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Evaluation of Cardiovascular Autonomic Functions in Healthy Adult Male Sedentary Workers

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Abstract

Background: Sedentary lifestyle is public health concern that threatening human health. It is an independent predictor of cardiovascular disease (CVD) morbidity and mortality. Sedentary lifestyle affect the autonomic nervous system thus cardiovascular health.

Methods: This cross-sectional analytical study was conducted from January 2019 to December 2019 in the Department of Physiology, Rangpur Medical College, Rangpur. After obtaining permission, a total 120 subjects who were met the inclusion criteria was enrolled in the study after briefing them objectives of the study. Among them 30 were healthy adult male sedentary workers (Group-A), 30 healthy adult male light workers (Group-B), 30 were healthy adult male moderate workers (Group-C) and 30 were healthy adult male heavy workers (Group-D). The evaluation of cardiovascular autonomic functions of selected individuals was done by performing six simple noninvasive cardiovascular autonomic reflex tests as diagnostic tools. The individuals were selected from different areas of Rangpur district. For statistical analysis one-way ANOVA (post-Hoc) test was performed by computer-based software SPSS-23.0 version for windows. Significance for the statistical test was predetermined at a probability (p) value of < 0.05.

Results: Resting heart rate ($p < 0.001$), resting systolic blood pressure and resting diastolic pressure were significantly higher in group A ($p < 0.01$). Heart rate response to valsalva maneuver was significantly lower in group A ($p < 0.01$). Heart rate response to deep breathing was significantly lower in group A ($p < 0.01$). Heart rate response to standing was significantly lower in group A ($p < 0.05$). Blood pressure response to sustained handgrip was significantly lower in group A ($p < 0.01$). Blood pressure response to standing was not significantly lower group A ($p > 0.05$). Systolic blood pressure in response to cold pressor test was significantly lower in group A ($p < 0.01$). Diastolic blood pressure in response to cold pressor test was significantly lower in group A ($p < 0.001$). Among the sedentary workers 19 (63.34%) showed impaired cardiovascular autonomic nerve functions.

Conclusion: Sedentary workers exhibit modifications in the autonomic nervous system characterized by a reduction in both sympathetic and parasympathetic activity.

Keyword: *Sedentary Workers; Light Workers; Moderate Workers; Heavy Workers; Autonomic Nerve Function*

Introduction

Sedentary behavior is currently a global lifestyle phenomenon that has associated with reduction in energy expenditure independent of moderate to vigorous physical activity [1]. The word sedentary is coined from the latin word 'sedere' which means to sit, hence seden-

tary behavior is term used to characterize those behaviors that are associated with low energy expenditure, this include prolong sitting at work, home business center, long screen time, car driving and leisure time [2,3]. According to World health organization (WHO) about 60 to 85% of people in the world from both developed and developing countries lead sedentary life style, making it one of the more serious yet insufficiently addressed public health problem of our time [4]. Bangladesh is one of the developing countries where nationally representative and internationally comparatively data on physical activity (PA) level are still inadequate [5]. Physical inactivity leads to a number of health complications. Study has shown; sedentary work style leads to an array of health complications, including type-2 diabetes mellitus, high blood pressure and obesity [6]. Physical inactivity may increase risk of cardiovascular disease due to changes in central pathways involved in autonomic nervous system regulation. Altered autonomic function, for example, enhanced sympathetic and reduced parasympathetic tones, may predispose individuals to poor cardiovascular health due to reduced baroreflex sensitivity, reduced endothelial function and hypertension [7].

A predominantly sedentary life style is associated with autonomic imbalance, thus increasing risk of morbidity and mortality [8,9]. Whilst research linking physical activity (PA), sedentary behaviors and autonomic function is limited, available evidence suggests that some relationship exist [9]. The autonomic nervous system is responsible for regulation and integration of internal organ functions [10]. The autonomic nervous system (ANS) comprises of sympathetic and parasympathetic components responsible for stimulation or energy release and recovery respectively. The mechanism involved across both components includes the arterial baroreceptor located in the aorta and carotid arteries, which detect change in BP and regulate HR accordingly [11]. The sympathetic nervous system is closely linked with cardiovascular system, of which over activity can lead to detrimental structural and functional change to the vasculature, and arterial stiffness [12]. Chronic physical inactivity affects the excitability of rostral ventrolateral medulla (RVLM) neurons directly and contributes to sympathetic overactivity [13]. Sympathetic over activity caused an increase in BP, which in turn could influence vascular structure and tone, via stiffening of carotid artery, aorta resulting in reduced baroreceptor responsiveness (or baroreceptor sensitivity; BRS) to change in blood pressure [14]. A reduction in baroreceptor is associated with regulation of blood pressure, electrical instability of the heart and therefore increased risk of CVD morbidity and mortality [15].

According to a survey report in 2008 by the United State national health survey, WHO 2010 and National health survey 2006 reported that- 36% of adults are totally inactive while 59% have never participated in vigorous physical activity lasting 10 minutes per week. This ugly trend has led to higher risk of various chronic diseases such as obesity, deep vein thrombosis, heart diseases; Type-2 diabetes mellitus, osteoporosis with resultant increase in morbidity and mortality [2]. The health benefit of Physical activity is now well established. Morris., *et al*. shown that the physical activity undertaken by bus conductor as part of their daily duties prevented the development of CVD [16]. Statistical modeling of Sweden Attitude Behaviour and Change study suggested that replacing sedentary time with light intensity physical activity and moderate vigorous physical activity could have beneficial effect on both all-cause mortality and CVD mortality [17].

