International Journal of Medical Research
&
Health Sciences

www.ijmrhs.com Volume 2 Issue 4 Oct-Dec Coden: IJMRHS Copyright @2013 ISSN: 2319-5886

Received: 14th July 2013 Revised: 12th Aug 2013 Accepted: 18th Aug 2013

Research article

GENDER DIFFERENCES IN AUTONOMIC FUNCTIONAL STATUS IN RESPONSE TO STRESS

Sahera Shabnam S[1], Gopathy Sridevi[2], *Prema Sembulingam3

[1]Student, final year, [2]Lecturer in the Department of Physiology, Sathyabama University Dental College and Hospital, Jeppiar Nagar, Rajiv Gandhi Salai, Chennai, Tamilnadu, India
[3]Professor of Physiology, Madha Medical College and Research Institute, Kuntrathur Main Road, Kovur, Thandalam near Porur, Chennai, Tamilnadu, India

***** Corresponding author email**:** prema_sembu@yahoo.com

ABSTRACT

Introduction: Men and women are similar in their cognitive appraisal of a stress. But their behavior is different when exposed to stress. As stress responses and cognitive abilities are closely associated with autonomic nervous system, an attempt had been made to evaluate the behavioral pattern of autonomic functional status in males and females under stressed conditions. M**ethodology:** 30 normal young male and female students (15 each) participated in this study. Systolic blood pressure (SBP), diastolic blood pressure (DBP), heart rate (HR) and heart rate variation (HRV) were recorded before and after postural change, Valsalva maneuver and cold exposure. **Results:** SBP and DBP decreased and HR increased after standing from lying posture ($p < 0.000$) in both the genders. But the changes were less in males than in females (SBP and HR – non significant, DBP $p < 0.008$,) 30:15 ratio was higher in males ($p < 0.001$) upon standing. After Valsalva maneuver, SBP decreased ($p < 0.05$) and DBP increased ($p < 0.000$) with a higher Valsalva ratio ($p < 0.002$) in females than in males. After exposure to cold, males showed more decrease in SBP and DBP and less increase in HR (non-significant) than females. **Discussion: R**esults reveal more sympathetic activity in males than in females when exposed to stress. This may be because of the altered baroreceptor mechanism, male-female type of fat distribution, difference in vascular bed resistance, influence of cortisol and hypothalamus-pituitary-adrenal axis. **Conclusion:** The fact that females have less tolerance to stress may help us in understanding the sex linked pathophysiology of cardiovascular diseases and developing a different approach in treating the similar cardiovascular disease in men and women.

Key words: Blood pressure, Heart rate, Heart rate variation, Postural change, Valsalva maneuver, Cold pressor test

INTRODUCTION

The World Health Organization (WHO) defines health as “A state of physical, mental and social wellbeing and not necessarily the absence of disease and infirmity”. The conventional definition of health normally fails to take care of “tension” or “stress”, the two universally recognized phenomena which are more prevailing in the developed countries, but by no means, absent elsewhere.

Stress of any kind induces physical and mental disturbances in an individual mainly because of its role in creating an imbalance between the demands of an environment and the capability of the individual to meet these demands. Sometimes it may end up with an anxiety-like state with the exaggerated response. The cognition of the stress and the physiological responses associated with stress are all believed to be integrated and interpreted in the autonomic nervous system (ANS)[1]. Among the two divisions of ANS, viz., Sympathetic division and the parasympathetic division, sympathetic division are concerned with “flight and fight” reactions which help an organism to cope up with emergency reactions with the expenditure of unusual bodily sources and parasympathetic division is concerned with the conservation of bodily sources.

Normally, the reciprocal inhibition between these two systems is responsible for the normal behavioral homeostasis in an individual[1] However, when exposed to a stressed situation, depending upon the type and intensity of the stress, a series of responses occur which are expressed in a slightly exaggerated pattern both physically and emotionally. It is generally believed and noticed that in a similar stress situation, the females react in a more pronounced manner, creating an anxiety-like state than the males.

Though But most of the studies were disproportionately based more on the males than on females. As a result, the processes involved in stress responses in females are less well understood. And, until the late 1990s, there was no scientific proof to show the sex differences in the autonomic functional status during stress. However, in the last decade, an avalanche of studies has come up to demonstrate such differences.

Leonard Sax had shown that exposure to stress modulates the autonomic functions in both males and females and parasympathetic nervous system (PNS) played a major role in females and sympathetic nervous system (SNS) played a major role in males in controlling autonomic responses [2]. According to Aimee Midei, females were capable of confronting the stress in a better way than males; he noticed that nonhuman female primates showed more substantial female preference under stress compared to males and their coping style is more emotion-focused than that of males[3] due to more involvement of SNS. Yet another report contradicted these statements with the suggestion that men and women responded identically to achievement-related stressor[4].

