ERCİYES ÜNİVERSİTESİ VETERİNER FAKÜLTESİ DERGİSİ
Journal of Faculty of Veterinary Medicine, Erciyes University
Research Article/ Araştırma Makalesi
19(1), 30-36, 2022
DOI: 10.32707/ercivet.1085242

Comparison of Wall Mounted and Mobile Blood Pressure Devices Values Obtained from Healthy Cats*

Vehbi GÜNEŞ[1,a], Ali Cesur ONMAZ[1,b], İhsan KELEŞ[1,c], Mehmet ÇİTİL[1,d], Gencay EKİNCİ[1,e], Emre TÜFEKÇİ[1,f]

[1]Erciyes University Faculty of Veterinary Medicine, Department of Internal Medicine, Kayseri-TURKEY
ORCID Numbers: [a]0000-0002-4047-4409, [b]0000-0002-9942-5134, [c]0000-0001-5751-9450, [d]0000-0001-9839-7533, [e]0000-0002-4551-8749, [f]0000-0002-9611-586X

Corresponding author: Emre TÜFEKÇİ; E-mail: tufekciemre@yahoo.com
How to cite: Gunes V, Onmaz AC, Keleş İ, Çitil M, Ekinci G, Tüfekçi E. Comparison of wall mounted and mobile blood pressure devices values obtained from healthy cats. Erciyes Univ Vet Fak Derg 2022; 19(1): 30-36

Abstract: This study was aimed to determine the possible differences between two different oscillometric devices measured blood pressure. Additionally, it was carried out to determine the range levels of blood pressure measured in healthy cats admitted to a small animal clinic. In different breeds, healthy 50 cats, the median age was 8.75 months, and ranged between 3 to 36 months were included in this study. Blood pressure values and pulse measurements of the cats were measured using the wall mounted (WMD) and mobile (MD) BP monitors. BP measurements were taken from the right front leg, *arteria radialis* on the mid of the *antebrachium* and tail root over the *arteria coccygea medialis* on the median line. Mean SBP measurements taken from right forelimb (135.90±16.34 mmHg) and tail (145.32±21.20 mmHg) by WMD were statistically different (P=0.020). Mean DBP (mmHg), MAP (mmHg) and Pulse (bpm) measurements were not different on different sites by each device (P>0.05). Mean SBP, DBP, MAP and pulse values of the right front forelimb using the mobile device were 136.10±16.37 mmHg, 83.74±17.0, 101.62±16.13 mmHg and 167 (134 -227) bpm respectively. As a result, oscillometric blood pressure mobile devices and wall-mounted devices are compatible and can be used interchangeably in measuring the blood pressure in healthy cats. It is recommended to use the right forelimb for measuring blood pressure in cats. The reference ranges derived from in this study can be used by veterinary clinicians or technicians.
Keywords: Blood pressure, cat, device, oscillometry, pulsation

Sağlıklı Kedilerde Duvara Monta ve Mobil Cihaz ile Ölçülen Kan Basıncı Değerlerinin Karşılaştırılması

Öz: Bu çalışma, küçük hayvan kliniğine getirilen sağlıklı kedilerde, iki farklı osilometrik kan basıncı ölçüm cihazı arasındaki olası farklılıkların belirlenmesi ve kliniğimizde kan basıncı referans değerlerinin oluşturulması amacıyla yapıldı. Farklı ırklardan, sağlıklı, ortanca 8.75 aylık (3-36), 50 kedi (28 erkek, 22 dişi) çalışmaya dahil edildi. Kedilerin kan basıncı değerleri ve nabız ölçümleri duvara monte (WMD) ve mobil (MD) kan basıncı monitörleri kullanılarak ölçüldü. Sağ ön ekstremite ölçümlerinde; manşetin kese kısmı, *antebrachium*'un orta kısmına gelecek şekilde, *arteria radialis* üzerine yerleştirildi. Kuyruk bölgesinden ölçülen değerleri için; manşetin kese kısmı *arteria coccygea medialis* üzerine gelecek şekilde mümkün olduğunca kuyruk köküne yakın yerleştirildi. Duvara monta edilmiş cihaz ile sağ ön ekstremite (135.90±16.34 mmHg) ve kuyruk (145.32±21.20 mmHg) bölgesinden ölçülen sistolik kan basıncı (SBP) değerleri arasında istatistiksel olarak anlamlı düzeyde bir fark görüldü (P=0.020). Her iki cihaz ile sağ ön ekstremite ve kuyruktan ölçülen DBP (mmHg), MAP (mmHg) ve Nabız (bpm) değerleri arasında ise bir fark görülmedi (P>0.05). Mobil kan basıncı ölçüm cihazı ile sağ ön ekstremiteden alınan SBP, DBP, MAP ve nabız değerleri, sırasıyla; 136.10±16.37 mmHg, 83.74±17.0, 101.62±16.13 mmHg ve 167 (134-227) bpm olarak ölçüldü. Sonuç olarak, her iki osilometrik kan basıncı ölçüm cihazının uyumlu olduğu ve sağlıklı kedilerin kan basıncının ölçülmesinde birbirinin yerine kullanılabileceği görüldü. Bu çalışma ile ERÜ Veteriner Fakültesi kliniklerinde türetilen KB değerlerinin veteriner hekimler veya teknisyenleri tarafından güvenle kullanılabileceğine karar verilmiştir.
Anahtar kelimeler: Cihaz, kan basıncı, kedi, osilometri, nabız

