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Blood pressure measurements in research: suitability of auscultatory, beat-to-beat, and ambulatory blood pressure measurements

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Objective **The objective of this study was to validate the accuracy of beat-to-beat measurements with those taken with an aneroid sphygmomanometer by auscultatory method. A secondary aim was to explore differences between auscultatory and beat-to-beat blood pressure (BP) with daytime ambulatory BP measurements.**

Participants and methods **A total of 46 participants, comprising 21 males, aged 47 ± 13 years, height 171 ± 8.5 cm and weight 82 ± 16.8 kg attended the Exercise Physiology Laboratory at the University of New England (Armidale, New South Wales, Australia). During the visit, participants had their BP – systolic BP (SBP) and diastolic BP (DBP) – measured using auscultatory methods and a Finometer. An ambulatory BP monitor was fitted during the same visit and worn for a minimum of 12 h.**

Results **Auscultatory measurements were slightly higher than beat-to-beat for both SBP and DBP. There was no difference between auscultatory and beat-to-beat SBP with a mean difference of 0.23 mmHg ($P = 0.87$). There were disparities between auscultatory and beat-to-beat DBP, with a mean difference of 4.82 mmHg ($P < 0.01$). Daytime ambulatory BP was higher than both auscultatory and beat-to-beat measurements for both SBP and DBP, with P less than 0.001 for all measures.**

Conclusion **There was a high level of reliability in the beat-to-beat SBP with that seen by auscultatory; however, there were disparities in DBP measurements using the same devices, which raise concerns over the accuracy of beat-to-beat DBP. Ambulatory systolic and diastolic measures were higher than beat-to-beat and auscultatory; however, they may be more suitable for monitoring diurnal changes in BP, depending upon the research model.** ***Blood Press Monit*** **24:18–23 Copyright © 2018 The Author(s). Published by Wolters Kluwer Health, Inc.**

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Introduction

Blood pressure (BP) measurement is generally taken at the brachial artery; however, monitors are available that take measurements at the wrist and finger. Because of the hydrostatic effect of differences in systolic and diastolic BPs (SBP and DBP, respectively), wrist and finger devices may be inaccurate if they are not held at heart height during measurement [1]. The most common BP measurement is brachial auscultation using a mercury sphygmomanometer and stethoscope listening for Korotkoff sounds. Mercury sphygmomanometer use is being diminished and replaced by aneroid and oscillometric BP devices [2].

The Finometer is a low-risk, noninvasive, photoplethysmographic, hemodynamic instrument that measures beat-to-beat BP by continuously monitoring finger arterial pressure [3]. High-frequency pressure vibration is used for BP measurement in the finger, based on the arterial volume-clamp method introduced by Penaz *et al.* [4,5]. A cuff is wrapped around the finger that keeps the diameter of the artery clamped at a constant diameter to maintain maximum arterial compliance, so that cuff pressure and intra-arterial pressure are at equal levels [4,6]. A photoplethysmograph containing a light source on one side, and an infrared receiver on the opposite side of the cuff estimates blood volume [7]. Because of the resistance in small arteries affecting finger arterial pressure, a height-adjusting component in the Finometer reconstructs brachial artery pressure from the finger artery [6]. This reduces pressure differences and has been shown to meet the American Association for the Advancement of Medical Instrumentation criteria [5]. Numerous conditions can affect the accuracy of the Finometer including temperature and arterial stiffness. Concerns over the accuracy of measurements from the Finometer during hypotensive events, alternating vascular tone and hemodynamic instability have been noted by Njoum and Kyriacou [8].

Ambulatory BP measurements taken over a 24-h period are currently considered the gold standard in some countries for BP measurement for hypertension diagnosis as it better reflects clinical outcomes [9–11]. A cuff is placed on the upper

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arm and the ambulatory BP device worn for 24 h, with BP measured every 15–30 min during the day and 30–60 min during the night [9]. Twenty four-hour ambulatory BP can be relevant for hypertension diagnosis in individuals at cardiovascular risk, assessment of treatment effects, and end-organ damage associated with hypertension [9,11,12]. Ambulatory BP is a strong predictor of clinical outcomes such as left ventricular hypertrophy, renal and vascular surrogate markers of end-organ damage, and presence or absence of nocturnal BP dipping [9].

