Original Article

Influence of gender and body mass index on autonomic reactivity in adults and middle-aged population

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Abstract

Background and Aim: Studies have reported that both age and gender influences cardiovascular reactivity among adult and elderly. The current study was conducted to assess the effect of body mass index (BMI) on autonomic reactivity tests of different age groups in both sexes.

Methods: The present study was conducted on 124 healthy volunteers categorized into adult population aged 20–45 years (male = 32, female = 31) and middle-aged population aged 46–60 years (male = 31, female = 30). Parameters for parasympathetic activity (30:15 ratio, standing to lying ratio, and deep breathing difference) were recorded using electrocardiograph. Sympathetic activity was assessed by cold pressure test (rise in diastolic blood pressure). Pearson's correlation coefficient was used to assess the association of BMI with autonomic reactivity.

Results: Adults males had larger positive correlation between BMI and autonomic reactivity than females, but in middle-aged, there is no significant difference between the sexes. Among females, premenopausal subjects have less correlation between BMI and autonomic reactivity compared to postmenopausal subjects.

Conclusion: Body mass index is correlated with autonomic reactivity in the younger population compared to the middle-aged population. Gender appears to alter the autonomic reactivity by affecting the BMI. BMI plays an important role in the modulation of autonomic functions.

Key words: 30:15 ratio, autonomic reactivity, body mass index, cold pressure test, deep breathing difference, standing to lying ratio

Received: 4th September, 2014; ***Revised:*** 14th November, 2014; ***Accepted:*** 26th November, 2014

INTRODUCTION

The main function of autonomic nervous system (ANS) is to regulate the milieu interior by controlling the visceral functions. Most internal functions are regulated by the ANS, which in turn are influenced by somatosensory inputs from various parts of the body.[1] The ANS is divided into sympathetic and parasympathetic nervous system that operate independently, but interact reciprocally to regulate the organ functions. The sympathetic system is referred to as "flight or fight" system while parasympathetic is considered as "feed or breed" system.[1]

Access this article online	
Quick Response Code:	Website: www.ijcep.org
	DOI: 10.4103/2348-8093.149767

Physiological conditions such as age, sex, race, and environment affect the functions of ANS.[2] Majority of deaths in elderly occurs due to cardiovascular (CV) disorders, accounting for a 1/3rd of the elderly mortality, of which 50% are due to sudden death and lethal ventricular arrhythmias. Age-related autonomic dysfunction in the CV regulatory control is a contributing factor for the increased incidence of CV dysfunctions in the elderly.

In previous studies, CV reactivity has been found to be exaggerated in obesity, which is considered as a risk factor for hypertension.[3,4] However, these studies were conducted in adolescent only. No study has been conducted till date to assess the effect of gender and body mass index (BMI) on autonomic functions in young adult and middle-aged Indian population. Therefore, the present study aimed at assessing the influence of BMI on autonomic reactivity tests in males and females of these two different age groups.

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MATERIALS AND METHODS

This cross-sectional study was conducted from January 2012 to March 2013 after obtaining approval from the institute ethics committee and written informed consent from the participants. A total of 124 healthy volunteers within the age group 20–60 years were recruited for the study irrespective of their socioeconomic class. The subjects were divided into adult group aged 20–45 years (male = 32, female = 31), and the middle-aged group aged 46–80 years (male = 31, female = 30). Among the females included in the study, all were premenopausal in the adult group and postmenopausal in the middle-aged group. Subjects having major illness, addiction, diabetes mellitus, hypertension, and coronary artery disease were excluded from the study.

BMI was calculated using the formula: Weight in kg/ height in meter square. After 15 min of supine rest, their heart rate (HR) was recorded, and blood pressure was measured using a sphygmomanometer. The following autonomic reactivity tests[5] were performed.

Parasympathetic tests

Lead II electrocardiogram (ECG) was recorded using an electrocardiograph (BPL Cardiac Model No-JOC 21206) for estimating HR. Tracing speed for ECG recording used was 25 mm/s during normal quiet breathing for a period of 1 min.

Heart rate response to standing (30:15 ratio)

After a complete rest of 15 min, the ECG recording was done. The subject was instructed to stand erect from the supine position as quickly as possible (within 3 s) with continuous ECG recording for at least 1-min. The ratio of the longest R-R around 30th beat after standing to the shortest R-R interval around 15th beat after standing was calculated for obtaining 30:15 ratio.