Introduction

Blood pressure (BP) measurement is a part of routine physical examination of companion animals in places. This physiological parameter is influenced by heart rate, cardiac output, and systemic vascular resistance (Taylor et al., 2017). It is affected by a various range of physical and pathological conditions, and therefore, considered to be an important parameter in evaluating the functional endurance of the cardiovascular system (Brown and Henik, 1998; Chetboul et al., 2003). In cats, measuring the BP is indicated when diseases associated with secondary systemic hypertension are diagnosed, or in patients with the evidence of target organ damage (Brown et al.,

Geliş Tarihi/Submission Date : 27.10.2021
Kabul Tarihi/Accepted Date : 25.01.2022
* The results of the present study had been presented at the "International Congress on Agriculture and Animal Sciences (ICAGAS), 7-9 November 2018, Alanya, Antalya, Turkey" in an abstract.

2007). The diseases that are associated with secondary systemic hypertension and those that require BP measurement in these patients include; chronic kidney disease, hyperthyroidism, primary hyperaldosteronism, and pheochromocytoma (Ash et al., 2005; Wimpole et al., 2010). Target organ damage may occur in cases of left ventricular hypertrophy, retinopathy or choroidopathy, progression of chronic kidney disease, encephalopathy or stroke (Nelson et al., 2002; Sansom et al., 2004).

The most accurate and reliable arterial BP measurement method is the direct or invasive method (Mandigers, 2005). This method is considered the gold standard of BP measurement. However, it is not suitable for clinical practice, as the technique is difficult, requires anesthesia or sedation, and is uncomfortable for the cat (Branson et al., 1997; Brown et al., 1998). For these reasons, non-invasive methods are utilized more often in clinical scenarios (Grandy et al., 1992; Binns et al., 1995; Caulkett et al., 1998; Brown et al., 2007). Either the doppler sphygmomanometer and or the oscillometric BP measurement devices are used to evaluate the BP and hypertension in conscious cats (Brown et al., 2007). Oscillometric BP monitors detect pressure vibrations transmitted into the cuff by the pulsing movements of the arterial wall. The monitor measures mean arterial pressure (MAP) and then uses algorithms to determine systolic blood pressure (SBP) and diastolic blood pressure (DBP) (Dorsch and Dorsch, 2008). In recent years, various wall-mounted diagnostic monitoring systems have been used, along with the mobile type BP measuring devices, which measures the patient's body temperature, pulse, SpO_2 and BP indirectly. Although they use the same principle, there may be marginal differences in BP values depending on the measuring devices and measuring locations. Emergency clinical scenarios demand a sensitive, calibrated and an accurate BP measurement method.

BP measurements, which are part of the clinical examination, are increasingly used in veterinary clinics. With the development of various devices, the mechanism of BP regulation can be understood, and patients can be provided with the right approach. However, there is a need to determine the suitability of different devices and reliable reference data measured with these devices.

In the present study, clinically healthy and conscious cats presented at the Veterinary Research and Teaching Hospital, Erciyes University, Kayseri–Turkey were used. The aim was to compare the results between the wall-mounted and the mobile BP measuring devices in terms of device performance and the measuring location differences. Both devices use the principle of indirect oscillometric method for measuring the BP values. Two locations selected for these measurements were; the right forelimb and the proximal tail area. In the present study, the secondary aim was to create a calibrated reference range for our own clinical utilization.

