

Gender based alteration in autonomic activity in young adults

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Abstract

The autonomic nervous system is a division of peripheral nervous system that controls automated body functions like heart rate, blood pressure, digestion and metabolism. Women have been seen to have lower cardiovascular risk and this is believed to be because of the regulatory influence of oestrogen on autonomic nervous system. The current study was conducted on 326 healthy medical students, 163 each of both sexes, in age group of 19 to 25 years, divided into Group-1 (males) and Group-2 (females). The parameters recorded and tests used were pulse rate, standing to lying ratio, 30:15 ratio, valsalva ratio and expiratory-inspiratory ratio for assessment of parasympathetic activity and pulse rate, blood pressure, orthostasis, cold pressor test, mental arithmetic test and corrected QT interval for assessment of sympathetic activity. Our findings show that young adult females have lower parasympathetic activity as compared to males of the same age group, who have a higher sympathetic activity.

Keywords: Autonomic nervous system, Parasympathetic activity, Sympathetic activity.

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Introduction

Sympathetic and Parasympathetic innervations in the heart play a major role in the regulation of cardiac function. The existence of sensory nerve endings in the heart was first suggested in 1894⁽⁴⁾. The Autonomic Nervous System is a division of the peripheral nervous system that controls automated body functions including heart rate, blood pressure, digestion and metabolism. It maintains internal homeostasis of cardiovascular, thermoregulatory, gastrointestinal, genitourinary, exocrine and pupillary functions.

We are thrust into the world of smooth muscle, which is under control of the autonomic nervous system. This system is amazingly extensive and is involved in the function of virtually every organ system⁽²⁸⁾. Damage to autonomic nervous system may occur in a variety of systemic disorders, like Diabetes Mellitus, Brain Tumours, Parkinsonism, Cerebral Infarction, Spinal Cord Lesions etc. Disorders of the peripheral nervous system like Amyloidosis, Polyneuritis, Chronic Alcoholism etc. may also lead to autonomic insufficiency⁽³²⁾.

As discussed earlier our cardiovascular system is governed by autonomic nervous system. Since women have a lower cardiovascular risk, and most of such studies were targeted at higher age groups^(1,16). The

literature search revealed paucity of studies in young adults about gender differences in the autonomic nervous system control. So, the present study was conducted with the aim to elicit such a difference, if any.

Materials and Methods

The study was conducted in the healthy undergraduate medical students. A total of 326 subjects were taken, 163 each from either of the sexes, in the age group of 19-25 years. The subjects were divided in two Groups, Group 1 consisted of males and Group 2 of females. While selecting the subject's utmost care was taken that none of them suffered from any major neuropsychiatric disorder or any other illness known to affect the functioning of the autonomic nervous system. While selecting females, phase of the menstrual cycle was kept in mind as certain differences have been reported in the pre-menstrual and post-menstrual phases⁽³³⁾. Thus, the females selected for the study were in the post-menstrual (follicular) phase.

The tests were performed on BPL CARDIART-108T/MK-V1 ECG machine and Mercurial sphygmomanometer at a comfortable environmental temperature of 25-28 degree Celsius. The subjects were rested for half an hour and it was ensured that the last meal had been taken at least 6 hrs. before the test so as to provide the basal conditions as far as possible.

Recording of Physical Anthropometry

For each subject the following parameters were recorded.

1. Height (in cms.).
2. Weight (in kgs.).
3. Body Surface Area (in sq.cms.)

It was calculated in each subject by using Dubois Nomo gram.⁽¹⁷⁾

The various tests performed were:

Tests to assess functions of parasympathetic nervous system:

1. **Pulse Rate:** Each subject's pulse rate was measured manually by palpatory method. Pulse rate can be used for both parasympathetic and sympathetic reactivity as there is dual innervations (autonomic) of heart⁽¹⁴⁾.
2. **Standing to lying ratio (S:L Ratio):** Each subject was asked to stand quietly and then to lie down without any support, while a continuous ECG was recorded from 20 beats before to 60 beats after lying down⁽⁴⁰⁾.

S/L Ratio =

Longest R-R interval during 5 beats before lying down
Shortest R-R interval during 10 beats after lying down

3. **30:15 Ratio:** Each subject laid quietly for 3 min., then stood up and remained motionless while a continuous ECG was recorded^(12,13).

30:15 Ratio=

R-R interval at beat 30 after standing.

R-R interval at beat 15 after standing.

4. **Valsalva Ratio:** Each subject was made to perform the valsalva manoeuvre for 15 sec. by blowing against a closed glottis through a mouth piece which was attached to an aneroid manometer and maintained a pressure of 40 mm. Hg. for 15 sec. A continuous ECG was recorded 1 min. before the manoeuvre (resting period), during the manoeuvre (strain period) and 1 min. subsequent to the strain^(12,13,23).

Valsalva Ratio=

Longest R-R interval after the strain
Shortest R-R interval during the strain

5. **Expiratory: Inspiratory Ratio(E:I Ratio):** Each subject's baseline recording of ECG was done for 30 sec. The subjects were visually guided to breathe slowly and deeply at 6 cycles per min.^(19,31)

E:I Ratio=

Longest R-R interval during expiration.