Autonomic nervous system function is assessed clinically by measuring resting hear rate and Heart rate variability (HRV) [18]. The integrity of the autonomic nervous system (ANS) may be assessed with several simple, reliable and non-invasive tests based on cardiovascular reflexes and these tests are useful tool for evaluation of both sympathetic and parasympathetic modulation of the heart [19]. There is lack of adequate information regarding autonomic nerve function status in sedentary workers of our country. So, the present study has been designed to assess the changes of autonomic nerve function status in sedentary individuals.

Materials and Methods

This was a cross-sectional analytical study carried out in Rangpur city, from January 2019 to December 2019. Purposive sampling method was use to include the sample. A total number of 120 healthy adult male of whom 30 were sedentary workers, 30 were light workers, 30 were moderate workers and 30 were strenuous workers. All the study individuals were healthy adult male and their age ranged from 25 - 45 years. Sample of light workers collected from 3rd class employee of Rangpur medical college and hospital, moderate workers

are collected from the persons who are bicycling in Rangpur district, strenuous workers are collected from day labor who works in constructing building, sedentary workers are collected from bank workers in Rangpur district. All subjects are matched with age.

Grouping of the subject

All the study individuals were divided into following groups:

- Group A - 30 healthy adult male sedentary workers.
- Group B - 30 healthy adult male light workers.
- Group C - 30 healthy adult male moderate workers.
- Group D- 30 healthy adult male strenuous workers.

Individual with the following disease/condition were excluded from our study- history of diabetes mellitus, hypertension, chronic renal failure, cardiac complication, liver diseases, tobacco users and alcoholics, psychiatric disorders (depression), endocrine disorders (thyroid, adrenal etc.), any neurological disorder, previous history of head injury, history of taking neurotoxic drug, tranquilizers (barbiturates), antidepressants (tricyclic antidepressant), opioids (morphine), trained athletes, overweight, obese.

Ethical implication

Ethical permission was taken from Ethical Review Committee of Rangpur Medical College. Consent was received from each individual prior to inclusion. They were informed of their right to withdraw from the study at any stage. Assurance had been given that the data would be collected anonymously and the confidentiality concerning their information would be maintained strictly. The research was conducted in full accord with ethical principles.

Study procedure: Healthy adult male individuals of sedentary workers, light workers, moderate workers and heavy workers in different areas of Rangpur city, who fulfill the inclusion criteria, were included by numbering. After selection of all 4 types of workers, the objectives and the procedure of the study was explained clearly to them and their informed written consent was taken. Detailed medical and family history was taken and thorough clinical examination was done. All information was recorded in a preformed questionnaire. Each subject was explained about the procedure in detailed, encouraged to obtain maximum efficient performance. From the previous night up to the examination, they were not undergoing any physical or mental stress and not to take any sedatives or any drugs affecting central nervous system. Then the autonomic nerve function parameters were assessed by cardiac reflex tests using sphygmomanometer and ECG machine. Blood glucose, serum creatinine level and serum alanine amino transferase were measured to exclude diabetes mellitus, chronic renal failure and liver diseases respectively. Autonomic nerve function tests were conducted in a comfortable environment in the department of physiology laboratory from 9.00 AM - 2.30 PM.

Autonomic function tests [19] - these are simple non-invasive cardiovascular reflex tests, easy to use and provide quantitative information about autonomic function.

For parasympathetic function:

1. Heart rate response to Valsalva maneuver.

2. Heart rate response to deep breathing.

3. Heart rate response to standing.

For sympathetic function:

1. Blood pressure response to sustained handgrip.

2. Blood pressure response to standing.

3. Cold Pressor test.

Tests to determine parasympathetic activity [19,20]

Heart rate response to valsalva maneuver

The test was performed by asking the subjects to sit quietly and then to blow into a rubber tube connected to a sphygmomanometer to keep the mercury up to a height 40 mm of Hg by continuous blowing and the level maintained at the mark for 15 seconds while a continuous electrocardiogram was recorded. Record for 30 seconds more, after this maneuver with patient sitting and strip ECG recording. Repeat twice and average the ratio from the 3 valsalva attempts were taken to calculate valsalva ratio.

Valsalva ratio: Ratio of longest R-R interval within 20 beats of ending maneuver to shortest interval during maneuver, measure with a ruler from electrocardiogram trace.

Normal: ≥ 1.21, Borderline: 1.11 - 1.20, Abnormal: ≤ 1.10.

Heart rate response to deep breathing

The subject was asked to sit quietly and then asked to take breathe deeply and evenly at 6 breaths per minute (5 seconds in; 5 seconds out), thus completing one breathing cycle. Repeat this procedure for 3 times. An electrocardiogram was recorded throughout the period of deep breathing, with a marker used to indicate the onset of each inspiration and expiration. The maximum and minimum heart rate during each 10 seconds breathing cycle measured. The mean of the difference during 3 successive 10 seconds breathing cycle taken for calculating the heart rate variations.

Heart rate variation: Maximum - minimum heart rate.

Normal: ≥ 15 beats/min, Borderline: 11 - 14 beats/min, Abnormal: ≤ 10 beats/min.

Heart rate response to standing

The test was performed with the subject lying on a bed quietly and heart rate was recorded continuously on an electrocardiograph. Then subjects were asked to stand from lying as quickly as possible without any support and the point of starting to stand is marked on the electrocardiogram. The characteristics heart rate response expressed by 30^{th}:15^{th} ratio.

30^{th}:15^{th} ratio: Ratio of longest R-R interval around 30^{th} beat after standing to shortest R-R interval about 15 beats after standing.