Standing to lying ratio

Subjects were instructed to stand quietly for 2 min and then lie down without any support while a continuous ECG was recorded. Standing to lying ratio (S/L ratio) was calculated using the formula:

S/L ratio = Longest R-R interval during 5 beats before lying down/shortest R-R interval during 10 beats after lying down.

Deep breathing difference

After 5 min rest, the patient was instructed to take deep inspiration over 5 s and followed by expiration over next 5 s for 1-min. The difference of the HR between maximum in the inspiratory cycle and minimum in expiration cycle was calculated.

Deep breathing difference (DBD) = Maximum HR − minimum HR.

Sympathetic test

Cold pressure test

Resting blood pressure was recorded with the sphygmomanometer. The subject was then asked to immerse his or her hand in cold water with the temperature maintained at 2°C. Blood pressure measurements were made from the other arm at 30 s intervals for a period of 2 min. Maximum change in the diastolic blood pressure was recorded.

Statistical analysis of data

Analysis was done using SPSS version 20 (SPSS Software Inc., Chicago, United States). Values were recorded as mean and standard deviation. One-way analysis of variance and the Tukey–Kramer *post-hoc* comparison was done to determine statistically significant differences. Pearson's correlation coefficient was calculated between the independent variable (BMI) and the dependent variables (30:15 ratio, S/L ratio, DBD, and cold pressure test) to assess the effect of BMI on autonomic reactivity. The probability values (P value) <0.05 was considered statistically significant.

RESULTS

Younger males showed significantly high BMI than young females as depicted in Table 1. This difference in BMI disappeared in the middle-aged population [Tables 1 and 2]. Though there was no significant difference in SBP and DBP among the gropus, HR difference was significant (P=0.007). 30:15 ratio was not significant across the group. However, S/L ratio and DBD was significantly more in adult group compared to middle-aged group [Table 1]. There was no significant difference between males and females of middle-aged group [Table 2]. However, BMI, S/L ratio and ΔBP were more in males compared to females in adult group [Table 2].

There was positive correlation of BMI with sympathetic activity (rise in diastolic blood pressure) and negative correlation with parasympathetic activity (30:15 ratio, S/L ratio and DBD) in younger males in comparison to younger females assessed by Pearson's correlation [Table 3].

DISCUSSION

In the present study, adult males (aged 20–45 years) had greater BMI compared to adult females. Although, studies have reported higher BMI in females, in this present study population, BMI was found to be increased in males compared to females. Furthermore, in males BMI

Table 1: Age, BMI, HR, blood pressure and autonomic reactivity parameters in different groups expressed in Mean±SD

Parameters	Adult group		Middle-aged group		*P*
	Male (*n*=32)	Female (*n*=31)	Male (*n*=31)	Female (*n*=30)	
Age (years)	38.1±2.5	38±2.4	52.6±8.5	52.8±8.7	<0.0001
BMI (Kg/m^2)	24±2.2	20.9±2.3	22.8±4.0	22.9±3.0	0.008
HR (bpm)	76.2±5.3	78.1±5.8	80.1±5.8	80.8±5.7	0.007
SBP (mmHg)	128±4.8	126±6.4	127.4±16.6	127.4±15.9	NS
DBP (mmHg)	80.7±5.6	81.0±6.0	77.1±8.9	77.8±8.7	NS
Parasympathetic parameters					
30:15 ratio	1.13±0.06	1.11±0.01	1.1±0.9	1.1±0.6	
S/L ratio	1.41±0.1	1.30±0.1	1.2±0.1	1.2±0.13	<0.0001
DBD	28.9±4.1	25.3±4.6	13±8.6	12±4.8	<0.0001
Sympathetic parameters					
Cold pressure test					
∆BP	15.6±7.3	21.4±10.7	20.6±10.5	19.20±7.23	0.0305

BMI: Body mass index, HR: Heart rate, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, 30:15 ratio: Ratio of the longest R-R around 30th beat after standing to the shortest R-R interval around 15th beat after standing, S/L ratio: Standing to lying ratio, DBD: Deep breathing difference, ∆BP Rise in diastolic blood pressure, NS: Not significant. Statistical analysis was done by ANOVA. *P<0.05 was considered significant

Table 2: Multiple comparison (*post hoc*)

