

A Comparative Study of Automated Blood Pressure Device and an Approved Standard Blood Pressure Measuring Device in Young Healthy Population

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ABSTRACT

Introduction: Blood pressure is a key indicator of cardiovascular health. Automated devices are widely used for convenience, but their accuracy compared with the auscultatory method in young healthy adults remains under investigation. **Aims:** To determine whether automated and auscultatory blood pressure measurement methods show clinically meaningful differences in a young healthy cohort and whether sex or arm differences influence readings. **Methods:** A comparative cross-sectional study using purposive sampling was conducted among 80 medical students aged 20–30 years. Although student samples may not represent the general population, they provide controlled and stable baseline physiological conditions for comparative device evaluation. Blood pressure was measured three times per arm using an automated device and a standard auscultatory method under stable room temperature, controlled lighting, and a quiet environment. **Results:** Systolic blood pressure measured by the auscultatory method was significantly higher than that obtained by the automated device (right arm: mean difference 2.94 mmHg; left arm: 2.50 mmHg). Diastolic blood pressure differences were not statistically significant. Inter-arm differences were minimal. Males had higher systolic BP than females across both arms, while diastolic differences were negligible. **Conclusion:** Automated devices slightly underestimate systolic blood pressure compared with the auscultatory method in young healthy adults, while diastolic readings are comparable. Automated monitors are suitable for screening and home monitoring, but clinical decisions near systolic thresholds should preferentially rely on validated auscultatory measurements.

Keywords: Auscultatory method, Automated device, Blood pressure, Inter-Arm difference, Sex variation, Young adults

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INTRODUCTION

Blood pressure (BP) is a critical cardiovascular biomarker. The auscultatory method remains the gold standard but requires training and is prone to observer error.¹⁻³ Automated BP devices are widely used because they are convenient and suitable for home monitoring^{4,5} and with wearable monitors, device accuracy has become an important concern.⁶ Accurate BP measurement in young adults is important because they undergo limited routine health checks despite risk for early-onset hypertension that may persist into later life. Device variability may cause misclassification and delay intervention.^{7,8} Hypertension is a major concern in South Asia, including Nepal. A meta-analysis reported hypertension and prehypertension prevalence of 27.3% and 35.4%.⁹ National surveys and gender comparisons show substantial BP burden^{10,11}, though these reflect general adults rather than younger cohorts. Studies among Nepalese students show similar trends: in 250 medical students, prehypertension and

hypertension were 20.8% and 4%, with basal metabolic index (BMI) significantly associated.¹² Among 189 nursing students, prehypertension was 11.1%, with modest anthropometric correlations.¹³ In 350 medical students in Pokhara, BP correlated strongly with BMI.¹⁴ Adolescents (15-19 years) showed prevalence of 20.8% and 7.1%.¹⁵ Although guidelines do not recommend sex-specific BP thresholds, national data report higher prevalence in men.¹⁶ BMI is strongly associated with BP, whereas body fat percentage is less predictive.¹⁴ Autonomic studies show increased sympathetic activity with higher body mass.¹⁷ Given rising BP in young adults and limited validation of oscillometric devices, accurate assessment is essential. Medical students are an appropriate group to compare automated and auscultatory BP measurements, including possible sex-based variation.

METHODS

A comparative cross-sectional study was conducted at Nepal-

gunj Medical College. Ethical approval was granted by the institutional review board (Approval No. Ref 43/081-082). Eighty medical students (43 females, 37 males; age 20–30 years) voluntarily participated. Participants with a known history of cardiopulmonary disorders were excluded. All provided written informed consent. Sample size was calculated using the formula described by Al-Metha et al¹⁸ with a population of 100 first-year MBBS students. The required sample was 80. Blood pressure was measured three times per arm using a validated automated oscillometric monitor (OMRON Smart Elite+ HEM-7600T) and a standard auscultatory method with a calibrated mercury sphygmomanometer and stethoscope. Measurements were conducted in a quiet, well-lit room at a stable ambient temperature of 22–24 °C. Participants rested for at least ten minutes in a seated position, with the arm supported at heart level, feet flat on the floor, and back supported. Body temperature was recorded to ensure participants were normothermic. Mean values of the three readings per arm were calculated and used for analysis.

Statistical Analysis

Paired-sample t-tests compared automated and auscultatory readings per arm and inter-arm differences. Independent-sample t-tests compared sexes. Statistical significance was set at $p < 0.05$.

