Research Article

Gender Based Comparison of Mean Arterial Pressure and Pulse Pressure after Stress Induction in Healthy Adults

Syed Shahmeer Raza[1], Attaullah Shah[1], Umema Zafar[2], Tooba Khan[3], Dur E Shehwar Ali[4,*], Farhan Ullah[5]

[1]*Department of Physiology, Gajju Khan Medical College/Bacha Khan Medical Complex, Swabi, Pakistan.*
[2]*Department of Physiology, Rehman Medical College, Peshawar, Pakistan.*
[3]*Department of Physiology, Khyber Medical College, Peshawar, Pakistan.*
[4]*Department of Physiology, Khyber College of Dentistry, Peshawar, Pakistan.*
[5]*Department of Acute Internal Medicine, Russells Hall Hospital, Dudley, England.*

Abstract: Background: Mean Arterial Pressure (MAP) and Pulse Pressure (PP) are both key parameters to diagnose and manage cardiovascular diseases and hypertension, a leading cause of mortality and morbidity globally. Men and women are physically different from each other.

Objective: Is to evaluate gender-based comparison of MAP and PP of healthy adults after stress induction.

Material and Methods: This cross-sectional study was designed and conducted in the Institute of Basic Medical Sciences (IBMS) at Khyber Medical University (KMU) from January 2022 to April 2022. A total of fifty-two participants including twenty-six males and twenty-six females were selected using convenience sampling. Sample size estimation was carried out using G*Power. Healthy adults between the age of 18-40 years were included in the study. Blood Pressure (BP) and Heart Rate (HR) were checked both before and after the stress induction. MAP and PP were calculated using the formulas obtained from the literature i.e., MAP = DP + 1/3 (PP) and PP = SBP-DBP.

Result: The mean age of males was 27.16 ± 4.28 years and that of females was 23.15 ± 2.86 years. Both pre and post stress comparison of mean difference between healthy adult males and females, revealed no significant difference between MAP (Post-Stress p=0.97 and Pre-Stress p=0.61), PP (Post-Stress p=0.18 and Pre-Stress p=0.05) and HR (Post-Stress p=0.11 and Pre-Stress p=0.57). Males had a higher PP than females in both pre and post stress phase. Females had a slightly higher MAP than males in the pre stress phase. In the post stress phase, MAP showed a positive correlation with HR and PP. While in the pre stress phase, all the variables (MAP, PP and HR) showed no correlation with each other.

Conclusion: MAP and PP show no significant difference between healthy adult males and females, after stress induction.

Keywords: Stress, Mean arterial pressure, Pulse pressure, Heart rate, Gender, Blood pressure.

INTRODUCTION

The Pulse Pressure (PP) is the difference of systolic minus diastolic BP i.e., the pressure exerted by the heart in the arterial tree per heartbeat. It is a key parameter to diagnose and manage cardiovascular diseases and hypertension. Various studies have reported the gender based differences in PP. Females were generally found to have higher PP values when compared to males [1, 2].

The Mean Arterial Pressure (MAP) is the estimate of mean pressure in the arterial vasculature during one cardiac cycle. It is a key parameter to diagnose and manage cardiovascular diseases and hypertension, a leading cause of mortality and morbidity globally. Gender-based differences in MAP have been reported in literature. Females were generally found to have lower MAP values when compared to males [3-7].

*Address correspondence to this author at the Department of Physiology, Khyber College of Dentistry, Peshawar, Pakistan.
Email: shehwar88@gmail.com

A thorough search of the literature reveals that the current evidence of the impact of gender-based differences in blood pressure indices of healthy adults after stress induction (exercise), remains poor. There is no published data on the gender-based comparison of MAP and PP in our study population. Increased sympathetic tone also occurs during exercise and in times of stress. These events increase both cardiac output and systemic vascular resistance thereby affecting MAP and PP [8, 9]. Hence, the measurement of both MAP and PP before and after stress via 6-Minute Walk Test (6-MWT) was taken into account in our study.

This study was planned to assess the effect of the stress induction i.e., 6MWT on Blood Pressure Indices (BPI) i.e., MAP and PP to asses the gender based differences between healthy adult males and females.

MATERIALS AND METHODS

This study was designed and conducted in the Institute of Basic Medical Sciences (IBMS) at Khyber Medical University from

January 2022 to April 2022, to assess the effect of the stress induction i.e., 6 minute walk test (6MWT) on BPI. A total of fifty-two participants including twenty-six males and twenty-six females were selected using convenience sampling. Sample size estimation was carried out using G*Power. Statistical test adopted was: difference between two independent means, test family was Paired Sample T test. A priori analysis was performed by keeping power at 95% (1-β) and 5% margin of error. Effect size was taken as 0.93. Allocation ratio was taken as 1. Sample size for group 1 was derived as 26 and group 2 was 26. Total sample size came out to be 52. Healthy adults between the age of 18 to 40 years both males and females were included in the study. The participants were enrolled from the varsity campus and constituted students, administrative staff and faculty fulfilling the inclusion criteria. Those with any cardiovascular or respiratory medical condition were excluded. Professional athletes and smokers were also excluded. Informed written consent was taken from all the study participants. Blood Pressure and Heart Rate were checked both before and after the stress induction. This was performed using the Omron M3 digital blood pressure monitor.