Materials and Methods

Animals

The study was carried out at the Veterinary Research and Teaching Hospital, Erciyes University, Kayseri-Turkey. A total of 50 cats being presented for their annual health check and vaccination were used in this study. Upon physical examination, they were found to be conscious, clinically healthy, and with a good body condition (BCS=3). Any infectious disease and pathological condition were not determined in animals included in this study. Among these healthy 50 cats, 22 were female and 28 were male. The median age was 8.75 months and ranged between 3 to 36 months. Mean body weights were 2.98±1.19 kg. Breeds of the cats used in this study were; 19 Tabby; 5 Siamese; 2 Sarman; 4 British Shorthair; 2 Persian; 5 Ankara; 5 Scottish Fold; 1 Siberian; 1 Smokin; 1 Bombay; and 5 Crossbreed cats.

Ethical approval

This work involved the use of non-experimental animals only (including owned or ownerless animals and data from prospective or retrospective studies). Established internationally recognized high standards ('best practice') of individual veterinary clinical patient care were followed. Therefore, ethical approval from a committee was not necessarily required.

Blood pressure measurements

In order to minimize the stress before blood pressure (BP) measurement, the cats were allowed an average of 5-10 minutes in order to acclimatize in the examination rooms along with their owners and they were kept relaxed in the same position during the procedure. The blood pressure of the cats was measured in the sternal position. Only the animal owner and the clinician were present in the room during the BP measurement. Data were obtained in two different clinical examination rooms. The same room was used for each device during BP measuring in all cats. In order to choose the most suitable cuff, the right forelimb and proximal tail region circumference of the cats were measured with the help of a flexible-tape measure. In order to select the most suitable width of the cuff for the cats, approximately 30% of the diameter of the right forelimb and the proximal tail was used as a standard. The cuff was then selected according to the criteria table specified by the commercial company, <2.05 cm (blue), 2.05-2.55 cm (orange), 2.55-3.05 cm (green), 3.05-3.55 cm (purple), 3.55-4.05 cm (brown), 4.05-4.55 cm (pink), and 4.55-5.55 cm (gray). Blood pressure values (i.e. SBP, DBP, and MAP) and pulse measurements of the cats were

measured using the wall mounted (WMD) (Provet, Vet Integrated Diagnostic System/Turkey) and mobile (MD) (Pettrust, BioCARE Corporation/Taiwan) BP monitors. For the BP measurement purpose from the right front leg; the bladder part of the cuff was applied neither too tight nor too loose over the *arteria radialis* on the mid of the *antebrachium*. The cuff was tightened and secured in such a position that the cuffs tube part could easily lie in an untangled position on the table near the device. For the BP values taken from the proximal tail region; the cuff was placed as close as possible to the tail root over the *arteria coccygea medialis* on the median line. Upon the device activation, the cuff was automatically inflated. The device displayed the SBP, DBP, MAP, and pulse values after measuring them using the oscillometric measurement method. *Antebrachium* was retained at the right atrium level during BP measurements. All the measurements were carried out by an experienced and qualified veterinarian. To avoid potential bias, devices used to measure blood pressure (WMD and MD) and measurement locations (Right forelimb, tail) were randomly selected. There was a waiting period of 5 minutes between the two devices usage (WMD, MD). A total of 4 readings were taken at an interval of 15 seconds between each consecutive reading. The arithmetic mean of these four readings were taken and used in the subsequent statistical analyses.

Statistical analyses

The suitability of the data to normal distribution was evaluated using the Shapiro-Wilk test. The data sets were expressed as median (1^{st}, 3^{rd} quartiles) and mean±standard deviation. In order to compare and statistically evaluate the BP and pulse variables, among the groups; One Way ANOVA test was used for normally distributed variables and Kruskal-Wallis test was used for non-normally distributed variables. Independent Sample t-test was used to compare the gender wise statistical differences in the BP measurements. The relationship between systolic blood pressure (SBP) and body weight and age variables were evaluated using Pearson and Spearman rho correlation test. Mean bias and limits of agreement (LOA: 1.96 times SD) values between WMD and MD monitors were calculated with the Bland-Altman method (Bland and Altman, 1999). The upper and lower limits of agreement were calculated as mean bias ± the standard deviation of the differences. Tukey HSD test was used in post hoc comparisons and $P<0.05$ was considered statistically significant. Statistical analysis was performed using IBM SPSS Statistics 21.0 (SPSS Inc, Chicago, IL, USA) program.