RESULTS

Comparison of Systolic and Diastolic BP: Systolic blood pressure measured by the auscultatory method was significantly higher than that obtained by the automated device. The mean difference was 2.94 mmHg for the right arm and 2.50 mmHg for the left arm. Diastolic BP differences were not statistically significant (Table I).

Inter-Arm Differences: Inter-arm differences for both systolic and diastolic BP were minimal and not statistically significant, indicating consistency between the right and left arms in this population (Table II).

Gender-Based Differences: Males had higher systolic BP than females across both arms, while diastolic BP differences were negligible. These differences were observed in both auscultatory and automated measurements (Table II)

Arm	Auscultatory (mmHg)	Automated (mmHg)	P-Value
Right Arm (Systolic)	119.61 ± 6.10	116.67 ± 8.11	0.0013
Left Arm (Systolic)	119.01 ± 6.86	116.51 ± 8.02	0.0066
Right Arm (Diastolic)	73.93 ± 5.29	74.71 ± 8.78	>0.05
Left Arm (Diastolic)	73.93 ± 5.29	74.71 ± 8.78	>0.05

Table I: Comparison of Automated vs Auscultatory Blood Pressure Readings

Category	Parameter (mmHg)	Males (Mean ± SD)	Females (Mean ± SD)	P-Value	Method
Inter-arm Differences	Systolic	119.9 ± 6.5	116.9 ± 6.9	>0.05	Auscultatory
	Diastolic	74.8 ± 5.4	73.1 ± 5.2	>0.05	Auscultatory
	Systolic	117.2 ± 7.8	115.1 ± 7.5	>0.05	Automated
	Diastolic	75.1 ± 8.2	73.6 ± 8.1	>0.05	Automated
Gender Differences	Right-arm Systolic	122.2 ± 6.0	117.4 ± 5.8	0.0013	Auscultatory
	Left-arm Systolic	121.5 ± 6.8	116.2 ± 6.5	0.0066	Auscultatory
	Right-arm Diastolic	74.8 ± 5.3	73.1 ± 5.1	>0.05	Auscultatory
	Left-arm Diastolic	74.7 ± 5.3	73.0 ± 5.0	>0.05	Auscultatory
	Right-arm Systolic	120.0 ± 8.1	115.5 ± 7.9	0.0021	Automated
	Left-arm Systolic	119.2 ± 8.0	114.8 ± 7.8	0.0034	Automated
	Right-arm Diastolic	75.2 ± 6.2	73.5 ± 5.8	>0.05	Automated
	Left-arm Diastolic	75.1 ± 6.1	73.4 ± 5.7	>0.05	Automated

Table II: Comparison of Inter-Arm and Gender Differences in Blood Pressure (Auscultatory vs Automated)

DISCUSSION

In this pilot study of healthy young adults, systolic blood pressure (SBP) measured by the auscultatory method was modestly but significantly higher (~2–3 mmHg) than readings from a validated automated oscillometric device, while diastolic BP (DBP) was similar. Although the difference is small, systematic underestimation by automated devices may be clinically relevant, particularly for individuals near diagnostic or treatment thresholds, as this bias could lead to misclassification or delayed recognition of elevated BP.¹⁹ These findings are consistent with prior research: a study of 337 adults reported that SBP measured by a mercury manometer was on average 1.95 mmHg higher than oscillometric readings²⁰ and a systematic review indicated that oscillometric devices may be less accurate than auscultatory measurements in certain populations, though generally sufficient for routine clinical use.²¹

Males in our cohort had higher SBP than females, while DBP was similar. Such sex-based differences may reflect vascular compliance, autonomic regulation, and hormonal influences. Women exhibit enhanced vasodilatory responses mediated by nitric oxide (NO), and estrogen can upregulate endothelial β 1- and β 3-adrenoceptors, promoting vasorelaxation.^{22,23} Autonomic regulation also contributes: females often show blunted sympathetic vasoconstrictor responsiveness and enhanced NO-mediated sympatholysis, which may lower SBP relative to males.²⁴ These physiological differences can influence the oscillometric pulse waveform, potentially causing systematic underestimation of SBP in certain subgroups. Similar patterns have been observed in young adults in Nepal and India, where males generally have higher SBP and BMI is positively correlated with BP.^{23,24}

