

Original Paper

A Comparison of Blood Pressure Data Obtained From Wearable, Ambulatory, and Home Blood Pressure Monitoring Devices: Prospective Validation Study

Sheikh Mohammed Shariful Islam, MBBS, MPH, PhD, FESC; Ralph Maddison, PhD

Institute for Physical Activity and Nutrition, Deakin University, Melbourne, Australia

Corresponding Author:

Sheikh Mohammed Shariful Islam, MBBS, MPH, PhD, FESC

Institute for Physical Activity and Nutrition

Deakin University

221 Burwood Highway

Burwood

Melbourne, 3125

Australia

Phone: 61 451733373

Email: shariful@deakin.edu.au

Abstract

Background: Blood pressure (BP) is an important marker for cardiovascular health. However, a person's BP data cannot usually be obtained simultaneously from different sources.

Objective: This study aimed to analyze and compare BP data obtained from 3 different sources, namely, wearable, ambulatory, and home BP monitoring devices.

Methods: During recruitment, we recorded participants' BP using a standardized digital BP monitoring device and simultaneously over 24 hours using wearable and ambulatory devices. In addition, participants' BP was measured over 7 days using wearable and home BP monitoring devices. Data from the wearable BP monitoring devices were extracted. The 24-hour ambulatory BP data were downloaded from the device to a computer. Home BPs were recorded 3 times per day (in the morning, afternoon, and evening, at regular times convenient to the participants) for 7 days and on a BP sheet.

Results: A total of 9090 BP measurements were collected from 20 healthy volunteer participants (females: n=10; males: n=10, mean age 20.3 years, SD 5.4 years). The mean (SD) systolic BP and diastolic BP values measured at enrollment were 112.35 (9.79) mm Hg and 73.75 (9.14) mm Hg, respectively. The 24-hour mean (SD) systolic BP and diastolic BP values measured using the wearable device were 125 (5) mm Hg and 77 (9) mm Hg, respectively. The 24-hour mean (SD) systolic BP and diastolic BP values recorded using the ambulatory device were 126 (10) mm Hg and 75 (6) mm Hg, respectively. The 7-day mean (SD) systolic BP and diastolic BP values measured using the wearable device were 125 (4) mm Hg and 77 (3) mm Hg, respectively. The 7-day mean (SD) systolic BP and diastolic BP values measured using the home device were 112 (10) mm Hg and 71 (8) mm Hg, respectively.

Conclusions: Our datasets serve as the basis for further studies where these data can be combined reasonably with data from similar studies to understand the impact of different devices on BP measurement. Moreover, the BP data acquired noninvasively from wearable, ambulatory, and home devices can be integrated with similar data from other studies to determine the utility of wearable BP monitoring devices in different groups of people.

(*JMIR Data* 2020;1(1):e22436) doi: [10.2196/22436](https://doi.org/10.2196/22436)

KEYWORDS

wearable devices; mobile phones; blood pressure; ambulatory blood pressure monitoring; home blood pressure devices

Introduction

High blood pressure (BP) is a major risk factor for cardiovascular diseases globally and leads to increased morbidity

and mortality [1-5]. However, a large number of people with high BP remain undetected and untreated [6,7]. Accurate BP measurement is essential for the diagnosis and management of hypertension [8]. Clinical BP measurements by health care

professionals may be inaccurate due to measurement bias and white coat hypertension, and these BP measurements can only provide BP readings at one point in time [9]. Several guidelines have suggested the use of home blood pressure monitoring (HBPM), but HBPM cannot measure nighttime BP, which has etiological importance [10]. Ambulatory blood pressure monitoring (ABPM) devices can measure the average 24-hour BP, but these are costly and not user-friendly [11].

In recent years, several cuffless wearable BP monitoring devices have been developed, which are unobtrusive, overcoming the barriers of other BP measurement techniques and offering the possibility to provide continuous measurements [12-15]. These wearable devices have the potential to estimate long-term average BP and nighttime BP, which is used to monitor adherence to BP-lowering therapy and BP control [16]. However, none of these devices have been approved as an alternative to standard sphygmomanometers or claimed comparable validity. Therefore, wearable devices' use for clinical purposes has not been established.

