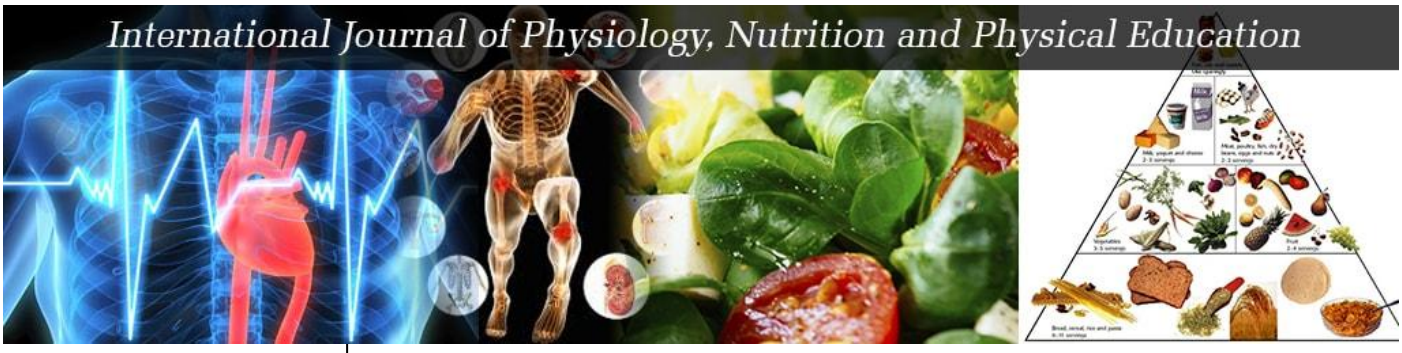

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Rucha Wagh
Department of Physiology, Rajiv Gandhi Medical College, Thane, Maharashtra, India

Srabani Bhattacharya
Department of Physiology, Rajiv Gandhi Medical College, Thane, Maharashtra, India

Aniruddha Malgaonkar
Department of Community Medicine, Rajiv Gandhi Medical College, Thane, Maharashtra, India

Sundaram Kartikeyan
Department of Community Medicine, Rajiv Gandhi Medical College, Thane, Maharashtra, India

Correspondence
Aniruddha Malgaonkar
Department of Community Medicine, Rajiv Gandhi Medical College, Thane, Maharashtra, India

Inter-arm and postural differences in blood pressure among healthy young adults

Rucha Wagh, Srabani Bhattacharya, Aniruddha Malgaonkar and Sundaram Kartikeyan

Abstract
This cross-sectional study was conducted on apparently healthy female (n=28) and male (n=34) young adults. Using identical pre-calibrated sphygmomanometers, the systolic and diastolic blood pressure was measured in both arms sequentially in supine, sitting, squatting, and standing positions after allowing a gap of at least five minutes between measurements in each posture. The gender-wise differences in inter-arm difference of systolic and diastolic blood pressure were not significant. However, in both sexes, between squatting and standing positions, the mean systolic and diastolic blood pressure was significantly higher. The present study draws attention to the shortcomings of taking a single blood pressure reading on only one arm. Inter-arm and postural differences in blood pressure may be suitable parameters to measure the status of the cardiovascular system. Measurement of blood pressure in the squatting position may be a potential tool for assessing regulation of blood pressure and for detecting latent hypertension.

Keywords: Blood pressure, inter-arm differences, posture

1. Introduction

In 1915, Sir William Osler first reported the inter-arm difference in blood pressure (BP). [1] The BP should be measured in both the arms at the first visit [2] because measurement in only one arm may lead to under-diagnosis of hypertension. [3,4] Simultaneous measurement of both arms is recommended since sequential measurement of BP overestimates the prevalence of systolic inter-arm difference. [5] Research studies have reported that the BP in the right arm is slightly higher. [4,6-10] A prospective study [11] from Indiana, USA found that the right and left arm should not be used interchangeably to record blood pressure and that BP readings should be taken on a pre-determined arm. A study [8] on 462 subjects reported that for systolic BP, the mean difference between the right and left arm was 1.1 mmHg while that for diastolic BP was 0 mmHg. Inter-arm difference of 10 mm Hg or more has been reported to be an independent prognostic marker in acute ischemic stroke, [12] while other researchers [13] found an association between inter-arm difference in systolic BP and a significant increased risk for future cardiovascular events. On the other hand, some researchers [14] have found that inter-arm difference in BP is frequent in young healthy individuals and is not associated with age, body mass index, and heart rate.

The difference between BP in the supine and sitting positions has been found to be associated with onset of systemic hypertension in later years. [15] Based on the observation of increased frequency of strokes in the early hours of the morning among users of Indian-style squatting toilets, a study [16, 17] from Kolkata, India reported that more than half of the haemorrhagic strokes occurred while the individuals were in squatting position. In normal healthy volunteers, squatting produced a small rise in systolic BP but not in diastolic BP. However, in hypertensives on treatment, squatting produced a significantly higher rise in both systolic BP and diastolic BP. [16, 17] Measurement of postural changes in BP may better differentiate persons at high risk of hypertension as compared to a single measurement of BP in sitting/supine position. [18]

The present study was carried out with the objective of determining postural and inter-arm differences in systolic and diastolic BP among young adults.