As the reported evidences reflect a lot of controversies, it is worthwhile to reinvade the field and re-search for the gender differences in autonomic functions in response to stress.

Objective: 1. To evaluate the autonomic functional status in normal subjects by using the cardiovascular parameters viz, BP, HR and HRV 2. To find out whether these parameters reflect any gender differences under various stressed situations

MATERIALS AND METHODS

30 normal young healthy students of both genders (15 in each gender) in the age group of 17 to 20 years participated in this study from Sathyabama Dental College and Hospital, Jeppiaar Nagar, Rajiv Gandhi Road, Chennai. All participants were non-exercisers, non-athletics and non-smokers. Those who were on medication for some reason or other and obese persons were excluded from this study. In females, recording was done in their pre-ovulatory period. The Institutional Ethical Committee had cleared the project. Written informed consent was obtained from all the participants after explaining the experimental procedure and making them fully aware of their role in the project. Simple bedside tests of autonomic functions based on the cardiovascular reflexes, postulated by Ewing and Clarke[5] and

adapted by Prema Sembulingam et al[6] were chosen for the present study.

The cardiovascular parameters recorded in the present study were blood pressure (BP) as systolic blood pressure (SBP) and diastolic blood pressure (DBP) to assess the sympathetic activity and heart rate (HR) and heart rate variation (HRV) to assess the parasympathetic activity. HRV was assessed in the form of 30:15 ratio and Valsalva ratio. These parameters were recorded under basal conditions and after various stressed conditions namely lying to standing posture, cold pressor test (CPT) and Valsalva maneuver (VM).

BP and HR were recorded by using fully automated BP apparatus (OMRON). HRV was assessed from Lead II Electrocardiogram (ECG) recorded in three channels Student Physiograph as 30:15 ratio in postural change and as a Valsalva ratio (VR) in Valsalva maneuver.

Procedure

1. Postural change: The subject was made to lie down in supine position. After five minutes of mental and physical rest, the basal BP and HR were recorded. Then, the subject was instructed to get up briskly and stand erect without any support and the three parameters were measured immediately after standing. Simultaneously, ECG was recorded continuously in lead II in the lying posture (10 waves), while getting up and after standing (60 waves). 30:15 ratios was calculated from the ECG as the longest R-R interval at around 30th beat divided by the shortest R-R interval at around 15th beat after standing.

2. **Valsalva maneuver**: After measuring the basal BP and HR in sitting posture, the subject was instructed to blow into the sphygmomanometer to raise the mercury column to about 40 mmHg[5, 6] and retain it at that level for 15 Sec. BP and HR were recorded immediately after 15 seconds' strain and an ECG was recorded continuously before (10 waves), during and after the strain (60 waves).

Valsalva ratio was calculated from the ECG as the ratio of the longest R-R interval after the maneuver to the shortest R-R interval during the maneuver.

3**. Cold pressor test:** CPT was performed as described by Hines and Brown[7] with a slight modification; ie., in the present study the test was performed in sitting posture whereas in the previous study, it was performed in supine posture. After recording the basal BP and HR, the subject was instructed to immerse the dominant hand up to the wrist joint in cold water with the temperature of 5^0 C for one minute. At the end of one minute, BP and HR were recorded from the other hand.

Statistical analysis: The data were analyzed in the computer by using Student't' test in SPSS Software (17th version). Values were expressed as mean ± SD and Significance was fixed at the level of $p < 0.05$.

RESULTS

Anthropometric parameters: There was no significant difference in the age and BMI between the males and females. But expectedly, the height and weight of the males were significantly more than those of females ($p < 0.002, 0.001$) (Table 1)

Effect of postural change on BP and HR in males and females: There was a highly significant decrease in SBP upon standing from lying posture ($p < 0.000$%) in both males and females and the decrease was less in males (-17.00 ± 11.15) than in females (-20.87 ± 11.29) though it was not statistically significant ($p < 0.168$) (Table 2)

DBP also showed highly significant decrease after standing from supine posture ($p < 0.000$) in both the groups (Table 2). Between the groups, the level of decrease was significantly less in males than in females ($p < 0.008$) (Table 2)

HR increased significantly after standing from a lying posture in both the groups ($p < 0.000$%) and the increase was less in males (16.87 ± 8.95) than in females (19.73 ± 8.21) but not significantly ($p < 0.354$) (Table 2).