Results

This study was carried out on healthy cats (n=50) presented to the Veterinary Research and Teaching Hospital, Erciyes University, Kayseri-Turkey. The cats showing no obvious signs and symptoms upon physical examination, were included in this study. Their ages ranged between 3-36 months (median, 8.75 months) and body weights ranged between 0.80 -5.37 kg (mean 2.98 kg). The cats' gender distributions were; 44% and 56% female and male, respectively. Two male and two female cats (Total=4) were found to be neutered and spayed respectively, according to their hospital record sheets. The average body temperature of the cats was 38.30±0.35°C. The average heart rate of the cats was 171±9.84 beats per minute. The mean circumference of the right forelimb and proximal tail area measurements were 3.43±0.56 cm and 2.88±0.62 cm, respectively.

The Table 1 summarizes the comparative values of BP (mmHg) and pulse (BPM); obtained after measuring both with a mobile and wall-mounted device, using the right forelimb and proximal tail area of healthy and conscious cats. The SBP values measured from the proximal tail area (145.32±21.20 mmHg) of the cats was found to be significantly higher than the values measured from the right forelimb (135.90±16.34 mmHg) using a wall-mounted BP measuring device ($P<0.05$). There was no difference

Table 1. Summary of blood pressure & pulse values of the right forelimb and tail (n= 50), obtained from both the devices

Devices	Groups	SBP (mmHg)	DBP (mmHg)	MAP (mmHg)	Pulse (bpm)*
WMD	Right Forelimb	135.90±16.34[a]	93.08±17.55	108.56±18.11	170 (155.75-193.75)
	Tail	145.32±21.20[b]	86.76±18.23	107.56±21.36	174 (156.50-201.0)
MD	Right Forelimb	136.10±16.37[ab]	85.24±14.98	101.62±16.13	167(154.75-189.75)
	Tail	142.38±18.25[ab]	91.02±17.52	108.16±18.05	182 (160-205.25)
	P-values	**0.020**	**0.082**	**0.202**	**0.178**

*WMD: Wall-Mounted Device, MD: Mobile Device, SBP: Systolic Blood Pressure, DBP: Diastolic Blood Pressure, MAP: Mean Arterial Pressure, BPM: beats per minute. Values are expressed as median (1^{st}, 3^{rd} quartiles) and mean ± SD. Different superscripts in the same column indicate statistically significant differences among groups, *: Not normally distributed*

in the DBP, MAP and Pulse values recorded using the wall-mounted devices (P>0.05). No statistically significant differences (P>0.05) was found between the mobile device in terms of SBP, DBP, MAP and Pulse values determined either from the right forelimb and the proximal tail region (Table 1). No statistically significant differences (P>0.05) was detected between mobile and wall adapted device with regards to SBP, DBP, MAP and Pulse values determined from the right forelimb and the proximal tail region (Table 1).

The BP values obtained in the present study from healthy cats (n=50) are summarized in Table 2. Blood pressure (mmHg) and pulse (bpm) values obtained from the right forelimb of cats using a mobile device were measured as SBP; 136.10±16.37, DBP; 83.74±17.0, MAP; 101.62±16.13, Pulse; 167 (134-227) (Table 2).

tion, there was no statistically significant differences between mean SBP values obtained from male and female cats, using the mobile device either from the right forelimb and or the proximal tail area (P>0.05) (Figure 1).

According to limit of agreement analyses (LOA) that was made in the present study, mobile and wall-mounted blood pressure measuring devices were found to be compatible. Compatibility between systolic blood pressure recorded by a wall-mounted device (WMD) and a mobile device (MD) with cuffs placed on the right forelimb demonstrated as mean bias of -0.2 mmHg and upper LOA value was 33.96, lower LOA value was −34.36 (Figure 2a). In addition, compatibility between systolic blood pressure recorded by a wall-mounted device (WMD) and a mobile device (MD) with cuffs placed on the proximal tail demonstrated as mean bias of 2.94 mmHg and upper LOA value was 41.98, lower LOA value was −36.10 (Figure 2b).