A number of studies have reported validation of wearable cuffless BP devices and smartphone sensors against cuff-based BP measurements [15,17,18]. However, most of these studies were conducted in laboratory and nonambulatory settings and provided little information on how these devices might work in a free-living environment. Therefore, in this study, we collected BP data using standard clinical BP at baseline, 24-hour BP using wearable and ambulatory devices, and 7-day BP using wearable BP monitoring and HBPM devices. The primary objective of this research was to validate the wearable device against an ABPM device. The secondary objective was to compare the mean 7-day wearable and home BP data. This dataset could be used to evaluate wearable BP monitoring devices and gain insights into the impact of different devices on measurement of BP. Furthermore, these data can be combined with BP data from similar devices for a meta-analysis to better understand the validity of wearable BP monitoring devices.

Methods

We conducted a prospective study to validate a wearable BP monitoring device against 24-hour data from ABPM and HBPM devices. A total of 20 healthy adult participants were recruited from Melbourne, Australia, using convenient sampling. As per the inclusion criteria, the study participants were adults (aged ≥ 18 years) with normal BP ($<140/90$ mm Hg) who were willing to wear an ambulatory device for 24 hours, a wearable device for 7 days, and record home BP 3 times per day for 7 days. Persons with high BP ($>140/90$ mm Hg), severe health conditions, and limited mobility and persons taking BP

medication were excluded. The study was conducted from October 2017 to April 2018.

Participants were provided a wearable BP monitoring device (Tmart Technologies) and an HBPM device (Omron HEM1, Omron Corp) to use for 7 days along with a 24-hour ABPM device for 1 day. Clinical BP was measured using an automated BP device (Omron Corp) at the time of enrolment. We recorded 3 clinical BP readings. The first reading was discarded, and the mean of the remaining 2 readings was calculated. Data from the wearable BP monitoring device were extracted, and 24-hour ambulatory BP data were downloaded from the device to a computer. Measurements of Home BP were taken 3 times per day (in the morning, afternoon, and evening at regular times convenient to the participants) for 7 days and were recorded on a BP sheet.

A research assistant was trained in data collection procedures and device operation for 1 week at Deakin University. Participants' demographic, anthropometric, and clinical data (including age, gender, education, marital status, occupation, income, weight, height, systolic and diastolic BP, pulse rate, waist and hip circumference, and race/ethnicity) were collected using a standardized questionnaire. Data on self-reported comorbidities, physical activity, diet, and medication use were collected.

Data were analyzed using MATLAB 2017a software and reported as mean, standard deviation, and range. We compared the measurements recorded by wearable BP monitoring device against the corresponding reference ambulatory and home measurements (eg, W1 vs R1, as shown in Table 1). We used a nonparametric Mann-Whitney *U* test to assess systemic biases between devices. The measurement biases for systolic and diastolic BP for the wearable BP monitoring devices were measured as reference BP (W1, when comparing against ABPM and R1, when comparing against HBPM). We also evaluated measurement accuracy by calculating the mean absolute difference and mean absolute percentage difference between the devices. Standardized Bland-Altman scatterplots and limits of agreement (LOA) were used to assess absolute reliability and the variability of measurement biases across the measurement range. Absolute reliability was measured by calculating the SE of measurement and 95% LOA. A *P* value of $<.05$ was considered statistically significant. Missing data were not imputed.

Written informed consent was obtained from all participants at the time of enrollment. The Deakin University Faculty of Health Human Ethics Advisory Group (HEAG-H 135_2017) approved the study.

Table 1. Procedure for reference and validation of wearable device blood pressure measurements.

Procedures	Measurement code
Initial BP^a measurements	
Take reference BP measurement (clinical BP)	R0 ^{b,c}
Take BP measurement using wearable device	T0 ^c
Validation BP measurements for accuracy evaluation	
Take first reference BP measurement (mean 24-hour, ABPM ^d device)	R1
Take first wearable device BP measurement (mean 24-hour, wearable BP monitoring device)	T1
Take second reference BP measurement (mean 7-day, HBPM ^e device)	R2
Take second wearable device BP measurement (mean 7-day, wearable BP monitoring device)	T2
Take third reference BP measurement (mean daytime, ABPM device)	R3
Take third wearable device BP measurement (mean daytime, wearable BP monitoring device)	T3
Take fourth reference BP measurement (mean nighttime, ABPM device)	R4
Take fourth wearable device BP measurement (mean nighttime, wearable BP monitoring device)	T4

^aBP: blood pressure.

^bNot used in the evaluation of reference BP distribution and variability criteria.