Effect of Valsalva maneuver on BP and HR in males and females: SBP showed highly significant decrease ($p < 0.000$) after VM in males and females and the level of decrease was less in males than in females (p = < 0.052) (Table 3)

DBP showed different behaviour in both the groups. In males DBP decreased significantly ($p < 0.000$) and in females it increased significantly ($p < 0.000$). Between the groups, the level of increase in females was more than the level of decrease in males ($p < 0.002$). HR increased slightly in males without significance but in females HR showed highly significant decrease after VM ($p < 0.002$) (Table 3)

Effect of cold pressor test on BP and HR in males and females: SBP, DBP and HR showed highly significant decrease after CPT in both males and females (p < 0.000, 0.007 and 0.000 respectively) and there was no significant difference in the level of decrease (Table 4)

30:15 ratios: 30:15 ratio was more in males than in females and the difference was highly significant ($p < 0.001$) (Table 5).

Valsalva ratio: VR was more in females than in males and the difference was highly significant ($p < 0.002$) (Table 5).

Table 1: Comparison of anthropometric parameters between males and females

variables	Gender	Mean ± SD	Mean difference	P value
Age (years)	Male	18.73 ± 0.70	0.40 ± 0.91	0.111
	Female	18.33 ± 0.62		
Height (cm)	Male	176.00 ± 7.72	10.17 ± 10.12	0.002*
	Female	165.83 ± 8.44		
Weight (kg)	Male	69.07 ± 8.44	11.33 ± 10.11	0.001*
	Female	57.73 ± 5.15		
BMI	Male	22.37 ± 3.09	1.39 ± 3.31	0.127
	Female	20.98 ± 1.43		

Table 2: Effect and the difference in the effect of postural change on BP and HR in males and females

Posture Parameters	Gender	Lying	Standing	P value	Mean difference: Lying to standing	P Vlaue
SBP (mm HG)	Male	109.60 ±10.21	92.60 ± 7.60	0.000*	- 17.00 ± 11.15	0.168
	Female	92.27 ±9.39	71.40 ±6.28	0.000*	- 20.87 ± 11.29	
DBP (mm HG	Male	72.53 ±5.24	60.60 ± 5.15	0.000*	- 10.27 ± 5.08	0.008*
	Female	65.27 ±6.76	48.40 ±6.27	0.000*	- 16.87 ± 7.09	
HR (beats/min)	Male	76.80 ±7.10	93.67 ± 6.16	0.000*	16.87 ± 8.95	0.354
	Female	69.60 ±10.25	89.33 ±9.08	0.000*	19.73 ± 8.21	

Table 3: Effect and the difference in the effect of Valsalva maneuver on BP and HR in males & females

VM Parameters	Gender	Before VM	After VM	p value	Mean difference	p value
SBP (mm HG)	Male	109.53 ±8.65	91.40 ±7.89	0.000*	- 18.13 ± 14.67	0.05*
	Female	103.00 ±14.41	71.93 ±8.81	0.000*	- 31.07 ± 15.32	
DBP (mm HG	Male	69.47 ±7.11	51.07 ±8.01	0.000*	- 10.27 ± 5.08	0.000*
	Female	55.87 ±5.10	78.07 ±7.36	0.000*	- 16.87 ± 7.09	
HR (beats/min)	Male	84.60 ± 10.43	87.47 ±9.24	0.319	3.40 ± 11.09	0.002*
	Female	78.00 ± 8.41	63.27 ±5.54	0.000*	11.13 ± 14.28	

VM - Valsalva maneuver

Table 4: Effect and the differences in the effect of cold pressor test on BP and HR in males and females

CPT Parameters	Gender	Before CPT	After CPT	p value	Mean difference after CPT	p value
SBP (mm HG)	Male	110.13 ±10.21	82.80 ±8.82	0.000*	- 27.33 ± 12.92	0.878
	Female	96.53 ±8.54	69.80 ±6.38	0.000*	- 26.73 ± 15.32	
DBP (mm HG	Male	64.87 ±6.63	50.53 ±5.36	0.000*	- 14.33 ± 8.56	0.389
	Female	61.87 ±8.24	51.33 ±7.06	0.007*	- 10.53 ± 13.01	
HR (beats/min)	Male	76.87 ±7.96	54.73 ±8.11	0.000*	- 22.13 ± 10.63	0.640
	Female	94.27 ±12.04	69.87 ±5.91	0.000*	- 24.49 ±13.58	