The Joint National Committee in the USA and the WHO-International Society of Hypertension, as well as the European Society of Hypertension/European Society of Cardiology endorse the use of 24-h ambulatory BP monitoring for diagnosing hypertension [10,13]. Ambulatory BP monitoring gives an estimate of the true BP, describes the diurnal rhythm, and estimates short-term variability [13]. Ambulatory BP monitors are accurate when the person wearing it is resting but may not be as accurate during physical activity [1,9]. Higher daytime ambulatory BP is indicative of increased cardiovascular risk; however, daytime BP is expected to be higher than nocturnal BP [14]. In a study by Ciolec *et al.* [15], daytime ambulatory BP was higher in participants in all cohorts than that seen over 24 h.

Researchers have used various forms of BP measurement in their research. There have been numerous studies comparing clinic/office BP and ambulatory BP, and a study comparing auscultatory and Finometer measurements [16–18]. Currently there is no direct comparison of aneroid sphygmomanometer, Finometer beat-to-beat, and ambulatory BP measurements. Because of concerns over the accuracy of Finometer BP measurements, our primary aim was to compare beat-to-beat resting BP measurements with those from an aneroid sphygmomanometer. Our secondary aim was to examine the difference between resting (auscultatory and beat-to-beat) and ambulatory BP measurements and compare this with previous studies.

Participants and methods

Study participants

A total of 46 participants, comprising 21 males, aged 47 ± 13 years, height 171 ± 8.5 cm and weight 82 ± 16.8 kg were recruited from Armidale (New South Wales, Australia) and the surrounding area. Participants attended the Exercise Physiology Laboratory at the University of New England on one occasion to have their BP measured by auscultatory method using an aneroid sphygmomanometer, a Finometer for beat-to-beat measurements, and an ambulatory BP monitor in the same visit. Participants had an ambulatory BP monitor attached to them after the auscultatory and Finometer measurements were taken; they then left and went about their normal routine and returned the monitor the following day.

Participant characteristics and mean BP overall, as well as normotensive and hypertensive breakdown are shown in Table 1. Participants classified as hypertensive were all prehypertensive, had mild hypertension, or were receiving pharmacotherapy to treat their BP, and had a resting SBP of at least 120 mmHg and/or a resting DBP of at least 80 mmHg. Participants were excluded if they had known cardiovascular disease or multiple comorbidities.

Table 1 Participant characteristics

Characteristics	All participants ($n = 46$) (mean ± SD)	Normotensive ($n = 18$) (mean ± SD)	Hypertensive ($n = 28$) (mean ± SD)
Males (n)	21	6	15
Age	47 ± 13.4	36 ± 12.0	54 ± 8.9
Height	171 ± 8.5	172 ± 7.4	170 ± 9.2
Weight	82 ± 16.8	76 ± 15.8	85 ± 16.8
Systolic blood pressure			
Sphygmomanometer	129 ± 11.0	121 ± 7.0	134 ± 10.3
Finometer	128 ± 12.7	121 ± 8.3	133 ± 13.0
Ambulatory	146 ± 14.2	137 ± 12.8	152 ± 12.2
Diastolic blood pressure			
Sphygmomanometer	76 ± 11.4	71 ± 9.7	80 ± 11.1
Finometer	71 ± 8.3	70 ± 4.5	72 ± 10.0
Ambulatory	86 ± 8.9	81 ± 7.8	90 ± 7.8

In accordance with the Declaration of Helsinki, all participants provided written informed consent before participation. This research was approved by the University of New England Human Ethics Committee, and all procedures were conducted in accordance with the University's guidelines. The research project is registered with ClinicalTrials.gov; the identifiers are NCT02458443 and NCT02458456.

Blood pressure measurements

All resting measurements were conducted in a quiet temperature-controlled room, 21–24°C, between 8 and 10 am. The laboratory is an isolated room with no outside noise; the only people present during measurements were the participant and the researcher. Participants rested for 10 min by lying supine on a massage table in the laboratory before any measurements being carried out. Auscultatory and Finometer measurements were carried out while the participant was lying supine on the massage table. BP was measured in each participant's nondominant arm to ensure resting and ambulatory BP measurements were all carried out on the same arm.