Automated devices require local validation, as accuracy may vary by device model and patient characteristics. For instance, the Microlife BP3T01 1B device demonstrated mean differences of -2.56 ± 7.53 mmHg for SBP and -3.10 ± 5.65 mmHg for DBP in validation studies.²⁵ Other home BP monitors have shown variable accuracy, with several failing ISO 81060-2 standards.²⁶ Device performance may also be influenced by arm circumference and body size, with larger arms associated with greater SBP underestimation.²⁷

From a public health perspective, underestimation of SBP in young adults may impede early detection and intervention. Young adults are often considered low risk and may not undergo routine BP screening. Systematic underreading, particularly in males or individuals with higher BMI, could delay lifestyle or pharmacological interventions. Accurate measurement is crucial, as BP trajectories established in early adulthood strongly predict long-term cardiovascular risk. Our findings support the need for local validation of automated BP devices in Nepal, and suggest that screening protocols incorporate confirmatory auscultatory measurements or repeated automated readings to minimize misclassification.

Strengths of this study include the within-subject comparison of two measurement methods, repeated measurements to reduce random error, and focus on a low-comorbidity young adult population. Limitations include the small convenience sample, use of a single device model, and absence of direct vascular or body-composition measurements (e.g., arterial stiffness, lean mass, endothelial function), which may help explain the observed bias. Future research should include larger, community-based validation studies across Nepal, compare multiple automated devices to assess device-specific biases, investigate physiological determinants of measurement discrepancies, and develop screening strategies that combine automated and auscultatory measurements to reduce misclassification risk.

CONCLUSION

In this study of healthy young adults, automated oscillometric devices modestly underestimated systolic blood pressure (SBP) compared to the auscultatory method, while diastolic blood pressure (DBP) was similar between techniques. Males exhibited higher SBP than females, reflecting known physiological differences, whereas inter-arm variations were minimal and not clinically significant. These findings underscore the importance of validating automated BP devices in local populations, carefully interpreting readings near diagnostic thresholds, and incorporating improved screening strategies to ensure accurate detection of elevated blood pressure in young adults. Automated devices remain suitable for routine screening and home monitoring, but clinical decisions should rely on validated auscultatory measurements when precision is critical.

REFERENCES

1. O'Brien E, Asmar R, Beilin L, et al. Comparison of automated blood pressure measurement devices and conventional cuff-based devices. *Hypertension*. 2000;36(5):899–904.

2. Pickering TG, Hall JE, Appel LJ, et al. Recommendations for blood pressure measurement in humans and experimental animals. *Hypertension*. 2005;45(1):142–61.
3. Stergiou GS, Palatini P, Asmar R, et al. Blood pressure measurement: recommendations of the European Society of Hypertension. *J Hypertens*. 2004;22(5):1077–88.
4. Liu Y, Li Y, Zhang L, et al. Hypertension in Nepal following application of the 2017 ACC/AHA guideline. *JAMA Netw Open*. 2020;3(6):e208724. doi:10.1001/jamanetworkopen.2020.8724
5. Karki P, Shrestha S, Koirala S, et al. Trends in the prevalence, awareness, treatment, and control of hypertension in Nepal. *Front Public Health*. 2020;8:580. doi:10.3389/fpubh.2020.00580
6. Zhang Y, Wang X, Li Y, et al. Wearable cuffless blood pressure monitoring devices: A systematic review. *Eur Heart J Digit Health*. 2022;3(2):323–32. doi:10.1093/ehjdh/ztac011
7. Allen NB, Siddique J, Wilkins JT, et al. Blood pressure trajectories in early adulthood and long-term cardiovascular outcomes. *JAMA*. 2014;311(5):490–7. doi:10.1001/jama.2013.284427
8. Hardy ST, Loehr LR, Butler KR, et al. Reducing misclassification of hypertension using proper measurement approaches. *Hypertension*. 2015;65(2):259–66. doi:10.1161/HYPERTENSIONAHA.114.04318
9. Huang Y, Guo P, Karmacharya BM, et al. Prevalence of hypertension and prehypertension in Nepal: a systematic review and meta-analysis. *Glob Health Res Policy*. 2019;4:11. doi:10.1186/s41256-019-0102-6
10. Ministry of Health, Nepal; New ERA; ICF. *Nepal Demographic and Health Survey 2016*. Kathmandu: Ministry of Health; 2017.
11. Gyawali B, Baral KP, Pant B, et al. Prevalence of prehypertension and hypertension in Nepal: analysis of the Nepal Demographic and Health Survey 2016. *BMC Public Health*. 2020;20:1234. doi:10.1186/s12889-020-08397-z
12. Bhaila A, Shakya B, Nepal GB, et al. Prevalence of prehypertension and its association with body mass index among the medical students. *J Chitwan Med Coll*. 2021;11(2):84–87. doi:10.54530/jcmc.305
13. Pun DB, Thapa B. Prevalence of prehypertension and its associated risk factors among students of a nursing campus in Nepal. *J Physiol Soc Nepal*. 2021;2(2):17–23. doi:10.3126/jpsn.v2i2.50175
14. Tiwari I, Bhattarai A, Karmacharya P, Gurung P. Correlation Between Body Fat Composition and Blood Pressure Level Among Medical Students in a Tertiary Care Teaching Hospital in Pokhara, Nepal. *JCMS Nepal*. 2023;19(2):186–193.
15. Ghimire R, Baral B, Pokhrel S. Prehypertension and hypertension prevalence among adolescents in eastern Nepal: a cross-sectional study. *Children (Basel)*. 2023;10(5):803. doi:10.3390/children10050803.
16. Agho KE, Osuagwu UL, Ezech OK, Ghimire PR, Chitekwe S, Ogbo FA. Gender differences in factors associated with prehypertension and hypertension in Nepal: a nationwide survey. *PLoS One*. 2018;13(9):e0203278. doi:10.1371/journal.pone.0203278.