CPT – Cold pressor test

Table 5: 30:15 ratio and Valsalva ratio in males and females

Parameter	Male	Female	Sig
30:15 ratio	1.52 ±0.24	1.26 ±0.16	0.001*
Valsalva ratio	2.06 ±0.51	2.35 ±0.44	0.002*

DISCUSSION

The results of the present study confirm the existence of gender difference in the functional status of ANS under basal conditions as well as stressed conditions. Males were found to have higher sympathetic activity than females which was revealed by the behavioral pattern of SBP, DBP, HR and 30:15 ratios in postural change and Valsalva maneuver (Table 2, 3, 4, 5). All these indicate that females have less tolerance to stress than the males. This correlates with the results of previous studies showing that women were significantly less capable of meeting the orthostatic challenges in maintaining BP than males[8, 9].

Various mechanisms were postulated for this gender difference in response to stress. Greater orthostatic intolerance in women was associated with less responsiveness of specific mechanisms of blood pressure regulation. Normally, BP is regulated by baroreflex mechanism and reninangiotensin mechanism through sympathetic nervous system (SNS)[10-12]. Immediately after standing from a lying position, blood pools in the legs, decreasing the venous return and cardiac output drastically. This leads to transient decrease in BP and increase in HR. These changes are attributed to cardiac vagal withdrawal leading to increased sympathetic activity[13]. The present study also shows that females demonstrated greater elevation in HR (non-significant) than the males (Table 2) upon standing from a lying position. Lack of statistical significance may be attributed to less number of subjects. Similar results were observed in other studies also[14, 15]. Leading to the hypothesis that vagal withdrawal may the more important mechanism than sympathetic activity in the regulation of BP in women [16, 17]. The results of the present study confirm those of previous investigations[18, 19] that women have significantly lower capacity to regulate blood pressure and maintain orthostatic function compared with men.

The greater 30:15 ratio in males in the present study also depicts a higher sympathetic activity in males (Table 5). According to Convertio, in males, the sympathetic discharge is more in lower limbs whereas in females it is more in upper limbs[17]. This may be the reason for greater 30:15 ratio in males than in females. Another school of thoughts postulates that these male-female differences in sympathetic activity are related to body fat distribution[17, 19]. Elevated sympathetic activity was found to be more common in 'male' type fat distribution than the female type fat distribution [11]. Frey and Hoffler found that in most of the vascular beds, males showed greater sympathetically mediated vasoconstriction than the females[16].

There are controversial statements regarding the effect of VM on BP and HR in the literature [13- 15]. Basically, VM initially creates a low intra-aortic pressure which stimulates the sympathetic nervous system. Following the release of the breath, a vagal response is triggered to decrease the heart rate. In the present study females showed highly significant decrease in DBP and HR and less significant decrease in SBP compared to that of males (Table 3) depicting a reduced sensitivity to baroreceptors during a VM[16]. This is further substantiated by the increased VR in females in our study.

When exposed to cold stress, SBP and DBP decreased both in males and females and the decrease was more in males than in females in the present study (non-significant) (Table 4). This result correlates with the results of the other studies[20,21]. The response to cold may be due to the stimulation of thermoreceptors leading to increased sympathetic activity and this is more pronounced in males than in females[20, 21]. The lack of statistical significance in our present study may be may be because of less number of subjects.

Rick Nauert further confirms the gender difference in the stress response. When exposed to stress, men develop "fight and flight" attitude through the hypothalamus-pituitary-adrenal (HPA) axis with elevated cortisol level and women adopts "tender and befriend" nature through activation of the limbic system-the higher center for emotions[22].

Vasan et al says that men and women differ in the size of the heart and blood vessels - men having larger size than the women of the same age and race. It comes as a surprise to know that men and women differ not only in the physiological aspects of stress management but also in their anatomical setup of organ sizes[23].

Admittedly, a number of subjects are less in the present study which may be the reason for lack of significance in a few places. But our results are substantiated by the previous documentations in the literature which encourages us to develop the study further in a different angle and prosper. The results may help us in designing sex-based diagnostic tools, understanding the sex linked pathophysiology of cardiovascular diseases and developing a different approach in treating the similar cardiovascular disease in men and women.

CONCLUSION

This study enlightens the growing evidence of the gender differences in the response to stress with the implication that females have less tolerance to stress than males. Understanding the differences in the physiological and emotional reactions to stress between boys and girls may help the parents and teachers to handle them more carefully and help them to develop positive coping strategies in life and challenge the stressors psychologically and psychosomatically and avoid unpleasant and unwanted incidents of suicides. Knowing the cause is the first step in preventing the consequences.

