

Cognition, heart rate variability and cardiovascular reactivity to stress in adults with sedentary behaviour – an exploration of sitting disease!!

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Abstract

Background: There is paucity of studies exploring the possible influence of prolonged sitting and non-exercise thermogenic activities on cognition and the autonomic function tests. Therefore this study evaluated effect of sedentary behaviour and Non-exercise thermogenic activities among adults.

Methodology:

A cross sectional study was designed to score 100 subjects of both genders of age 18-40 years into Inactive (<600Mets min/week, measuring activity) and Health enhancing physically active group (HEPA) group(>3000Mets min/week) by using International physical activity questionnaire(IPAQ).^{2,17} Stroop test to assess cognition and cardiovascular reactivity to stress was evaluated. Heart rate variability (HRV) was assessed in both the groups.

Results:

There was significant decrease in high frequency component of HRV in sedentary group individuals compared to HEPA group (Table-2). There is significant increase of LF/HF ratio of HRV in sedentary group compared to HEPA group, (p value 6.246e-11, significant)(Figure 1, 2). There is significant decrease in standard deviation of NN intervals and PNN50 (the proportion of NN50 divided by total number of NNs) of HRV in sedentary group (p value 3.275e-16 and 5.396e-11 respectively, significant, Table-2). The number of errors during Stroop test was significantly higher in the sedentary group (p value 9.186e-08, significant) (Figure 4).

Conclusion:-

The present study showed that sedentary group has an overall depressed heart rate variability, increased cardiovascular reactivity to stress and poor cognition as compared to the physically active group. Therefore reducing and breaking up sitting time with intermittent light-intensity activity may play a role in maintaining good cardiovascular and optimal brain health.

Keywords: Metabolic Equivalent of Task (MET), Non-exercise Activity Thermogenesis (NEAT), International physical activity questionnaire (IPAQ), health enhancing physically active group (HEPA) group.

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I. Introduction

Recent population-based studies suggest that prolonged, unbroken sitting times exert detrimental effects on cardio metabolic biomarkers, irrespective of the total time spent sedentary and total time spent in moderate- to vigorous-intensity physical activity.¹

Sedentary behaviours are defined by both their posture and their low energy expenditure – typically in the range of 1.0–1.5 METs (metabolic equivalent of task).² Moderate-to-vigorous physical activities involves an energy expenditure of 3–8 METs.

United States Federal Guidelines recommend at least 30 minutes of moderate-intensity physical activity on at least 5 days of the week, in addition to the light-intensity activities of daily living, which is referred to as ‘baseline activity’.³ American College of Sports Medicine recommends 30 minutes of moderate-intensity physical activity on 5 days per week or relatively more intense exercise for less time (20 minutes on 3 days per week). However, the National Institutes of Health recommends that Non-exercise Activity Thermogenesis (NEAT) defined as the energy expended for everything done that is not sleeping, eating or sports-like exercise. should be evaluated. These trivial activities increase metabolic rate substantially.^{4,5}

Previous experimental studies have demonstrated that uninterrupted sitting is deleteriously associated with fatigue,^{6,7} and central nervous system functions.⁸ Therefore the health implications in non-exercising sedentary life for around 15 hours, other than the exercising hours is a matter of concern and needs to be explored further.¹⁰⁻¹⁶

There is paucity of studies exploring the possible effects of prolonged sitting and non-exercise thermogenic activities among the Indian adults. Therefore this study evaluated the effect of sedentary behaviour and health enhancing physically active life style on cognition, cardiovascular reactivity to stress and autonomic function tests in Indian adult population. The long version of International physical activity questionnaire (IPAQ) was used to get information of time spent in vigorous, moderate intensity activity and in sedentary behaviour.¹⁷ It is hypothesized that sedentary behaviour will have detrimental effects on cognition, heart rate variability and cardiovascular reactivity to stress.