Shortest R-R interval during inspiration.

Tests to assess functions of sympathetic nervous system:

1. **Pulse Rate:** Each subject's pulse rate was measured manually by palpatory method.
2. **Blood Pressure:** Each subject's blood pressure was measured by auscultatory method with mercurial sphygmomanometer.
3. **Orthostasis:** Resting blood pressure of each subject was recorded in supine position after 5 min. of rest. Subjects' were then asked to stand up and immediately on standing blood pressure was recorded. The postural fall in the blood pressure was the difference between the systolic blood

pressure in the lying and that in the standing position^(12,13).

4. **Cold Pressor Test:** In this test, resting blood pressure of each subject was recorded with the subject sitting comfortably. The subjects were then asked to immerse their hand in cold water and the temperature was maintained at 4-5 degree Celsius throughout the procedure. Blood pressure was recorded from the other arm at the end of 30 second and at the end of 60 sec. and then the subjects were made to remove their hand. Maximum increase or decrease in the systolic and diastolic blood pressures were determined and recorded as change from the basal values⁽²⁰⁾.
5. **Mental Arithmetic Test:** Subjects were made to rapidly solve some mathematical problems like subtracting a one-or two- digit number from a three- or four- digit number depending on the subject's skill level while the blood pressure was being recorded, change in systolic and diastolic blood pressure from the basal values were calculated and recorded^(5,27).
6. **Corrected QT Interval (QTc Interval):** Each subject's QT interval was measured from the ECG and then standardised by converting it to QTc interval. For this Bazette's formula was used^(25,47).

QTc Interval =

$$\frac{\text{QT interval}}{\text{R-R interval}}$$

R-R interval

QT interval, R-R interval and QTc interval were expressed in seconds.

Statistical Analysis: For each variable group of autonomic function tests performed in the study, mean and standard deviation of the results were calculated. To find any significant change between the two groups Student's paired 't' test with equal variances assumed was used and $p < 0.05$, $p < 0.001$ and $p > 0.05$ was considered significant, highly significant and not significant respectively.

Results

In the current study, number of subjects were same in both the groups. As depicted in Table 1 the mean values of age, height, weight and body surface areas were higher in Group 1 as compared to Group 2 and were statistically highly significant.

Table 1: Anthropometric data of the groups

Groups	Age(years)		Height(cm)		Weight(kg)		Body Surface Area(sq. mts)	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Boys	18.44	1.53	165.7	6.73	56.5	7.29	1.62	0.11
Girls	17.63	0.55	154.6	4.08	50.7	4.68	1.46	0.06
P-Value	<0.001		<0.001		<0.001		<0.001	
Significance	Highly Significant		Highly Significant		Highly Significant		Highly Significant	

On comparison of parasympathetic functions between the two groups as depicted in Table 2 the mean values of Valsalva Ratio, E:I Ratio, 30:15 Ratio and S:L Ratio were higher in Group 1 than in Group 2 and all these variables were highly significant($p < 0.001$). The mean value of Pulse Rate was higher in Group 1 than Group 2 but was not statistically significant($p > 0.05$).

Table 2: Comparison of parasympathetic functions of groups

S. No.	Parameter	Males		Females		P Value	Significance
		Mean	S.D.	Mean	S.D.		
1.	Pulse Rate (beats/min)	78.5	5.23	77.65	4.28	>0.05	Not Significant
2.	Valsalva Ratio	1.28	0.08	1.16	0.11	<0.001	Highly Significant
3.	E:I Ratio	1.28	0.08	1.20	0.12	<0.001	Highly Significant
4.	30:15 Ratio	1.06	0.04	1.01	0.05	<0.001	Highly Significant
5.	S:L Ratio	1.06	0.05	1.00	0.04	<0.001	Highly Significant

When we compared the sympathetic functions between the two groups as reflected in Table 3, the mean values of Systolic blood pressure, Systolic blood pressure after 30 and 60 secs. during Cold Pressor Test(CPT), Systolic blood pressure and Diastolic blood pressure during Mental Arithmetic Test were higher in Group 1 than in Group 2 and all these variables were highly significant statistically($p < 0.001$). The mean value of Diastolic blood pressure after 30 secs. was higher in Group 1 when compared with that of Group 2 and was not significant statistically($p > 0.05$). The mean value of Diastolic blood pressure was slightly higher in Group 2 than in Group 1 but was statistically not significant($p > 0.05$). Mean values of Systolic blood pressure during Orthostasis and Diastolic blood pressure after 60 secs. during CPT in Group 2 were higher than that of Group 1 and statistically were highly significant($p < 0.001$). The mean values of Pulse Rate was seen to be slightly higher in Group 1 than in Group 2 but failed to be statistically significant($p > 0.05$) while the mean value of QTc Interval was same in both the groups with no statistical difference($p > 0.05$).

