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Research Article

EVALUATION OF CARDIOVASCULAR AUTONOMIC FUNCTION TESTS IN OBESE AND NON-OBESE HEALTHY INDIANS

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ABSTRACT

Autonomic nervous system (ANS) is a centre for the coordination of different body systems. Since the ANS is involved in energy metabolism and in the regulation of almost all visceral systems. It is conceivable that one or more subgroups of persons with idiopathic obesity have an alteration in their autonomic nervous system that may account for several clinical consequences of obesity. This observational study was conducted to find the association of Autonomic Function Tests among obese and non-obese participants. Among 90 participants, 45 were obese and 45 were non-obese, aged 18-40 years of either gender was enrolled after getting their voluntary written consent. In both the groups, Cold Pressure Test and Hand Grip Test were performed for evaluating sympathetic functions. Standing test (30:15 RR Ratio), Standing to Lying ratio, and Valsalva ratio were performed for evaluating parasympathetic functions. Chi-square and unpaired t test was employed for statistical analysis. A statistically significant association of Autonomic Function Tests among obese and non-obese participants was found as per BMI and Body Fat Percentage criteria. Study explored that obesity was associated with ANS dysfunction as compared to non-obese; this relationship was observed primarily in terms of sympathetic and parasympathetic activity. The results of this study are indicative of autonomic insufficiency among obese participants.

Keywords: *Atisthulata*, Autonomic Function Tests, Obesity, *Sthulata*.

1. INTRODUCTION

Acharya charak has explained eight types of *ninditiya purusha* (censurable individual); *atisthula* (morbid obesity) is one of them. Obesity is associated with several life threatening complications including diabetes, hypertension, coronary artery diseases, joint disorders, skin disorders, anorectal problems etc [1]. Some key etiological factors of *atisthula* includes dietary and lifestyle indicators (e.g., sedentary habit and high-calorie diet), and genetic and hereditary factors, involving *rasa* (plasma) and *meda* (adipose tissue) as important *dushyas* (affected tissues). The cardinal features explained in *Charak Samhita* are pendulous movement of the buttocks, breasts and abdomen during walking [2]. This is due to the excess deposition of fats. The causes of obesity are excess intake of a heavy, sweet, cold and fatty diet, lack of physical exercise, abstinence from sexual intercourse, sleeping during the day, uninterrupted cheerfulness, lack of mental activities, and hereditary/genetic defects. These consequences may lead to an excess formation of fat (*medas*) (with further accumulation of only fat) and consequent depletion of *dhatu* [3].

A regulatory system that maintains constant energy storage is likely to involve complex interactions among humoral, neural, metabolic, and psychological factors, and it has been suggested that the Autonomic Nervous System (ANS) may be central in the coordination of this system [4, 5]. The autonomic nervous system (ANS) is thought to contribute to the pathophysiology of obesity [6]. Increased adiposity had been linked to alterations in both sympathetic and parasympathetic activities [7]. Decreased adiposity after weight reduction has also been associated with improved ANS function [8, 9]. Autonomic dysfunction can be assessed by performing various autonomic function tests. Autonomic nervous system (ANS) is a centre for the coordination of different body systems. Since the ANS is involved in energy metabolism and in the regulation of almost all visceral systems. It is conceivable that one or more subgroups of persons with idiopathic obesity have an alteration in their autonomic nervous system that may account for several clinical consequences of obesity [10]. Laitinen *et al* in their study showed that total body fat and central body adiposity are associated with altered autonomic activity [11].

Peterson et al. (1988) discovered a reduced sympathetic activity with increased body fat and identified an inverse relationship between sympathetic and parasympathetic activity [12]. Rossi et al. (1989) found a poorer parasympathetic function in obese participants, but no abnormalities in sympathetic activities [13]. Aronne et al. have also documented a reduction in parasympathetic activity (1995) [14]. A study by Aronne et al. (1997) assessed moderately overweight subjects with increasing or decreasing weight [15]. Many disorders are caused by changes in autonomic activity (eg, hypertension, heart failure). Body temperature, hydration and electrolyte balance, and blood pressure are all difficult to control. The primary objective of the present study was to investigate the association of Autonomic function tests between obese (*sthula*) and Non-obese (*asthula*) individuals.