Table 2. Summary of the blood pressure and pulse values of the right front forelimb of healthy and conscious cats using the mobile device, (n=50)

Groups	Mean/ Median	1st-3rd quartiles	95% CI of Median
SBP (mmHg)	136.10±16.37	124.00-146.25	131.45-140.75
DBP (mmHg)	83.74±17.0	69.00-96.25	78.91-88.57
MAP (mmHg)	101.62±16.13	90.75-112.00	97.04-106.20
Pulse (bpm)*	167.00 (134.00-227.00)	154.75-189.75	164.80-178.96

*SBP: Systolic Blood Pressure, DBP: Diastolic Blood Pressure, MAP: Mean Arterial Pressure, bpm: beats per minute. All data were presented as mean ± standard deviations, median (1st and 3rd quartiles) and 95% CI of median, *: Not normally distributed*

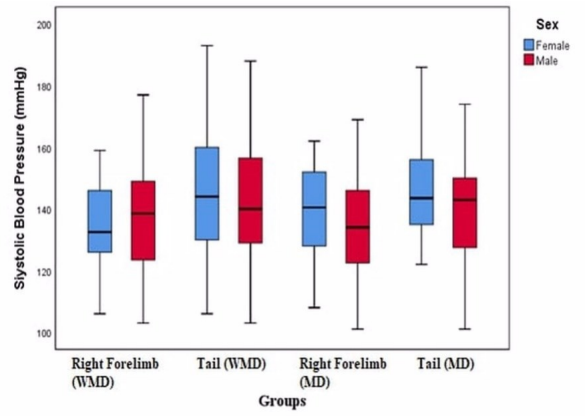

Figure 1. Comparison of systolic blood pressure (SBP, mmHg) values measured from the right forelimb and proximal tail region of male and female cats, WMD: Wall-Mounted Device, MD: Mobile Device, Independent samples t-test, P>0.05, (n=50).

Significant correlation between SBP and age (P=0.928, coefficient of correlation=0.006) were not determined, either. Furthermore, there was no significant correlation between SBP and body weight (P=0.055, coefficient of correlation=0.136). In addi-

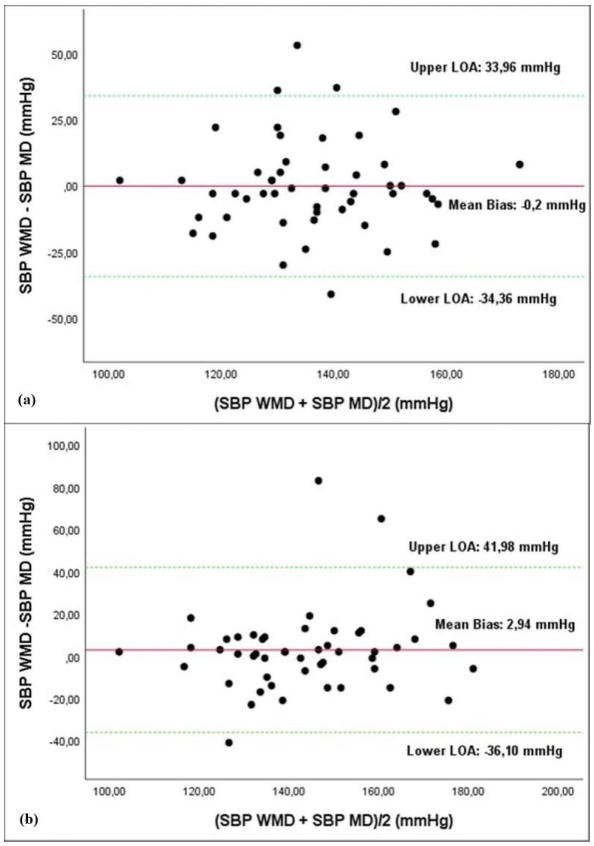

Figure 2 (a,b). Bland-Altman plots for assessing the agreement between systolic blood pressure recorded by a Wall Mounted Device (WMD) and a Mobil Device (MD) with cuffs placed on the right forelimb (a) and proximal tail region (b). In the Bland-Altman plots, the mean bias (continuous line) and limits of agreement (LOA) (mean bias ± 1.96xSD, dashed lines) are shown.

