



# Comparison of Thames Medical CAT+ Doppler and AutoCAT+ Automatic Blood Pressure Monitor devices for non-invasive blood pressure measurement in cats.

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# Comparison of Thames Medical CAT+ Doppler and AutoCAT+ Automatic Blood Pressure Monitor devices for non-invasive blood pressure measurement in cats.

**Eleanor Marriott BVSc MANZCVS (Medicine of Cats) CertAVP MRCVS.**

## Abstract

*Objectives* A comparative assessment of systolic blood pressure (SBP) measurement was carried out for anaesthetised and conscious cats by using two non-invasive approaches based on the Doppler method and a newly developed oscillometric instrument.

*Methods* Systemic blood pressure (SBP) was recorded on 131 occasions in 26 cats entering a shelter environment. Six of these cats were monitored while under a general anaesthetic for elective procedures and the rest were conscious during routine health assessment. A paired approach was followed using the Doppler method followed immediately by the oscillometric approach. Mean values and coefficient of variations were calculated. A normal distribution was confirmed before a standard Bland-Altman analysis was completed.

*Results* The mean SBP ± standard deviation for the 131 paired readings was 113.3 ± 23.9 mmHg and 116 ± 26.7 mmHg for the Doppler and oscillometric methods respectively. The small difference in means was not significant. Anaesthetised cats had significantly lower SBP values than those that were conscious. The data set for 16 cats with three replicated paired measurements and a subset of 12 with five such replicated measurements also provided similar normally distributed mean values and a high correlation coefficient. The Bland-Altman plot suggested a positive bias of the oscillometric approach of + 3.07 ± 12.3 mmHg (limits of agreement of -21.0 to 27.1 mmHg) and + 4.93 ± 9.38 mmHg (limits of agreement of -13.5 to 23.3 mmHg) for the 16 and 12 cat subgroups respectively. There was 100% agreement between the two methods in allocation to a hypertension class.

*Conclusions and relevance* The results establish that the new AutoCAT+ instrument met some of the guidelines for assessing such instruments for veterinary use with cats with a normal range of blood pressure. Further work is needed with a larger data set spanning hypotension to hypertension for complete validation.

**Keywords:** blood pressure, CAT+ Doppler, AutoCAT+, hypertension

## Introduction

The measurement of systolic blood pressure is a vital parameter that should be routinely assessed in all cats. The International Cat Care Veterinary Society recommends a BP assessment at least every 12 months in cats aged 7 years and over.[1] Systemic hypertension and target organ damage are common clinical findings in feline medicine. They require accurate and regular blood pressure measurements for diagnosis and monitoring.[1] Blood pressure should also be routinely measured in cats undergoing general anesthesia.[2]





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The most accurate and precise measurement of SBP requires direct measurement with a pressure transducer reading via a catheter inserted into an artery.[3-6] This makes it an inappropriate approach for routine clinical investigations on grounds of cost, the need for anaesthesia, and appropriate expertise. Consequently, an indirect approach prevails for routine measurement using an inflatable/deflatable cuff attached to the limb or tail of a cat with procedures well defined.[1, 7] A commonly used approach uses a Doppler probe emitting high frequency sound waves coupled to a detector that provides an audible signal when the decreasing cuff inflation allows arterial blood flow to restart. The advantages of this non-invasive method (portable, inexpensive, conscious patient, less technical skill to perform, rapid result) are somewhat offset by concerns that readings more closely relate to mean blood pressure rather than the higher peak SBP. [3-6] This might lead to a false negative interpretation if the clinician refers to SBP levels.

There is a longstanding interest in developing alternatives to the Doppler approach also using an inflatable/deflatable cuff. Oscillometric methods measure the difference between the cuff and arterial pressure continuously as the cuff deflates. An average between the systolic and diastolic BP is obtained and machine-specific algorithms are used to estimate SBP. [8] Such equipment has been calibrated against direct SBP measurements[3-6] and the Doppler method.[9-11]

The Doppler method of blood pressure has been found to be more repeatable and easier to obtain than oscillometric readings.[12] Common problems reported are detecting a signal and issues associated with the cuff. Many veterinary professionals report greater confidence in Doppler machines.[13] However, some veterinary professionals report that they find oscillometric machines easier and quicker to use.[13] The main concerns with oscillometric machines reported were cuff placement and the frequency of failure to gain a measurement.[12-14] Many veterinary professionals report that cats often appear more tolerant of oscillometric machines.