2. METHODS

2.1. Study design

The present study design was an observational study. During the study, measurements were made on a single occasion. We followed STROBE guidelines while reporting the findings of the study.

2.2. Informed Consent and Ethical Consideration

This study was approved by the Institutional Ethical Committee (IEC) before starting the study (CBP-IEC/2019/KS/MD/03 dated 21/12/2020). Prior to the inclusion of participants in the study, written informed consent was taken through mandated Performa. Participants were briefed about their voluntary participation in the study.

2.3. Study setting

The study was carried out at the PG Dept. of Kriya Sharir, CBPACS, New Delhi. Autonomic Function Tests were performed among obese and non-obese participants from November 2020 to November 2021. The data generated through autonomic function tests was confined to obese and non-obese participants only. Data generated from a total of 90 participants, i.e., 45 obese and 45 non-obese participants was used for analysis.

2.4. Study participants

For the present study, a total of 90 participants, i.e., 45 obese and 45 non-obese participants, fulfilling the inclusion criteria, aged 18-40 years of either gender, had been enrolled after getting their voluntary written consent.

2.5. Inclusion criteria

1. Participants having a BMI of 30 kg/m^2 or above, aged between 18-40 years of either gender, were included in the obese group.
2. Participants having a BMI of 19–24 kg/m^2 or above, aged between 18-40 years of either gender, were included in the non-obese group.
3. 25% of body fat in the case of men's and > 35% in women's, who did not have any underlying systemic illness were included in the study in the obese group.
4. The non-obese group included men with 25% body fat and women with 35% body fat who did not have any underlying systemic illness.

2.6. Exclusion criteria

1. Obese individuals having a BMI 40 $\geq$40kg/m^2 were not included in the study.
2. Non-obese individuals having a BMI 19kg/m^2 were not included in the study.
3. Any systemic illness that affects the normal distribution of fat and the autonomic nervous system, drug abused, neurological disorders, paralysed individuals, pregnant women, chronic liver illness, Hypothyroidism or obesity due to hormonal disorders.

2.7. Data Collection Methods

All data was recorded by the investigator in a case report form (CRF) and instantly recorded in the database. All information regarding the study was properly documented, carefully handled, and scrupulously stored in order to ensure its accurate interpretation and verification. The original CRFs were also kept. All the selected participants for the study were informed about all the autonomic function tests to be performed.

The Cold Pressure Test and Hand Grip Test were performed in both groups to assess sympathetic functions. Parasympathetic functions were assessed using the standing test (30:15 RR Ratio), standing to lying ratio, and Valsalva ratio. These tests were performed sequentially, and participants were asked to take a break before the tests. A Digital Handgrip Dynamometer was used for the handgrip test, a digital sphygmomanometer was used to record blood pressure, and ECG was recorded with lead Ⅱto calculate heart rate.

2.7.1. *Cold pressure test*

The participant was asked to immerse one hand up to the level of the wrist in cold water maintained at 4-5°C for 2 minutes. Baseline blood pressure and changes in blood pressure were recorded from the other arm at a 30 second interval. Baseline blood pressure and the maximum rise in blood pressure were compared.

2.7.2. *Hand grip test*

Resting BP and HR were recorded and the participant was asked to take a full grip on the dynamometer with their dominant hand. 30% of maximum isometric tension (Tmax) was calculated and asked the participant to maintain a tension at Tmax for 5 minutes. BP was recorded at 30 sec intervals for 5 minutes. The diastolic blood pressure was compared before and after the procedure.

2.7.3. *Standing test (30:15 RR Ratio)*

The participant was asked to lie down supine. The ECG standard limb lead II was applied to record the RR interval and the BP cuff. The change in blood pressure from supine to standing position was compared at the end of the 1st and 3rd minutes after standing. Heart rate from the R-R interval at the 15th beat and at the 30th beat was calculated. Determined the 30:15 Ratio, which is considered a cardiac vagal effect.