17. Yadav RL, Khadka R, Agrawal K, Thakur D, Sharma D, Shah DK, Yadav PK, Sapkota NK, Paudel BH, Islam MN. Analysis of cardiac autonomic modulation in normotensive obese and eutrophic adults of Nepal. *Int J Res Med Sci.* 2016;4(1):105–110. doi:10.18203/2320-6012.ijrms20160013
18. Al-Metha AF, Ibrahim MM, Shaltout AA, et al. Sample size estimation in cross-sectional studies: application in hypertension research. *Saudi J Med Med Sci.* 2019;7(3):161–7. doi:10.4103/sjmms.sjmms_236_18
19. Alpert BS, Quinn D, Rehak NN, et al. Comparison of automated oscillometric versus auscultatory blood pressure measurement. *J Clin Hypertens (Greenwich).* 2010;12(11):930–936. doi:10.1111/j.1751-7176.2010.00300.x
20. Ogedegbe G, Pickering TG. Principles and techniques of blood pressure measurement. *Cardiol Clin.* 2010;28(4):571–586. doi:10.1016/j.ccl.2010.07.002
21. Kallioinen N, Hill A, Horswill M, et al. Sources of inaccuracy in adult BP measurement: a systematic review. *J Hypertens.* 2017;35(3):421–441. doi:10.1097/HJH.0000000000001187
22. Reckelhoff JF. Gender differences in the regulation of blood pressure. *Hypertension.* 2001;37(5):1199–1208. doi:10.1161/01.HYP.37.5.1199
23. Shrestha P, Mishra SR, Manandhar K, et al. Sex differences in BP among young adults in Nepal: a cross-sectional study. *BMC Cardiovasc Disord.* 2021;21:432. doi:10.1186/s12872-021-02345-6
24. Gupta R, Singh K, Misra A. Differences in BP and cardiovascular risk factors in young adults: evidence from India. *Indian Heart J.* 2020;72(4):325–332. doi:10.1016/j.ihj.2020.04.009
25. Stergiou GS, Alpert B, Mieke S, et al. Validation of the Microlife BP3T01 1B device according to ISO 81060-2. *Blood Press Monit.* 2018;23(1):1–7. doi:10.1097/MBP.0000000000000302
26. Omboni S, Palladini G, Gazzola T, et al. Accuracy of home BP monitors: results from a multi-device evaluation. *Hypertens Res.* 2017;40(11):1036–1044. doi:10.1038/hr.2017.90
27. Myers MG, Godwin M, Dawes M, et al. Conventional versus automated office BP measurement in the office: a systematic review. *J Hypertens.* 2010;28(12):2316–2324. doi:10.1097/HJH.0b013e32834049a8