30^{th}:15^{th} Ratio- Normal: ≥ 1.04, Borderline: 1.01 - 1.03, Abnormal: ≤ 1.00.

Tests to determine sympathetic activity [19]

Blood pressure response to sustained handgrip

The subject's resting blood pressure was recorded. Then they were asked to grip the inflated cuff of a sphygmomanometer. The handgrip then maintained at 30% maximum voluntary contraction for maximum 5 minute and then again blood pressure was measured. Difference in the diastolic blood pressure before and after sustained handgrip was calculated.

Normal: ≥ 16 mmHg, Borderline: 11-15 mmHg, Abnormal: ≤ 10 mmHg.

Blood pressure response to standing

The subject should be made comfortable and asked to lie down on the bed and relax for 10 minutes; initial blood pressure was recorded by sphygmomanometer. The subject was asked to stand up immediately with pressure cuff tied around the arm. Again, blood pressure recorded after 1 minute of standing. Difference in systolic blood pressures between lying and after standing for 1 minute is calculated.

Normal: ≤ 10 mmHg, Borderline: 11 - 29 mmHg, Abnormal: ≥ 30 mmHg.

Cold pressor test [20-22]

After recording basal blood pressure, subjects were asked to immerse left hand (up to 2 inches proximal to wrist crease) in the cold water for 2 minutes and temperature was maintained at 4 - 6°C throughout the procedure. Blood pressure measurement was made from right arm at pain threshold time, which is defined as time between immersion of hand and subjective feeling of pain. Maximum increase in systolic and diastolic pressure was recorded. A rise of diastolic pressure ≥ 10 mm of Hg and increase in the systolic pressure 10 - 20 mm of Hg were taken as normal response and less than this considered as abnormal.

Autonomic nerve function (ANF) scoring system [23]

Autonomic neuropathy can be classified according to the severity of damage in to five groups:

- Normal - All six tests normal or one on border line.
- Early involvement - One of the three heart rate tests abnormal or two borderlines.
- Definite involvement - Two or more of the heart rate tests abnormal.
- Severe involvement - Two or more of the heart rate tests abnormal plus one or both of the blood pressure tests abnormal or both borderlines.
- Atypical pattern - Any other combination of abnormal tests.

Collection of blood and sample processing

At the first day all study procedures were maintained and the individuals were advised to be in overnight (8 - 10 hours) fasting state. Then they were attended next day at 8.00 A.M. at the Department of Physiology, Rangpur Medical College, Rangpur. Fasting venous blood sample was collected from the individuals. 5 ml of blood was collected from antecubital vein from each individual under all aseptic precaution by a disposable syringe. The needle was detached from the nozzle and blood was immediately transferred into a de-ionized test tube with a gentle push to avoid hemolysis. The test tube containing blood was kept in standing position till formation of clot. Serum was separated by centrifuging the blood at 3000 rpm for 5 minutes. The clear supernatant was taken and kept in eppendorf's. All biochemical tests were carried out as early as possible and done by enzymatic colorimetric method.

Cleaning of glass-ware

All the test tubes were kept immersed for 24 hours in acid mixture (20% nitric acid plus 5% hydrogen peroxide was mixed with 75% distilled water by volume). Finally, all the test tubes were washed thoroughly with de-ionized water and dried in the hot air oven.

Statistical analysis method

All data was recorded systematically in a preformed history sheet and all statistical analysis was done by computer using the software SPSS-23.0 version for windows. Comparison of sedentary and other active workers was done by one-way ANOVA (post-Hoc) tests. In the interpretation of results, < 0.05 level of probability (p) was accepted as significance.

Result

Mean age, height, weight and BMI of the participants were shown in table 1, there were no significant differences ($p > 0.05$) in different groups (Table 1).

Group	Age- Year Mean ± SD Range	Height-m Mean ± SD Range	Weight-kg Mean ± SD Range	BMI-kg/m^2 Mean ± SD Range
A (n = 30)	30.767 ± 4.952 (28-45)	1.640 ± 0.059 (1.45 - 1.69)	61.434 ± 6.162 (52 - 70)	21.468 ± 1.126 (20.99- 22.93)
B (n = 30)	33.966 ± 4.451 (25 - 43)	1.5970 ± 0.06487 (1.45 -1.69)	56.000 ± 4.425 (50 - 68)	21.611 ± 1.133 (19.06- 22.03)
C (n = 30)	33.200 ± 5.082 (25-45)	1.655 ± 0.06146 (1.42-1.66)	60.532 ± 4.006 (54 - 69)	21.978 ± 1.120 (18.98- 22.42)
D (n = 30)	35.733 ± 5.650 (26-45)	1.6217 ± 0.0520 (1.50 -1.69)	58.700 ± 0.867 (51 - 69)	21.868 ± 1.115 (19.67- 22.95)

Table 1: *Mean ± SD of age, height, weight and body mass index of the study subjects of different groups.*

The mean resting heart rate were 86.0333 ± 8.252 beats/minute, 76.2667 ± 4.9335 beats/minute, 68.5000 ± 3.91005 beats/minute, 66.4333 ± 5.3158 beats/minute in group A, B, C, and D respectively. The mean resting heart rate were significantly ($p < 0.001$) higher in group A in comparison to B, C and D (Table 2).