^cNot used in the assessment of the test device accuracy.

^dABPM: ambulatory blood pressure monitoring.

^eHBPM: home blood pressure monitoring.

Results

BP data obtained by different devices are shown in [Table 2](#), and the validation of the wearable device ([Figure 1](#)) has been reported in a previous study [13]. A total of 9090 BP measurements were collected from 20 healthy volunteer participants (females: n=10; males: n=10; mean age 20.3 years,

SD 5.4 years). The mean BP at baseline during enrollment was 112 (SD 74) mm Hg. Mean (LOA) biases and precision between the wearable and ambulatory devices over 24 hours were 0.5 (−10.1 to 11.1) mm Hg for SBP and 2.24 (−17.6 to 13.1) mm Hg for DBP. The mean biases (LOA) and precision between the wearable and home device over 7 days were −12.7 (−28.7 to 3.4) mm Hg for SBP and −5.6 (−20.5 to 9.2) mm Hg for DBP [10].

Table 2. Blood pressure data measured using different devices.

BP ^a data	Wearable BP monitoring device (24 hours)	ABPM ^b device (24 hours)	Wearable BP monitoring device (7 days)	HBPM ^c device (7 days)
SBP^c, mm Hg				
Mean (SD)	125 (5)	126 (10)	125 (4)	112 (10)
Range	119-138	111-150	113-139	85-135
DBP^d, mm Hg				
Mean (SD)	77 (9)	75 (6)	77 (3)	71 (8)
Range	72-87	64-90	68-87	50-90

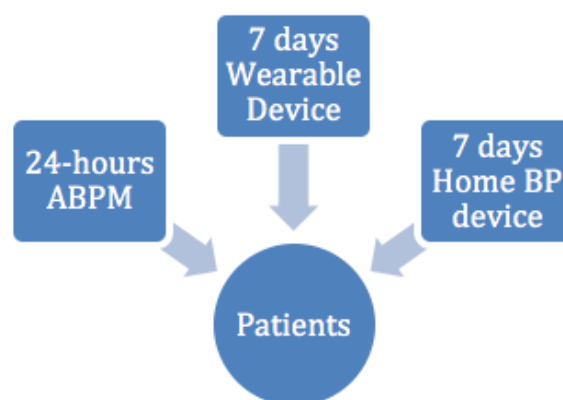
^aBP: blood pressure.

^bABPM: ambulatory blood pressure monitoring.

^cHBPM: home blood pressure monitoring.

^cSBP: systolic blood pressure.

^dDBP: diastolic blood pressure.

Figure 1. Validation process of the wearable blood pressure monitoring device. ABPM: ambulatory blood pressure monitoring; BP: blood pressure.

Discussion

In this study, we collected BP data using a standard digital BP device at baseline, a gold-standard ABPM device for 24 hours, and a cuffless wearable device and a standard HBPM device for 7 days. Our results suggest that the wearable device compared well with the gold-standard ambulatory device over 24 hours, as BP measurement biases were within acceptable limits. However, these findings are not sufficient on their own to recommend wearable devices as a replacement for established ambulatory devices. In contrast, measures of wearable BP monitoring device differed systematically from those of HBPM device over 7 days. Given the comparability of wearable and ambulatory measures, this finding suggests that the home device systematically underestimated BP.

The utility of the wearable BP monitoring devices is in their ability to measure BP in free-living environments and during daily activities, providing a better assessment of a person's BP and cardiovascular health. Further, the recent development of new technologies, such as smartphone apps, sensors, and wearable devices might allow cuffless BP devices to support remote BP monitoring as part of a telemedicine package [19,20]. This will enable patients to review their periodic BP, communicate with health care providers, and titrate their BP

medications. Such technologies can be useful, effective, and cost-effective interventions for managing BP in future routine clinical practices [21-23]. Such interventions could also be useful in low-income settings where hypertension is highly prevalent and there is a lack of trained professionals to provide health care services [24-29].

However, the use of wearable BP monitoring devices for remote monitoring will require validation of these devices in free-living environments in robust studies. The wearable BP monitoring devices, along with a care platform, might allow provision of automated personalized interventions based on the individual user. Previous studies have reported that simple approaches such as mobile phone text messages might help to reduce cardiovascular risks [4,30,31]. Thus, automated text messaging with health information, behavior change components [32], high BP alerts, and titration options might change future BP management and allow it to be integrated with a telemedicine service [23].