Discussion

The reference ranges for the data used in BP analysis on cats is still debatable and is improving day by day through researchers. In this study; the interchangeability between the wall-mounted and the mobile devices used routinely for measuring the BP in cats were evaluated. The most suitable site for the accurate BP measurement was also concluded.

The aim was to develop a reference range which would be derived directly from the cats living in Kayseri and could be applied and used as a reference range for the local cat population. The statistical relationship of factors, such as age, gender, and body weight on the cat's BP readings were also evaluated. A study based on the data obtained from 203 cats and using the oscillometric blood pressure measuring device reported the mean systolic BP as 139.4±26.9 mmHg and in another recent study that used data from 137 cats, mean BP values were reported to be147 mmHg (IQR; 134-158) (Bodey and Sansom, 1998; Hori et al., 2019). In the present study, the SBP (mmHg) values measured from the right forelimb (135.90±16.34, 136.10±16.37) and tail region (145.32±21.20, 142.38±18.25) were found to be compatible with the SBP values reported in previous studies (Bodey and Sansom, 1998; Payne et al., 2017; Hori et al., 2019).

In this study, we found no statistically significant difference between the mobile and the wall-mounted oscillometric blood pressure measuring devices in terms of the measured blood pressure values (SBP, DBP, MAP, and Pulse) (P>0.05). Therefore, either of the device modules can be used safely to measure BP in cats [mean bias of the right forelimb; -0.2 mmHg, mean bias of the tail; 2.94 mmHg, [Figure 2 (a,b)]. However, it was noted that the BP values measured from the tail region with either of the devices showed higher values when compared with those measured from the right forelimb of the same patient. Particularly, the SBP (145.32±21.20 mmHg) values measured from the proximal tail area were found to be significantly higher than the values measured from the right forelimb (135.90±16.34 mmHg) (P=0.020) using wall mounted device. A study on eight anesthetized cats done to investigate the accuracy of two different species-specific oscillometric blood pressure measuring devices reported that SBP (mmHg) values measured from the tail were higher than those measured from the front forearm extremity. In another study, the mean margin of error (mean bias: 7.2 mmHg and 10.9 mmHg) was also found to be higher for the measurements taken from the tail region comparatively (Cerejo et al., 2017). Similarly, in another study, where oscillometric BP measurements were carried out in conscious cats, it was stated that the mean BP values taken from the coccygeal artery were 8.7% higher than those taken from the radial artery (Cannon and Brett, 2012).

In the present study, when SBP (mmHg) values obtained from the coccygeal artery with either of the devices compared with the values obtained from the radial artery [the mean difference and percentage of difference were respectively; WMD; 9.42 mmHg (6.93%), MD; 6.28 mmHg (4.61%)] were comparatively always higher. In two articles, it was previously stated that the best place in order to measure the accurate BP in cats is the median artery in the forelimb (Haberman et al., 2004; Zeugswetter et al., 2018). The tail region inflicts less amount of stress and is tolerated well both by awake and restrained cats (Cannon and Brett, 2012). One of the reasons for differences in the measured BP values may be due to the personal error in choosing the cuff size. Placing and tightening of the cuff on the tail area due to the amount of hair on the base of the tail might be

another reason. Conical-shaped tails can lead to distal spaces or slipping of the cylindrical cuffs and peripheral pulse pressure amplification (Hershet al., 2014; Zeugswetter et al., 2018).

The most common errors in BP measurement are related to the cuff size selection (Carr, 1994; Durham, 2019). Another possible cause of SBP differences between the measurement locations may be due to the differences in the peripheral pulse pressure amplification. It may also be due to the fact that cats move their tails during the measurement. Oscillometric monitors are sensitive to arrhythmias and motion artifact (Binns et al., 1995). In the present study, direct measurements, which are the gold standard method for measuring the BP, were not performed. Therefore, the average error margin of the results obtained from the tail area and the right anterior extremities relative to the direct method have not been evaluated. However, according to recent literature (Cannon and Brett, 2012; Cerejo et al., 2017) and in accordance with the instructions given in the user manual of the mobile device (user manual, best choice: front leg > hind leg > tail), we can conclude that the results obtained from the right anterior limb may be more accurate.