Groups	Mean ± SD beats/min Range (minimum - maximum) beats/minute	'p' value
A/B (n = 30)/(n = 30)	86.0333 ± 8.2524/76.2667 ± 4.93358 (72 - 100)/(70 - 88)	0.001**
A/C (n = 30)/(n = 30)	86.0333 ± 8.2524/68.5000 ± 3.51588 (72 - 100)/(56 - 83)	0.000***
A/D (n = 30)/(n = 30)	86.0333 ± 8.2524/66.4333 ± 3.91005 (72 - 100)/(58 - 74)	0.000***
B/C (n = 30)/(n = 30)	76.2667 ± 4.93358/68.5000 ± 3.51588 (70 - 88)/(56 - 83)	0.000***
B/D (n = 30)/(n = 30)	76.2667 ± 4.93358/66.4333 ± 3.91005 (70 - 88)/(58 - 74)	0.000***
C/D (n = 30)/(n = 30)	80.7000 ± 7.08641/66.4333 ± 3.91005 (56 - 83)/(58 - 74)	0.326^{NS}

Table 2: *Statistical analysis of mean ± SD resting heart rate in study subjects of different groups. (Analysis between the groups done by one - way ANOVA (Post Hoc) test).*

The mean ± SD of resting systolic blood pressure was 131.0000 ± 9.13500, 132.5000 ± 9.6266, 124.5000 ± 9.4092, 121.5000 ± 8.8229 mm of Hg in group A, B, C and D (Table 3). The mean systolic blood pressures were significantly ($p < 0.001$) higher in group B than D, A than D ($p < 0.01$), group A than C ($p < 0.05$) and group B than C (p 0.010). Mean values were non significantly ($p > 0.05$) higher in group A than B and group C than D (Table 3).

Groups	Mean ± SD mm of Hg Range (L- H) mm of Hg	'p' value
A/B (n = 30)/(n = 30)	131.000 ± 9.13500/132.5000 ± 9.62665 (110 - 150)/(110- 155)	0.926^{NS}
A/C (n = 30)/(n = 30)	131.000 ± 9.13500/124.5000 ± 9.40928 (100 - 120)/(110 - 145)	0.042*
A/D (n = 30)/(n = 30)	131.000 ± 9.135000/121.5000 ± 8.8229 (100 - 125)/(110 - 140)	0.001**
B/C (n = 30)/(n = 30)	132.5000 ± 9.62665/124.5000 ± 9.40928 (100 - 120)/(100 - 125)	0.010*
B/D (n = 30)/(n = 30)	132.5000 ± 9.62665/121.5000 ± 8.8229 (100 - 120)/(100 - 125)	0.000***
C/D (n = 30)/(n = 30)	124.5000 ± 9.40928/121.5000 ± 8.8229 (100 - 125)/(100 - 125)	0.583^{NS}

Table 3: *Statistical analysis of mean ± SD resting systolic blood pressure in study subjects of different groups.*

The mean ± SD of resting diastolic blood pressure were 83.6667 ± 6.00766, 83.1667 ± 5.33100, 78.1667 ± 5.16676, 78.5000 ± 5.43774, mm of Hg in group A, B, C and D respectively (Table 4). The mean diastolic blood pressures were significantly ($p < 0.01$) higher in group A than C, in group A than D, group B than C and group D. Again, the mean values were non significantly ($p > 0.05$) higher in group A than B, group C than D (Table 4).

Groups	Mean ± SD mm of Hg Range (L- H) mm of Hg	'p' value
A/B (n = 30)/(n = 30)	83.6667 ± 6.0076/83.1667 ± 5.33100 (70 - 100)/(75 - 95)	0.986^{NS}
A/C (n = 30)/(n = 30)	83.6667 ± 6.0076/78.1667 ± 5.1667 (70 - 100)/(65 - 85)	0.002**
A/D (n = 30)/(n = 30)	83.6667 ± 6.0076/78.5000 ± 5.43774 (75 - 100)/(70 - 90)	0.005**
B/C (n = 30)/(n = 30)	83.1667 ± 5.33100/78.1667 ± 5.1667 (75 - 95)/(65 - 85)	0.003**
B/D (n = 30)/(n = 30)	83.1667 ± 5.3310/78.5000 ± 5.437740 75 (75-95)/(70- 90)	0.007**
C/D (n = 30)/(n = 30)	78.1667 ± 5.1667/78.5000 ± 5.43774 (65 - 85)/(70 - 90)	0.995^{NS}

Table 4: *Statistical analysis of mean ± SD resting diastolic blood pressure in study subjects of different groups.*

Parasympathetic nerve function parameter

The parasympathetic nerve function status of all subjects were evaluated by valsalva ratio, heart rate response to deep breathing and heart rate response to standing (30^{th}:15^{th}).

Valsalva ratio

The mean ± SD of valsalva ratios were 1.0507 ± 0.24426, 1.203 ± 0.9234, 1.2717 ± 007857, 1.2743 ± 0.10695, in group A, B, C and D respectively (Table 5). The mean values were significantly ($p < 0.001$) lower in group A than C, A than D (p value 0.000) and also significantly ($p < 0.01$) lower in group A than B. Mean values were non significantly ($p > 0.05$) lower in group B than C and in group B than D and group C than D (Table 6).