II. Methodology

A cross sectional study was designed to score 110 participants of both genders between age 18-40 years based on physical activity using International physical activity questionnaire (IPAQ). The study was conducted in Department of Physiology, Hamdard Institute of Medical Sciences and Research, Delhi in year 2017-18. Subjects were categorized into Inactive (sedentary life style) (<600Mets minutes/week, measuring activity) and HEPA group (>3000Mets minutes/week) by using IPAQ.¹⁷ Exclusion criteria were subjects with cardiovascular disorders, cognitive dysfunction, respiratory problems and colour blindness. Ten individuals who did not meet criteria were not included in the study. Written informed consent was taken from all 60 male and 40 female subjects after the project was approved by the Institute's Research project advisory committee and procedures were carried out according to the Declaration of Helsinki stating ethical principles for medical research involving human subjects.

International Physical Activity Questionnaire (IPAQ):-

Long version of International physical activity questionnaire (IPAQ) with 12 country reliability and validity was used to capture physical activity in a variety of daily situations.¹⁷ IPAQ produces higher estimates of physical activity and Non-exercise Activity Thermogenesis (NEAT) i.e. the energy expended for everything done that is not sleeping, eating or sports-like exercise activities.

Classification of physical activity is based on the metabolic equivalents minute/week scores which are equivalent to kilocalories for a person i.e. Inactive (sedentary life style) group with <600Mets minutes/week, measuring activity and Health enhancing physically active group (HEPA) with >3000Mets minutes/week.

Stroop Test: This was used as an experimental stressor and to assess the impact of attentional fatigue through cognitive processes. Approximately 30 seconds into the task the subject's blood pressure and heart rate was measured using Omron HEM-CR24 Upper Arm Blood Pressure Monitor. The increase in blood pressure and heart rate during Stroop test indicates cardiovascular reactivity to stress.¹⁹ Time taken for completion of each exercise of Stroop test and the average number of errors was noted in both the groups.

Heart rate variability (HRV): Assessment of the autonomic function was done in both the groups using LabChart data analysis software, AD Instrument.¹⁹ The time domain and frequency domain analysis of HRV was done in uniform settings.

III. Results:

100 adult subjects were categorised into two groups based on their physical activity as metabolic equivalents minutes per week (METS minutes /week),

CATEGORIES	Inactive (Sedentary)	Health enhancing physically active group (HEPA)
METS minutes/week	343.44±122.71	4303.65±982.61

D	HRV	SEDENTARY	HEPA	P value	Significance
		MEAN±SD	MEAN±SD		
	HF (ms ²)	762.67±468.57	5182.47±2308.7	<2.2e-16	Highly Significant
	LF (ms ²)	1034.92±613.45	2382.67±1207.68	4.185e-10	Significant
	LF/HF ratio	1.41±0.84	0.45±0.17	6.246e-11	Significant

RMSSD (ms)	134.21±63.59	71.14±23.52	5.779e-09	Significant
PNN50 (%)	35.82±28.18	75.44±26.86	5.396e-11	Significant
SDNN (ms)	49.66±12.33	132.74±51.41	3.275e-16	Significant
II) Stroop Test				
No. of Errors	8.04±4.6	3.96±1.62	9.186e-08	Significant
Duration to complete test (Seconds.)	86.83±15.03	83.54±7.59	0.1631	Not Significant
Increase in SBP (mmHg)	6.42±10.51	3.67±8.64	0.1481	Not Significant
Increase in DBP (mmHg)	7.92±9.29	-3.81±9.36	4.499e-09	Significant
Increase in H.R (beats/min.)	13.13±11.53	3.35±8.54	3.685e-06	Significant
METSminutes/week	343.44±122.71	4303.65±982.61	<2.2e-16	Highly Significant

P value < 0.001-Highly significant, p value 0.01 to 0.05- Significant, ≥ 0.05- Not significant.

SBP-Systolic blood pressure, DBP-Diastolic blood pressure, H.R-Heart rate, SDNN -standard deviation of NN intervals and PNN50-the proportion of NN50 divided by total number of NNs. LF/HF ratio-Low frequency/High frequency,HRV.