We observed no significant correlation between age and SBP (mmHg) ($P>0.05$, $r=0.150$) during this study. However, the recent studies have reported that the SBP (mmHg) increases with the age, both for healthy and non-healthy cats i.e. chronic renal failure particularly (Bijsmans et al., 2015; Hori et al., 2018). It has also been hypothesized that there may be an increase in SBP (mmHg) value due to the loss of endothelial function as a result of natural senescence processes (Smulyan et al., 2001). In the present study, the SBP values measured were limited to an age group (3-36 months), and also due to small sample size (n=50), we did not work on a statistical relationship between the other age groups (i.e. adult/ prime, mature, senior, geriatric).

If we had incorporated all age groups along with a greater sample size in this study, we could have found some correlation between SBP value and age upon subsequent statistical analysis.

The availability of published data investigating the effect of gender on SBP is limited. In one of the study investigating the effect of epidemiological factors on BP values in 780 healthy cats, it was stated that the median SBP (122.2 [112.0-137.6] mmHg) value of male cats was higher than female cats comparatively (119.6 [109.5-129.6] mmHg) ($P<0.001$) (Payne et al., 2017). However, in the present study, no statistically significant difference was observed between male and female cats in terms of SBP, DBP and MAP measurements ($P>0.05$). The statistical insignificance between the BP measurements of male and female cats may be due to the low sample size (n = 50), and hence the results obtained from cats in this study represent a certain age group only (i.e. young, 3-36 months). However, Payne et al. used 780 cats from different age groups (juvenile, young adult, adult, senior), including healthy and neutered cats and was able to draw a statistical inference regarding the relationship between SBP and gender from his collected data (Payne et al., 2017).

Conclusions

Inferring from the statistical analysis of the present study; both oscillometric BP measurement monitors (Mobile Devices, Wall-Mounted Devices) are compatible and can be used interchangeably in measuring the blood pressure in healthy and conscious cats. It is recommended to use as reference values the right forelimb instead of the proximal tail area for measuring blood pressure in cats. The reference ranges hence derived from our study will be used as an indigenous and self-calibrated reference range for our own clinical procedures. Recommended future directions in the light of our present study, we advise using high definition oscillometric (HDO) devices, in order to conduct a more controlled and accurate study which should include a greater sample size of cats of various age groups (adult, mature, senior, geriatric) along with a graded stress level monitoring and where the group variances would be also homogeneous.

Acknowledgment: The authors thank master, Ph.D. students, and animal owners for their assistance.

References

Ash AR, Harvey AM, Tasker S. Primary hyperaldosteronism in the cat: A series of 13 cases. J Feline Med Surg 2005; 7(3): 173-82.

Bijsmans ES, Jepson RE, Chang YM, Syme HM, Elliott J. Changes in systolic blood pressure over time in healthy cats and cats with chronic kidney disease. J Vet Intern Med 2015; 29(3): 855-61.

Binns SH, Sisson DD, Buoscio DA, Schaeffer DJ. Doppler ultrasonographic, oscillometrics phygmomanometric and photoplethysmographic techniques for noninvasive blood pressure measurement in anesthetized cats. J Vet Intern Med 1995; 9(6): 405-14.

Bland JM, Altman DG. Measuring agreement in method comparison studies. Stat Methods Med Res 1999; 8(2): 135-60.

Bodey AR, Sansom J. Epidemiological study of blood pressure in domestic cats. J Small Anim Pract 1998; 39(12): 567-73.

Branson KR, Wagner-Mann CC, Mann FA. Evaluation of an oscillometric blood pressure monitor on anaesthetised cats and the effect of cuff placement and fur on accuracy. Vet Surg 1997; 26(4): 347-53.

Brown S, Atkins C, Bagley R, Carr A, Cowgill L, Davidson M, Egner B, Elliott J, Henik R, Labato M, Littman M, Polzin D, Ross L, Snyder P, Stepien R. Guidelines for the identification, evaluation and management of systemic hypertension in dogs and cats. J Vet Intern Med 2007; 21(3): 542-58.

Brown SA, Henik RA. Diagnosis and treatment of systemic hypertension. Vet Clin North Am Small Anim Pract 1998; 28(6): 1481-94.

Cannon MJ, Brett J. Comparison of how well conscious cats tolerate blood pressure measurement from the radial and coccygeal arteries. J Feline Med Surg 2012; 148(12): 906-9.

Carr AJ. Blood pressure measurement in small animal practice. Vet Tech 1994; 15: 163-7.