2. Materials and Methods

2.1 Study setting: This complete enumeration, cross-sectional, comparative study was conducted at Rajiv Gandhi Medical College, Kalwa, Thane, located about 30 kms from Mumbai, Maharashtra state, India. Each academic year, 60 students are admitted to the MBBS course at this college.

2.2 Inclusion criteria: All apparently healthy first-year MBBS students aged 18 years and above, of either sex, who gave written informed consent to participate in the study were included in the study.

2.3 Exclusion criteria: Those who were known hypertensives and those who did not give written informed consent were excluded.

2.4 Procedure: After obtaining permissions from the Institutional Ethics Committee (IEC) and institutional authorities for conducting the study, the purpose of the study was explained to first-year MBBS students and written informed consent was obtained from those willing to participate in the study. To preclude inter-observer and inter-instrument variations, the same set of researchers measured the systolic and diastolic BP in mm Hg using identical pre-calibrated sphygmomanometers (Diamond BPMR-120; Industrial Electronic and Allied Products, Pune-Satara Road, Pune, Maharashtra), in all participants. The systolic and diastolic BP was simultaneously measured in left and right arms in the following sequence of positions - supine, sitting, squatting, and standing - after allowing a gap of at least five minutes between BP measurements in each posture. Recommended procedure [19] was followed for BP measurement. The absolute value of the inter-arm difference (AVIAD) in BP was calculated.

2.5 Statistical Analysis: The data were entered in MS Excel (Microsoft Corporation, Redmond, WA, USA) and statistically analyzed using EpiInfo Version 7.0 (public domain software package from the Centers for Disease Control and Prevention, Atlanta, GA, USA). Categorical data were presented as percentages and continuous data as Mean and Standard Deviation (SD). The t-value was calculated using Student's t-test. Statistical significance was determined at $P<0.05$.

3. Results and Discussion

A total of 62 students (females: n=28; 45.16% and males: n=34; 54.84%) participated.

3.1 Gender-wise difference in inter-arm difference in BP:

The gender-wise differences in inter-arm difference (IAD) of systolic BP (taken in supine, sitting, squatting, and standing positions) were not statistically significant. (Table-1)

Table 1: Gender-wise mean IAD in systolic blood pressure (mm Hg)

Posture	Females (n=28)	Males (n=34)	t value	*P* value
	Mean ± SD	Mean ± SD		
Supine	2.71 ± 4.40	2.47 ± 4.05	0.223	0.824
Sitting	2.50 ± 3.83	3.35 ± 4.14	0.832	0.409
Squatting	1.36 ± 2.25	1.94 ± 3.09	0.828	0.411
Standing	4.29 ± 6.29	3.53 ± 5.89	0.490	0.626

IAD = Inter-arm difference; SD = Standard deviation

The gender-wise differences in mean IAD of diastolic BP (taken in supine, sitting, squatting, and standing positions) were also not statistically significant. (Table-2)

Table 2: Gender-wise mean IAD in diastolic blood pressure (mm Hg)

Posture	Females (n=28)	Males (n=34)	t value	*P* value
	Mean ± SD	Mean ± SD		
Supine	2.64 ± 4.22	2.41 ± 4.48	0.206	0.837
Sitting	2.64 ± 5.14	4.06 ± 5.01	1.098	0.277
Squatting	3.43 ± 5.07	1.94 ± 3.32	1.391	0.169
Standing	3.00 ± 4.41	2.59 ± 4.22	0.373	0.71

IAD = Inter-arm difference; SD = Standard deviation

Though some studies [20,21] have reported gender-wise differences in BP in the standing position, other studies [22,23] did not find gender differences.

3.2. Mean BP in either arm in various postures

In the present study, among females, the mean systolic BP taken on both arms was significantly higher between squatting-standing and supine-standing positions. (Table-3)

Table 3: Mean systolic BP (mm Hg) among females (n=28)

Arm	Posture			
	Supine	Sitting	Squatting	Standing
Left arm	113.64 ± 6.91	115.21 ± 7.67	122.93 ± 9.07	114.71 ± 7.43
t- values & *P*-values	Supine versus Sitting: t=0.805; *P*=0.424 Sitting versus Squatting: t=3.439; *P*=0.001 * Squatting versus Standing: t=3.710; *P*=0.0005 * Standing versus Supine: t=0.558; *P*=0.579.			
Right arm	114.86 ± 7.09	115.64 ± 6.78	122.86 ± 8.44	115.50 ± 7.54
t- values & *P*-values	Supine versus Sitting: t=0. 421; *P*=0.675 Sitting versus Squatting: t=3.529; *P*=0.0008 * Squatting versus Standing: t=3.441; *P*=0.001 * Standing versus Supine: t=0.579; *P*=0.754			