Figure 1: LF/HF ratio in both groups

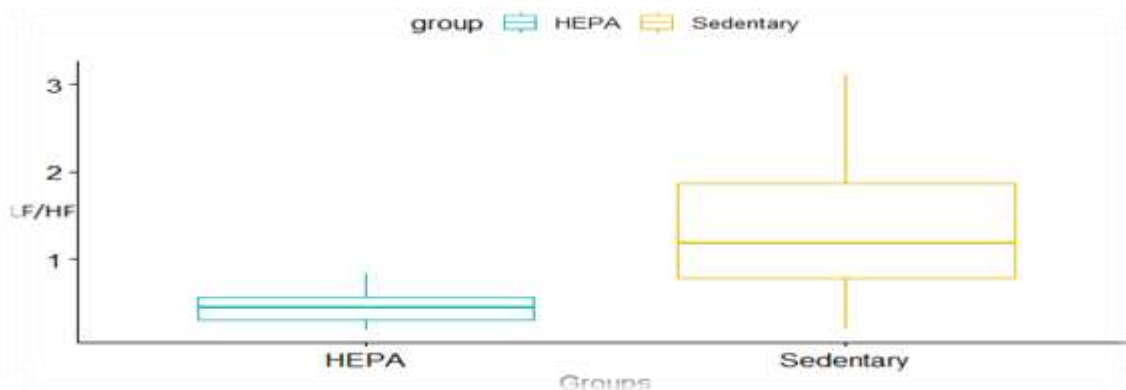


Figure 1 shows significant increase of LF/HF ratio in sedentary group compared to HEPA group.

Figure 2: Correlation of LF/HF ratio with MET of sedentary group

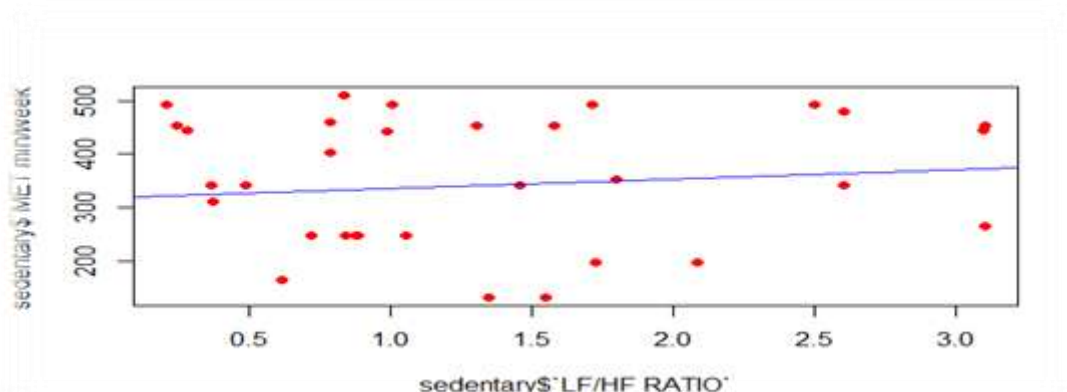
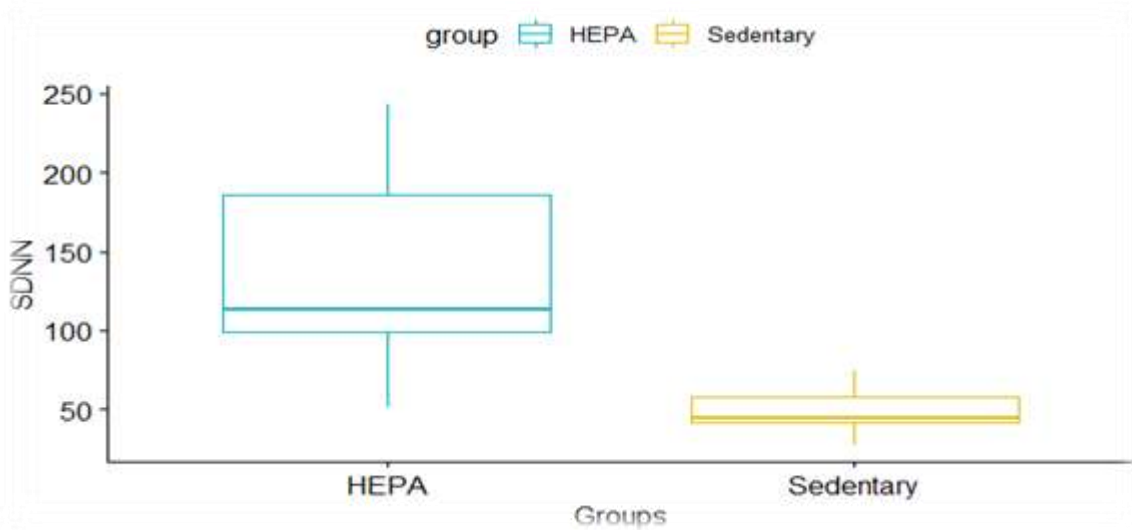