Auscultatory measurements were carried out using an aneroid Heine Gamma G7 sphygmomanometer (Heine Optotechnik, Herrsching, Germany) that was purchased before commencement of the study; calibration specifications from the manufacturer were received with the manometer. Brachial BP measurements were conducted according to recommended guidelines, using a Littmann Classic IISE stethoscope to listen for the Korotkoff sounds [1,19]. A researcher proficient at auscultatory measurements carried out all measurements using the diaphragm of the stethoscope; palpation of the brachial artery at the antecubital fossa ensured correct cuff bladder and diaphragm placement. The cuff was placed

2–3 cm above the antecubital fossa and deflated at a rate of 2–3 mmHg/s; phase 5 was used to determine diastole [1]. Three BP measurements were recorded, each separated by a 5-min rest period, followed by another 5-min rest period before Finometer measurements. Participants were asked to relax and remain silent during BP measurement and rest periods.

Beat-to-beat continuous BP measurements were then recorded for 2 min using a Finometer Midi Model-2 (Finapres Medical Systems B.V., Amsterdam, The Netherlands). The Finometer was calibrated against the Heine manometer by a technician in accordance with recommended guidelines, before commencement of the study and at fortnightly intervals. A t-piece was used to connect the Heine manometer to the Finometer, and measurements were checked at 50-mmHg intervals to ensure the accuracy of recordings. The finger cuff was placed on the middle finger of the nondominant hand, and the height correction unit was used to correct hydrostatic BP changes for the hand being away from heart level. The researcher listened to heart sounds with a stethoscope to ensure that the height correction unit was placed at heart height.

At completion of resting BP measurements, participants then wore an ambulatory BP monitor (A&D Australasia Pty Ltd, Thebarton, South Australia, Australia) for a minimum of 12 h. Calibration of the ambulatory BP monitor was performed by a technician to ensure that it was equivalent to the Heine sphygmomanometer. The monitor's cuff was placed on the nondominant arm of participants to enable them to conduct their regular daily activities unhindered. Participants were instructed to relax their arm by their side and not to use it when the cuff started to inflate, to prevent overinflation and ensure measurement accuracy. The monitor was programmed to record BP measurements every 15 min, and participants were instructed on the earliest time that the monitor could be removed to ensure 12 h of data were collected.

Data analysis

BeatScope Easy software (MedTach Inc., Burlington, Ontario, Canada) that records waveforms and beat-to-beat data was used to unpack the Finometer data into a Microsoft Excel spreadsheet (Microsoft Corporation, Redmond, Washington, USA). Excel was then used to calculate the mean and SD of each participant's 2-min SBP and DBP measurements. Doctor Pro3 software (A&D Australasia Pty Ltd., Thebarton, South Australia, Australia) was used to download each participant's data from the ambulatory BP monitor. The data were exported to Excel and compared with a summary provided by the Doctor Pro3 software for accuracy; the first 12 h of data from each participant were then used for analysis.

Multivariate analysis of variance (ANOVA) and paired samples *t*-tests were carried out to determine differences between the various groups. Correlations between auscultatory, Finometer, and ambulatory BP were conducted using Pearson's correlation coefficient, and then linear regression was carried out to explore the relationships further. Data analysis was carried out using IBM SPSS Statistics 22 (SPSS Inc., Chicago, Illinois, USA). *P* values less than or equal to 0.05 were considered statistically significant.

Results

Adherence to auscultatory, Finometer, and ambulatory BP measurements was 100% in all participants. Kolmogorov–Smirnov normality tests were *P* greater than 0.05 for each of the groups analysed, indicating the data were normally distributed. One participant appeared to be an outlier for SBP in cuff and ambulatory BP measurements, as there was no effect on the 5% trimmed mean for both; the data were retained for analysis.