Caulkett NA, Cantwell SL, Houston DM. A comparison of indirect blood pressure monitoring techniques in the anesthetized cat. Vet Surg 1998; 27 (4): 370-7.

Cerejo SA, Teixeira-Neto FJ, Garofalo NA, Rodrigues JC, Celeita-Rodríguez N, Lagos-Carvajal AP. Comparison of two species-specific oscillometric blood pressure monitors with direct blood pressure measurement in anesthetized cats. J Vet Emerg Crit Care 2017; 27(4): 409-18.

Chetboul V, Lefebvre HP, Pinhas C, Clerc B, Boussouf M, Pouchelon JL. Spontaneous feline hypertension: clinical and echocardiographic abnormalities, and survival rate. J Vet Intern Med 2003; 17(1): 89-95.

Dorsch JA, Dorsch SE. Noninvasive blood pressure monitors. In: Understanding Anesthesia Equipment. 5th ed. Philadelphia, Pennsylvania: Lippincott Williams & Wilkins, 2008, pp. 837-43.

Durham HE. Arterial, blood pressure measurement. Vet Tech 2019; 1: 1-19

Grandy JL, Dunlop CI, Hodgson DS, Curtis CR, Chapman PL. Evaluation of the Doppler ultrasonic method of measuring systolic arterial blood pressure in cats. Am J Vet Res 1992; 53(7): 1166-9.

Haberman CE, Morgan JD, Kang CW, Brown SA. Evaluation of Doppler ultrasonic and oscillometric methods in cats. J Appl Res Vet Med 2004; 2(4): 279-89.

Hersh LT, Sesing JC, Luczyk WJ, Friedman BA, Zhou S, Batchelder PB. Validation of a conical cuff on the forearm for estimating radial artery blood pressure. Blood Press Monit 2014; 19(1): 38-45.

Hori Y, Heishima Y, Yamashita Y, Iguchi M, Nakamura K, Isayama N, Onodera H, Kitade A, Kanno N, Hirakawa A, Katagi M, Ibaragi T, Yamano S, Aramaki Y, Sawmda T. Epidemiological study of indirect blood pressure measured using oscillometry in clinically healthy cats at initial evaluation. J Vet Med Sci 2019; 81(4): 513-6.

Hori Y, Heishima Y, Yamashita Y, Isayama N, Kanno N, Nakamura K, Iguchi M, Ibaragi T, Onodera H, Aramaki Y, Hirakawa A, Yamano S, Katagi M, Kitade A, Sawmda T. Relationship between indirect blood pressure and various stages of chronic kidney disease in cats. J Vet Med Sci 2018; 80(3): 447-52.

Mandigers P. Noninvasive blood pressure measurements in dogs and cats. Tijdschr Diergeneeskd 2005; 130(7): 198-201.

Nelson OL, Reidesel E, Ware WA, Christensen WF. Echocardiographic and radiographic changes associated with systemic hypertension in cats. J Vet Intern Med 2002; 16(4): 418-25.

NIBP Cuff Selection and Placement: Accessed Address: http://www.leadingedgevet.com/node/196; Accessed Date: 02.10.2020.

Payne JR, Brodbelt DC, Luis Fuentes V. Blood pressure measurements in 780 apparently healthy cats. J Vet Intern Med 2017; 31(1): 15-21.

Sansom J, Rogers KS, Wood JLN. Blood pressure assessment in healthy cats and cats with hypertensive retinopathy. Am J Vet Res 2004; 65(2): 245-52.

Smulyan H, Asmar RG, Rudnicki A, London GM, Safar ME. Comparative effects of aging in men and women on the properties of the arterial tree. J Am Coll Cardiol 2001; 37(5): 1374-80.

Taylor SS, Sparkers AH, Briscoe K, Carter J, Sala SC, Jepson RE, Reynolds BS, Scansen BA. ISFM Consensus guidelines on the diagnosis and management of hypertension in cats. J of Feline Med Surg 2017; 19(3): 288-303.

Wimpole JA, Adagra CFM, Billson MF, Pillai DN, Foster DF. Plasma free metanephrines in healthy cats, cats with nonadrenal disease and a cat with suspected phaeochromocytoma. J Feline Med Surg 2010; 12(6): 435-40.

Zeugswetter FK, Tichy A, Weber K. Radial vs coccygeal artery Doppler blood pressure measurement in conscious cats. J Feline Med Surg 2018; 20(10): 968-72.