2.7.4. *Standing-to-lying ratio (S/L RATIO)*

The ECG leads were connected for recording lead II. The participant was asked to lie down in supine position. ECG was recorded for 20 beats before and for 60 beats after lying down. The point of change of position on the ECG paper was noted. The average of R-R interval during 5 beats before lying down and 10 beats after lying down was noted down.

2.7.5. *Valsalva ratio: Valsalva maneuver*

The participant was asked to sit on a stool and the procedure was explained. The ECG lead was connected, and applied BP cuff on the participant's arm and asked to close the nostril with his/her hand. Disconnected the cuff from another BP apparatus and asked the participant to take a deep breath, blow into the manometer and maintain a pressure of 40 mmHg for 15 sec. Recorded the ECG for 15 sec during straining and for 45 sec after the release of strain. The ratio of longest R-R interval after the strain to the shortest R-R interval during the strain was calculated.

2.8. Outcome Measures

The outcome of the study was measured in terms of systolic blood pressure, diastolic blood pressure, mean arterial pressure, pulse pressure and heart rate. The outcome of the study was compared between Obese and Non-obese participants.

2.9. Statistical Analysis

Categorical data were summarized in proportions and percentages (n%). Chi square test was used to check associations. A p value of <0.05 was considered statistically significant. The data was entered in MS EXCEL spreadsheet and analysis was done using Statistical Package for Social Sciences (SPSS) software version 23.0.

2.9.1. *The chi sq test*

The Chi-Square Test was used to determine association between two variables. It is really a hypothesis test of independence. The null hypothesis is that the two variables are not associated, i.e., independent. The alternate hypothesis is that the two variables are associated.

2.9.2. *Unpaired t Test*

The unpaired t-test (or independent t-test) is a statistical test that determines whether there is a difference between two unrelated groups. The unpaired t-test is used to make a statement about the population based on two independent samples. To make this statement, the mean value of the two samples was compared.

3. OBSERVATIONS AND RESULTS

Total 90 participants were enrolled for the study, out of them, 46 (51.1%) were men and 44 (48.9%) were women. Majority of the participants 67 (74.4%) were residing in Urban area while 23 (25.6%) were Rural habitants. The analysis of data obtained for occupation depicted that maximum 42 (46.7%) was doing desk work, 31 (34.4%) were students, (15) 16.7% were housewives and rest 2 (2.2%) were field workers. The illustrations of table one depicted that according to BMI criterion, 45 (50%) participants were obese and rest 45 (50%) participants were non-obese. Further, according to body fat percentage, 46 (51.1%) participants were obese and rest 44 (48.9%) participants were non-obese (Table 1).

Table 1: Showing demographic distribution of participants

Character	Categories		Number of Participants (n%)
Gender	Men		46 (51.1%)
	Women		44 (48.9%)
Habitat	Rural		23 (25.6%)
	Urban		67 (74.4%)
Occupation	Student		31 (34.4%)
	Desk work		42 (46.7%)
	Housewife		15 (16.7%)
	Field Work		2 (2.2%)
Participants Distribution	According to BMI	Obese	45 (50%)
		Non-Obese	45 (50%)
	According to Body Fat Percentage	Obese	46 (51.1%)
		Non-Obese	44 (48.9%)

Table 2: Association of Autonomic Function Tests among Obese and Non-obese participants as per BMI Criterion

