

# A Comparative Study of Blood Pressure Recording from Conventional Mercury Sphygmomanometer to Recording from Aneroid and Digital Device in Healthy Volunteers

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## ABSTRACT

**Introduction:** Measurement of blood pressure accurately is of utmost importance in detection of hypertension and monitoring a wide range of clinical conditions. The use of mercury sphygmomanometer, which was considered gold standard is declining due to the environmental concerns. Since the use of non-mercury devices has increased, the accuracy of these devices needs to be ascertained. Hence, this study was conducted.

**Aims & Objectives:** To measure and compare the blood pressure recordings using mercury sphygmomanometer, aneroid and digital apparatus.

**Materials and Methods:** This cross-sectional study was conducted on 102 first year MBBS students of MMC & RI, Mysore, aged between 18 & 20 years, who voluntarily agreed. Blood Pressure was recorded using mercury manometer, followed by aneroid and then by digital apparatus giving 5 minutes interval between the recordings. The data was analyzed using appropriate statistical methods.

**Results:** The mean SBP by Mercury, aneroid and digital manometers was  $108.58 \pm 10.68$ ,  $107.11 \pm 12.41$  and  $116.5 \pm 13.54$  respectively. Mean DBP by Mercury, aneroid and digital manometers were  $71.84 \pm 7.44$ ,  $72.94 \pm 7.95$  and  $75.39 \pm 8.71$ , respectively. There was no statistically significant difference except with the DBP recordings of aneroid & digital apparatus, which had a 'p' value of .002.

**Conclusion:** The systolic and diastolic BP measured by these apparatus (mercury, aneroid & digital) are comparable and can be used interchangeably in practice.

**Keywords:** Aneroid manometer, Blood pressure, Digital manometer, Mercury sphygmomanometer.

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## INTRODUCTION

Measurement of blood pressure accurately is of utmost importance in detection of hypertension and monitoring a wide range of clinical conditions. A wrong measurement of blood pressure may result in inappropriate treatment. It's almost a decade since the Minamata Convention, an international treaty designed to protect human health and the environment from anthropogenic emissions and release of mercury compounds<sup>1</sup> (Minemata 2013) was approved by many nations, usage of mercury in health sector still continues in many developing countries. Mercury sphygmomanometers need to be phased out, not because of any technological advances but because of environmental concerns.<sup>2</sup> While mercury sphygmomanometer is still accepted as the 'gold standard' for routine clinical measurement, it always had two challenges to overcome - One poor observer technique, and another problem due to poor maintenance of the devices. The fact that mercury is a non-degradable pollutant, further raises the question on its usage. The use of mercury in sphygmomanometers is already in the process of being eliminated due to the danger it poses to the environment. Studies also suggest that mercury sphygmomanometers are not adequately maintained and require expertise that is not available for accurate measurement of blood pressure.<sup>3,4</sup> Their use should be discouraged on these grounds before a ban for other perhaps less justifiable reasons are argued out.

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Before complete ban of mercury manometers are stringently brought in, a viable reliable alternative need to be brought in place. Hence, the study was taken up to measure and compare the Blood Pressure (BP) recordings using different devices.

## MATERIALS AND METHODS

This is a cross sectional study conducted among the first year MBBS students of Mysore medical college and Research Institute. Ethical clearance was taken from the institutional ethics committee. About 102 students, aged between 18 to

21 years, who voluntarily agreed to be the part of the study was recruited after ruling out any co morbid conditions. Both male and female students formed the study group. Anthropometric measurements were recorded. After explaining the procedure, informed consent was obtained from all the participants of the study. Weight was measured in kilograms using standard weighing scale. Height in centimeters was measured using a non-stretchable tape fixed to a vertical wall, with the participant standing on a level surface without shoes. Blood pressure was recorded after allowing the student to rest for 5 minutes by conventional mercury manometer (Diamond mercurial BP apparatus), followed by aneroid (Diamond Dial Type BP monitor- BPDL 270) and digital (Omron Automatic BP Monitor HEM-7120) instruments giving 5 minutes interval between recordings. The Blood Pressure was recorded at specified time of the day to avoid changes due to diurnal variation.