It is good practice to calibrate all oscillometric equipment for the measurement of SBP. The purpose of this study was to use standard procedures to compare the readings of a new oscillometric machine for use with cats with that of the accepted standard Doppler machine.

## Materials and Methods

### *Animals*

This study took place at a rescue cattery (RSPCA Taylor's Rehoming Centre) during routine health visits to the cats there and at Castle Veterinary Clinic during general anaesthesia for elective procedures. A total of 97 paired measurements were made on conscious cats and 34 paired measurements for those under general anaesthesia. Conscious cats were examined in their normal environment (RSPCA Taylor's Rehoming Centre). Anaesthetised cats had the measurements taken as part of their routine anaesthetic monitoring at Castle Veterinary Clinic.

### *Machines*





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A single Doppler (CAT+ Doppler, Thames Medical) and a single oscillometric machine (AutoCAT+ Automatic Blood Pressure Monitor, Thames Medical) were used throughout the study.

*Measuring the blood pressure*

After being allowed to acclimate to the handling area with a familiar handler, each cat had the right forelimb clipped distal to the carpal pad on the palmar aspect and ultrasound gel was applied. Each cat then had their limb measured with a tape measure and blood pressure cuff size was determined using the range printed on the cuff (Cat+ Doppler, Thames Medical). This ensured that cuff width was 30-40% that of limb circumference. The cat was acclimated to the cuff by inflating and deflating it. The sensor of the doppler blood pressure machine (Cat+ Doppler, Thames Medical) was applied to the palmar aspect of the distal metacarpals and the blood pressure was taken using the common digital branch of the radial artery. Immediately after taking the blood pressure the cuff was disconnected from the spygmanometer and attached to the oscillometric machine (AutoCAT+, Thames Medical) to measure SBP. Thus, the paired readings were taken in the same position as close as possible temporally. Repeat paired measurements were made where cats remained calm and allowed repeated measurements. This resulted in a varying number of paired readings per cat for analysis. All readings for conscious cats were taken by the author. Readings taken under general anaesthetic were taken by a Registered Veterinary Nurse who had received training in the use of both methods of blood pressure measurement.

*Statistical Analysis*

Most analyses used a standard statistical package (SPSS v30; IBM) with figures produced using Excel. Methodology followed a standard text.[15] Means were obtained and given throughout with their sample standard deviations (SD). The value sets were compared using paired sample t tests and Pearson's Correlation coefficient (R) was calculated. Linn's Concordance Correlation Coefficient (Lin's CCC) was determined for the data pairs and Fisher's R to Z transformation was carried out to derive its 95% confidence limits using an application in Excel.[16] Linear regression was completed for individual paired measurements and subsequently for a subset of 16 and 12 cats for which a minimum of 3 or 5 paired replicated measurements were gained respectively (SPSS, Regression, curve estimation). The effect of anaesthesia on those cats receiving that treatment was analysed using Univariate ANOVA in SPSS for both the Doppler and AutoCat+ measurements. Bland Altman plots were obtained in SPSS (Analyse, Descriptive statistics) and plotted in Excel with the limit of agreement set for the bias of 1.96 x SD. Power analysis was carried out after other analyses to determine an appropriate sample size for further work using the online R Statistics Package (version 4.5.1) with the package pwr.

## Results

The SBP of a total of 26 cats was measured during a routine health examination or general anaesthetic by the Doppler and then the AutoCAT+ methods with a minimal delay between switching instruments. They had known ages ranging from 6 months to 15 years.





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A total of 131 paired readings were obtained but the number of paired readings achieved for each cat depended on it remaining calm. They are plotted in Figure 1. It includes a few high or low values. No values were set aside. The mean for these 131 values analysed per cat by the Doppler method was 113.3 ± 23.9 mmHg (mean ± sample standard deviation, SD). The coefficient of variation (CV) was 21.1%. The corresponding mean for the AutoCat+ method was 116.3± 26.7 mmHg (CV = 23.0%). The small difference in the two means is not significant (P = 0.51).