Our study has several limitations. Data were collected from a small number of healthy participants using convenience sampling. Wearable and home BP data were collected over 7 days only, and we did not consider seasonal or other variations. Moreover, data from people with high BP are needed to better

understand how BP changes with different activities in daily life.

Future research is needed to understand how the wearable BP monitoring devices perform over long term in different groups of people against standard BP measurement using a standardized

protocol for the validation of wearable BP monitoring devices. These data measured by wearable BP monitoring devices can be further analyzed for a daytime versus nighttime comparison or can be included in a meta-analysis of similar studies to support our initial findings and provide insights into cardiovascular health.

Acknowledgments

This project was funded by the Institute for Physical Activity and Nutrition, School of Exercise and Nutrition Science, Faculty of Health, Deakin University. We acknowledge the support of our study participants, data collectors, and investigators. SMSI is funded by the Institute for Physical Activity and Nutrition and a postdoctoral fellowship of the National Heart Foundation of Australia.

Conflicts of Interest

None declared.

References

1. Parati G, Torlasco C, Pengo M, Bilo G, Ochoa JE. Blood pressure variability: its relevance for cardiovascular homeostasis and cardiovascular diseases. *Hypertens Res* 2020 Jul;43(7):609-620. [doi: [10.1038/s41440-020-0421-5](https://doi.org/10.1038/s41440-020-0421-5)] [Medline: [32203448](https://pubmed.ncbi.nlm.nih.gov/32203448/)]
2. GBD 2017 Disease and Injury Incidence and Prevalence Collaborators. Global, regional, and national incidence, prevalence, and years lived with disability for 354 diseases and injuries for 195 countries and territories, 1990-2017: a systematic analysis for the Global Burden of Disease Study 2017. *Lancet* 2018 Nov 10;392(10159):1789-1858 [FREE Full text] [doi: [10.1016/S0140-6736\(18\)32279-7](https://doi.org/10.1016/S0140-6736(18)32279-7)] [Medline: [30496104](https://pubmed.ncbi.nlm.nih.gov/30496104/)]
3. Islam SMS, Purnat TD, Phuong NTA, Mwingira U, Schacht K, Fröschl G. Non-communicable diseases (NCDs) in developing countries: a symposium report. *Global Health* 2014 Dec 11;10:81 [FREE Full text] [doi: [10.1186/s12992-014-0081-9](https://doi.org/10.1186/s12992-014-0081-9)] [Medline: [25498459](https://pubmed.ncbi.nlm.nih.gov/25498459/)]
4. Shariful Islam SM, Farmer AJ, Bobrow K, Maddison R, Whittaker R, Pfaeffli Dale LA, et al. Mobile phone text-messaging interventions aimed to prevent cardiovascular diseases (Text2PreventCVD): systematic review and individual patient data meta-analysis. *Open Heart* 2019;6(2):e001017. [doi: [10.1136/openhrt-2019-001017](https://doi.org/10.1136/openhrt-2019-001017)] [Medline: [31673381](https://pubmed.ncbi.nlm.nih.gov/31673381/)]
5. Chow CK, Islam SMS, Farmer A, Bobrow K, Maddison R, Whittaker R, et al. Text2PreventCVD: protocol for a systematic review and individual participant data meta-analysis of text message-based interventions for the prevention of cardiovascular diseases. *BMJ Open* 2016 Oct 17;6(10):e012723. [doi: [10.1136/bmjopen-2016-012723](https://doi.org/10.1136/bmjopen-2016-012723)] [Medline: [27798018](https://pubmed.ncbi.nlm.nih.gov/27798018/)]