Figure 3 : SDNN in both groups



PNN50 and SDNN of HRV: Table-2 shows significant decrease in PNN50 (- the proportion of differences in consecutive NN intervals that are longer than 50ms) and SDNN, standard deviation of NN intervals (Fig:3) in sedentary group compared to that of HEPA group.

StroopTest: Number of errors during Strooptest was significantly higher in the sedentary group compared to that of HEPA group (Table-2). The error rate has shown positive correlation in the sedentary group (figure 4).

Figure 4-Correlation of Error rate in Sedentary Group

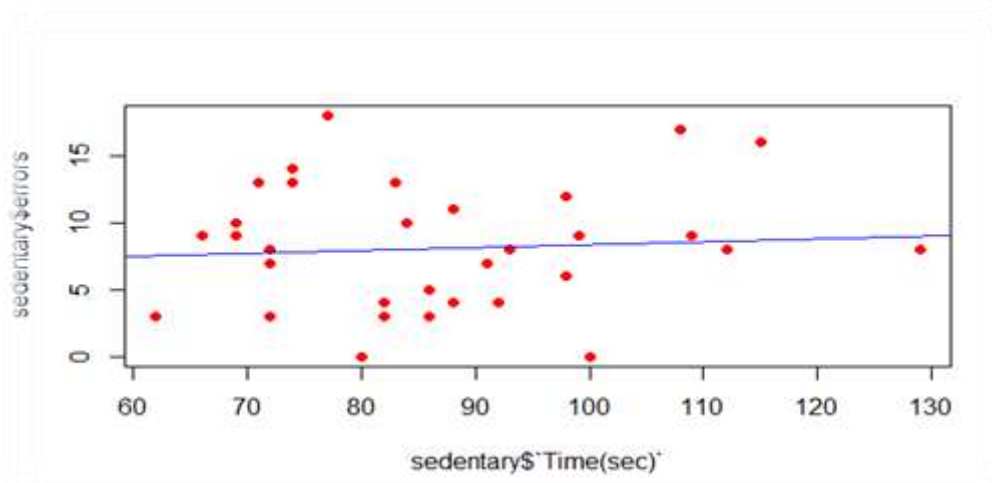


Figure 5: Increase in Diastolic Blood Pressure during Stroop Test



Fig. 5 shows that the increase in diastolic blood pressure during Stroop test was significantly higher in sedentary group compared to that of HEPA group.

IV. Discussion

The results of the present study showed that sedentary group with physical activity <600 METs minutes/week had an overall depressed heart rate variability, decreased cognitive abilities and increased cardiovascular reactivity to stress.

Stroop test for cognition:

The Stroop test enables researchers to gain insights into the complex interactions between mental concentration, error detection and awareness, target selection, detection and resolution.¹⁸ Previous studies suggest that excessive sedentary time has deleterious effects on glycaemic variability which can affect cognition.²⁰ Studies also show that regularly interrupting sitting time with short bouts of either light-intensity or moderate-intensity walking lowered postprandial glucose and insulin concentrations when compared with prolonged sitting.²¹ Physical activity has shown to increase cerebral blood flow²² and expression of neurotrophins²³ linked to both acute neuronal activation and long-term functional and structural changes in the brain.²⁴ On the contrary sedentary behaviours, have been linked to adverse long-term effects such as detrimental cognitive development in early childhood.²⁵ The results of our study are similar to results of previous studies on sedentary behaviour by Falck et al. In the present study, it was observed that there was a significant ($p=0.0250$) increase in number of errors during Stroop test and an increase in time duration to complete Stroop test by the sedentary group as compared to that of HEPA group. The error rate has shown positive correlation in the sedentary group (figure 4). This indicates a cognitive decline in the group with sedentary behaviour.