Fuller comparison of means and their variance was based on 16 cats for which a minimum of 3 paired measurements were achieved and the subset of 12 animals for which at least 5 paired measurements were made. The occasional aberrant readings observed in Fig 1a do not affect the resultant means (Figs 1b and Fig 1c). The means with 3 paired replicated readings were 106 ± 24.4 mmHg (CV= 22.9%) and 110 ± 24.1 mmHg (CV = 21.9%) for the Doppler and AutoCat+ approaches respectively. These means were similar (paired t test, P = 0.245). For the 12 cats from which at least 5 paired readings were obtained, the means were 98.6 ± 22.6 mmHg (CV= 22.8%) and 105 ± 23.5 mmHg (CV = 24.5%). These means were also similar using the paired t test (P= 0.165). Pearson's R and Lin's CCC for the group of 12 cats was 0.826 (0.480 to 0.950) and 0.934 (0.809 and 0.978) respectively. Values in brackets are 95% confidence limits. Lin's coefficient was determined using the 5th replicate reading for each cat. The effect of anaesthesia had a significant effect on SBP for both Doppler and AutoCat+ methods (P<0.001, Univariate ANOVA). That approach also established that there was a small but significant effect of age for the group of 16 cats with both methods (P<0.025 in both cases) but not for cuff size (P = 0.52 in both cases). The means for sex were significantly different for Autocat only (P =0.009).

Linear regression of the AutoCAT+ and Doppler methods (Figure 1a) established a significant correlation (P<0.001) for the 131 paired readings. The slope with the intercept set at zero was 1.018 ± 0.021 which does not differ from 1 (t=0.866, P> 0.5). As expected, that high level of relationship was achieved for the paired readings with either 3 or 5 replicated measurements with $R^2$ indicating that 98.7% and 99.3% of the variance was described by the regression lines for 3 and 5 replicated measurements respectively (Figure 1b, 1c).

INSERT FIGURE 1

**Figure 1** Relationship between the two methods for **a**) individual 131 paired measurements of SBP of 26 cats **b**) the means for 16 cats for which there were a minimum of 3 replicated paired measurements and **c**) the means for 12 cats with a minimum of 5 replicated paired readings. Cats were either under a general anaesthetic (closed symbols) or conscious (open symbols).

Further analysis of the level of agreement of the two methods was based on the standard Bland-Altman analysis for the data set with 3 replicated measurements and its subset with 5. This plots the residual SBP value for AutoCAT+ after subtracting the paired Doppler reading against the mean for the two readings (Figure 2). This analysis was conducted after confirming the difference between the two methods did not deviate significantly from a normal distribution. The Limits of agreement (LOA) is set at ± 1.96 SD from the mean.





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147 INSERT FIGURE 2

148 **Figure 2** A Bland-Altman plot for **a**) the means for 16 cats for which there were a minimum of 3
149 replicated paired measurements and **b**) the means for a sub-set of 12 of those cats with 5 replicated
150 measurements. Each mean bias is given with its SD value and shown as solid line relative to a zero
151 bias which is given as a dotted line. The upper and lower limits of agreement are set at ± 1.96 SD
152 from the mean and shown as dashed lines. Cats were either under a general anaesthetic (closed
153 symbols) or conscious (open symbols).

154 For the 16 cats with 3 pairs of replicated measurements reading the mean bias was + 3.07 ±12.3
155 mmHg with the limits of agreement shown as 1.96 x SD above and below that mean. For the subset
156 of 12 cats with 5 replicated measurements the mean bias was 4.93 ± 9.38 mmHg and a similar
157 range for the limits of agreement (Fig 2).

158 All cats but one present in both the 3 and 5 replicated data set were in the no risk category for
159 hypertension based on the four risk categories used previously.[11] The remaining male neutered cat
160 aged 11 years had a mean SBP of 148 ± 2.47 mmHg and 151 ± 2.41 mmHg by the Doppler and
161 AutoCAT+ methods respectively. This small difference was statistically significant (P = 0.19) but
162 both methods placed it in the low-risk category (140-159 mmHg).[7]

163 The paired t test for the 12 cat data set has a Coehn's d of 0.429 and a Lin's CCC of 0.934. Using
164 these values, the estimated appropriate sample size for future work is 25 cats (R package pwr, P=
165 0.05).