6. Chow CK, Teo KK, Rangarajan S, Islam S, Gupta R, Avezum A, PURE (Prospective Urban Rural Epidemiology) Study investigators. Prevalence, awareness, treatment, and control of hypertension in rural and urban communities in high-, middle-, and low-income countries. *JAMA* 2013 Sep 04;310(9):959-968. [doi: [10.1001/jama.2013.184182](https://doi.org/10.1001/jama.2013.184182)] [Medline: [24002282](https://pubmed.ncbi.nlm.nih.gov/24002282/)]
7. Carnagarin R, Fonseca R, Brockman D, Hering D, Matthews VB, Mihailidou A, et al. May Measurement Month 2017: an analysis of blood pressure screening results from Australia-South-East Asia and Australasia. *Eur Heart J Suppl* 2019 Apr;21(Suppl D):D14-D16 [FREE Full text] [doi: [10.1093/eurheartj/suz052](https://doi.org/10.1093/eurheartj/suz052)] [Medline: [31043866](https://pubmed.ncbi.nlm.nih.gov/31043866/)]
8. Stergiou GS, O'Brien E, Myers M, Palatini P, Parati G, STRIDE BP Scientific Advisory Board. STRIDE BP: an international initiative for accurate blood pressure measurement. *J Hypertens* 2020 Mar;38(3):395-399. [doi: [10.1097/HJH.0000000000002289](https://doi.org/10.1097/HJH.0000000000002289)] [Medline: [31688462](https://pubmed.ncbi.nlm.nih.gov/31688462/)]
9. Bhatt H, Siddiqui M, Judd E, Oparil S, Calhoun D. Prevalence of pseudoresistant hypertension due to inaccurate blood pressure measurement. *J Am Soc Hypertens* 2016 Jun;10(6):493-499 [FREE Full text] [doi: [10.1016/j.jash.2016.03.186](https://doi.org/10.1016/j.jash.2016.03.186)] [Medline: [27129931](https://pubmed.ncbi.nlm.nih.gov/27129931/)]
10. Dilek M, Adibelli Z, Aydogdu T, Koksar AR, Cakar B, Akpolat T. Self-measurement of blood pressure at home: is it reliable? *Blood Press* 2008;17(1):34-41. [doi: [10.1080/08037050701758018](https://doi.org/10.1080/08037050701758018)] [Medline: [18568690](https://pubmed.ncbi.nlm.nih.gov/18568690/)]
11. Williams B, Mancia G, Spiering W, Agabiti Rosei E, Azizi M, Burnier M, ESC Scientific Document Group. 2018 ESC/ESH Guidelines for the management of arterial hypertension. *Eur Heart J* 2018 Sep 01;39(33):3021-3104. [doi: [10.1093/eurheartj/ehy339](https://doi.org/10.1093/eurheartj/ehy339)] [Medline: [30165516](https://pubmed.ncbi.nlm.nih.gov/30165516/)]
12. Islam S. PS 15-24 A Review of Cuffless Blood Pressure Measuring Devices Potential for Use in Routine Clinical Practice. *Journal of Hypertension* 2016;34(Supplement 1):e465 [FREE Full text] [doi: [10.1097/01.hjh.0000501232.99910.05](https://doi.org/10.1097/01.hjh.0000501232.99910.05)]
13. Islam SMS, Cartledge S, Karmakar C, Rawstorn JC, Fraser SF, Chow C, et al. Validation and Acceptability of a Cuffless Wrist-Worn Wearable Blood Pressure Monitoring Device Among Users and Health Care Professionals: Mixed Methods Study. *JMIR Mhealth Uhealth* 2019 Sep 14;7(10):e14706 [FREE Full text] [doi: [10.2196/14706](https://doi.org/10.2196/14706)] [Medline: [31628788](https://pubmed.ncbi.nlm.nih.gov/31628788/)]
14. Arakawa T. Recent Research and Developing Trends of Wearable Sensors for Detecting Blood Pressure. *Sensors (Basel)* 2018 Aug 23;18(9) [FREE Full text] [doi: [10.3390/s18092772](https://doi.org/10.3390/s18092772)] [Medline: [30142931](https://pubmed.ncbi.nlm.nih.gov/30142931/)]