Ambulatory SBP and DBP were higher than both auscultatory and Finometer BP measurements, with Finometer being lowest across all groups, as shown in Table 1. A one-way between groups multivariate ANOVA was performed to investigate the BP differences with the measuring device groups. Multivariate ANOVA of auscultatory, Finometer, and ambulatory SBP indicates that there was a significant difference among groups, with a Wilk's λ of 0.006 ($P<0.01$). Similar results were seen with auscultatory, Finometer, and ambulatory DBP, with a Wilk's λ of 0.008 ($P<0.01$).

Resting blood pressure

Although auscultatory measures were slightly higher than Finometer, paired samples *t*-test indicates that there is no overall difference between auscultatory SBP of 128.5 mmHg and Finometer SBP of 128.3 mmHg ($P=0.87$), as shown in Tables 1 and 2. Similar results were seen when the data were separated into normotensive and hypertensive groups. In the normotensive group, the auscultatory SBP was 120.7 mmHg and Finometer SBP 121.0 mmHg ($P=0.89$). However, the hypertensive group had an auscultatory SBP of 133.5 mmHg and Finometer SBP of 133.0 mmHg, $P=0.79$. The Bland–Altman plot in Fig. 1 illustrates the difference between auscultatory and Finometer SBP measurements plotted against auscultatory measurements of all participants combined.

Differences were seen in overall resting DBP measures, which indicated that auscultatory DBP of 76.3 mmHg was significantly higher than Finometer DBP of 71.5 mmHg ($P<0.01$). In the normotensive group, auscultatory DBP of 70.6 mmHg was only slightly higher than Finometer of 70.4 mmHg ($P=0.94$). The hypertensive group saw a much higher auscultatory DBP of 80.0 mmHg than the Finometer 72.2 mmHg ($P<0.001$). The Bland–Altman plot in Fig. 2 illustrates the difference between auscultatory and Finometer DBP measurements plotted against auscultatory measurements of all participants combined.

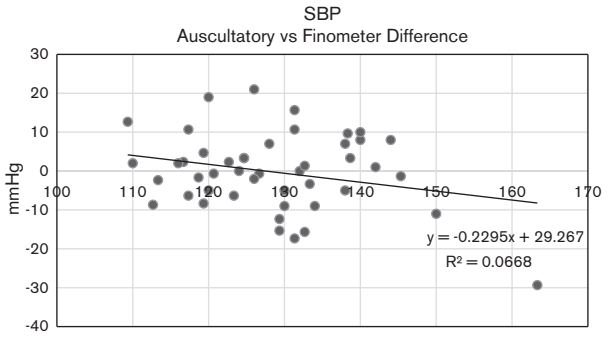
There was a positive linear association between auscultatory and Finometer for both SBP and DBP among each group.

Table 2 Mean difference between measurement devices

	Mean difference	SD of mean difference	95% CI of the difference (lower–upper)	*P* value
All participants				
Systolic blood pressure				
Sphygmomanometer vs. Finometer	0.23	9.81	−2.68 to 3.15	0.87
Sphygmomanometer vs. ambulatory	−17.48	11.04	−20.76 to −14.20	<0.001
Finometer vs. ambulatory	−17.71	13.35	−21.68 to −13.75	<0.001
Diastolic blood pressure				
Sphygmomanometer vs. Finometer	4.82	10.67	1.65–7.99	<0.01
Sphygmomanometer vs. ambulatory	−9.88	9.61	−12.74 to −7.03	<0.001
Finometer vs. ambulatory	−14.70	9.05	−17.39 to −12.02	<0.001
Normotensive participants				
Systolic blood pressure				
Sphygmomanometer vs. Finometer	−0.26	8.17	−4.32 to 3.80	0.89
Sphygmomanometer vs. ambulatory	−16.36	12.42	−22.53 to −10.18	<0.001
Finometer vs. ambulatory	−16.10	11.53	−21.83 to −10.36	<0.001
Diastolic blood pressure				
Sphygmomanometer vs. Finometer	0.20	10.40	−4.97 to 5.38	0.94
Sphygmomanometer vs. ambulatory	−10.15	8.99	−14.62 to −5.68	<0.001
Finometer vs. ambulatory	−10.35	7.51	−14.09 to −6.62	<0.001
Hypertensive participants				
Systolic blood pressure				
Sphygmomanometer vs. Finometer	0.55	10.87	−3.67 to 4.76	0.79
Sphygmomanometer vs. ambulatory	−18.20	10.23	−22.17 to −14.23	<0.001
Finometer vs. ambulatory	−18.75	14.51	−24.38 to −13.12	<0.001
Diastolic blood pressure				
Sphygmomanometer vs. Finometer	7.79	9.91	3.94–11.63	<0.001
Sphygmomanometer vs. ambulatory	−9.71	10.14	−13.65 to −5.78	<0.001
Finometer vs. ambulatory	−17.50	8.95	−20.97 to −14.03	<0.001