For the purpose of stress induction, an exercise based, simple and affective test called the Six-minute walk test (6MWT) was used. It is very safe and well established self-paced assessment tool to measure the capacity of exercise in an individual [10]. This test is carried out by making the participant/patient walk in straight laps, on a flat surface and as fast as possible.

The difference of systolic minus diastolic BP is defined as PP, it is the pressure exerted by the heart in the arterial tree per heartbeat. While MAP is the estimate of mean pressure in the arterial vasculature during one cardiac cycle. MAP and PP were calculated using the formulas: MAP = DP + 1/3 (PP) and PP = SBP-DBP [1, 4].

STATISTICAL ANALYSIS

All THE data was processed in SPSS version 26.0. for MacBook Pro. The statistical test applied was "Paired Sample T Test" and all the data both pre and post stress was organised in a tabulated form. Matrix scatter plot was obtained for the data to check for correlation between the variables.

RESULT

A total of fifty-two healthy young adults were included in this research. Twenty-six males and twenty-six females. The mean age of males was 27.16±4.28 and that of females was 23.15±2.86 years. The average height of males was 165.15±5.23 cm and females were 158.20±24 cm. Both the parameters were significantly different in both the genders, $p<0.01$.

Both pre and post stress comparison of mean difference between healthy adult males and females, was no significant difference between MAP (Post-Stress p=0.97 and Pre-Stress p=0.61), PP (Post-Stress p=0.18 and Pre-Stress p=0.05) and HR (Post-Stress p=0.11 and Pre-Stress p=0.57) (Tables **1**, **2**).

Table 1. Comparison of Blood Pressure Indices (MAP and PP) between Healthy Adult Males vs Females after Stress.

	Group Statistics (Post Stress)				
	Gender	**Mean± Std. Deviation**	**Mean Difference**	**Sig. (2-tailed)**	**95% CI of the Mean Difference**
Mean Arterial Pressure (MAP) DP + 1/3(PP)	Male	101.31±10.23	-0.12	0.97	-7.13, 6.88
	Female	101.18±11.4			
Pulse Pressure	Male	45.3±8.9	-3.72	0.18	-9.33, 1.88
	Female	41.6±8.9			
Heart Rate	Male	103.79±15.98	9.2	0.11	-2.38, 20.8
	Female	113±18.95			

Table 2. Comparison of Blood Pressure Indices (MAP and PP) between Healthy Adult Males vs Females before Stress.

	Group Statistics (Pre Stress)				
	Gender	**Mean± Std. Deviation**	**Mean Difference**	**Sig. (2-tailed)**	**95% CI of the Mean Difference**
Mean Arterial Pressure (MAP) DP + 1/3(PP)	Male	99.1±11.09	1.75	0.61	-5.15, 8.65
	Female	100.85±11.85			
Pulse Pressure	Male	40.24±6.63	-4.84	0.06	-10.05, 0.36
	Female	35.4±11.96			
Heart Rate	Male	89.85±13.03	-1.93	0.57	-8.86, 5.01
	Female	87.93±9.72			

Although the variables were statistically insignificant but upon comparison of the means, males had a higher PP than females in both pre and post stress phase. Post stress PP for males was 45.3±8.9 while for females it was 41.6±8.9 with a mean difference of -3.72 (p=0.18). While pre stress PP for Males was 40.24±6.63 mm Hg while for Females was 35.4±11.96 with a mean difference of -4.84 (p=0.06).

Females had a slightly higher MAP than males in the pre stress phase. HR was higher in males in comparison to females in the pre stress phase while in the post stress phase, HR was higher in females than males.

In the post stress phase, matrix scatter plot between variable shows that MAP is positively correlated to HR and PP. HR is negatively correlated to PP. While the pre stress matrix scatter plot showed that all the variables (MAP, PP and HR) had no correlation with each other (Figs. **1**, **2**).