	Adult male vs female	Middle aged males vs females
Parameters		
Age (years)	NS	NS
BMI (Kg/m^2)	<0.001	NS
HR (bpm)	NS	NS
Parasympathetic parameters		
S/L ratio	<0.001	NS
DBD	NS	NS
Sympathetic parameters		
Cold pressure test		
∆BP	<0.05	NS

HR: Heart rate, S/L ratio: Standing to lying down ratio, DBD: Deep breathing difference, ∆BP: Rise in diastolic blood pressure. Statistical analysis was done by Post-hoc multiple comparison. *P<0.05 was considered significant

Table 3: Correlation of BMI with autonomic reactivity parameters among males and females subjects in different age groups

Parameters	Adult group (*r*)		Middle-aged group (*r*)	
	Male (*n*=31)	Female (*n*=32)	Male (*n*=31)	Female (*n*=30)
RR ratio	−0.592	−0.580	−0.50	−0.499
S/L ratio	−0.553	−0.530	−0.51	−0.50
DBD	0.794	0.704	0.690	0.680
Cold pressure test	0.49	0.38	0.50	0.54

Data are expressed as Mean±SD. Statistical analysis was done by Pearson's correlation. The level of significance depicted for BMI in relation to autonomic reactivity parameters. BMI: Body mass index, SD: Standard deviation, S/L ratio: Standing to lying down ratio, DBD: Deep breathing difference, RR: Relative risk

had a significant positive correlation with sympathetic reactivity and negative correlation with parasympathetic reactivity than the females of same age group [Table 3]. Lower BMI in females may be explained by the fact that female sex hormone estrogen increases HDL, decreases LDL and total cholesterol, thereby reduces the prevalence of obesity in premenopausal females.[6] Reports also suggest that estrogen induces endothelium-dependent vascular relaxation via the nitric oxide, prostacyclin, and hyperpolarization pathways. Furthermore, surface membrane estrogen receptors decrease intracellular free Ca^{2+} concentration and perhaps protein kinase C-dependent vascular smooth muscle contraction.[7,8] Thus, it is believed that the protective effects of estrogen on the CV system decreases the incidence of CV disease in premenopausal compared to postmenopausal women.

Our results also demonstrate younger females having positive correlation with parasympathetic activity. Premenopausal women had higher vagal, but lower sympathetic modulation of HR than the age-matched men had, whereas these gender-related autonomic differences disappeared in the elderly, which is in agreement with Liu *et al*.[9] There is no significant difference between middle-aged males and females, when parameters (resting pulse rate, blood pressure, 30:15 ratio, S/L ratio, DBD, cold pressure test and BMI) were compared across the groups. It may be due to the effect of estrogen on the vascular bed that disappears after menopause. This finding corroborates with the report of Weitz *et al*., that the activity of sympathetic nervous system shows gender specific differences with lower sympathetic nerve activity to the muscle vascular bed in women as compared with men, the difference that vanishes after menopause.[10] Higashi *et al*. showed that both menopause and hypertension are associated with endothelial dysfunction and could be the risk factors for coronary heart disease.[11] Studies have also observed that baroreceptor control of HR is altered during the regular menstrual cycle and estradiol appears to exert CV modulation of HR than the age-matched men did, whereas these gender-related autonomic difference disappears in the middle-aged group.[12,13]

The major finding is the increase in BMI in younger males, which could adversely influence the CV autonomic parameters during their adulthood (aged 20–45 years), but not in females that could be due the protective effects of estrogen. However, the gender difference in their autonomic and CV dysfunctions was not observed among middle-aged subjects, in this study. This could be due to both aging and declined estrogen, which are associated with autonomic alterations seen among postmenopausal women.

Limitations of the study

The sample size in the present study is moderate, especially the sample was drawn from one limited geographical area, which is inadequate for extrapolating the application of these findings to the general population. Also, we have not estimated male and female sex hormones to correlate the influence of gonadal hormones on autonomic reactivity and CV risks in both the genders. Therefore, future studies with larger sample size are warranted for detailed of assessment of BMI and gender on autonomic functions in different age groups.

CONCLUSION

Findings of the present study suggest that adult males have higher BMI and increase sympathetic reactivity and decrease parasympathetic reactivity than females of same age group. But in the middle-aged group, there is no significant difference in autonomic reactivity between sexes.

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How to cite this article: Nayak M, Ray N. Influence of gender and body mass index on autonomic reactivity in adults and middle-aged population. Int J Clin Exp Physiol 2014;1:303-6.

Source of Support: Nil, **Conflict of Interest:** Nil.