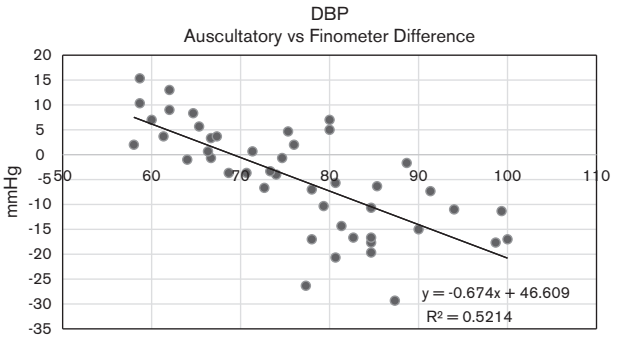
CI, confidence interval.

Fig. 1



Bland–Altman plot of systolic blood pressure (SBP) auscultatory measurement and the difference in the Finometer measurement. Data shown are SBP of all participants to illustrate the difference in Finometer − auscultatory measurements (*y* axis) plotted against the auscultatory measurements (*x* axis). The correlation coefficient between the difference and auscultatory measurements is 0.0668 ($P=0.083$). The solid black line represents the regression slope of the difference. The regression equation is $y=-0.2295x+29.267$; indicating a slope of −0.2295 ($P=0.083$) with the intercept 29.267 ($P=0.086$).

Fig. 2



Bland–Altman plot of diastolic blood pressure (DBP) auscultatory measurement and the difference in the Finometer measurement. Data shown are DBP of all participants to illustrate the difference in Finometer − auscultatory measurements (*y* axis) plotted against the auscultatory measurements (*x* axis). The correlation coefficient between the difference and auscultatory measurements is 0.5214 ($P=1.483$). The solid black line represents the regression slope of the difference. The regression equation is $y=-0.674x+46.609$, indicating a slope of −0.674 ($P=1.483$) with the intercept 46.609 ($P=1.677$).

Pearson's correlation coefficient and linear regression r^2 results are detailed in Table 3. Significant strong correlations were seen for SBP with overall data for all participants ($r=0.67$, $P<0.001$) and the hypertensive group ($r=0.59$, $P=0.01$). There was a strong correlation for SBP among the normotensive group, which was not significant ($r=0.44$, $P=0.07$). Similar results were seen for DBP, with strong significant correlation for the overall data ($r=0.45$, $P<0.01$) and the hypertensive group ($r=0.56$, $P<0.01$). The normotensive group had a negligible correlation, which was not significant for DBP ($r=0.07$, $P=0.79$).

Resting versus ambulatory blood pressure

Ambulatory SBP and DBP measurements were significantly higher than both resting auscultatory and Finometer measurements for all measures overall, as well as when separated into normotensive and hypertensive groups. Overall, the average ambulatory SBP of 146.0 mmHg was higher than the