166 **Discussion**

167 Two of the key requirements of a blood measurement approach are accuracy and precision. The
168 AutoCAT+ method showed similar mean values compared with the Doppler method for 131 paired
169 readings of 26 cats with means of 113.3 ± 23.9mmHg and 116.3 ± 26.7 mmHg respectively. The
170 coefficient of variation values of circa 20% are appreciable but within the range listed in previous
171 work.[9] Further analysis was based on the 16 cats for which 3 paired replicated measurements were
172 made and the subset of 12 cats with 5 replicated paired measurements. In both cases the values did
173 not deviate significantly from a normal distribution. These preliminary tests ensured reliable
174 application of the Bland-Altman analysis. The small difference in means is demonstrated in Figure
175 2. The mean bias and SD values are 3.07 ± 12.3 mmHg and 4.93 ± 9.38 mmHg for 3 paired and 5
176 paired replicated measurements respectively. This suggests that the accuracy of the AutoCAT+
177 method is very similar to that of the Doppler approach but that conclusion requires validation with
178 a larger data set. Previous work has established that oscillometric approaches frequently provides
179 higher mean SBP than the Doppler method. In previous work on cats, 6 of 7 oscillometric means
180 were greater than those obtained by paired Doppler approach by 8-21 mmHg on five occasions
181 and 53 mmHg for the 6th.[9-11] The Doppler method has also been reported to underestimate SBP
182 cats relative to direct measurements. [3-6] The positive bias of the AutoCAT+ approach in this work





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was less than in several previous studies. In this preliminary dataset with 16 cats, classification agreement was complete in all but one case.

It is standard practice to use replicated measurements of blood pressure to assess variability. This is assessed by the mean bias and the limits of agreement (± 1.96 SD of the differences) in Figure 2. The limit of agreement was ± 25.6 mmHg and ± 18.4 mm Hg for the three and five paired replicated measurements respectively. This indicates an acceptable level of precision. The values are less than 50% of those in three previous comparisons of oscillometric and Doppler approaches.[9, 11, 17] This and the Lin's CCC value of 0.934 indicate an encouraging level of precision. The bias in this work as that of others is clinically wide. The resultant risk of a false positive or negative diagnosis of hypertension should be mitigated. This can be addressed by multiple assessments over several weeks or in 7-14 days when severe hypertension is putatively detected.[7]

Guidelines for assessing oscillometric monitors for veterinary use in the United States are available.[18] The AutoCat+ instrument meets many of the latter's guidelines. The 12 cats with 5 replicated measurements provided a Pearson's Correlation coefficient (R) of 0.826 and a Lin's CCC of 0.934. Overinterpreting the strength of association that they indicate is unwise but they suggest a moderate fit.[19-20] AutoCAT+ shows promising potential based on several commonly used features of device validation including some specified in previous work.[18] Power analysis suggests a subsequent study with 25 individuals is sufficient for further evaluation and an achievable number of cats. It should include a wide range of hypotension and hypertension values.

## Conclusions

The results establish that the new AutoCAT+ instrument met guidelines for assessing such instruments for veterinary use with cats. Further work is needed with a larger data set spanning the hypertension range for complete validation.

## Acknowledgements

The author thanks Prof. Howard Atkinson for advice on analysis of the data and assistance with the statistical aspects of the paper. Additionally, the author thanks the RSPCA Taylors Rehoming Centre for allowing the cats in their care to take part in this study, Tess Every for assistance in holding each cat for blood pressure and Laura Akister for assistance in recording the findings. And finally, thanks to the team at Castle Veterinary Clinic in assisting with the data collection from anaesthetised cats.

## Conflict of Interest

Thames Medical developed and provided the oscillometric equipment evaluated in this work.

## Funding

No funding.