Tests for sympathetic functions	According to BMI				Unpaired t test	
	Obese		Non Obese			
	Mean	SD	Mean	SD	t-value	p-value
Cold pressor test						
Changes in SBP	12.29	6.87	19.00	12.62	-3.13	**0.002**
Maximum DBP	80.93	9.61	85.00	8.05	-2.17	**0.033**
Changes in DBP	8.64	5.75	12.49	8.20	-2.58	**0.012**
Hand grip test						
Changes in DBP	8.78	5.38	12.47	7.08	-2.78	**0.007**
Tests for parasympathetic functions	According to BMI				Unpaired t test	
	Obese		Non Obese			
	Mean	SD	Mean	SD	t-value	p-value
Standing test (30:15 RR Ratio)						
SBP - STANDING POSTION	124.36	9.05	118.53	12.92	2.46	**0.016**
CHANGES IN SBP	3.80	6.25	0.24	8.43	2.27	**0.025**
(30:15) R-R RATIO_HEART RATE	0.97	0.13	1.07	0.15	-3.21	**0.002**
Standing to lying ratio (S/L Ratio)						
Heart Rate : S/L RATIO	1.05	0.27	1.10	0.23	-0.96	0.338
Valsalva ratio						
Changes in R-R interval	0.69	0.43	0.98	0.56	-2.72	**0.008**

The analysis of table 2 depicted that the mean change in SBP of obese participants was 12.29 mmHg and the mean change in SBP of non-obese participants was 19.00 mmHg as per BMI criterion. By applying unpaired t test, the association of change in SBP was found statistically significant ($p<0.01$) among obese and non-obese participants as per BMI criterion.

The mean of maximum DBP of obese participants was 80.93 mmHg and the mean of maximum DBP of non-obese participants was 85.00 mmHg as per BMI criterion. The association of maximum DBP among obese and non-obese participants was found statistically significant ($p<0.05$) as per BMI criterion by applying unpaired t test.

The mean change in DBP of obese participants was 8.64 mmHg and the mean change in DBP of non-obese participants was 12.49 mmHg as per BMI criterion. By applying unpaired t test, the association of change in DBP among obese and non-obese participants was found statistically significant ($p<0.05$) as per BMI criterion.

The mean change in DBP of handgrip test for obese participants was 8.78 mmHg and the mean change in

DBP of handgrip test for non-obese participants was 12.47 mmHg as per BMI criterion. By applying unpaired t test, the association of change in DBP among obese and non-obese participants was found statistically significant ($p<0.01$) as per BMI criterion.

The mean SBP in standing position was 124.36 mmHg for obese participants and the mean SBP in standing position was 118.53 mmHg for non-obese participants. The association of SBP in standing position among obese and non-obese participants was found statistically significant ($p<0.05$) as per BMI criterion.

The mean of change in SBP from supine to standing position for obese participants was 3.80 mmHg and the mean of change in SBP from supine to standing position for non-obese participants was 0.24 mmHg as per BMI Criterion. The association of SBP changes with posture among obese and non-obese participants was found statistically significant ($p<0.05$) as per BMI criterion.

The mean 30:15 R-R ratio was 0.97 for obese participants and the mean 30:15 R-R ratio was 1.07 for non-obese participants as per BMI criterion. The association of heart rate at 30th and 15th beat with change in the body posture among obese and non-obese participants was found statistically significant ($p<0.01$) as per BMI criterion.

The mean S/L Ratio was 1.05 for *sthula* participants and the mean S/L Ratio was 1.10 for *asthula* participants as per BMI criterion. The association of the Heart Rate: S/L Ratio in among *sthula* and *asthula* participants was not found statistically significant as per BMI criterion.

The mean change in R-R interval for obese participants was 0.69 and the mean change in R-R interval for non-obese participants was 0.98 as per BMI criterion. By applying unpaired t test, statistically significant ($p<0.01$) association was found among obese and non-obese participants with change in R-R interval as per BMI criterion.