**STATISTICAL METHODS**

Data was entered in Microsoft Excel and was analysed using descriptive statistics by mean and Standard Deviation (SD), inferential statistics was done by using paired t-test and Pearson correlation test. Bland Altman plot was used to graphically represent the mean difference between two measurements v/s mean of the two measurements (Figs. 1-4). All measurements were done by using SPSS 21.0 and  $p < 0.05$  was considered as statistically significant.

**RESULTS**

The study group had 102 participating students, 45 girls and 57 boys with a mean age of 18.3 years, as shown in the Table 1. For Statistical analysis, the recordings were paired into

six groups. Pair 1 compared systolic BP recorded using sphygmomanometer with systolic BP recorded using aneroid manometer. Pair 2 the recording compared Systolic BP from mercury manometer with digital recording. Pair 3 compared Systolic BP recorded from aneroid to digital instrument. Further Pair 4,5 and 6 compared diastolic BP similar to the comparison of systolic BP between mercury manometer, aneroid and digital devices in the first three groups, as shown in Table 2.

On analysis of paired groups, most pairs did not show statistically significant difference, except pair 6 which compared diastolic BP recordings of aneroid and digital devices, which had a p value of .002 (Table 3). Blood pressure

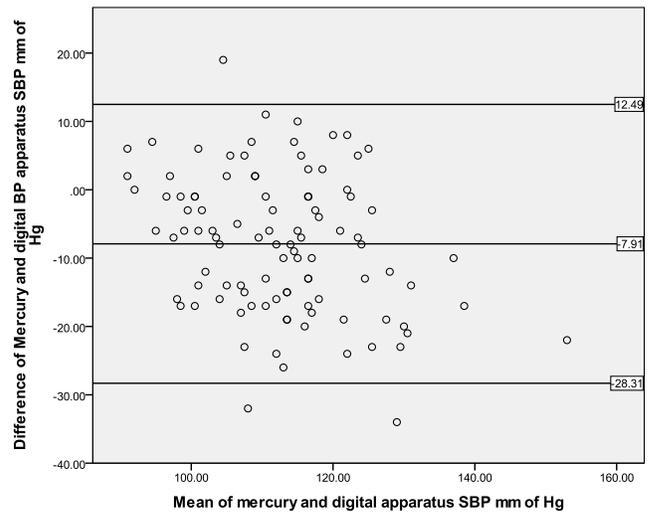


Fig. 2: Bland Altman plot comparing SBP of MSM and Digital Apparatus

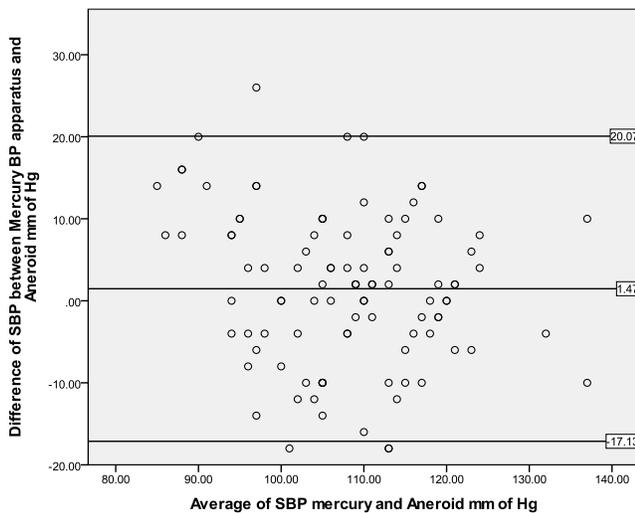


Fig. 1: Bland Altman plot comparing SBP of MSM and Aneroid Apparatus

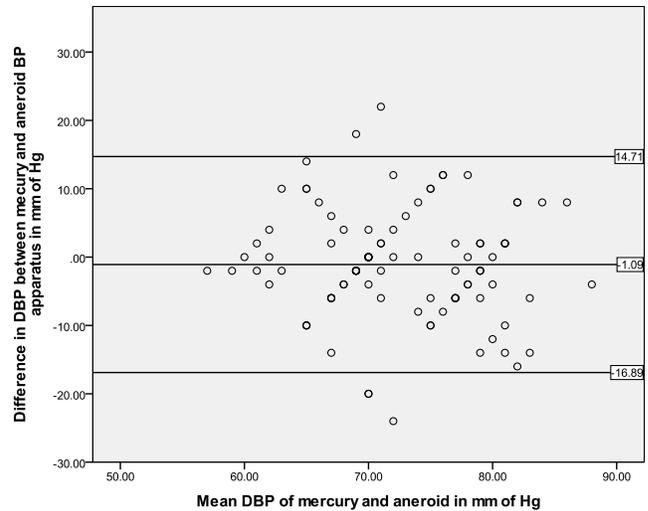


Fig. 3: Bland Altman plot comparing DBP of MSM and Aneroid Apparatus.

**Table 1:** Tgewise distribution of participants (in years)

	Mean	Median	Percentile 25	Percentile 75	Standard Deviation	Minimum	Maximum