## Ethical Approval





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The work described in this manuscript involved the use of non-experimental (owned or unowned) animals. Established internationally recognized high standards ('best practice') of veterinary clinical care for the individual patient were always followed and/or this work involved the use of cadavers. Ethical approval from a committee was therefore not specifically required for publication in JFMS. Although not required, where ethical approval was still obtained, it is stated in the manuscript.

**Informed Consent**

Informed consent (verbal or written) was obtained from the owner or legal custodian of all animal(s) described in this work (experimental or non-experimental animals, including cadavers, tissues and samples) for all procedure(s) undertaken (prospective or retrospective studies).

For any animals or people individually identifiable within this publication, informed consent (verbal or written) for their use in the publication was obtained from the people involved.

**References**

1. Taylor SS, Sparkes AH, Briscoe K, et al. **ISFM Consensus Guidelines on the Diagnosis and Management of Hypertension in Cats**. *Journal of Feline Medicine and Surgery*. 2017; 19: 288–303.
2. Bailey K, Briley J, Duffee L, et al. **The American College of Veterinary Anesthesia and Analgesia Small Animal Anesthesia and Sedation Monitoring Guidelines 2025**. *Veterinary Anaesthesia and Analgesia*.
3. Klevans LR, Hirkaler G and Kovacs JL. **Indirect blood pressure determination by Doppler technique in renal hypertensive cats**. *Am J Physiol*. 1979; 237: H720–3.
4. Caulkett NA, Cantwell SL and Houston DM. **A comparison of indirect blood pressure monitoring techniques in the anesthetized cat**. *Vet Surg*. 1998; 27: 370–7.
5. Grandy JL, Dunlop CI, Hodgson DS, Curtis CR and Chapman PL. **Evaluation of the Doppler ultrasonic method of measuring systolic arterial blood pressure in cats**. *Am J Vet Res*. 1992; 53: 1166–9.
6. Binns SH, Sisson DD, Buoscio DA and Schaeffer DJ. **Doppler ultrasonographic, oscillometric sphygmomanometric, and photoplethysmographic techniques for noninvasive blood pressure measurement in anesthetized cats**. *J Vet Intern Med*. 1995; 9: 405–14.
7. Acierno MJ, Brown S, Coleman AE, et al. **ACVIM consensus statement: Guidelines for the identification, evaluation, and management of systemic hypertension in dogs and cats**. *J Vet Intern Med*. 2018; 32: 1803–22.
8. Lewis PS, British and Irish Hypertension Society's Blood Pressure Measurement Working P. **Oscillometric measurement of blood pressure: a simplified explanation. A technical note on behalf of the British and Irish Hypertension Society**. *J Hum Hypertens*. 2019; 33: 349–51.
9. Cerna P, Archontakis PE, Cheuk HO and Gunn-Moore DA. **Comparison of Doppler ultrasonic and oscillometric devices (with or without proprietary optimisations) for non-invasive blood pressure measurement in conscious cats**. *Journal of Feline Medicine and Surgery*. 2020; 23: 121–30.