15. Watanabe N, Bando YK, Kawachi T, Yamakita H, Futatsuyama K, Honda Y, et al. Development and Validation of a Novel Cuff-Less Blood Pressure Monitoring Device. *JACC Basic Transl Sci* 2017 Dec;2(6):631-642 [FREE Full text] [doi: [10.1016/j.jacbts.2017.07.015](https://doi.org/10.1016/j.jacbts.2017.07.015)] [Medline: [30062178](https://pubmed.ncbi.nlm.nih.gov/30062178/)]
16. Griggs D, Sharma M, Naghibi A, Wallin C, Ho V, Barbosa K, et al. Design and development of continuous cuff-less blood pressure monitoring devices. 2016 Presented at: 2016 IEEE Sensors; 30 October-3 November; Orlando, FL. [doi: [10.1109/icsens.2016.7808908](https://doi.org/10.1109/icsens.2016.7808908)]
17. Boubouchairopoulou N, Kollias A, Chiu B, Chen B, Lagou S, Anestis P, et al. A novel cuffless device for self-measurement of blood pressure: concept, performance and clinical validation. *J Hum Hypertens* 2017 Jul;31(7):479-482 [FREE Full text] [doi: [10.1038/jhh.2016.101](https://doi.org/10.1038/jhh.2016.101)] [Medline: [28124684](https://pubmed.ncbi.nlm.nih.gov/28124684/)]
18. Luo H, Yang D, Barszczyk A, Vempala N, Wei J, Wu SJ, et al. Smartphone-Based Blood Pressure Measurement Using Transdermal Optical Imaging Technology. *Circ Cardiovasc Imaging* 2019 Aug;12(8):e008857. [doi: [10.1161/CIRCIMAGING.119.008857](https://doi.org/10.1161/CIRCIMAGING.119.008857)] [Medline: [31382766](https://pubmed.ncbi.nlm.nih.gov/31382766/)]
19. Duan Y, Xie Z, Dong F, Wu Z, Lin Z, Sun N, et al. Effectiveness of home blood pressure telemonitoring: a systematic review and meta-analysis of randomised controlled studies. *J Hum Hypertens* 2017 Jul;31(7):427-437 [FREE Full text] [doi: [10.1038/jhh.2016.99](https://doi.org/10.1038/jhh.2016.99)] [Medline: [28332506](https://pubmed.ncbi.nlm.nih.gov/28332506/)]
20. Goldberg EM, Levy PD. New Approaches to Evaluating and Monitoring Blood Pressure. *Curr Hypertens Rep* 2016 Jun;18(6):49. [doi: [10.1007/s11906-016-0650-9](https://doi.org/10.1007/s11906-016-0650-9)] [Medline: [27137524](https://pubmed.ncbi.nlm.nih.gov/27137524/)]
21. Chow CK, Ariyaratna N, Islam SMS, Thiagalingam A, Redfern J. mHealth in Cardiovascular Health Care. *Heart Lung Circ* 2016 Aug;25(8):802-807. [doi: [10.1016/j.hlc.2016.04.009](https://doi.org/10.1016/j.hlc.2016.04.009)] [Medline: [27262389](https://pubmed.ncbi.nlm.nih.gov/27262389/)]
22. Islam SMS, Peiffer R, Chow CK, Maddison R, Lechner A, Holle R, et al. Cost-effectiveness of a mobile-phone text messaging intervention on type 2 diabetes—A randomized-controlled trial. *Health Policy and Technology* 2020 Mar;9(1):79-85. [doi: [10.1016/j.hlpt.2019.12.003](https://doi.org/10.1016/j.hlpt.2019.12.003)]
23. Soron TR, Shariful Islam SM, Ahmed HU, Ahmed SI. The hope and hype of telepsychiatry during the COVID-19 pandemic. *Lancet Psychiatry* 2020 Aug;7(8):e50 [FREE Full text] [doi: [10.1016/S2215-0366\(20\)30260-1](https://doi.org/10.1016/S2215-0366(20)30260-1)] [Medline: [32711713](https://pubmed.ncbi.nlm.nih.gov/32711713/)]
24. Islam SMS, Mainuddin A, Islam MS, Karim MA, Mou SZ, Arefin S, et al. Prevalence of risk factors for hypertension: A cross-sectional study in an urban area of Bangladesh. *Glob Cardiol Sci Pract* 2015;2015(4):43 [FREE Full text] [doi: [10.5339/gcsp.2015.43](https://doi.org/10.5339/gcsp.2015.43)] [Medline: [26779518](https://pubmed.ncbi.nlm.nih.gov/26779518/)]
25. Shariful Islam SM, Niessen LW, Ferrari U, Ali L, Seissler J, Lechner A. Effects of Mobile Phone SMS to Improve Glycemic Control Among Patients With Type 2 Diabetes in Bangladesh: A Prospective, Parallel-Group, Randomized Controlled Trial. *Diabetes Care* 2015 Aug;38(8):e112-e113. [doi: [10.2337/dc15-0505](https://doi.org/10.2337/dc15-0505)] [Medline: [26207059](https://pubmed.ncbi.nlm.nih.gov/26207059/)]