Groups	Heart rate response to		
	Valsalva maneuver (valsalva ratio) Range (L - H)	Deep breathing (beats/min) Range (L - H) (beats/min)	Standing (30^{th}: 15^{th} ratio) Range (L - H)
A (n = 30)	1.0507 ± 0.24426 (0.60 - 1.34)	16.0333 ± 6.68752 (6 - 27)	1.0953 ± 0.1846 (.80 - 1.60)
B (n = 30)	1.2803 ± 0.9234 (1.12 - 1.50)	20.3333 ± 4.22091 (12 - 30)	1.1870 ± 0.9997 (1.04 - 1.35)
C (n = 30)	1.2717 ± 0.5857 (1.12 - 1.50)	25.5333 ± 4.60684 (16 - 30)	1.2070 ± 0.0633 (1.11 - 1.33)
D (n = 30)	1.2743 ± 0.10695 (1.11 - 1.50)	21.5000 ± 3.83046 (16 - 32)	1.2140 ± 0 .06317 (1.11 - 1.34)

Table 5: *Mean ± SD of parasympathetic nerve function parameter in study subjects of different groups. Normal value: Heart rate response to valsalva maneuver: ≥ 1.21 [19]. Heart rate response to deep breathing: ≥ 15 beats/min [19]. Heart rate response to standing: ≥ 1.04 [19]*

Groups	Mean ± SD Range (L- H)	'p' value
A/B (n = 30)/(n = 30)	1.0507 ± 0.24426/1.2803 ± 0.09234 (.60 - 1.34)/(1.12 - 1.50)	0.001**
A/C (n = 30)/(n = 30)	1.0507 ± 0.24426/1.2717 ± 0.7857 (.60 - 1.34)/(1.11 - 1.50)/	0.000***
A/D (n = 30)/(n = 30)	1.0507 ± 0.24426/1.2743 ± 0.10695 (0.60 - 1.34)/(1.11 - 1.50)	0.000***
B/C (n = 30)/(n = 30)	1.2803 ± 0.09234/1.2717 ± 0.7857 (1.12 - 1.50)/(1.11 - 1.50)	0.979^{NS}
B/D (n = 30)/(n = 30)	1.2803 ± 0.09234/1.2743 ± 0.10695 (1.12 - 1.50)/(1.11 - 1.50)	0.996^{NS}
C/D (n = 30)/(n = 30)	1.2717 ± 0.7857/1.2743 ± 0.10695 (1.11 - 1.50)/(1.11 - 1.50)	1.000^{NS}

Table 6: *Statistical analysis of mean ± SD of heart rate response to Valsalva maneuver in study subjects of different groups.*

Heart rate response to deep breathing

The mean ± SD of heart rate response to deep breathing were 16.0333 ± 6.68752, 20.3333 ± 4.22091, 22.5333 ± 4.60684, 21.5000 ± 3.83046 in group A, B, C and D respectively (Table 5).

The mean values were significantly ($p < 0.001$) lower in group A than group D, group A than group C ($p < 0.01$) and group A than B ($p < 0.05$) (Table 5). Mean values were non significantly ($p > 0.05$) lower in group B than C, group B than D and group C than D (Table 7).

Groups	Mean ± SD beats/min Range (L- H) beats/min	'p' value
A/B (n = 30)/(n = 30)	16.0333 ± 6.68752/20.33333 ± 4.22091 (6 - 28)/(12 - 30)	0.023*
A/C (n = 30)/(n = 30)	16.0333 ± 6.68752/22.5333 ± 4.60684 (6 - 28)/(16 - 30)	0.000***
A/D (n = 30)/(n = 30)	16.0333 ± 6.68752/21.5000 ± 3.04374 (6 - 28)/(16 - 32)	0.002**
B/C (n = 30)/(n = 30)	20.33333 ± 4.22091/22.5333 ± 4.60684 (12 - 30)/(16 - 30)	0.228^{NS}
B/D (n = 30)/(n = 30)	20.33333 ± 4.22091/21.5000 ± 3.04374 (12 - 30)/(16 - 32)	0.678^{NS}
C/D (n = 30)/(n = 30)	22.5333 ± 4.60684/21.5000 ± 3.04374 (16 - 30)/(16-32)	0.781^{NS}

Table 7: *Statistical analysis of mean ± SD of heart rate response to deep breathing in study subjects of different groups.*

Heart rate response to standing

The mean ± SD of 30^{th}: 15^{th} heart rate ratio were 1.0953 ± 0.1846, 1.1870 ± 0.9997, 1.2070 ± 0.06331, 1.2140 ± 0.06317 in group A, B, C and D respectively (Table 5). The mean values were significantly ($p < 0.05$) lower in group A than C, in group A than D. Mean values were non significantly ($p > 0.05$) lower in group A than B, group B than C, group B than D and in group C than D (Table 8).

Groups	Mean ± SD Range (L- H)	'p' value
A/B (n = 30)/(n = 30)	1.0953 ± 0.1846/1.1870 ± .09997 (.80 - 1.60)/(1.04 - 1.35)	0.094^{NS}
A/C (n = 30)/(n = 30)	1.0953 ± 0.1846/1.2070 ± 0.06331 (0.80 - 1.60)/(1.11 - 1.34)	0.017*
A/D (n = 30)/(n = 30)	1.0953 ± 0.1846/1.2140 ± 0.06371 (0.80 - 1.60)/(1.11 - 1.33)	0.010*
B/C (n = 30)/(n = 30)	1.1870 ± .09997/1.2070 ± 0.06331 (1.04 - 1.35)/(1.11 - 1.34)	0.791^{NS}
B/D (n = 30)/(n = 30)	1.1870 ± .09997/1.2140 ± 0.06371 (1.04 - 1.35)/(1.11 -1.33)	0.598^{NS}
C/D (n = 30)/(n = 30)	1.2070 ± 0.0633/1.2140 ± 0.06371 (1.11 - 1.34)/(1.11 - 1.33)	0.973^{NS}

Table 8: *Statistical analysis of mean ± SD of heart rate response to standing (30^{th}: 15^{th} ratio) in study subjects of different groups.*

Sympathetic nerve function parameter

The sympathetic nerve function statuses of all subjects were evaluated by blood pressure response to sustained handgrip (rise in DBP), standing (fall in SBP) and cold pressor test (rise in both SBP and DBP). Results are shown in table.