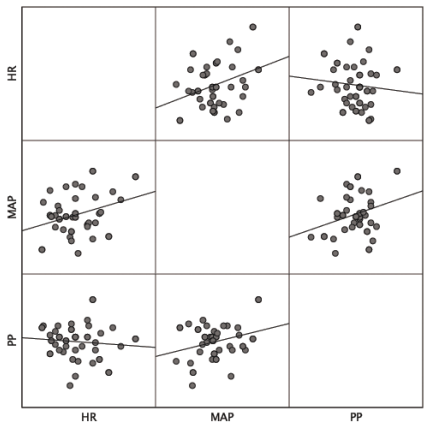

Fig. (1). Matrix Scatter Plot between Variables Post Stress Shows that MAP is Positively Correlated to HR and PP. HR is Negatively Correlated to PP.

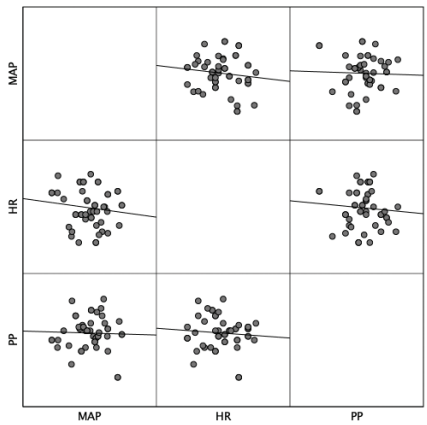

Fig. (2). Matrix Scatter Plot between Variables Pre Stress Show that All the Variables (MAP, PP and HR) Showed no Correlation with each other.

DISCUSSION

Although the variables were statistically insignificant but upon comparison of the means, males had a higher PP than females in both pre and post stress phase. These are in somewhat in corroboration to the already available evidence. It has been reported that females tend to have a lower PP than males in the early adulthood but increases as women age [11, 12]. This results in a raised PP in females in comparison to males at older ages. The findings highlight that the possible mechanisms behind the high PP in aging women differs from those in men. Estrogen is thought to protect women against hypertension and postmenopausal women don't have this protection [13]. However, a study carried out by Sakboonyarat *et al*. examined the PP in 62,113 active-duty Royal Thai Army personnel, reporting no statistically significant difference in PP between males and females. Males had a PP of 50.2 ± 11.1 mm Hg, while for females it was 49.3 ± 11.9 mm Hg and a p-value of 0.001 [14].

The pathophysiology behind the gender-based differences in PP isn't fully known. Several factors contribute to the difference. One such factor is arterial stiffness. This hardening of arteries is more prevalent in females [15]. It leads to quick pressure wave transmission from the heart into the peripheral arteries. Thus, resulting in raised PP [16]. Estrogen is another factor to have an effect on arterial hardening and may contribute to higher PP in women [17].

The results, although insignificant, reported a lower pre stress MAP for Males in comparison to Females. However, several studies have reported that females had lower MAP than males. Research conducted on Japanese population reported a statistically significant difference in MAP between males and females. Males had a MAP of 94.0 ± 6.6 mm Hg, while for females it was 91.8 ± 6.5 mm Hg and a p-value of 0.03 [18]. The gender-based difference in MAP has also been observed in young adults, with girls having lower MAP than boys [4].

The exact mechanism leading to gender-based differences in MAP isn't completely identified. Several factors contribute to the difference. One such factor is body size and composition. This smaller body size may lead to low cardiac output and BP [19]. Another factor is the vasodilatory effect of estrogen, resulting in low levels of MAP in females [20]. This gender-based difference in MAP has important clinical implications. The raised MAP in men may explain why men tend to have higher incidence cardiovascular diseases [21].

In conclusion, gender-based difference in blood pressure should be taken into account in the diagnosis and management of hypertension.

LIMITATIONS

Our study does have some limitations. Firstly, the grades of stress could have been defined and their effect on BPI studied. Secondly, a larger sample size with equal proportions of male and female participants would be better in studying gender differences. Lastly, it was a single centre study, which is another potential limitation to consider.

CONCLUSION

BPI i.e., MAP and PP show no significant difference between healthy adult males and females, after stress induction.

AUTHORS' CONTRIBUTION

- **Syed Shahmeer Raza**: Conceptualization of project, Statistical Analysis.
- **Attaullah Shah**: Data collection, Writing of manuscript.
- **Umema Zafar**: Literature search, Conceptualization of project.
- **Tooba Khan**: Statistical Analysis, Literature search.
- **Dur E Shehwar Ali**: Drafting, Revision, Writing of manuscript, Statistical Analysis.
- **Farhan Ullah**: Data collection, Writing of manuscript

CONFLICT OF INTEREST

Declared none.

ACKNOWLEDGEMENTS

Declared none.

REFERENCES

[1] Raza SS, Khan NW, Fida N, Zafar U, Ali DE, Shah A. Comparison of blood pressure indices (mean arterial pressure and pulse pressure) after induction of stress between post-COVID-19 and healthy adults. J Med Sci 2023; 31(4): 305-8. 10.52764/jms.23.31.4.10

[2] Safar ME, Asmar R, Benetos A, *et al*. Interaction between hypertension and arterial stiffness: an expert reappraisal. Hypertension 2018; 72(4): 796-805.