ACKNOWLEDGEMENT

This project is the "Student's research project" scheme of ICMR in the Year 2011, Ref.No: 2011-02610. We are thankful to ICMR for sponsoring our undergraduate project. Our thanks are due to Sathyabama University Dental College for permitting us to apply for the scheme and encouraging us to complete it successfully. Our thanks are due to our lab technician, Ms. Sunitha, for her valuable technical assistance.

REFERENCES

1. Martin B. Anxiety and neurotic disorders. John Wiley and Sons, Inc. New York. 1971; 21-34
2. Leonard Sax. Six Degrees of Separation. What Teachers Need to Know about the Emerging Science of Sex Differences? Educational Horizons Spring. 2006; 190-200
3. Aimee Midei. Gender Differences in Behavioral Responses to Stress. Fight or Flight vs Tend and Befriend. Molecular Psychiatry 2003;310-206-9
4. Ptacek JT, Dodge KL. Gender differences in coping with stress: when stressor and appraisals do not differ. Pers Soc Psychol B. 1994; 20: 421–30.
5. Ewing DJ and Clarke BF; Diagnosis and management of diabetic autonomic neuropathy.Br Med Journal. 1982; 285: 916-18
6. Prema Sembulingam, Sembulingam, Namasivayam.. Evaluation of autonomic status in generalized anxiety disorder patients. Biomedicine 2000; 20(2):109-121
7. Hines EA and Brown GE. The cold pressor test for measuring the reactibility of the blood pressure; Deta concerning 571 normal and hypertensive subjects. The American Heart Journal. 1936; 11 (1): 1-9
8. Frey MAB, and GW Hoffler. Association of sex and age with responses to lower-body negative pressure. J. Appl. Physiol. 1988; 65: 1752–56
9. Frey MAB, Mathes KL, Hoffler GW. Cardiovascular responses of women to lower body negative pressure. Aviat. Space Environ. Med. 1986;7: 531–38
10. Guyton and Hall. Text Book of Medical Physiology 12th Ed. Saunders ELSEVIER. Page 201
11. Ganong's Review of Medical Physiology, a LANGE medical book, 23rd Ed. Tata McGraw Hill Education Private Limited, Page 558
12. Sembulingam K, Prema Sembulingam. Essentials of Medical Physiology, 6th Ed, JAYPEE Brothers Medical Publishers (P) LTD. 2013; Chapter 103, Page 607-609
13. Ewing DJ, Hume I, Campbell I W, Murray A, Neilson JMM and Clarke BF. Autonomic mechanism in the initial heart response to standing. J Appl Physiol. 1980. 49: 809-814
14. Montgomery LD, PJ Kirk, PA Payne, RL Gerber, SD Newton, and BA Williams. Cardiovascular responses of men and women to lower body negative pressure. Aviat. Space Environ. Med. 1977;48: 138–45
15. White DD, Gotshall RW, and A Tucker. Women have lower tolerance to lower body

negative pressure than men. J. Appl. Physiol. 1996;80: 1138–43

16. Frey MAB, Hoffler GW. Association of sex and age with responses to lower-body negative pressure. J. Appl. Physiol. 1988;65:1752–56
17. Convertio VA. Gender differences in autonomic functions associated with blood pressure regulation. American Journal of Physiology: 1909;20:8
18. Hogan TR, Cubitt M, Ecken MK, and Davis JE. Effect of gender on orthostatic tolerance (Abstract). Med. Sci. Sports Exerc. 1995;27: S188
19. Jones PP, Snitker S, Skinner JS, Ravussin E. Gender differences in muscle sympathetic nerve activity: effect of body fat distribution. American Journal of Physiology.1996; 270 : 363-66.
20. Bartelink ML, de Wit A,Wollersheim H,Theeuwes A and Thien T. Skin vascular reactivity in healthy subjects: influence of hormonal status. Journal of Applied Physiology. 1993;74(2): 727-32
21. Bartelink ML, Wollersheim H, Leesmans E, de Boo T, Thien TA standardized finger cooling test for Reynaud's phenomenon: diagnostic value and sex differences. European Heart Journal. 1993;14:614-62.
22. Rick Nauert. Response to stress is gender specific. http://psychcentral.com/news/ 2007/ 11/20/respose-tstressis gender specific/ 1559. Source: University of Pennsylvania School of Medicine
23. Vasan RS, Larson MG, Levy D, Evans JC, Benjamin EJ. Distribution and categorization of echocardiographic measurements in relation to reference limits: The Framingham Heart Study. Formulation of a height- and sex-specific classification and its prospective validation. Circulation 1997;96: 1863–73