Age	18.3	18.0	18.0	19.0	.6	17.0	20.0

recorded from Mercury manometer, Aneroid and Digital recording devices did not show any statistically significant differences.

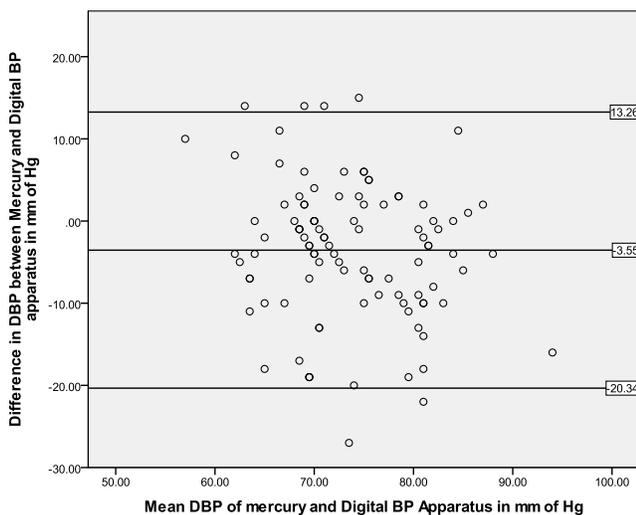


Fig. 4: Bland Altman plot comparing DBP of MSM and Digital Apparatus.

## DISCUSSION

Hypertension is a 'silent killer' that has long been recognized as one of the major risk factors for cardiovascular disease and premature deaths.<sup>5</sup> It's a growing problem globally and causes significant burden on the health system.<sup>6</sup> Recording of Blood pressure is the most important step in clinical examination, that gives an overview of cardiovascular homeostasis. It is said that BP measurement is the 'clinical procedure of greatest importance that is performed in the sloppiest manner.'<sup>7</sup> Accurate measurement of BP is crucial in treatment, as it reduces strokes, heart attack and heart failure. In most developing countries, blood pressure is measured by auscultation using a mercury sphygmomanometer, but in recent years it is replaced by automated and non-mercury devices due to environmental concerns. The two commonly used alternatives to mercury sphygmomanometers are aneroid and digital devices.<sup>8</sup>

In our study we chose healthy students of a single class with almost similar age as participants ensuring that no confounding factors were influencing the results. BP measurements by aneroid and digital devices were compared with standard properly calibrated mercury sphygmomanometer readings in normotensive healthy volunteers. This study demonstrated that there was no statistically significant difference in the

Table 2: Mean and standard deviation of systolic and diastolic bp measurements among different pairs (mm Hg)