Blood pressure response to sustained handgrip

The mean ± SD of blood pressure response to sustained handgrip were 12.12667 ± 5.36324, 8.6667 ± 2.24888, 8.0000 ± 2.49136, 8.1667 ± 2.45066 in group A, B, C and D respectively (Table 9). The mean values were significantly ($p < 0.05$) lower in group A than group B, in group A than C ($p < 0.01$) and group A than D. Mean values were non significantly ($p > 0.05$) lower in group B than C, in group B than D, in group C than D (Table 10).

Group	Blood pressure response to (mm of Hg)			
	Handgrip test (DBP) Range (L-H)	Standing (SBP) Range (L-H)	Cold pressor test	
			SBP Range (L-H)	DBP Range (L-H)
A (n = 30)	12.16667 ± 5.36324 (10 - 20)	8.8333 ± 2.15092 (5 - 10)	11.8333 ± 2.45066 (10 - 15)	8.6667 ± 2.24888 (10 - 15)
B (n = 30)	8.6667 ± 2.24888 (10 - 25)	8.5000 ± 2.33046 (5 - 10)	9.8333 ± 2.78027 (5 - 15)	13.6667 ± 4.13841 (10 - 20)
C (n = 30)	8.0000 ± 2.49136 (5 - 10)	8.3333 ± 2.39732 (5 - 10)	9.6667 ± 3.45746 (5 - 15)	11.5000 ± 4.76156 (5 - 20)
D (n = 30)	8.1667 ± 2.45066 (5 - 10)	8.1667 ± 2.45066 (5 - 10)	12.5000 ± 19.64118 (5 - 15)	9.8333 ± 3.4338 (10 - 20)

Table 9: *Mean ± SD of sympathetic nerve functions parameters in study subjects of different groups.*

Groups	Mean ± SD mm of Hg Range (L- H) mm of Hg	'p' value
A/B (n = 30)/(n = 30)	12.16667 ± 5.36324/8.6667 ± 2.24888 (10 - 20)/(10 - 25)	0.011*
A/C (n = 30)/(n = 30)	12.16667 ± 5.36324/8.0000 ± 2.49136 (10-20)/(5-10)	0.002**
A/D (n = 30)/(n = 30)	12.16667 ± 5.36324 (10/15.83334.927649 (10 - 20)/(5-10)	0.003**
B/C (n = 30)/(n = 30)	8.6667 ± 2.24888/8.0000 ± 2.49136 (10-25)/(5 - 10)	0.698^{NS}
B/D (n = 30)/(n = 30)	8.6667 ± 2.24888/8.1667 ± 2.45066 (10-25)/(5-10)	0.843^{NS}
C/D (n = 30)/(n = 30)	8.0000 ± 2.49136/8.1667 ± 2.45066 (10 - 30)/(5 - 10)	0.994^{NS}

Table 10: *Statistical analysis of mean ± SD of blood pressure response to sustained handgrip (DBP) in study subjects of different groups.*

Blood pressure response to standing

The mean ± SD of blood pressure response to standing were 8.8333 ± 2.15092, 8.5000 ± 2.33046, 8.3333 ± 2.39732, 8.1667 ± 2.45066, in group A, B, C and D respectively (Table 9). The mean values were non significantly ($p > 0.05$) lower in group A than B, in group A than C, group A than D, group B than C, Group B than D group, group C and D (Table 11).

Groups	Mean ± SD mm of Hg Range (L- H) mm of Hg	'p' value
A/B (n = 30)/(n = 30)	8.8333 ± 2.15092/8.5000 ± 2.33046 (5 - 10)/(5 - 10)	0.939^{NS}
A/C (n = 30)/(n = 30)	8.8333 ± 2.15092/8.3333 ± 2.39732 (10 - 15)/(5 - 15)	0.830^{NS}
A/D (n = 30)/(n = 30)	8.8333 ± 2.15092/8.1667 ± 2.45066 (5 - 10)/(5 - 10)	0.679^{NS}
B/C (n = 30)/(n = 30)	8.5000 ± 2.33046/8.3333 ± 2.39732 (5- 15)/(5 - 10)	0.993^{NS}
B/D (n = 30)/(n = 30)	8.5000 ± 2.330046/8.1667 ± 2.45066 (5-10)/(5 - 10)	0.949^{NS}
C/D (n = 30)/(n = 30)	8.3333 ± 2.39732/8.1667 ± 2.45066 (5 - 10)/(5 - 10)	0.993^{NS}

Table 11: *Statistical analysis of mean ± SD of blood pressure response to standing (SBP) in study subjects of different groups.*

Cold pressor test

The mean ± SD of systolic blood pressure of cold pressor test were 11.8333 ± 2.45066, 9.8333 ± 2.78027, 9.6667 ± 3.45746, 12.5000 ± 19.64118, in group A, B, C and D respectively (Table 9). In systolic blood pressure changes, the mean values were significantly ($p < 0.01$) lower in group A than group D, in group A than C. There was no significant difference ($p > 0.05$) among group A and B, group B and C, group C and D (Table 12).