Table 3 Correlations between measurement devices

	Correlation	r^2	*P* value
All participants			
Systolic blood pressure			
Sphygmomanometer vs. Finometer	0.67	0.45	< 0.001
Sphygmomanometer vs. ambulatory	0.64	0.42	< 0.001
Finometer vs. ambulatory	0.51	0.27	< 0.001
Diastolic blood pressure			
Sphygmomanometer vs. Finometer	0.45	0.20	< 0.01
Sphygmomanometer vs. ambulatory	0.58	0.34	< 0.001
Finometer vs. ambulatory	0.45	0.20	< 0.01
Normotensive			
Systolic blood pressure			
Sphygmomanometer vs. Finometer	0.44	0.19	0.07
Sphygmomanometer vs. ambulatory	0.32	0.10	0.19
Finometer vs. ambulatory	0.47	0.22	0.05
Diastolic blood pressure			
Sphygmomanometer vs. Finometer	0.07	0.005	0.79
Sphygmomanometer vs. ambulatory	0.49	0.24	0.04
Finometer vs. ambulatory	0.36	0.13	0.15
Hypertensive			
Systolic blood pressure			
Sphygmomanometer vs. Finometer	0.59	0.34	0.01
Sphygmomanometer vs. ambulatory	0.60	0.36	< 0.001
Finometer vs. ambulatory	0.34	0.11	0.08
Diastolic blood pressure			
Sphygmomanometer vs. Finometer	0.56	0.32	< 0.01
Sphygmomanometer vs. ambulatory	0.47	0.22	0.01
Finometer vs. ambulatory	0.52	0.27	< 0.01

auscultatory of 128.5 mmHg and Finometer SBP of 128.3 mmHg (both $P < 0.001$). The normotensive group ambulatory SBP of 137.1 mmHg was significantly higher than both auscultatory SBP of 120.7 mmHg and Finometer of 121.0 mmHg ($P < 0.001$ for both). The hypertensive group also had significantly higher ambulatory SBP of 151.7 mmHg, whereas auscultatory was 133.5 mmHg and Finometer 133.0 mmHg (both $P < 0.001$).

There was also a significant difference between ambulatory, auscultatory, and Finometer DBP compared with ambulatory DBP for all participants overall, as well as separated into normotensive and hypertensive groups. Overall ambulatory DBP of 86.2 mmHg was significantly higher than auscultatory of 76.3 mmHg and Finometer of 71.5 mmHg ($P < 0.001$ for both). Ambulatory DBP in the normotensive group at 80.7 mmHg was significantly higher than auscultatory at 70.6 mmHg and Finometer at 70.4 mmHg (both $P < 0.001$). The hypertensive group saw similar results with significantly higher ambulatory DBP of 89.7 mmHg compared with auscultatory DBP of 80.0 mmHg and Finometer DBP 72.2 mmHg (both $P < 0.001$).

There was a strong significant association between auscultatory and ambulatory SBP ($r = 064$, $P < 0.001$) and Finometer and ambulatory SBP ($r = 0.51$, $P < 0.001$) with overall data from all participants combined. Conflicting results were seen when the data were separated into hypertensive and normotensive groups, as shown in Table 3. The hypertensive group saw a strong significant association between ambulatory and auscultatory SBP ($r = 0.60$, $P < 0.001$), and a moderate association with Finometer, which was not significant ($r = 0.34$, $P = 0.08$). Among the normotensive group, there was a moderate association which was not significant for ambulatory versus auscultatory SBP ($r = 0.32$, $P = 0.19$), whereas Finometer had a strong association, which was borderline significant ($r = 0.47$, $P = 0.05$).

Similar results were seen for DBP with a strong significant association for auscultatory versus ambulatory ($r = 0.58$, $P < 0.001$) and Finometer versus ambulatory ($r = 0.45$, $P < 0.01$) among all participants overall. The hypertensive group had strong significant associations of DBP for both ambulatory versus auscultatory ($r = 0.47$, $P = 0.01$) and Finometer ($r = 0.52$, $P < 0.01$). There was a significant association between ambulatory and auscultatory DBP in the normotensive group ($r - 0.49$, $P = 0.04$), and a moderate association with the Finometer, which was not significant ($r = 0.36$, $P = 0.15$).

Discussion

Auscultatory BP measurements using auscultatory techniques are adequate for monitoring an individual's BP for medical use; however, there are other devices available for use in a research setting. Because of auscultatory measurements providing an instantaneous measure, short-term changes in BP are unable to be detected, resulting in a possible inaccurate representation of the individual's BP over time [8]. Utilizing beat-to-beat continuous BP measurements provides data at every heartbeat, but owing to their size and cost, they may not always be the most effective tool for use during research. Ambulatory BP monitors are the current gold standard for measurement; however, physical exertion may interfere with the monitor and provide inaccurate recordings [9].