Table 3: Comparison of sympathetic functions of groups

S. No.	Parameter	Males		Females		P- Value	Significance
		Mean	S.D.	Mean	S.D.		
1.	Pulse Rate(mm.Hg.)	78.5	5.23	77.65	4.28	>0.05	Not Significant
2.	B.P.(mm.Hg.)Systolic Diastolic	118.7	4.58	116.5	5.06	<0.001	Highly Significant
		74.6	4.54	74.9	4.21	>0.05	Not Significant
3.	Orthostasis Systolic (change in B.P. mm.Hg.)	4.63	2.36	8.42	3.84	<0.001	Highly Significant
4.	CPT(after 30secs)Systolic (change in B.P. mm.Hg.) Diastolic	17.7	4.5	14.6	4.39	<0.001	Highly Significant
		3.3	3.36	2.8	2.85	>0.05	Not Significant
5.	CPT(after 60secs)Systolic (change in B.P. mm.Hg.) Diastolic	21.8	5.73	19.3	3.87	<0.001	Highly Significant
		4.0	2.11	5.4	2.87	<0.001	Highly Significant
6.	Mental arithmetic test (change in) Systolic B.P. mm.Hg.)Diastolic	23.3	6.19	19.5	4.17	<0.001	Highly Significant
		3.6	2.06	2.7	2.18	<0.001	
7.	QTc Interval (secs.)	0.37	0.03	0.37	0.03	>0.05	Not Significant

Discussion

In the current study, changes were observed in most of the parameters of both parasympathetic as well as sympathetic function tests while comparing young adult males and females.

Results of our study that young adult females have lower parasympathetic functions concurred with the studies carried out by Storm *et al.*,⁽⁴³⁾ Cowan *et al.*,⁽⁷⁾ Ramaekes *et al.*,⁽³⁸⁾ Mehta *et al.*,⁽³²⁾ Gandhi *et al.*,⁽¹⁶⁾ Mehta *et al.*,⁽³³⁾ and Prasad *et al.*⁽³⁷⁾.

Mean values of systolic blood pressure during orthostasis and diastolic blood pressure during cold pressor test especially after 60 secs. in females were higher than that in males and being highly significant statistically.

Mean values of QTc interval was same in both the groups while that of pulse rate was higher in males with no statistical significance.

The results clearly indicate that sympathetic activity is higher in young adult males as compared to young adult females. These findings are in agreement with those reported by Cowen *et al.*,⁽⁷⁾ Gandhi and Singh⁽¹⁵⁾, Mehta and Kumar⁽¹⁾, Gandhi *et al.*,⁽¹⁶⁾. Age and sex related changes in some autonomic functions have also been reported by Chu-TS *et al.*⁽⁶⁾. A gradual decline in parasympathetic functions have been reported but in the elderly⁽⁸⁾. Prasad *et al.*,⁽³⁷⁾ also concluded that sympathetic activity was higher in females and parasympathetic activity was lower in females in a study conducted on 100 subjects. The authors⁽³⁷⁾ used only a single variable each to test for parasympathetic and sympathetic functions in comparison to five variables and six variables to test parasympathetic and sympathetic functions respectively in the current study. Mehta and Kumar⁽¹⁾ also reported that sex and age do have an influence on the autonomic functions.

Neumann and Schmid⁽³⁵⁾ reported results which were in contrast with the results of current study. Dharwadkar *et al.*,⁽⁹⁾ inferred in their study that there occurs a decrease in cardiovascular parasympathetic functions a decade earlier in females as compared to males. Some other authors^(15,16) have reported that the parasympathetic activity was lower in females while sympathetic activity was higher in males and that mainly the age and to a lesser extent gender were important factors affecting the autonomic nervous system activity. Some other studies have reported that men show greater sympathetic activity and higher responsiveness than women^(10,22). It has been demonstrated in normal women and men that there are gender related differences in the level of MSNA (muscle sympathetic nerve activity), its vascular effect and its baroreceptor reflex control with a lower central sympathetic output to the periphery in females than in males, brought about by a greater baroreceptor reflex inhibitory effect by arterial blood pressure.⁽²⁾ It has been reported that men have a predominance of sympathetic effects on the heart interval using analysis of the heart rate^(2,26,38,45) and

higher circulating catecholamines than women^(2,27,39). These findings have implications regarding lower cardiovascular events observed in females than in males. The female sex hormones have long been associated with a protective effect on the cardiovascular system. Increased levels of sympathetic nerve activity are also associated with increased risk of cardiovascular morbidity⁽³⁴⁾. In men, sympathetic nerve activity is typically elevated compared to women of the same age (although this is not always the case and may depend on the phase of the menstrual cycle)⁽¹⁷⁾.

Conclusion

Thus, from the above discussions and results from a relatively good enough sample, the authors conclude that young adult females show lower parasympathetic nervous system activity as compared to the males of the same age group. There may be some role of female sex hormones in autonomic modulation. The exact impact of the neuro-hormonal axis on the age-related changes in the autonomic nervous system remains to be elucidated.

Limitation

Estimation of gonadal hormones, catecholamines and correlation of their levels with autonomic variables would have provided better understanding of influence of hormones on gender differences in age-related changes in autonomic activity.

The authors recommend more such studies in future so that appropriate precautions and preventions can be designed to prevent the occurrence and devise treatment guidelines of diseases related to autonomic nervous system.

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