DOI: 10.1177/1098612X261424313

10. Knies M, Teske E and Kooistra H. **Comparison of Doppler ultrasonic sphygmomanometry, oscillometry and high-definition oscillometry for non-invasive blood pressure measurement in conscious cats**. *Journal of Feline Medicine and Surgery*. 2024; 26.
11. Casas C and Dye C. **Comparison of Thames Medical CAT+ Doppler and SunTech Vet 20 oscillometric devices for non-invasive blood pressure measurement in conscious cats**. *Journal of Feline Medicine and Surgery*. 2024; 26.
12. Jepson RE, Hartley V, Mendl M, Caney SM and Gould DJ. **A comparison of CAT Doppler and oscillometric Memoprint machines for non-invasive blood pressure measurement in conscious cats**. *Journal of Feline Medicine and Surgery*. 2005; 7: 147–52.
13. Caney SM, Page S and Gunn-Moore DA. **Understanding the barriers to blood pressure assessment in cats**. *Journal of Feline Medicine and Surgery*. 2023; 25.
14. Navarro I, Summers S, Rishniw M and Quimby J. **Cross-sectional survey of non-invasive indirect blood pressure measurement practices in cats by veterinarians**. *Journal of Feline Medicine and Surgery*. 2022; 24: 1195–202.
15. Snedecor GW and Cochran WG. Statistical Methods. 8th Edition ed. Ames, Iowa, USA.: Iowa State University, 1989, p.503.
16. Zaiontz, C . **Lin's Concordance Correlation Coefficient.** Lin's Concordance Correlation Real Statistics Using Excel. https://real-statistics.com/reliability/interrater-reliability/lins-concordance-correlation-coefficient/ Accessed on 29/10/2025).
17. Cremer J, da Cunha A, Aulakh K, Liu CC and Acierno MJ. **Validation of the oscillometric blood pressure monitor Vet20 SunTech in anesthetized healthy cats**. *Vet Anaesth Analg*. 2020; 47: 309–14.
18. Brown S, Atkins C, Bagley R, et al. **Guidelines for the identification, evaluation, and management of systemic hypertension in dogs and cats**. *Journal of veterinary internal medicine*. 2007; 21: 542–58.
19. Buriko O Chalifoux, N.V., Clarkin-Breslin, R. and Silverstein, D.C. **Comparison of a viscoelastic point-of-care coagulation monitor with thromboelastography in sick dogs with hemostatic abnormalities**. *Vet Clin Pathol.* 2022; 52: 217–227.
20. Buczinski, S. **Variables in Veterinary Medicine: What the Different Possible Indicators Tell, and How to Use and Report Them.** *Animals*. 2023; 13: 2793.





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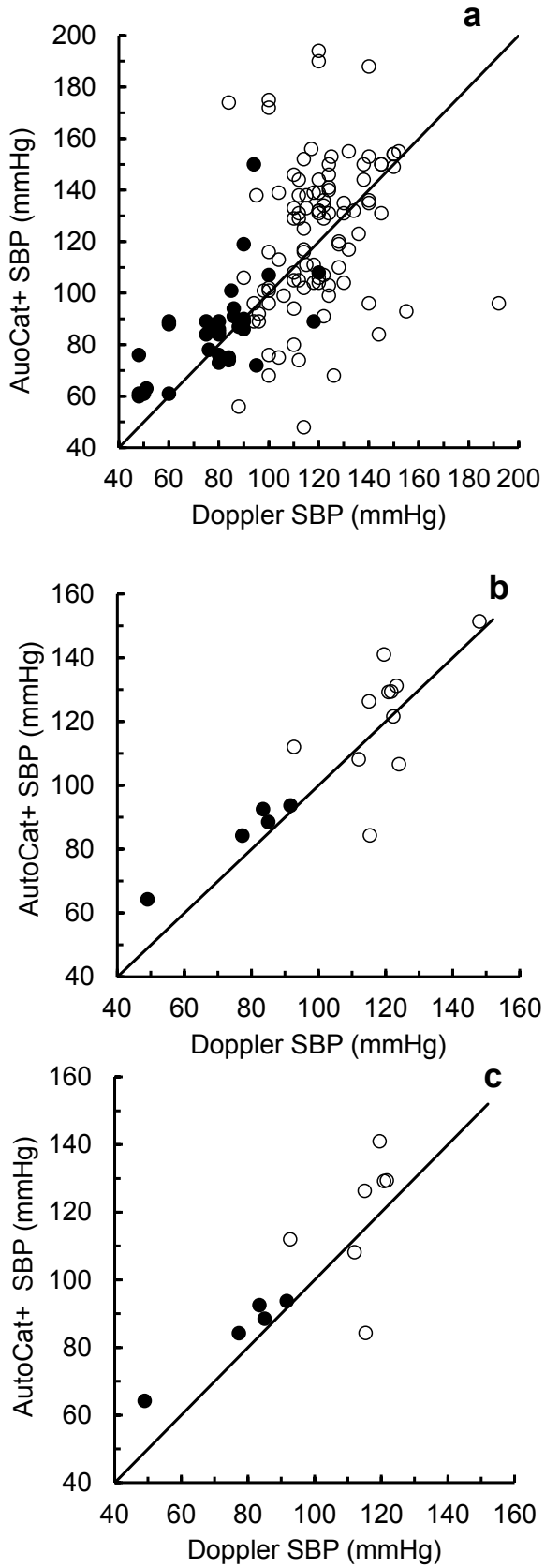
*Comparison of Doppler and Oscillometric instruments*