The data in our study showed that SBP was the same for both auscultatory and beat-to-beat measures, indicating a high accuracy of SBP measurement. In a study carried out by Schutte *et al.* [18] with 102 participants, there were no differences for either SBP or DBP between auscultatory and Finometer measurements. There was an overall decline of 0.23 mmHg from auscultatory to Finometer SBP in our study, which was not significant, whereas Schutte *et al.* [18] saw a difference of −1.8 mmHg, with Finometer SBP higher than auscultatory. Finometer DBP was lower than auscultatory in both our study and that by Schutte *et al.* [18]. Although there was a significant overall difference in DBP in our study of 4.8 mmHg, Schutte *et al.* [18] saw a greater accuracy of 0.9 mmHg.

Discrepancies between the auscultatory and Finometer DBP may be because of either the Finometer recording DBP incorrectly, or human error hearing the Korotkoff sounds fade at diastole. Interpretation of Korotkoff sounds, reactions to auditory cues, auscultation method (diaphragm vs. bell of stethoscope), deflation rate, and cuff size can all affect the accuracy of auscultatory BP measurement [19,20]. According to Ruiz-Rodriguez *et al.* [21], there is a tendency for DBP to be overestimated

during auscultatory measurement, which may explain the discrepancy seen in our study. High DBP measurements have also been known to be attributed to slow deflation rates causing venous congestion, phasic changes in arterial pressure, or faint Korotkoff sounds from the patient [1].

The data in our study indicated that systolic and diastolic ambulatory BPs were both significantly higher than auscultatory and Finometer resting SBP and DBP in both the normotensive and hypertensive groups. Juhanoja *et al.* [22] also saw higher SBP and DBP measurements with daytime ambulatory BP compared with home and office BP measurements. We saw a 17.5-mmHg increase in SBP with ambulatory BP compared with the auscultatory, whereas Juhanoja *et al.* [22] saw an increase of 5.6 mmHg in office SBP and 8.4 mmHg in home SBP. Although we saw an increase in DBP of 9.9 mmHg from auscultatory to ambulatory DBP, there were no differences between daytime ambulatory BP, home and office DBP seen by Juhanoja *et al.* [22].

A meta-analysis carried out by Banegas *et al.* [16] indicates that daytime ambulatory BP is generally lower in individuals with hypertension than that seen in a clinic, and saw a 17.4-mmHg decrease in SBP with ambulatory BP. Similar differences were seen in DBP with an increase of 9.9 mmHg in our research, and a decrease of 8.4 mmHg seen by Banegas *et al.* [16]. According to Ishikawa *et al.* [17], lower ambulatory BP than clinic measurements indicate white coat hypertension, whereas higher ambulatory BP than clinic measurements indicate masked hypertension. Ishikawa *et al.* [17] also noted that home BP measurements were either lower than or similar to daytime ambulatory BP. Ambulatory BP measures may be more meaningful than clinic/office BP when diagnosing hypertension, and a better predictor of cardiovascular risk and outcomes including coronary morbid or fatal events and stroke [10].

Conclusion

Despite concerns over beat-to-beat accuracy, the data indicate that SBP measurements correlate with an aneroid sphygmomanometer, although there is still some doubt of the accuracy of DBP measurements. The Finometer is suitable for monitoring continual beat-to-beat BP, but it is cumbersome and may not be suitable for a lot of studies owing to its size. As such, the Finometer is more suited to studies where researchers want to monitor continual change of BP in a dedicated setting. Ambulatory BP monitors provide a portable method of measuring BP, enabling researchers to see changes over a period of numerous hours.

Study limitations

Although the same person performed all auscultatory measures in this study, there is still the propensity for human error; use of an oscillometric automated BP sphygmomanometer may clarify the accuracy of Finometer DBP. Differences between resting and ambulatory BP may not be so large had we looked at 24-h ambulatory BP, or if the participants wore the monitor on a day when they were not as active.

Acknowledgements

Conflicts of interest

There are no conflicts of interest.

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