Table 3: Association of Autonomic Function Tests among Obese and Non-obese participants as per Body Fat Percentage Criterion

Tests for sympathetic functions	According to Body Fat Percentage				Unpaired t test	
	Obese (Obese)		Non Obese (Aobese)			
	Mean	SD	Mean	SD	t-value	p-value
cold pressor test						
Maximum SBP	131.84	13.10	138.23	13.37	-2.28	**0.025**
CIP (changes in SBP)	11.98	7.06	19.48	12.38	-3.55	**0.001**
CIP (changes in DBP)	8.67	6.01	12.55	8.03	-2.60	**0.011**
Hand grip test						
Changes in DBP	9.04	6.05	12.27	6.65	-2.41	**0.018**
Tests for parasympathetic functions	According to Body Fat Percentage				Unpaired t test	
	Obese (Obese)		Non Obese (Aobese)			
	Mean	SD	Mean	SD	t-value	p-value
Standing test (30:15 RR ratio)						
SBP - standing postion	124.29	9.10	118.48	12.96	2.45	**0.016**
changes in SBP	3.85	6.28	0.11	8.41	2.39	**0.019**
Pulse Rate - Supine positon	86.58	10.73	81.80	10.53	2.12	**0.037**
(30:15) R-R ratio_heart rate	0.98	0.15	1.06	0.14	-2.50	**0.014**
Standing to lying ratio (S/L ratio)						
Heart Rate : S/L ratio	1.07	0.27	1.08	0.22	-0.20	0.843
Valsalva ratio						
changes in R-R interval	0.69	0.42	0.98	0.56	-2.78	**0.007**

The analysis of table 3 depicted that the mean of maximum SBP of obese participants was 131.84 mmHg and the mean of maximum SBP of non-obese participants was 138.23 mmHg as per Body Fat criterion. By applying unpaired t test there was statistically Significant association ($p<0.05$) found between obese and non-obese participants with the maximum SBP as per Body fat Percentage criterion. The mean of change in SBP was 11.98 mmHg among obese participants and the mean of change in SBP 19.48

mmHg among non-obese participants as per Body fat percentage criterion. By applying unpaired t test, statistically significant ($p<0.01$) association was found between obese and non-obese participants with the change in SBP as per Body fat percentage criterion. The mean of change in DBP of obese participants was 8.67 mmHg and the mean of change in DBP of non-obese participants was 12.55 mmHg as per Body Fat percentage criterion. By applying unpaired t test, statistically significant association ($p<0.05$) was found between obese and non-obese participants with the change in DBP participants as per Body Fat percentage criterion. The mean change in DBP of handgrip test for obese participants was 9.04 mmHg and the mean change in DBP of handgrip test for non-obese participants was 12.27 mmHg as per Body Fat Percentage criterion. By applying unpaired t test, the association of change in DBP among obese and non-obese participants was found statistically significant ($p<0.05$) as per Body Fat Percentage criterion. The mean SBP in standing position was 124.29 mmHg for obese participants and the mean SBP in standing position was 118.48 mmHg for non-obese participants as Per Body Fat Percentage Criterion. The association of SBP in standing position among obese and non-obese participants was found statistically significant ($p<0.05$) as Per Body Fat Percentage Criterion. The mean of change in SBP from supine to standing position was 3.85 mmHg for obese participants and the mean of change in SBP from supine to standing position was 0.11 mmHg for non-obese participants as Per Body Fat Percentage Criterion. The association of SBP with changes in posture among obese and non-obese participants was found statistically significant ($p<0.05$) as Per Body Fat Percentage Criterion.

The mean pulse rate in supine position was 86.58 per min for obese participants and the mean pulse rate in supine position was 81.80 per min for non-obese participants as per Body Fat Percentage Criterion. The association of pulse rate in supine position among obese and non-obese participants was found statistically significant ($p<0.05$) as per Body Fat Percentage Criterion. The mean 30:15 R-R RATIO was 0.98 for obese participants and the mean 30:15 R-R RATIO was 1.06 for non-obese participants as per Body Fat Percentage criterion. The association of heart rate at 30^{th} and 15^{th} beat with change in the body posture among obese and non-obese participants was found statistically significant ($p<0.05$) as per Body Fat Percentage criterion. The mean S/L Ratio was 1.07 for *sthula* participants and the mean S/L Ratio was 1.08 for *asthula* participants as per Body Fat Percentage criteria. The association of the Heart Rate: S/L Ratio in among *sthula* and *asthula* participants was not found statistically significant as per Body Fat Percentage criteria. The mean change in R-R interval for obese participants was 0.69 and the mean change in R-R interval for non-obese participants was 0.98 as per Body Fat Percentage criterion. By applying unpaired t test, statistically significant ($p<0.01$) association was found among obese and non-obese participants with mean change in R-R interval as per Body Fat Percentage criterion.