26. Islam SMS, Tabassum R. Implementation of information and communication technologies for health in Bangladesh. *Bull World Health Organ* 2015 Nov 01;93(11):806-809 [FREE Full text] [doi: [10.2471/BLT.15.153684](https://doi.org/10.2471/BLT.15.153684)] [Medline: [26549909](https://pubmed.ncbi.nlm.nih.gov/26549909/)]
27. Shariful Islam S, Lechner A, Ferrari U, Seissler J, Holle R, Niessen LW. Mobile phone use and willingness to pay for SMS for diabetes in Bangladesh. *J Public Health (Oxf)* 2016 Mar;38(1):163-169. [doi: [10.1093/pubmed/fdv009](https://doi.org/10.1093/pubmed/fdv009)] [Medline: [25687131](https://pubmed.ncbi.nlm.nih.gov/25687131/)]
28. Karim MA, Majumder AAS, Islam KQ, Alam MB, Paul ML, Islam MS, et al. Risk factors and in-hospital outcome of acute ST segment elevation myocardial infarction in young Bangladeshi adults. *BMC Cardiovasc Disord* 2015 Jul 22;15:73 [FREE Full text] [doi: [10.1186/s12872-015-0069-2](https://doi.org/10.1186/s12872-015-0069-2)] [Medline: [26197888](https://pubmed.ncbi.nlm.nih.gov/26197888/)]
29. Rawal LB, Joarder T, Islam SMS, Uddin A, Ahmed SM. Developing effective policy strategies to retain health workers in rural Bangladesh: a policy analysis. *Hum Resour Health* 2015 May 20;13:36 [FREE Full text] [doi: [10.1186/s12960-015-0030-6](https://doi.org/10.1186/s12960-015-0030-6)] [Medline: [25990240](https://pubmed.ncbi.nlm.nih.gov/25990240/)]
30. Ricci-Cabello I, Bobrow K, Islam SMS, Chow CK, Maddison R, Whittaker R, et al. Examining Development Processes for Text Messaging Interventions to Prevent Cardiovascular Disease: Systematic Literature Review. *JMIR Mhealth Uhealth* 2019 Mar 29;7(3):e12191 [FREE Full text] [doi: [10.2196/12191](https://doi.org/10.2196/12191)] [Medline: [30924790](https://pubmed.ncbi.nlm.nih.gov/30924790/)]
31. Shariful Islam SM, Chow CK, Redfern J, Kok C, Rådholm K, Stepien S, et al. Effect of text messaging on depression in patients with coronary heart disease: a substudy analysis from the TEXT ME randomised controlled trial. *BMJ Open* 2019 Feb 20;9(2):e022637. [doi: [10.1136/bmjopen-2018-022637](https://doi.org/10.1136/bmjopen-2018-022637)] [Medline: [30787075](https://pubmed.ncbi.nlm.nih.gov/30787075/)]
32. Cho Y, Lee S, Islam SMS, Kim S. Theories Applied to m-Health Interventions for Behavior Change in Low- and Middle-Income Countries: A Systematic Review. *Telemed J E Health* 2018 Oct;24(10):727-741 [FREE Full text] [doi: [10.1089/tmj.2017.0249](https://doi.org/10.1089/tmj.2017.0249)] [Medline: [29437546](https://pubmed.ncbi.nlm.nih.gov/29437546/)]

Abbreviations

- ABPM:** ambulatory blood pressure monitoring
- BP:** blood pressure
- DBP:** diastolic blood pressure
- HBPM:** home blood pressure monitoring
- LOA:** limits of agreement
- SBP:** systolic blood pressure

Edited by G Eysenbach; submitted 11.07.20; peer-reviewed by R Gupta, W Evans; comments to author 04.08.20; revised version received 28.08.20; accepted 07.09.20; published 04.11.20

Please cite as:

Islam SMS, Maddison R

A Comparison of Blood Pressure Data Obtained From Wearable, Ambulatory, and Home Blood Pressure Monitoring Devices: Prospective Validation Study

JMIR Data 2020;1(1):e22436

URL: <https://data.jmir.org/2020/1/e22436>

doi: [10.2196/22436](https://doi.org/10.2196/22436)

PMID:

©Sheikh Mohammed Shariful Islam, Ralph Maddison. Originally published in JMIR DATA (<http://data.jmir.org>), 04.11.2020. This is an open-access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0/>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work, first published in JMIR Data, is properly cited. The complete bibliographic information, a link to the original publication on <http://data.jmir.org>, as well as this copyright and license information must be included.