		Mean	N	Standard Deviation	Standard Error Mean
Pair 1	MSM_SBP	108.588	102	10.6895	1.0584
	A_SBP	107.118	102	12.4107	1.2288
Pair 2	MSM_SBP	108.588	102	10.6895	1.0584
	D_SBP	116.500	102	13.5440	1.3411
Pair 3	A_SBP	107.118	102	12.4107	1.2288
	D_SBP	116.500	102	13.5440	1.3411
Pair 4	MSM_DBP	71.843	102	7.4445	.7371
	A_DBP	72.941	102	7.9539	.7875
Pair 5	MSM_DBP	71.843	102	7.4445	.7371
	D_DBP	75.392	102	8.7146	.8629
Pair 6	A_DBP	72.941	102	7.9539	.7875
	D_DBP	75.392	102	8.7146	.8629

MSM-Mercury Sphygmo Manometer, A-Aneroid ; D-Digital; SBP-Systolic Blood Pressure ; DBP-Diastolic Blood Pressure

Table 3: Comparison of differences in SBP and DBP among paired groups.

Paired Sample Test		Paired Differences						
		Mean	SD	95% CI of the Difference		t	df	P
				Lower	Upper			
Pair 1	MSM_SBP - A_SBP	1.47	9.3	-.3586	3.2998	1.595	101	.114
Pair 2	MSM_SBP - D_SBP	-7.91	10.2	-9.9278	-5.8957	-7.785	101	.000
Pair 3	A_SBP - D_SBP	-9.38	11.0	-11.5434	-7.2213	-8.612	101	.000
Pair 4	MSM_DBP - A_DBP	-1.09	7.9	-2.6651	.4691	-1.390	101	.168
Pair 5	MSM_DBP - D_DBP	-3.54	8.4	-5.2023	-1.8958	-4.258	101	.000
Pair 6	A_DBP - D_DBP	-2.45	7.7	-3.9703	-.9316	-3.200	101	.002

SBP and DBP measured by aneroid & digital apparatus when compared with mercury sphygmomanometer. However, the DBP readings between aneroid & digital apparatus showed significant difference.

There are many studies which compare the BP measurement by different apparatus. In children aged between 8 & 17 years, a study compared BP measurement with aneroid & mercury sphygmomanometers in 727 individuals participating in the National Health & Nutrition Examination Survey (NHANES), concluded that an accurate & well calibrated aneroid could be an acceptable alternative.<sup>9</sup>

A comparison of aneroid & mercury BP monitors among participants in SEARCH for Diabetes in Youth Study, found no difference between aneroid & mercury sphygmomanometer in mean SBP, while the DBP was slightly lower with aneroid monitor.<sup>10</sup>

In a study on nursing students, the amount of bias for mean SBP & DBP was clinically non significant and aneroid & LED manual were comparable.<sup>11</sup> Another study conducted on patients from tribal state of Jharkhand, concluded that automated BP machine had a fair degree of agreement with a manual BP device.<sup>12</sup>

Though another study showed significant differences between the mercury & aneroid measures & also between mercury & digital measures, variations were within the threshold set by Association for Advancement of Medical Instrumentation guidelines, with diastolic pressures lower than mercury measures.<sup>13</sup>

A study in a large London teaching hospital shows that, majority of the mercury sphygmomanometers and their associated cuffs and tubing, had serious problems which would give rise to major errors in blood pressure measurement. Further, the study points out that manometers are reliable only when properly maintained and serviced, and when used by knowledgeable health professionals.<sup>14</sup>

Mercury sphygmomanometer seems to have outlived their role in modern medicine.<sup>10</sup> Alternately, automated & validated devices like digital and aneroid instruments which are less liable to measurement and observer error need to be brought into clinical practice replacing mercury sphygmomanometers.

## CONCLUSION

With the inevitable scenario of phasing out mercury sphygmomanometers in clinical practice for various reasons, a reliable and low maintenance substitute is the need of the hour. With studies comparing the efficacy of conventional mercury-based apparatus to digital and aneroid alternatives, and proving that their readings are comparable to mercury ones, the process of phasing out of mercury manometer can happen with a robust and reliable alternative in aneroid & digital ones. The readings are comparable and can be used interchangeably in practice.

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