4. DISCUSSION

The aim of this study was to evaluate any association of autonomic regulation between obese and non-obese participants, so that an early intervention could decrease mortality, morbidity and the health risks related to autonomic dysregulation and obesity. Previous studies by Rossi et al., and Grewal et al., have reported that there is marked decrease in autonomic function in obese and non-obese patients for the parasympathetic as well as sympathetic division [16, 17]. The mean SBP change of obese participants on exposure to cold water was less as compared to non-obese participants because of hypofunctional sympathetic response in obese participants. This can be interpreted as non-obese participants are more prone to sympathetic stimuli as compared to obese participants. The impaired Cold Pressure Response in obese could possibly be because of hypofunctional sympathetic nervous system [18]. The relationship between body composition and BP levels has well been established in epidemiological studies. Ideally, body fat percent should correlate better with Blood pressure (BP) [19]. Significant association ($p<0.05$) found between obese and non-obese participants with the maximum SBP as per Body fat Percentage criterion. By applying unpaired t test, statistically significant ($p<0.01$) association was found between obese and non-obese participants with the mean of change in SBP as per Body fat percentage criterion. The interpretation of above analysis indicates that the mean SBP change of obese participants on exposure to cold water (4°C) was less as compared to non-obese participants as per Body fat percentage criterion because of hypofunctional sympathetic response in obese participants. For the Isometric exercise, the obese group revealed truncated response as compared to the non-obese group. The above analysis can be interpreted as the change in DBP of obese participants was less as compared to non-obese participants as per BMI criterion. A rise of more than 15mmHg in DBP is normal, whereas less than 10mmHg rise indicates sympathetic insufficiency. In our result, the change in DBP was less than 10mmHg in case of obese participants which shows sympathetic insufficiency. The results of the present study show that the heart rate response to standing (30:15), and valsalva ratio in obese participants were significantly lower as compared to the non-obese group, it indicates decrease in parasympathetic nerve function and baroreflex sensitivity in obese participants. Baroreceptors resetting may occur in obese individuals due to atherosclerosis that hardens the carotid sinus walls. Obese group is less responsive to blood pressure changes to posture. Similar results were shown by some other investigators [20].

5. CONCLUSION

The aim of this study was to see the association of Autonomic Function Tests among obese and non-obese participants as per BMI and Body Fat Percentage criterion. The association of Cold Pressure test and Hand Grip Test among obese and non-obese participants was found statistically significant. This indicates hypo-functioning of sympathetic activity among obese group. The association of Standing Test (30:15 RR Ratio) with change in the body posture from supine to standing position among obese and non-obese participants as per BMI and Body Fat Percentage criterion was found statistically significant. This finding is indicative of autonomic insufficiency among obese participants. The association of standing to lying ratio (S/L Ratio) among obese and non-obese participants as per BMI and Body Fat Percentage criterion was not found statistically significant. It is due to normal parasympathetic activity among obese and non-obese participants. In the present study, the association of changes in heart rate by Valsalva Maneuver among Obese and Non-obese participants was found statistically significant. It is due to autonomic disturbances among *obese* group as compared to non-obese group per both BMI and Body Fat Percentage Criterion**.** Study explored that obesity was associated with ANS dysfunction as compared to non-obese; this relationship was observed primarily in terms of sympathetic and parasympathetic activity. Obesity is associated with ANS dysfunction may be the cause of various cardiovascular complications. So, if autonomic dysfunction is diagnosed early by doing autonomic function Examination, it may prove an important aid in identification of those who are prone to weight gain and at higher risk of cardiovascular complications.

Conflicts of Interest
Nil

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None

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