* Significant

The mean diastolic BP, on the right arm in females, was significantly higher (P=0.046) only between squatting-standing positions. (Table-4)

Table 4: Mean diastolic BP (mm Hg) among females (n=28)

Arm	Posture			
	Supine	**Sitting**	**Squatting**	**Standing**
Left arm	74.64 ± 6.01	77.64 ± 7.06	79.21 ± 7.29	76.93 ± 6.98
t- values & *P*-values	Supine versus Sitting: t=1.712; *P*=0.092 Sitting versus Squatting: t=0.819; *P*=0.416 Squatting versus Standing: t=1.195; *P*=0.237 Standing versus Supine: t=1.316; *P*=0.194			
Right arm	75.79 ± 7.02	76.50 ± 7.25	79.07 ± 6.36	75.50 ± 6.72
t- values & *P*-values	Supine versus Sitting: t=0.372; *P*=0.711 Sitting versus Squatting: t=1.410; *P*=0.164 Squatting versus Standing: t=2.042; *P*=0.046 * Standing versus Supine: t=0.158; *P*=0.875			

* Significant

Among males, the mean systolic BP, on both arms, was significantly higher only between squatting-standing positions. (Table-5)

Table 5: Mean systolic BP (mm Hg) among males (n=34)

Arm	Posture			
	Supine	**Sitting**	**Squatting**	**Standing**
Left arm	124.88 ± 10.52	126.53 ± 9.00	131.35 ± 7.90	124.71 ± 11.65
t- values & *P*-values	Supine versus Sitting: t=0.695; *P*=0.489 Sitting versus Squatting: t=1.373; *P*=0.174 Squatting versus Standing: t=2.322; *P*=0.039 * Standing versus Supine: t=0.063; *P*=0.95			
Right arm	123.94 ± 12.40	126.47 ± 9.97	132.12 ± 7.69	123.61 ± 11.99
t- values & *P*-values	Supine versus Sitting: t=0.927; *P*=0.357 Sitting versus Squatting: t=1.690; *P*=0.096 Squatting versus Standing: t=2.215; *P*=0.037 * Standing versus Supine: t=0.260; *P*=0.796			

* Significant

The mean diastolic BP in males, on both arms, was significantly higher only between squatting-standing positions. (Table-6)

Table 6: Mean diastolic BP (mm Hg) among males (n=34)

Arm	Posture			
	Supine	**Sitting**	**Squatting**	**Standing**
Left arm	79.41 ± 8.01	82.76 ± 7.35	84.65 ± 5.71	80.82 ± 7.85
t- values & *P*-values	Supine versus Sitting: t=1.797; *P*=0.077 Sitting versus Squatting: t=1.184; *P*=0.241 Squatting versus Standing: t=2.301; *P*=0.025 * Standing versus Supine: t=0.733; *P*=0.466			
Right arm	78.53 ± 7.21	80.82 ± 8.09	84.35 ± 6.39	81.81 ± 7.30
t- values & *P*-values	Supine versus Sitting: t=1.232; *P*=0.222 Sitting versus Squatting: t=1.828; *P*=0.061 Squatting versus Standing: t=2.467; *P*=0.028 * Standing versus Supine: t=1.637; *P*=0.106			

* Significant

During squatting, the intramuscular pressure in the lower limb and gluteal muscles compresses the blood vessels and restricts the flow of blood causing relative ischaemia. Consequently, locally-mediated vasodilatation occurs in the blood vessels within the lower limb and gluteal muscles. [24-26] On standing, there is sudden decrease in compression of the lower limb muscles along with reduction in vascular resistance in the blood vessels of the lower limbs due to the local vasodilatation that has occurred in the blood vessels within the muscles. [26, 27] Standing up from a squatting position entails substantial muscular effort. Studies [26, 28] have found that swift vasodilatory mechanisms act in accordance with the intensity of muscular effort. Thus, vasodilatation in the lower limb would be more when a person stands up from a squatting position, as compared to that when a person stands up from a supine or sitting position. Consequently, a large amount of arterial blood is shifted from the chest to the infra-diaphragmatic expandable venous capacitance system. [26] This results in decrease in BP when a person stands up from a squatting position.

4. Limitations

This cross-sectional study was carried out on apparently healthy young adults without any long-term follow-up. A long-term longitudinal study would be required on apparently healthy persons and known hypertensive patients in order to devise suitable interventions.

5. Conclusion

The present study draws attention to the shortcomings of taking a single BP reading. A significant inter-arm difference in BP may be a prospective marker that indicates the need for

further investigations. Measurement of BP in both arms should be a regular feature of follow-up of hypertensive patients. The postural changes in BP may be a suitable parameter in community-based studies to measure the reactivity of cardiovascular system to postural changes and thus as a potential marker. The squatting position may be employed as a tool to assess the effect of this posture on BP regulation and to detect latent hypertension.

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