grade inflammation [26,27]. Study done by Machel B. et al., Wichi R.B. et al., and Sapolsky R.M. also revealed that the lifestyle changes in terms of less physical activity, stress results in increased sympathetic function, blood pressure variability, decreased vagal activity, reduced HRV, and reduced baroreflex sensitivity [28-30]. Findings of this study also reveal the same with changes in both the sympathetic and parasympathetic function with the reduced physical activity level.

Fathima D et al., reveals that the sedentary nature with poor posture or prolonged sitting has impact on the ANS, resulting in reduced HRV [31]. This study also states that there is significant association of the parasympathetic division of ANS with reduced physical activity level. This suggests that there is significant association within the physical activity level and the autonomic function in the less physically active participants. Hence, we can reject the null hypothesis and accept the alternat hypothesis. The functional capacity is the major indicator of an individual's health and well-being. This functional status depends upon the normal functioning of the internal organs, which is maintained by the ANS. The two divisions of the ANS acts in different extremes, but the balanced action of both division is mandatory to maintain the normal homeostasis of the internal organs. The autonomic dysfunction leads to the changes in the sympathovagal balance, thus causes the early attainment of the heart rate and reduces the functional capacity. This study also reveals the same where there is progressive reduction in the Six-Minute Walk Test (SMWT) with dysfunction in the ANS, particularly with the parasympathetic dysfunction. The same has been replicated in the other studies too [32,33].

The study by Millet G. et al. revealed that the autonomic dysfunction leads to the alterations in the heart rate and the vascular bed in response to the environmental changes [34]. This results in sympathetic overactivity and reduced parasympathetic function, causing imbalance in the ANS, which subsequently impairing the functional capacity of the individual. Notably, in this study, SMWT is not associated with the sympathetic division, which could be due to the disparities in the number of samples in the low and moderate physical activity groups. However, variations in the walking distance still indicated underlying autonomic shifts, particularly in parasympathetic withdrawal, suggesting a complex relationship that merits further investigations.

The major strength to the study is its inclusion of the sedentary population, which provides valuable insight for the preventive research and measuring the ANS using the Ewing's battery of test which assess the sympathetic and parasympathetic division separately. Clinical implications includes that early identification of the autonomic dysfunction in young sedentary adults can prompt timely lifestyle intervention. Incorporating physical activity may restore the autonomic function, improve functional capacity, and reduce the long-term cardiometabolic risk. Further studies should explore the effectiveness of specific exercise training modalities—such as high-intensity interval training, physical activity, or lifestyle modifications—in improving the autonomic function and functional capacity of the individual.

Limitation(s)

The major limitations is the subjective measure of the physical activity, and also the smaller number of samples for the moderate PA group compared to low PA group, which restricts the generalisability of the findings.

CONCLUSION(S)

According to the present study result an association was observed between the physical activity level and the divisions and overall autonomic function in Ewing's battery of test. The definite CAN was more prevalent in the low physical activity group compared to the moderate group, while normal autonomic function was higher among moderately active individuals. Also, there is significant association between the SMWT and the parasympathetic division and overall autonomic function, but not for the sympathetic division of the ANS.

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PLAGIARISM CHECKING METHODS: [Jain H et al.]

- Plagiarism X-checker: Jun 17, 2025
- Manual Googling: Jul 24, 2025
- iThenticate Software: Jul 26, 2025 (11%)

ETYMOLOGY: Author Origin

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