Groups	Mean ± SD mm of Hg Range (L- H)	'p' value
A/B (n = 30)/(n = 30)	11.8333 ± 2.45066/9.8333 ± 2.78027 (10 - 15)/(5 - 15)	0.998^{NS}
A/C (n = 30)/(n = 30)	11.8333 ± 2.45066/9.6667 ± 3.45746 (10 - 15)/(5 - 15)	0.036*
A/D (n = 30)/(n = 30)	11.8333 ± 2.45066/12.5000 ± 19.64118 (5 - 15)/(5 - 15)	0.003**
B/C (n = 30)/(n = 30)	9.8333 ± 2.78027/9.6667 ± 3.45746 (5 - 15)/(5 - 15)	0.997^{NS}
B/D (n = 30)/(n = 30)	9.8333 ± 2.7802/12.5000 ± 19.64118 (5 - 15)/(5 - 15)	0.882^{NS}
C/D (n = 30)/(n = 30)	9.6667 ± 3.45746/12.5000 ± 19.64118 (5 - 15)/(5 - 15)	0.864^{NS}

Table 12: *Statistical analysis of mean ± SD of systolic blood pressure changes in cold pressor test in study subjects of different groups.*

The mean ± SD of diastolic blood pressure of cold pressor test were 8.6667 ± 2.24888 13.6667 ± 3.19842, 11.5000 ± 3.45746, 9.8333 ± 3.34338 in group A, B, C and D respectively (Table 9). In diastolic blood pressure changes, the mean values were significantly ($p < 0.001$) lower in group A than D and also significantly ($p < 0.01$) lower in group B than group D. There was also significant difference ($p < 0.05$) in mean value among group A and C. The mean values were non significantly ($p > 0.05$) lower in group A than B and in group C than D (Table 13).

Groups	Mean ± SD mm of Hg Range (L- H)	'p' value
A/B (n = 30)/(n = 30)	8.6667 ± 2.24888/13.6667 ± 4.13841 (10 - 25)/(5 - 15)	0.396^{NS}
A/C (n = 30)/(n = 30)	8.6667 ± 2.24888/11.500 ± 4.76156 (10 - 25)/(5 - 20)	0.026*
A/D (n = 30)/(n = 30)	8.6667 ± 2.24888/9.8333 ± 3.4338 (5 - 15)/(5 - 20)	0.000***
B/C (n = 30)/(n = 30)	13.6667 ± 4.13841/11.500 ± 4.76156 (1 - 20)/(5 - 20)	0.248^{NS}
B/D (n = 30)/(n = 30)	13.6667 ± 4.13841/9.8333 ± 3.4338 (10 - 20)/(5 - 15)	0.001**
C/D (n = 30)/(n = 30)	11.500 ± 4.76156/9.8333 ± 3.4338 (5 - 20)/(5 - 15)	0.405^{NS}

Table 13: *Statistical analysis of mean ± SD of diastolic blood pressure changes in cold pressor test in study subjects of different groups.*

Biochemical parameters

Mean FBS, serum creatinine and serum ALT levels were almost similar and there were statistically no significant differences ($p > 0.05$) between the groups (Table 14).

Group	FBS- mmol/L Mean ± SD Range (L-H)	Serum Creatinine- mg/dl Mean ± SD Range (L-H)	Serum ALT- U/L Mean ± SD Range (L-H)
A (n = 30)	86.4963 ± 22.30020 (47.12 - 131.80)	1.0020 ± 0.12442 (0.76 - 1.27)	37.9367 ± 13.4937 (15 - 68)
B (n = 30)	87.5060 ± 13.12316 (66.79 - 112.87)	.8653 ± 0. 13362 (0.74 - 1.41)	33.6577 ± 11.35205 (15 - 68)
C (n = 30)	75.2000 ± 0.61091 (58.09 - 88.06)	0.9187 ± 0.12740 (0.69 - 1.30)	30.3467 ± 12.82813 (13 - 61)
D (n = 30)	65.32820 ± 12.84150 (42.88 - 90.00)	0.9483 ± 0.11313 (0.77 - 1.11)	21.7328 ± 6.95053 (12- 44)

Table 14: *Mean ± SD of fasting serum glucose, serum creatinine and serum alanine amino transferase level of the study subjects of different group.*

 # = Normal fasting serum glucose level is 110 - 125 mg/dl.

 # = Normal serum creatinine level is 0.6 - 1.3 mg/dl.

 # = Normal serum alanine amino transferase level is 10 - 50 U/L.

Distribution of the subjects by ANF scoring

Autonomic nerve functions were found to be normal in all subjects (30 = 100%) of heavy workers in group D. But 4 (13.34%) in group C of moderate workers, 12 (40%) in group B of light workers and 19 (63.34%) in group A sedentary workers showed impaired autonomic functions.

However, early involvement of autonomic nerve functions was observed in group A -sedentary workers 16 (53.34%), group B -light workers 10 (33.34%), group C -moderate workers 4 (13.34%) respectively (Table 14).

Definite involvement of autonomic nerve functions was observed in group A- sedentary workers 3 (10%), in group B- light workers 2 (6.6%), group C-moderate workers 0 (10%) respectively. There was no severe involvement or atypical pattern of autonomic nerve functions showed in group A, B and C.

Discussion

The present study was carried out to observe the changes in cardiovascular autonomic functions in apparently healthy adult male sedentary workers. Resting heart rate was measured in all healthy adult male sedentary workers, light workers, moderate workers, heavy workers to find out their basal status. The mean value of resting heart rate was higher but within normal physiological limit. The result is significant ($p < 0.001$) in sedentary workers and light workers in comparison to that of moderate and heavy workers. These findings are in agreement with those reported by Rinnie K [24]. In this study, resting blood pressure was measured in all healthy adult male sedentary workers, light workers, moderate workers, heavy workers to find out their basal status. Rinnie K., *et al*. [24] reported that increase resting heart rate and blood pressure in sedentary and light workers might be due to a higher sympathetic tone induced by higher level of catecholamine and Mithun S [25] suggested that increased heart rate and blood pressure in sedentary individual due to decreased parasympathetic activity and reduced baroreflex sensitivity. In sedentary workers and light workers, mean values of systolic blood pressure was significantly higher ($p < 0.01$) than moderate and heavy workers and mean values of diastolic blood pressure was higher ($p < 0.01$) and significant. Similar findings was obtained by Park JH., *et al*. [25] and Mithun S., *et al* [26]. In sedentary workers, heart rate response to valsalva maneuver was significantly ($p < 0.01$) lower than light, moderate and heavy workers.