Heart rate variability:

The most commonly used HRV parameters in ANS evaluation are the frequency-domain, time-domain, and Poincaré plot parameters. Low-frequency (LF) modulation (0.04-0.15 Hz) of R-R interval changes corresponds to the sympathetic and parasympathetic activities together. High-frequency (HF) modulation (0.15-0.4 Hz) of R-R interval changes is primarily regulated through innervation of the heart through the parasympathetic (vagal) nerve. The Time-domain standard deviation (SD) of all N-N intervals (SDNN) reflect the total variability and along with the root mean square of SDs between adjacent N-N intervals (RMSSD) reflects parasympathetic activity.¹⁹ The present study showed a significant decrease of high frequency component of HRV in the sedentary group (Table-2). This indicates decreased vagal drive in sedentary life style group. LF/HF ratio less than 1 is considered as good cardiovascular health.¹⁹ LF/HF ratio > 1 in the sedentary subjects (fig:1), depressed heart rate variability and decreased HF component of HRV indicates increased sympathetic overdrive and depressed Vagal activity in this group. It was also observed that there was a significant decrease of time domain measures of heart rate variability namely, SDNN and PNN50 in sedentary group compared to HEPA group (Fig-3, table-1). This indicates poor parasympathetic dominance in sedentary group with measuring activity <600 METs minutes/week. This has strong association with pathogenesis of various cardiovascular disorders and sudden cardiac death.¹⁹

Cardiovascular reactivity to stress:

Prolonged sedentary behaviour have been shown to acutely reduce insulin sensitivity and increase triglyceride levels in adults²⁶, effects which are likely due to reductions in lipoprotein lipase and glucose transport protein activity in skeletal muscle.²⁷ Similarly, frequent walk breaks have been shown to greatly reduce the acute metabolic impact of prolonged sitting in overweight adults.²⁸

In the present study it was observed that there was a significant increase in diastolic blood pressure (fig.5) and heart rate during Stroop test indicating increased peripheral resistance and cardiovascular reactivity to stress in sedentary life style group (Table-1). This can be corroborated with the results of heart rate variability of this study, which showed significant decrease in high frequency component of HRV in the sedentary group. Significant increase of LF/HF ratio (> 1) in sedentary group compared to HEPA group (fig.1), depressed heart rate variability and HF component of HRV indicates increased sympathetic overdrive and depressed Vagal activity in the sedentary subjects. In the present study increased sympathetic drive has probably caused the increased cardiovascular reactivity to stress reflected as increased diastolic blood pressure and heart rate during Stroop test in sedentary life style group.

Recent research has shown that a person who works out 45 minutes a day 5 times a week but who sits 60 hrs at desk job has still a sedentary life style.²⁹ Limited literature is available regarding effect of sedentary life style and Non-exercise thermogenic activities on autonomic functions, cognition and cardiovascular reactivity to stress in Indian adult population.

V. Conclusion

The present study showed that sedentary group with <600 METs minutes/week measuring activity has an overall depressed heart rate variability and increase cardiovascular reactivity to stress which is not only a simple reflection of sympathetic overdrive but also reflects depressed vagal activity. Sympathetic and parasympathetic ratio in terms of LF/HF ratio higher than 1 is considered as bad cardiovascular health and has strong association with pathogenesis of various cardiovascular disorders and sudden cardiac death. The sedentary group also had higher value of time duration to complete Stroop test and increased number of errors during the test. This indicates poor cognitive abilities in sedentary group.

This study therefore concludes that reducing and breaking up sitting time with intermittent light-intensity activity may play a role in maintaining good cardiovascular health and optimal cognition. This can also forestall increased cardiovascular reactivity to stress and cognitive decline.

Conflict of interest: None

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