**Figure 1**



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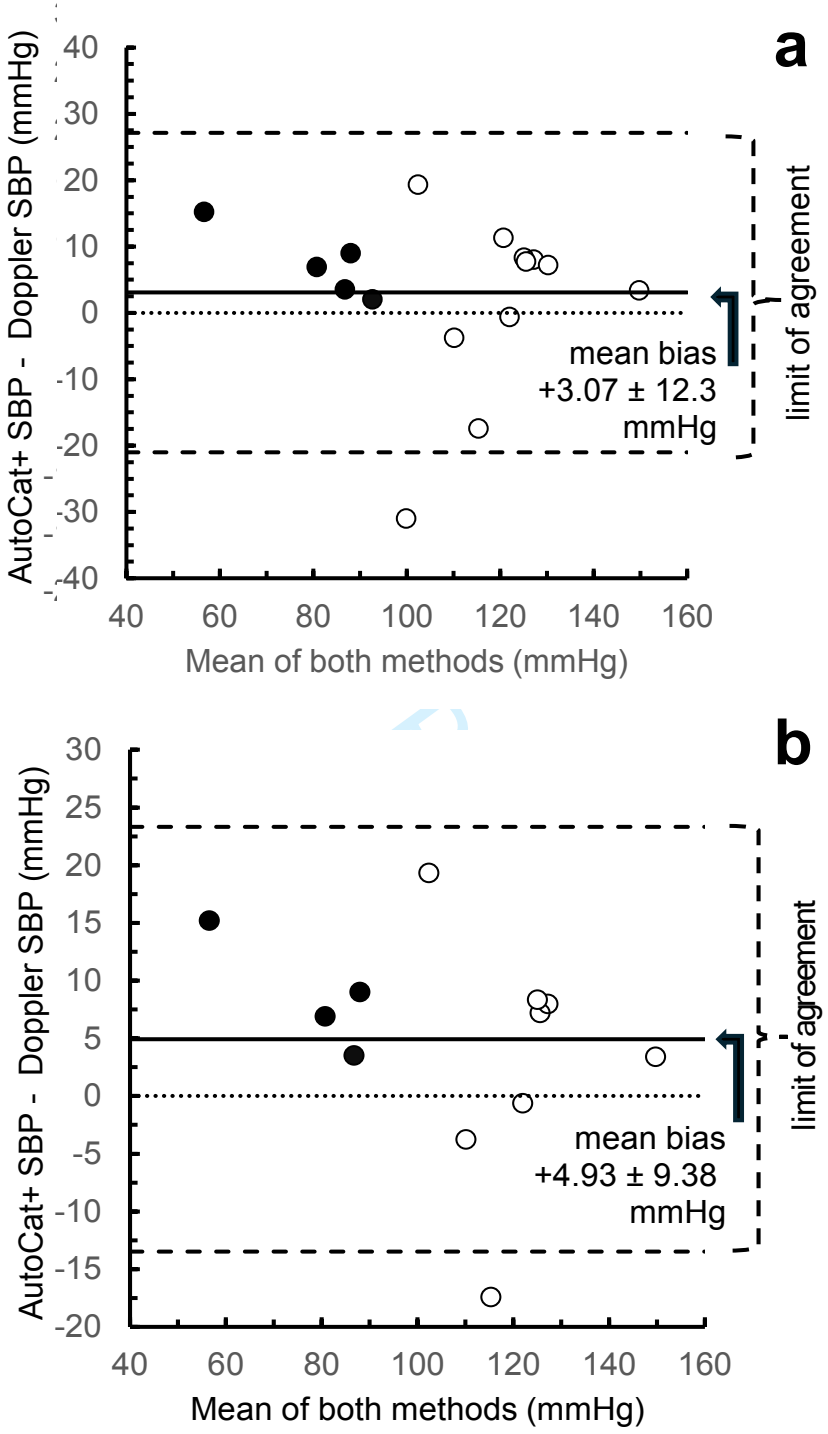




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