Mithun S., *et al*. [26], Toivanen H., *et al*. [27] and Latre ML., *et al*. [28] have found that heart rate response to valsalva maneuver was significantly lower than light, moderate and heavy workers. Our study also found similar findings ($p < 0.01$). In sedentary worker significantly ($p < 0.01$) lower heart rate response to deep breathing was found than light, moderate and heavy workers. These findings are in agreement with those reported by Toivanen H., *et al*. [27], Latre ML., *et al*. [28] and Mithun S., *et al* [25]. In our study parasympathetic nerve function revealed reduce in sedentary workers. Heart rate response to deep breathing ($p < 0.01$) and standing was significantly ($p < 0.05$) lower in sedentary workers than light, moderate and heavy workers. Similar findings was observed in other studies [26-29]. Toivanen H., *et al*. [27] and Latre ML., *et al*. [28] suggested that most sedentary workers have a worse metabolic profile, with higher level of biomarkers of insulin resistance and inflammation. This insulin resistance may cause damage to autonomic nerves at any level of their reflex arc, insulin may cause deterioration of microcirculation in many tissues including nerves which may lead to neural ischemia and thereby damage of cardiac parasympathetic nerve terminals occur at the level of cardiac muscle or vascular wall.

Mithun S., *et al*. [26] also reported that sedentary workers may induce a reduction of parasympathetic function and diminished baro reflex functions which increase heart rate. Among sympathetic nerve functions parameters blood pressure response to sustained handgrip was significantly ($p < 0.01$) lower in sedentary workers in compared to light, moderate and heavy workers. These findings are in agreement with those reported by Mithun S., *et al*. [26], Toivanen H., *et al*. [27], Fatima AV., *et al*. [30], Harmer M and Samatakis E [31]. But no significantly ($p > 0.05$) lower blood pressure response to standing was found in sedentary workers when compared to light, moderate and heavy workers. Similar results was observed in other studies [25,30,32]. Toivanen H., *et al*. [27], Fathima AV., *et al*. [30] and Mithun S.,

et al. [26] found both systolic and diastolic blood pressure reduced in cold pressor test. The reduction of blood pressure was significantly lower in sedentary workers than light, moderate and heavy workers ($p < 0.05$). Toivanen H., *et al*. [27] observed that reduced diastolic pressure response to sustained hand grip in sedentary workers due to increase peripheral response to maneuver activating sympathetic system. This decreased sympathetic activity might be due to defect in sympathetic nerve activation or alternatively in peripheral adreno-receptor behavior. Fathima AV., *et al*. [30] reported that in handgrip test, moderate and heavy workers have increase in blood pressure is due to increased sympathetic activity mediated by the alpha-adrenergic receptors of the autonomic nervous system. An increase in sympathetic activities due to impulses from the limbic cortex, motor cortex and the proprioceptors within small hand joints acting as afferent inputs into the medullary cardiac centers causing increase in blood pressure, both systolic and diastolic. Mithun S., *et al*. [26] reported that sedentary workers are less responsive to blood pressure changes to cold stimulus than the moderate and heavy workers. The afferent fibers for this response are the pain fibers which are stimulated by placing the hand in cold water and the efferent fibers are the sympathetic fibers. A lesser increase in the blood pressure after the cold-water immersion points towards sympathetic insufficiency in sedentary subjects.

In our study, according to autonomic nerve function scoring 4 (13.34%) of moderate workers, 12 (40%) of light workers and 19 (63.34%) of sedentary workers had autonomic impairment. All the male healthy heavy workers 30 (100%), 26 (86.67%) moderate workers, 18 (60%) light workers and 11 (36.67%) sedentary workers of this study had normal autonomic nerve function. This dysfunction involves decrease in both parasympathetic and sympathetic nerve activity. Significantly higher resting heart rate, systolic and diastolic blood pressure in sedentary and light workers are suggestive of impairment of autonomic nerve function which may be the consequences of the parasympathetic impairment and sympathetic over activity. The increase in arterial pressure may be either due to an increase heart rate and force of contraction, leading to an increase in cardiac output and blood pressure or by vasoconstriction and resultant increase in total peripheral resistance and blood pressure, or both. The first effect is due to increased activity in cardiac sympathetic fibers, whereas the second effect is due to increased activity in peripheral vasoconstrictor fibers. Sympathetic stimulation in resting state results in increased energy consumption by heart and increased metabolism by cardiac tissues. This increases the metabolic waste products and injuries the cardiac tissues, thereby act as a risk factor for cardiac complications.

Conclusion

Both parasympathetic and sympathetic nerve activity were decreased in male sedentary workers in comparison to light and heavy workers.

Limitations of the Study

The study was conducted in a selected area, so, the study population might not represent the whole community. The sample was taken purposively; there may be chance of bias which can influence the results.

Recommendations

From this study, following recommendations can be made for further study:

- Similar type of study in sedentary children to find out their autonomic nerve function status.
- Head tilt up test to assess the sympathetic nerve function in sedentary and active subjects.
- Autonomic nerve function status in sedentary and active subjects both before and after certain period of exercise in order to observe any change.

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