[3] Faulkner JL, Belin de Chantemèle EJ. Sex hormones, aging and cardiometabolic syndrome. Biol Sex Differ 2019; 10: 1-9.

[4] Flynn JT, Kaelber DC, Baker-Smith CM, *et al*. Clinical practice guideline for screening and management of high blood pressure in children and adolescents. Pediatrics 2017; 140(3): e20171904.

[5] Lorenzo C, Aung K, Stern MP, Haffner SM. Pulse pressure, prehypertension, and mortality: The San Antonio heart study. Am J Hypertens 2009; 22(11): 1219-26. doi: 10.1038/ajh.2009.151. Epub 2009 Aug 20. PMID: 19696747.

[6] Mitchell GF, Wang N, Palmisano JN, *et al*. Hemodynamic correlates of blood pressure across the adult age spectrum: Noninvasive evaluation in the Framingham Heart Study. Circulation 2010; 122(14): 1379-86.

[7] DeMers D, Wachs D. Physiology, Mean Arterial Pressure. Treasure Island (FL): StatPearls Publishing 2023.

[8] Unger T, Borghi C, Charchar F, *et al*. 2020 International Society of Hypertension global hypertension practice guidelines. Hypertension 2020; 75(6): 1334-57.

[9] Williams B, Mancia G, Spiering W, *et al*. 2018 ESC/ESH Guidelines for the management of arterial hypertension: The Task Force for the management of arterial hypertension of the European Society of Cardiology (ESC) and the European Society of Hypertension (ESH). Eur Heart J 2018; 39(33): 3021-104.

[10] ATS Committee on Proficiency Standards for Clinical Pulmonary Function Laboratories. ATS statement: Guidelines for the six-minute walk test. Am J Respir Crit Care Med 2002; 166: 111-7.

[11] Skurnick JH, Aladjem M, Aviv A. Sex differences in pulse pressure trends with age are cross-cultural. Hypertension 2010; 55(1): 40-7.

[12] Ji H, Kim A, Ebinger JE, *et al*. Sex differences in blood pressure trajectories over the life course. JAMA Cardiol 2020; 5(3): 255-62. doi:10.1001/jamacardio.2019.5306

[13] Doublier S, Lupia E, Catanuto P, J Elliot S. Estrogens and progression of diabetic kidney damage. Curr Diabetes Rev 2011; 7(1): 28-34.

[14] Sakboonyarat B, Poovieng J, Sangkool T, *et al*. Relationship between pulse pressure and body mass index in active-duty Royal Thai Army personnel in Thailand. BMC Cardiovasc Disord 2023; 23(1): 1-3.

[15] Zang J, Shi J, Liang J, *et al*. Pulse pressure, cognition, and white matter lesions: a mediation analysis. Front Cardiovasc Med 2021; 8: 654522.

[16] Thorin-Trescases N, de Montgolfier O, Pinçon A, Raignault A, Caland L, Labbé P, Thorin E. Impact of pulse pressure on cerebrovascular events leading to age-related cognitive decline. Am J Physiol-Heart Circ Physiol 2018; 314(6): H1214-24.

[17] Miller VM, Duckles SP. Vascular actions of estrogens: Functional implications. Pharmacol Rev 2008; 60(2): 210-41. doi: 10.1124/pr.107.08002. Epub 2008 Jun 25. PMID: 18579753; PMCID: PMC2637768.

[18] Kataoka H, Sawara Y, Kawachi K, Manabe S, Mochizuki T, Nitta K. Impacts of sex differences in pulse pressure among patients with chronic kidney disease. J Pers Med 2019; 9(4): 52. doi: 10.3390/jpm9040052. PMID: 31835400; PMCID: PMC6963663.

[19] Evans JM, Wang S, Greb C, *et al*. Body size predicts cardiac and vascular resistance effects on men's and women's blood pressure. Front Physiol 2017; 8: 561. doi: 10.3389/fphys.2017.00561. PMID: 28848448; PMCID: PMC5552717.

[20] Colafella KMM, Denton KM. Sex-specific differences in hypertension and associated cardiovascular disease. Nat Rev Nephrol 2018; 14(3): 185-201. doi: 10.1038/nrneph.2017.189. Epub 2018 Jan 30. PMID: 29380817.

[21] Shufelt CL, Pacheco C, Tweet MS, Miller VM. Sex-specific physiology and cardiovascular disease. Adv Exp Med Biol 2018; 1065: 433-54. doi: 10.1007/978-3-319-77932-4_27. PMID: 30051400; PMCID: PMC6768431.

Received: April 21, 2023 Revised: September 19, 2023 Accepted: September 28, 2023